E-Energy

Trend Report 2009/2010

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Marie-Luise Lorenz · Christian Menkens · Nikolaus Konrad
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E-Energy

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Preface

The demand for energy in today's world is ever increasing. At the same time, fossil resources are rapidly depleting and the climate change that was long regarded as nothing but a scientific theory has become an accepted fact. This situation creates one of the greatest challenges of present times. Energy efficiency is a must at all levels, a transition to renewable energy sources must take place and greenhouse gas emissions have to be reduced. The push towards sustainable energy supply includes a decentralized, intelligent energy distribution system that will rely heavily on communication and information technology.

Most major economies are sponsoring the modernization of energy distribution grids with significant amounts of money. The German E-Energy initiative for example mobilizes some € 140 million and has been declared a beacon project by Federal Chancellor Dr. Angela Merkel. United States president Barack Obama said in his famous speech on energy: "Creating a new energy economy isn't just a challenge to meet, it's an opportunity to seize".

Especially our young generation faces these challenges and opportunities to shape a world with clean and sustainable energy supply for the generations to come. Thus we are pleased that this year's Trend Seminar class of the Center for Digital Technology & Management has taken on exploring trends and developing business models with regard to E-Energy. In the first half of the seminar, the 21 students with a broad range of backgrounds managed to get an understanding of this complex and multi-faceted subject – from technological developments over business and market opportunities to legal and political trends. In the second half of the seminar, they developed five business ideas based on the trends identified.

The findings and ideas summarized in this trend report are of remarkable relevance given the limited amount of time that the students had. It is the fresh and unbiased thinking shown in business ideas such as the E-Energy OS, the ECOperation, the Storage Cloud, the Virtual Prosumer and the Tariff Sheriff that can help pave the way for the transformational change ahead.

The European energy markets have recently seen a fundamental transformation. Driven by European legislation markets for gas and electricity have been opened for more competition. Vertically integrated firms were unbundled by separating production from distribution in order to ensure competitors a non-discriminatory access to the grid. At the same time and due to climate change issues of future energy supply and efficient energy usage have gained increasing attention. In this context the German government has launched new public programs named E-Energy and E-Mobility. These initiatives aim at enhancing energy efficiency, securing supply, and mitigating climate change through innovative and intelligent integration of advanced digital technology into the generation, distribution, and efficient consumption of energy. With the ongoing increase of energy supply from renewable resources (wind, solar, water, biogas) the ratio of adjustable (e.g., nuclear, coal, or gas power plants) to fluctuating power generation is assumed to change from around 1:6 today to 1:1.3 in 2030. This will exert remarkable strain on the energy system and, especially, the grid infrastructure. More than before grids will have to be able to satisfy fluctuating energy demand and, at the same time, they will have to cope with volatile energy supply from renewable resources. This poses enormous challenges to the predictability and controllability of the energy system. The described constellation calls for intelligent solutions. By enabling all components of an energy system to exchange information, grid management as well as the management of energy consumption could operate in a more anticipatory and balanced fashion. This would enable the reduction of carbon emissions because energy would be produced, distributed and used more efficiently. It is intended to create an ICT-based network for the entire energy system. The convergence of ICT with the energy system is referred to as E-Energy or "internet of energy" which covers all value-added steps of the energy chain. E-Energy comprises concepts and visions such as "smart grids", "smart metering", and "smart markets for energy". In international discussions the substantial perspectives of the convergence between ICT and energy are expressed with the inequality: $\text{energy} + \text{information} < \text{energy}$. It is evident that the subject of E-Energy is of utmost importance for our future and needs a huge amount of further research and development for an eventual proper functioning.

We very much applaud the initiative of our CDTM assistants and students to address this complex issue in this year's trend seminar. We are very happy that the creativity and perseverance of our excellent students contribute to the knowledge on E-Energy and will help to spread the E-Energy idea. We think that the results of this seminar are remarkable and deserve further attention.

We are impressed by the enthusiasm and dedication of the students who have produced these results during some seven weeks of intensive work. We thank Mr. Ludwig Karg, the director of the E-Energy accompanying research, for his support of this seminar and the CDTM assistants Marie-Luise Lorenz and Christian Menkens, for the tutoring of this seminar and Georg Kalus for his support.

Munich, October 23, 2009

Arnold Picot Manfred Broy

For more information about the CDTM and its related projects,
please visit http://www.cdtm.de.

The entire trend report was written by CDTM students in 2009. The papers compiled here do not claim to be scientifically accurate in every case; they are rather meant to give a structured and broad overview of trends relevant in the context of E-Energy.

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Nomenclature

ACCC	Aluminum Conductor Composite Core
ACSR	Aluminum Conductor Steel Reinforced
AMI	Advanced Metering Infrastructure
API	Application Programming Interface
BEMI	Bidirectional Energy Management Interface
CAES	Compressed Air Energy Storage
CCS	Carbon Capture and Storage
CCS	Carbon Capture and Storage
CEV	City Electric Vehicle
CHES	Compressed Hydrogen Energy Storage
CHP	Combined Heat and Power
CO2	Carbon Dioxide
CSR	Corporate Social Responsibility
DENA	Deutsche Energie-Agentur GmbH
DER	Distributed Energy Resource
DG	Distributed Generation
DOD	Depth of Discharge
DR	Demanded Response
DRP	Demand-Response-Programs
ECA	E-Car Alliance
EEG	Erneuerbare-Energien-Gesetz (Renewable Energies Act)
EEX	European Energy Exchange

EnWG	Energiewirtschaftsgesetz (Energy Industry Act)
EU	European Union
FACTS	Flexible Alternate Current Transmission Systems
GHG	Greenhouse Gas
GIL	Gas Insulated Line
GIS	Gas Insulated Switchgear
HAN	Home Area Network
HVDC	High Voltage Direct Current
ICE	Internal-Combustion Engine
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
LON	Local Operating Network
NEEX	New European Energy Exchange
PLUS	Power Link Universal System
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of the Petroleum Exporting Countries
OpenADR	Open Automated Demand Response
ORC	Organic Rankine Cycle
OTC	Over-the-counter
PaaS	Platform as a Service
PBEV	Plug-in Battery Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PLUS	Power Link Universal System
PMU	Phasor Measurement Unit
PnP	Plug and Play

PV	Photovoltaics
RAS	Remedial Action Schemes
RFID	Radio Fequency Identification
ROI	Return on Investment
SCADA	Supervisory Control and Data Acquisition
PLUS	Power Link Universal System
SOA	service-oriented architecture
SPS	Special Protection Systems
TCO	Total Cost of Ownership
TSO	Transmission System Operator
UCTE	Union for the Co-ordination of Transmission of Electricity
UHVAC	Ultra High Voltage Alternating Current
UHVDC	Ultra High Voltage Direct Current
UPnP	Universal Plug and Play
V2G	Vehicle to Grid
VDN	Verband der Netzbetreiber e. V.
VP	Virtual Prosumer
VPN	Virtual Private Network
WAM	Wide Area Monitoring
WAP	Wide Area Protection

Part I

Trends

Chapter 1

Technology Trends

Raphael Haase, Robert Kowalski, Tobias Nendel,
László Vidos, David Wehner

At the moment, the efficiency of energy consumption can be significantly improved. This is vital as the scarcity of resources has become more visible in the last few years. This chapter outlines the present state of technologies that are relevant to E-Energy as well as future developments. The new technologies can help both in saving money and making the existing resources last longer.

1.1 Introduction

Dr. Angela Merkel, Federal Chancellor of Germany, declared E-Energy a beacon project due to its vital importance in terms of both innovation and the national economy at the 2008 National IT Summit.

New, intelligent technical solutions lay the foundation of using scarce resources more efficiently. More specifically, this can be accomplished by upgrading the existing technologies with the ability to make intelligent decisions through modern information and communication technology. Integrating all of these improved technologies concerning the generation, storage, transmission and distribution leads to what is often referred to as the "Internet of Energy": A system that consumes energy more efficiently, matches supply and demand faster and more fine grained and also offers an increased reliability.

This report presents both the current state of the technologies as well as their upcoming trends.

1.2 Status Quo

Concerning E-Energy, many technological fields have to be covered in order to ensure a successful implementation of this concept into the current power grid. First of all, due to the scarcity of resources, power generation faces re-orientation towards the use of renewable energies. Since these include the problem of volatility, energy storage systems are developed, to guarentee a stable energy supply. Nevertheless, power still needs to be distributed to the customers. But, given the E-Energy concept, several problems with the current power grid arise. Furthermore, current power consumption technologies already help to lower the total wastage of energy and to reduce the amount of energy to be produced and the load the power grid has to handle. Finally, ICT systems will be used to control energy flows. The following chapters will cover the technological status quo of these five fields.

1.2.1 Generation

During the last two decades there has been a continuous development within the energy generation sector. The foreseeable scarcity of fossil fuels has spurred on research and development activities especially in the field of renewable energies. In Germany, the share of renewable energy sources in total gross electricity consumption accounted for 14.8 percent in 2008 [23, p. 6]. Figure 1.1 provides an overview of the variety of renewable energy sources that are used to generate electricity or heat and defines the process of converting primary energy sources into secondary energy. For simplicity reasons the following section deals only with the most relevant energy sources for the generation sector (see gray boxes in figure 1.1).

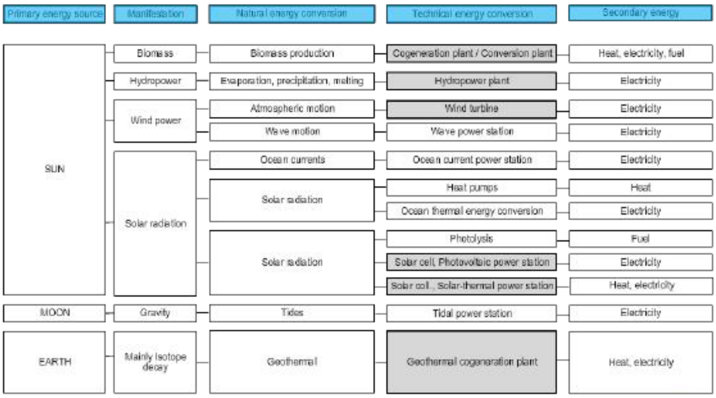

Figure 1.1: Renewable Energy Sources
Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety [24, p. 7]

1.2.1.1 Renewable Energies

- **Wind power** is the most important renewable source of electricity in Germany [23, p. 6]. Wind energy is converted into a useful form of energy such as electricity using wind turbines. In order to control the mechanical loads equally a turbine is equipped with three rotor blades. The rotor diameter reaches up to 115 meters, the hub height reaches up to 120 meters and since 1980 the nominal power of a single turbine has increased from 30 kWh to 5,000 kWh [19].

- **Hydropower** is the generation of electricity through use of the gravitational force of falling or flowing water. Most hydroelectric power is generated from the potential energy of dammed water driving a water turbine and generator. There are three different types of hydroelectricity in Germany: run-of-the-river plants, storage power stations and pumped storage plant.

- **Solar power** is the energy received by the earth from the sun in the form of solar radiation, which can be transformed into electricity (photovoltaic, solar thermal electricity) or heat (solar thermal heating). Photovoltaic power is the direct conversion of solar radiation into electrical energy using semiconductors. Absorbed photons from the sunlight enable electrons in a semiconductor to flow, generating a current [24, p. 132]. Solar thermal electricity transforms solar radiation into heat, transfers it to a heat transfer medium like oil or air, and finally drives generators like steam or gas turbine to produce electricity. Currently, parabolic trough power plants and tower power plants are widely used.

- **Geothermal power** uses the heat energy from the Earth's interior. Holes, that are up to 5,000 meters deep, are drilled and are filled with a heat-transfer medium that circulates through the rock layers. The medium is heated up and returns to the surface. Depending on the medium's temperature the heat energy can be used for heat as well as power generation. Currently, the most efficient method is the hard, dry rock method: Water under a very high pressure is used to create cracks and gaps in the deep rock layers. Increased permeability of the rock and a natural heat exchanger is obtained. As a consequence the heat-transfer medium can absorb more heat during one circulation [24, p. 114].
- **Biomass power**, or biopower, is the use of biomass to generate electricity. Biopower system technologies include direct-firing and cofiring (combustion), gasification, pyrolysis and anaerobic digestion (liquefaction) [46]. Biomass fuels include among others timber, industrial wood residues, sawmill by-products and logging remains [24, p. 98].

1.2.1.2 Fossil Fuels

Fossil-fuels are the primary source of energy in Germany [23, p. 9]. Therefore, they provide the base load of the electricity generation. Fossil-fuel power plants first combust the coal, gas or oil creating tremendous amounts of heat. This heat is used to evaporate water in boilers. The resulting steam expands and runs a steam turbine, generating electricity [17]. Due to the strong dependency on fossil fuels for power generation solutions to reduce the high emission of greenhouse gases such as Carbon Capture and Storage (CCS) are developed [61].

1.2.2 Storage

Storage will play an important role according to envisioned E-Energy developments [44]. Therefore, a swarm of storage technologies and capacities is to be expected. This section first presents an overview of currently available storage technologies, after which it highlights some of the fields' general shortcomings as of today.

1.2.2.1 Basics of Storage Technologies

Figure 1.2 visualizes the overview of storage methods:

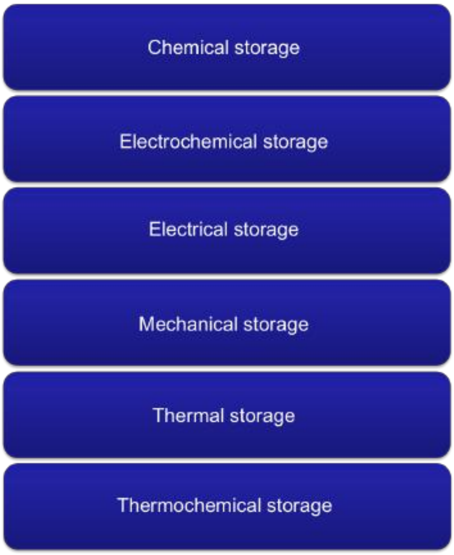

Figure 1.2: Overview of Storage Methods

- **Chemical** energy carriers store energy in the form of a chemical substance. They are produced either naturally, like crude oil, or artificially, like hydrogen. Forms of chemical storage include biofuel, hydrogen, liquid nitrogen, hidrocarbon (e.g. crude oil, natural gas or coal) and synthetic hydrocarbon fuel.

- **Electrochemical** storage systems first transform electrical energy into chemical energy (e.g. charging a battery). The storage system is then capable of converting chemical energy back into electrical energy again. In addition to conventional lead acid batteries, electrochemical storage also include advanced batteries (e.g. sodium/sulphur, zinc/bromide or metal/air), fuel cells and Redox Flow Systems.

- **Electrical** storage media use electric or electromagnetic fields to store energy. Some technologies based on this principle are capacitors, supercapacitors and Superconducting Magnetic Energy Storages.

- **Mechanical** energy storage first need energy to bring the storage media into motion. When energy is drawn from it, the movement of the storage media is converted into electricity. For example, using energy to pump water up a hill into a storage reservoir is a way of storing energy mechanically, as the water can be later released to produce electricity with the use of a turbine driven by the mass of the flowing water. Relevant examples are Compressed Air Energy Storage, flywheels, hydraulic accumulators and pumped storage plants.

- **Thermal** storage media are either heated up or cooled down and thus can store heat or cold, respectively. Some technologies are able to store energy for a long period of time, while some only use the heat of the daytime sun to keep homes warm during the night. Thermal storage technologies include ice storage, molten salt, cryogenic liquid air or nitrogen, solar ponds, steam accumulators, water, air and bricks.

- **Thermochemical** ways of storing are applied when heat is stored by inducing a reversible chemical reaction, while the temperature of the storage media itself is left unchanged. Exposure to specific conditions then makes the storage media to emit heat. Such thermochemichal storage carriers are for example zeolite, silica gel and metal hydride.

1.2.2.2 Shortcomings of Storage Technologies

Cost-efficiency plays a vital role in increasing the use of each type of storage. Other than cost, current research also focuses on improving performance, e.g. reliability, safety, size, materials used, durability, capacity, efficiency [21] and start up time of the system. For example, the issue with batteries in general is that they are expensive, have a short lifetime and a small capacity, are dangerous as they can heat up and the materials used in them are not environmentally friendly [56, p. 97].

Most importantly, today's technologies do not have the capacity to store large amounts of energy or are too costly. In general, they are not performing well enough for the mass market. Furthermore, they do not posess the ability to communicate. Therefore, some improvements in technology will have to emerge before storage can serve the needs of the E-Energy sector [370, p. 59].

1.2.3 Transmission and Distribution

Germany's current power grid follows a hierarchical command-and-control approach. This means that the infrastructure is predominantly based on large central power stations connected to high voltage transmission systems, which supply power uni-directionally to medium and low voltage distribution systems and is controlled centrally by the resident energy provider [57, p. 15]. Energy can be induced at any layer and mainly follows the one-way power flow downwards. This structure is the vertical alignment of the grid and its voltage values are defined within the DIN IEC 60038 (VDE 0175) norm. Additionally, there is a horizontal division for power exchange. On the one hand, there is the European continental exchange which is determined in the Operation Handbook by the Union for the Co-ordination of Transmission of Electricity (UCTE)[1]. On the other hand, the Transmission Codes of the Verband der Netzbetreiber e. V. (VDN) regulate the exchange with Germany's adjacent countries.

1.2.3.1 Transmission Grid Layers

Figure 1.3 shows the different layers of today's power grid.

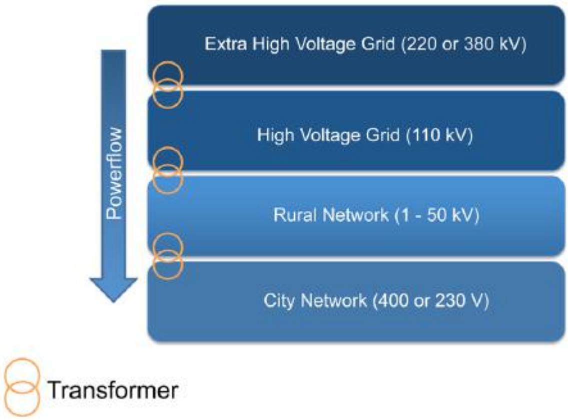

Figure 1.3: Power grid layers

The top layer is the Extra High Voltage Grid, with a voltage level of 220 or 380 kV. This grid is the basis of the transmission and interconnection networks, which often link the far-off generation centers and consumption areas via **Aluminum Conductor Steel Reinforced (ACSR)** cables [38, pp. 120-123] according to EN 50182 [28, p. 362], conducting a three-phase Alternating Current. As the figure shows, there are transformer stations between each layer, stepping down the voltages to the according ones of the next layer.

The next layer is the High Voltage Grid, with a voltage level of 110 kV, which forms the sub-transmission networks. In this layer the energy from the Extra High Voltage Grid is received, transformed into lower voltages and transported to large-scale industry customers.

[1] integrated into ENTSO-E (European Network of Transmission System Operators for Electricity) in July 2009

1.2.3.2 Distribution Grid Layers

On the Rural Network layer the power is stepped down from transmission level voltage to a distribution level voltage of 1 to 50 kV and is transported via radial field cables [38, pp. 120-123] to small-scale industry and the City Network's substations.

The last layer is the City Network with a voltage level of 400 or 230 V. Normally it has a radial, loop or network topology [42, p. 29] and represents the last mile to households or smaller customers.

1.2.3.3 Problems of Current Power Grid

The E-Energy concept relies heavily on renewable energies, which pose a threat to the current power grid. The supply is often intermittent, causing fluctuations and strain on the grid [11, p. 911 ff], leading to grid bottlenecks and congestions [35, p. 66]. Additionally the problems of high energy loss, e.g. due to ACSR cables, over long range transmission [11, p. 911 ff] and the insufficient connections between high and low load centers [10, p. 5] have to be solved.

Another related problem is the inefficient power consumption, as when less power is needed, the less has to be transported or distributed. Therefore, the following paragraph will address the topic of power consumption.

1.2.4 Consumption

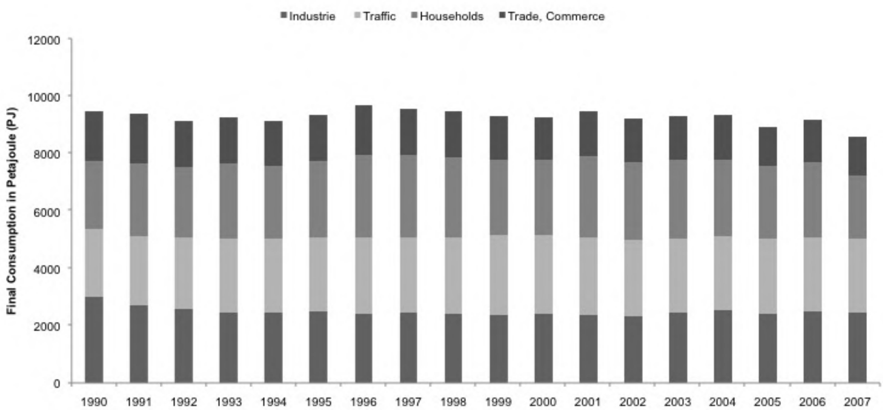

Figure 1.4: German energy consumption ordered by their application areas
Source: according to Federal Ministry of Economics and Technology [25, p. 7]

In a continuously growing economy the total energy consumption has been stagnating at nearly the same level (see figure 1.4). This is an result of continuously improving electrical technologies and an explanation for the market growth of energy saving technologies by nearly 100 percent in the last years [6, p. 22].

1.2.4.1 Inefficient Power Consumption

Most of the energy saving potential in the German industry sector can be utilized by using more modern technologies [53, p. 4]. High energy consumers are lighting installation, compressed air systems, pumping systems, refrigeration, ventilation and industrial furnace. For example lighting installation are often equipped with conventional electronic ballast, inefficient light bulbs and bad or often no reflectors. Current electrical drives, that are used in many industrial processes are operating up to 50 percent less energy efficient than modern, comparable alternatives [53, p. 8].

The private Sector provides an even bigger opportunity for energy saving technologies. Devices that consume a lot of energy in a typical German household are refrigerators, the heaters, washing machines, wash dryers or the dish washers. But also small appliances like light bulbs, kettles or time switchers are wasting energy [6, p. 25]. Nevertheless, first efforts have been taken to push consumers to use more energy efficient appliances. Therefore, the European Union introduced the energy label and banned the selling of energy wasting light bulbs.

1.2.4.2 Smart Meters

Like their predecessors, smart meters measures the consumed energy within a certain time. But other than their predecessors, smart meters are capable of bi-directional communication. Existing products either communicate over the landline or via the power line. They provide their operator with real time data about consumption and are capable of transmitting those data to the power provider for billing and analyzing purposes. Over 900 utilities for smart metering are on the German energy market and nearly all major energy suppliers are testing different approaches of smart metering[8, p. 34]. Due to the experiences gathered from pilot projects, the estimated coverage of smart meters is about 0.01 percent [8, pp. 37-39].

1.2.4.3 Energy Independent Buildings

Other efforts have been taken in the sector of zero-energy buildings. While there are many approaches considering these buildings, they all have in common, that they are consuming their energy from low-cost, locally available, non polluting, renewable sources [60, p. 2]. These concepts includes many technologies from production over storage to efficient consumption. The Fraunhofer-Institute gave proof of this concept in their research project “Das Solarhaus Freiburg” [4].

1.2.5 Information & Communication Technology

Despite E-Energy being a new topic, a major part of the information and communication technology that can be used for future products already exists.

1.2.5.1 Private Cloud Computing

Today, most companies and institutions take care of their IT infrastructure themselves. This infrastructure is referred to as the private cloud [9, p. 1]. In this model, servers are directly controlled by their owners. That means that owners have to buy or rent hardware and software and administer them. Also, every server device usually has one or multiple clear roles like a home automation server or a mail server. These roles can not be exchanged so easily. For example, a software that analyzes and optimizes the power consumption of a private home could not be transferred to another server so easily [45]. This implies that when buying a new software like the mentioned optimization software, users might have to buy a separate server device as well.

1.2.5.2 Existing Communication Protocols

There are a number of communication standards for home automation that can potentially be used to optimize the usage of energy [50, p. 158]. Standards like the KNX Standard or Local Operating Network (LON) [50, p. 158] are common in home automation. They are the base for communication and can be used with multiple wired and wireless Physical Layer[2] technologies like Powerline or Radio Frequency [50, p. 158]. Both KNX and LON are open and can be implemented by anyone. Nevertheless, home appliances usually use proprietary protocols for all or some layers above the Transport Layer, which renders integrating such devices with ones of other vendors or different kinds of devices unfeasible [12, p. 15].

Internet standards like TCP/IP and HTTP are used by some home automation appliances that allow accessing Internet content as an addition to their main functionality, e.g. the Gira InfoTerminal [7]. Also, concepts of using Internet protocols for basic home automation tasks exist [30].

1.2.5.3 Traditional Data Security

Data security is usually reached in one of two ways: either through access restrictions or through encryption combined with authentication mechanisms like digital signatures. Access restrictions can consist of storing certain data only in an isolated wired network that can not be accessed from outside (like the Internet). Alternatively, IT systems can be protected by a firewall that controls

[2] according to the OSI Reference Model

which information may leave and enter a network [62, p. 245]. Individual systems can also be made completely inaccessible from the Internet.

Encryption can be implemented through technologies like Virtual Private Network (VPN) when communicating over the Internet [62, p. 279]. Additionally, when data is stored on mobile devices like laptops or mobile phones, data can be encrypted on the storage media to avoid data theft when hardware is stolen [36].

1.3 Trends

In the following part, this report outlines the technological trends in the E-Energy market until 2015. For the generation and storage of energy, there is a clear trend towards making the means of using renewable energies more efficient and therefore more attractive as well as a higher share of distributed generators and storages. To allow consumers to become producers in the future, it is neccessary to upgrade the transmission and distribution grid to allow transferring energy in both directions. Furthermore, energy consuming devices are going to be more efficient. And finally, information and communication technology provides the foundation of making devices smart by enabling them to communicate over the Internet and querying current energy prices, thus allowing them adapt their behavior to supply and demand.

1.3.1 Generation

In the near future renewable energies will play in increasingly important role in the energy generation sector. A major trend within the renewable energy sector will be the improvement of existing technologies. Wind turbines will become larger and more powerful. The degree of efficiency of solar cells will increase and new technologies (e.g. organic photovoltaics) will be applied. Due to small power stations becoming increasingly efficient the share of power from decentralized generators will grow and enable the decentralization of power generation. For simplicity reasons this section focuses only on the most relevant renewable energy sources for the electricity generation.

1.3.1.1 Increasing Efficiency of Renewable Energies

Within the **wind energy** sector there are two major trends: extension of offshore wind energy and the re-powering of onshore turbines. Since economically and ecologically suitable areas to further expand wind power on land are scarce, the very large potential at sea will be used to generate electricity (annual yield between 85 and 100 TWh) [368, p. 67]. A suitable form of foundation for the new 5 MW turbines must be found. Among recent developments are monopiles, tripods, jackets, tripiles and “suction bucket” [23, p. 34]. To reduce the mechanical load for off-shore wind turbines novel drivetrains, new materials for wind turbine rotors and improved control systems will be applied [59, pp. 4-7]. To increase efficiency new types of automatic transmission will be used [33]. All these effects are currently tested in the Alpha Ventus offshore wind park in the North Sea. Repowering is the trend to replace older wind turbines with bigger and more efficient turbines. The concept is to use less turbines to produce more electricity [23, p. 69].

The **solar power** sector will see several trends. Different types of silicon will be applied for photovoltaics: monocrystalline silicon, polycrystalline silicon and thin-film cells. Another future concept is the tandem cell, which uses several semiconductor materials to absorb a larger solar spectrum [23, pp. 77-78]. Organic photovoltaics will use organic cells to produce electricity [26, p. 22]. For solar thermal electricity new types of power plants will be used: fresnel trough power plants, parabolic dish power plants and solar chimney power plants [23, pp. 83-84].

Wind and solar power are intermittent energy sources. Therefore, they will be a challenge for the existing grid. Figure 1.5 illustrates that the output of a single wind turbine is very volatile. The construction of a wind farm (see thin curve in figure 1.5) or the installation of wind farms in different locations will only partially solve the problem (see bold curve in figure 1.5). Thus, new storage technologies and improved grids will be necessary to use renewable energy resources efficiently.

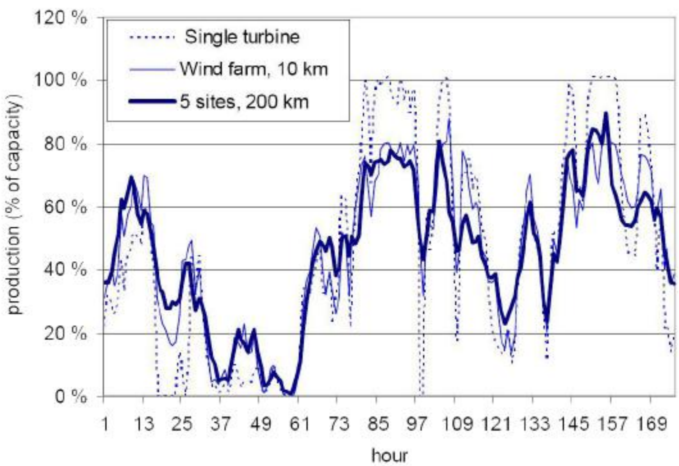

Figure 1.5: The power output from one single wind turbine, from a wind farm and from multiple wind farms
Source: Norgaard and Holttinen [48]

The **biomass** sector will move towards more efficient and smaller power plants, especially Combined Heat and Power (CHP) generation systems. CHP is an integrated system, located at or near a building or facility, satisfying at least a portion of the facility's electrical demand and utilizing the heat generated by the electric power generation equipment to provide heating, cooling to a building [43, p. 1].

The exploitation of existing deep bore holes, the production of high-strength materials, alloys, and pumps which can withstand the particularly aggressive properties of thermal water as well as the improvement of the Organic Rankine Cycle (ORC) are the important trends within the geothermal power sector [23, pp. 114,120].

1.3.1.2 Decentralization of Power Generation

Distributed Power Generation is a new concept of energy generation and closely linked to the so-called "Virtual Power Plant". A virtual power plant is a network consisting of a number of small, peripherally installed electricity-producing devices which are connected to each other and which are enabled so as to replace the centrally available electrical power of generating plants [5, p. 16]. Small, decentralized power stations like photovoltaic systems, small biomass plants, small wind turbines, and a small-capacity CHP plants will be used in that context [23, p. 133]. This concept will allow for a flexible response to unexpected changes in the load curve. Due to the distribution and independence of the small power stations the concept is also very reliable.

1.3.2 Storage

In the future, customers will be given broader choices over their electricity consumption in many ways. One of them is the choice to use energy not necessarily when it is available, but rather when it is needed. To bridge the time gone between energy generation and consumption, storage is put to use. This section identifies two trends concerning storage technologies. These are Smart Storage and the development of storage for mass application.

1.3.2.1 Smart Storage

A goal in the future will be not to simply store energy, but to store it in an intelligent storage system that is able to decide when to load and unload energy. To achieve this, storage systems have to be capable of communicating. They either receive a command from the customer or a signal from the power supplier. Customers can decide to purchase energy when it is inexpensive. After storing the amount purchased, customers will be able to use or sell energy at a time when they wish to do so. This requires collaboration among customer, supplier and other customers. Therefore, smart storage needs to be connected to the grid. Storage systems will posses intelligence in the sense that they are able to make decisions on their own, e.g. using a smoothing algorithm to store parts of the output of a wind turbine based on weather forecasting [18]. Storage capacities of plug-in vehicles can be used to balance the load as they will be connected to the grid, too. During peak hours they will represent a source of energy supply, while during a low in the load they will charge themselves with electricity and thus help to increase current demand. As this vision largely relies on communication systems [27, p. 59], developments in storage technology lead towards the concept of storage combined with ICT.

1.3.2.2 Developing Storage for Mass Application

To boost the expansion of the technology described previously, storage technologies need to be established on a wider basis first, which calls for a facilitation of their application.

Transformation allows for storing energy that is otherwise lost and for storing when it is cheap to buy. The energy of the daytime sun will need to be stored in order to be used later during the night. The utilization of renewable energies, which are of intermittent nature, is growing [27, p. 51]. Inexpensive energy can be used for pumping water up a hill, only to regain energy from it later, thus helping balancing the load curve while saving on energy production. Surplus energy generation can be transformed to storable hydrogen using electrolysis. These examples combined with the fact that the earth is running short on fossil resources suggests a wider utilization of storage systems in the future [27, p. 4]. A growing demand for these systems calls for the facilitation of their application through developments in their technologies, as they are still not always economical enough or do not perform as needed. The following examples emphasize this point and present some developments.

The liquid battery, an emerging technology, costs about a third of the best batteries available today. It has a longer discharge time and is capable of absorbing a lot of electricity in a short time [15, pp. 46]. One considerable problem of plug-in vehicles which are run by batteries is that charging should function not only in the parking garage, but also in parking slots on the street. Regarding super-capacitors, research targets material development and energy management [21]. Research on flywheels includes improved materials and manufacturing, to achieve long term mechanical stability and cost-efficiency [20] as well as raise operating time to several hours [20]. A drawback of thermal storage systems in general is the loss of heat during storage. Based on similar thinking is the idea to increase the efficiency of Compressed Air Energy Storage by capturing the heat emitted by the running system. An adiabatic version, which is capable of that, could be commercialized by 2015 [27, p. 16]. To reduce costs, improvements in the technology of Superconducting Magnetic Energy Storage focus on high-temperature super-conducting materials and on low-temperature power electronics [21]. Concerning pumped-hydro sites, research will aim at working on drawbacks like construction time and capital expenditure [20] as well as on overcoming specific geographical restrictions.

1.3.3 Transmission and Distribution

In general there are several general trends, that can be identified. First of all, the power grid will receive a major upgrade, in order to support the approach of an intelligent power grid. Moreover, new long-range transmission technologies reduce the problem of transportation losses. Last but not least, a new small-scale distribution method, called Micro Grid induces new trends for the distribution lines.

In contrast to the current approach in transmission and distribution, the trend goes towards a symmetrical peer-to-peer strategy, which can be found in Smart Grids, described below. This means that, instead of flowing uni-directional, power will be distributed in a bi-directional way [57, p. 16] between users with their own generators, becoming producers and consumers at the same time [55, p. 100]. In order to successfully shift from the old approach to the new one, the above mentioned current problems of the power grid have to be solved. According to the Deutsche Energie-Agentur (dena), grid congestions and fluctuations can be eliminated by extending the Extra High Voltage Grid with further open wires and adding more phase shift transformers. In doing so, also the problem of insufficient interconnection between high and low load centers is addressed and solved [35, pp. 66, 67]. Furthermore, due to the technology trends described in the subchapter Intelligent Large-Scale Transmission Grid the issue of long range transmission will be resolved, too.

1.3.3.1 Intelligent Transmission and Distribution

An intelligent transmission and distribution grid is also called smart grid and describes the current trend within energy networks. A basic overview can be seen in figure 1.6.

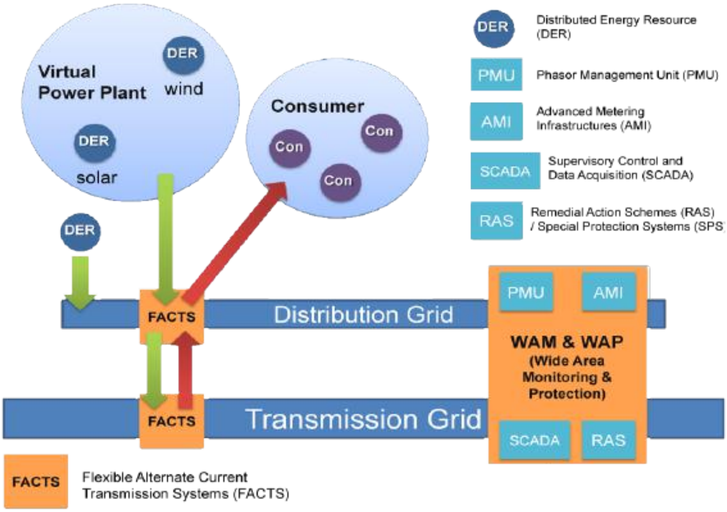

Figure 1.6: Transmission and distribution technologies for smart grids

Within a Smart Grid, power generation is decentralized and is based on clusters of small **distributed generation (DG)** installations, like photovoltaic, wind turbines or other renewable energy sources, which can feed the power directly into the grid or follow the concept of **Virtual Power Plants** [10, p. 6]. Due to the symmetrical approach in smart grids, power can flow from **Distributed Energy Resources (DER)** into the distribution and transmission network and consumers can even feed their produced energy into it. This will be achieved by the use of intelligent **Flexible Alternate Current Transmission Systems (FACTS)**. These are defined by the IEEE as "a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability." [34, pp. 1848-1853]. Consequently, by using FACTS between producers and consumers, it will be possible to route the power between these nodes [55, p. 2006]. Due to the smart grid's bi-directional power floats, illustrated by the opposing arrows in the figure, an advanced sensoring and metering within the energy network is mandatory. Therefore, **wide area monitoring and protection (WAM and WAP)** systems will be installed within the grid. A vital component for monitoring are **Phasor Measurement Units**

(PMU). These units provide synchronized phasor measurements of voltages and currents from dispersed locations within the grid [49, p. ii]. Another key technology for monitoring are **Advanced Metering Infrastructures (AMI)** for load profiling. The needed information is gathered by measuring, collecting and analyzing energy usage. In contrast to collect data on the energy usage **Supervisory Control and Data Acquisition (SCADA)** systems collect data from various sensors from a power plant or the grid itself and provide the information in central management stations. For protection purposes **Special Protection Systems (SPS)** or **Remedial Action Schemes (RAS)** are used to detect abnormal conditions and automatically perform switching operations to avoid network collapse [40, p. 2]. The integration of an **ICT** infrastructure makes the grid smart by linking the above described technologies and allows the decentralized digital management of the grid. Due to this smartness, load balancing (leveling high peaks and demand valleys in energy consumption) and **Demanded Response (DR)** mechanisms (manage customer consumption of electricity in response to supply conditions) can easily be implemented in combination with smart storages.

1.3.3.2 Large Scale Transportation

Intelligent large-scale transmission grids pose as an extension to smart grids, but concentrate on long range electricity transmissions and are usually called Super Grids. For these, it is essential to reduce power loss and to increase power transfers. Several trends can be identified to solve these problems: One way to improve transfer capability is to use **Aluminum Conductor Composite Core (ACCC)** instead of ACSR cables. Due to the use of special composite materials, cables are lighter and have greater current carrying capacity. Another way to achieve improved transfer capability is superconductivity, by using a superconductor electricity pipeline, which would significantly reduce line loss. Furthermore, the already mentioned FACTS technologies will also contribute to the improvement of power flow [57, p. 28]. **Ultra High Voltage Direct Current (UHVDC)**, **Ultra High Voltage Alternating Current (UHVAC)**, **High Voltage Direct Current (HVDC)** and the **HVDC Power Link Universal System (HVDC PLUS)**, which is currently developed by Siemens, are technologies for transmission lines, which represent trends for an even more effective long range transmission of high and ultra high voltages [14, pp. 13-17][10, p. 6].

1.3.3.3 Fragmentation of the Power Grid

Another modification of the Smart Grid, concerning small-scale distribution, is the micro grid. It is a controlled entity, that is interconnected or isolated from the main distribution grid, which combines a Low Voltage distribution system (City Network), various distributed energy sources, storage devices and controllable loads [31, pp. 197-212]. As a result, it can operate connected to the Rural Network or isolated from the main grid [55, p. 109]. It is also possible that the micro grid induces the generated power into the grid. Trends for the distribution lines are the use of **Gas Insulated Lines (GIL)** in combination with **Gas Insulated Switchgear (GIS)** [57, p. 28], which are also under further development by Siemens. The benefits of this technology are the reduction of power flow problems and the risk of power failure of electrical transmission systems [54] and that it needs less space, due to the isolation by gas. Nevertheless, it is likely that for cost reasons, current distribution cabling will still be used, too.

As many new technologies are used in transportation and distribution, there will be new innovations in the field of power consumption as well, which will be described in the following paragraph.

1.3.4 Consumption

Upcoming technologies will empower the consumers to decide, from whom and to which times and prices they consume their energy. They will be able to give more decision power to the grid operator, letting the grid decide, when it is smart, to do energy consuming work.

1.3.4.1 Intelligent and Efficient Consumption

The trend in the private sector leads from smart meters to an intelligent household with smart appliances. Daily technologies like washing machine, dish washer or heater, will be aware of their current consumption, the current energy market and can decide on their own, when it is efficient to operate[58, p. 46]. Current industry players like the ZigBee Alliance pushing the trend for consumer appliances towards wired and wireless communication over the home area network (HAN) [8, p. 48]. With their standards, connected devices will be able to communicate with each other and exchange information about their status and receive messages [32, p. 3].

Apart from making the appliances smarter, the energy efficiency of existing technologies will increase [6, p. 22]. Especially big appliances in a common German household bear a lot of potential for energy savings. [6, p. 23]

1.3.4.2 Interconnected Energy Consuming Technologies

Once the mentioned system of a smart grid is established and multiple households can communicate with the power provider, it is possible to extend the concept of a Virtual Power Plant to an Virtual Power System. This term describes not only the production side, but also the consumption side. It describes a closed circle of production and consumption, acting as an independent subsystem, which balances supply and demand on its own.

Emerging E-Mobility concepts will not only bring new chances for energy storage technologies but also chances for new distribution and consumption technologies. Smart charging facilities will ensure, that the new electricity consuming cars will neither increase the peak loads [51, p. 14], nor overload the power grid when multiple cars are plugged in at the same time [51, p. 9]. Information and communication technology will enable those new consumers to meet these requirements.

1.3.5 Information and Communication Trends in E-Energy

New technological developments play a key part in E-Energy as they are the basic enabling technologies that allow devices to make intelligent decisions.

1.3.5.1 Public Cloud Computing

Public Cloud Computing is a trend in the whole IT industry and means that computing is provided as a service over the Internet to the general public [9, p. 1]. The provider of a cloud computing service usually takes care of developing and deploying the software as well as building and maintaining the infrastructure on which the cloud computing service runs. This has numerous advantages for users: Users do not have to install or update software [29]. Cloud computing providers use highly redundant hardware [16] that is very robust, which minimizes the risk of unavailability or data loss. Robustness and constant availability is essential to an infrastructure that controls E-Energy devices [2, p. 34]. Additionally, cloud computing is highly scalable [29, p. 10], thus allowing consumers to easily add new devices to their homes without having to buy additional peripherals (like home servers) for that purpose. Scalability will also be an advantage when future software that controls E-Energy devices performs comprehensive analyses, which are very compute-intensive [9, p. 7].

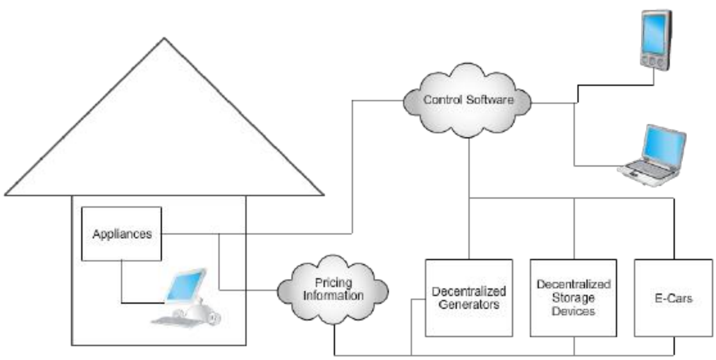

Figure 1.7: Cloud-based demand-supply response and control

1.3.5.2 Internet-Connected Appliances

In the future, a lot more appliances will be connected to each other over the Internet [22, p. 16]. This will allow on the one hand a bi-directional communication between devices on the consumer's site and the grid operator and also a direct exchange of information between the consumer's devices. Such information could be pricing information or status information about other devices in the same house. Controlling household appliances through a graphical web interface built with standard web technologies like in Google's PowerMeter [3] is another possible feature of future appliances [52]. Figure 1.7 illustrates a system of household appliances as well as decentralized generators, storages devices and plug-in hybrid electric cars, which can all be controlled via a service in the cloud and which can respond in realtime to changes in energy prices.

Additionally, there is a trend towards using the service-oriented architecture (SOA) concept when designing communication protocols for connected appliances [50, p. 27]. SOA is a concept in which functionality is encapsulated as a service. It is used both as a concept in system development and the integration of systems. Services are loosely coupled and, therefore, allow totally different technical devices to communicate with each other without knowing the other's implementation [13, pp. 2 ff]. Furthermore, SOA-based applications only need to implement one interface instead of a separate interface implementation for each communication path between one device and the others[12, p. 20].

SOA is often implemented through web services [50, p. 8]. Therefore, the communication between intelligent and connected energy devices relies on the standard Internet protocol stack. This includes TCP/IP for the network and transport layer [50, pp. 49, 60, 100]. There are numerous alternatives for the physical and media access layer like the common Wireless LAN or wired Ethernet within houses and WiMax for transmission within longer ranges [50, p. 169].

With SOA as a foundation, there also is a trend towards standardizing the semantics of the exchanged data. A common semantics is not part of the SOA concept, but is required to effectively couple systems together [50, pp. 13, 34].

1.3.5.3 Supply-Demand Response and Monitoring

One of the first standards for exchanging pricing and signaling information is the Californian standard Open Automated Demand Response (OpenADR) [41]. OpenADR is a standard for the communication between a grid operator and consuming devices. It allows these devices to automatically respond to fluctuating energy demand and therefore prices without human interaction [39].

Another new standard called Bidirectional Energy Management Interface (BEMI) goes one step further: It makes a bi-directional communication between consumer devices and decentralized generators possible. Accordingly, both sides can adjust their consumption and generation respectively. It can also be used to exchange related information like outdoor weather forecasts that allow cooling devices to respond in advance [47].

1.3.5.4 Data Security for Connected Devices

While it was possible in the past to restrict access to certain devices from external networks like the Internet, the new effort to connect most devices to the Internet clearly exposes them a lot more to threats [2, p. 36]. At the same time, appliances should not be more difficult to use in order to follow security requirements. Accordingly, new standards that describe security requirements like IEEE 1686 [1] or IEC 62351 [50, p. 148 ff] have been developed. Other new standards like OpenADR include security mechanisms directly [41, p. 37]. Furthermore, existing technologies like Radio Data System can be enhanced by additional security measures [37, p. 37].

As of yet, there is no clear technological trend of how much data will be distributed among systems that users can directly control (like home appliances) and public cloud systems, especially in the light of privacy.

1.4 Conclusion

This report presented the status quo of used technologies and upcoming trends in the energy market regarding the E-Energy concept. The tradional parts of the energy value chain, production, transmission, distribution and consumption, are facing big changes in the upcoming decades. Energy production from renewable energies will play a major role in the next years. Many of those small-scale plants will be installed at the level of the distribution grids and will work in a bi-directional way. With the increasing ease of feeding energy into the power grid, and the growing efficiency of the renewable technologies, the role of the consumers will change. They will not merely be consumers but also producers of energy. To use the whole potential of the small scale energy plants, storage technologies will play a significant role. Especially the upcoming E-Mobility trend is seen as a major opportunity to store overproduction. Information and communication technology will support and connect all these parts of the value chain to an intelligent grid, that will be able to make decisions. The ability to communicate enables the power grid to balance the production and consumption site within peak and low times and will unleash existing efficiency potential.

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2 Chapter 2

Market Trends and Customer Needs

Birgit Braun, Manuel Braun, Dominik Facher,
Georg Alexander Kiener

Fundamental changes in the energy markets create challenges and opportunities that correspond considerable growth potential. ICT based infrastructure will introduce new market mechanisms and structures and will emphasize the role of market places as efficient coordinators. A decentralized energy system that is marked by an increasing importance of renewables enables active consumers and producers to take these new challenges to maximize their individual benefits. Increasing competition fosters the trend towards energy efficiency in all steps of the value chain. In addition new markets that require solutions at the intersection of energy and ICT will develop. Precise understanding of the market developments is indispensable to emerge successful in the upcoming years.

2.1 Introduction

Growing global demand for energy, decreasing reserves of fossil fuels and ecological problems are creating challenges for the society. The liberalization and amendments of laws in the energy sector introduced fundamental changes to the European markets. These changes affect providers, as well consumers of electricity. A profound analysis of the status quo is essential to understand the new market structures, the competitive situation and the role of new market places. As open markets require more communication and interfaces between all market players, technological progress has crucial influence on the developments in the energy markets. Modern information and communication technologies (ICT) have the potential of creating an intelligent network with enhanced solutions for grid and energy management. Smart control through real-time networking of system components focus on the coordination of processes and are required to achieve ambitious efficiency targets. An E-Energy system based on ICT optimization has far reaching impacts on the future development of and within a society. Therefore the examination of the energy market in Germany furthermore needs to address the situation in the different customer segments, as well as their possibilities, activities and needs. Due to the increasingly important position of the consumers in the value chain, especially their energy usage behavior and technology acceptance is decisive for determining upcoming developments in 2015. Consequently external environmental changes, in combination with liberalized market structures, system integration through ICT and changes in consumer behavior define new market processes, market structures and market offerings. Finally, potential trends in the E-Energy market can be specified. On the basis of these market trends, companies have the possibility to develop comprehensive strategies in order to achieve a competitive advantage.

2.2 Status Quo

For the determination of upcoming trends in 2015, it is essential to examine the status quo within the energy sector. In order to understand the market impacts of the changing energy system, the subsequent chapter gives a broad overview of the structures and processes within the German energy market under consideration of international developments. Following on that, the consumer segments and their behavior, needs and wants will be analyzed.

2.2.1 Energy Market Overview

The total demand for primary energy in Europe in 2007 was at a level of 21007 TWh. Germany has the leading position within an European comparison of primary energy consumption, with a share of 18% [79]. The secure supply of energy is of crucial importance for the economic system in Germany and the dominant sources of energy for final usage are fuel, gas and electricity, with 77% overall share. Thereby it is important that the consumption of electricity is increasing with annual growth rates between 0.2% and 1.6% since the late 1990's and accounted for 22% of the energy for final usage. [69][76, p. 22]

The development led to a gross electricity consumption in Germany of 617 TWh in 2008 or accordingly a total net electricity consumption of 542 TWh, with the industry sector consuming 43%, Businesses 27%, Private Households 27% and Transportation spending an electric energy share of 3% [76, p. 23]. Hence there are two important influences on electricity demand. Firstly, the economic growth has direct impact on the consumption development of the industrial sector. Secondly, the development of the demographic change and the size and number of private households affects the energy consumption. [75, p. 2][78, p. 4]

To compensate this demand, power plants produced 639 TWh of electric energy in 2008 [76, p. 26]. The efficiency factor for electricity production arrived at a historical maximum of 42% [76, p. 19]. The gross electricity production relies on a balanced energy mix in Germany, with hard coal contributing 21%, lignite 23% and nuclear energy 23% as most important sources. Moreover renewable energy sources achieved increasing significance by generating 93 TWh or accordingly 15% of the gross electricity consumption in 2008, compared to 14% in 2007 [86, p. 12]. In particular wind-power with 40.4 TWh has been a valuable contributor [86, p. 16]. Figure 2.1 illustrates the described relationships. Overall, the installed capacity for electricity generation through renewables has increased by the factor three since the introduction of the Eneuerbare-Energien-Gesetz (EEG) in the year 2000.

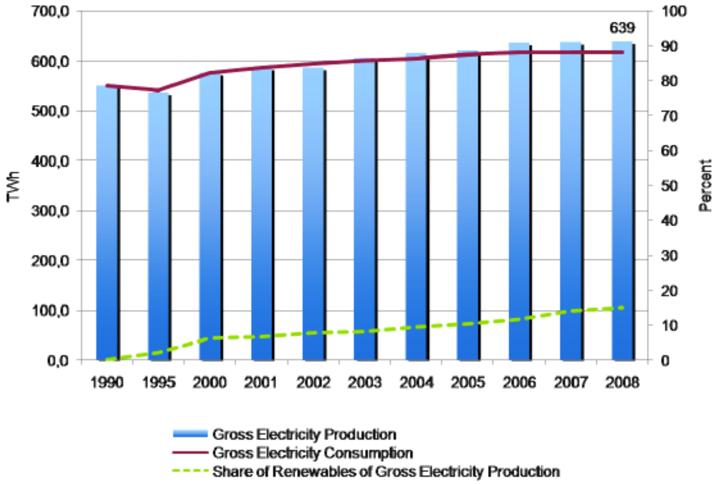

Figure 2.1: Gross electricity production and consumption in Germany 1990-2008
Source: Adapted from mBM [76, p. 19]

On a European basis, Germany is the country producing the most electricity, ahead of France (580 TWh) and UK (397 TWh). All these companies depend on fossil energy carriers as predominant source for electricity production [80, p. 86]. Germany's strong dependency on imports of fossil resources leads to coherent price risk [77, p. 51].

The difference in electric energy production and consumption in Germany occurs due to the international trading balance of minus 22.5 TWh. Electricity imports of 40.2 TWh where mainly traded with France and Scandinavian countries. Moreover exports summed up to 62.7 TWh, mainly provided over the borders of Austria and Netherlands. Due to it's central position in Europe, Germany has the highest level of electricity exchange. This is enabled due to the integration in an interconnected grid system. [93]

2.2.1.1 Market Structure

The value chain in the electricity market consists of six steps: energy resources, power generation, transmission, distribution, retail and consumption.

Historically the market structure in Germany was marked by few powerful and strongly vertically integrated companies. Consumers adapted to the system by sourcing their electricity from the locally separated providers. The liberalization of the electricity markets has the long-term goal of establishing a single European market for efficient electricity allocation, as well as empowering position of the consumer [104, p. 19]. Energy exchange markets have been formed and through unbundling, whereby energy transmission networks are run independently from the production and supply side, the market mechanisms were changed. Today most of the value chain parts theoretically underlie free market competition. As the transmission and distribution of electricity cannot be managed by competition and is basically a natural monopoly, grid access management and grid fees are regulated for the affected grid operators. The recent market-opening of the control-system was one more step towards self-regulation of markets by competition [77, p. 52].

After all the regulatory changes the number of companies on the German market increased and the variety of energy providers is unique for a national electricity market in the EU [80, p. 119]. Moreover, new energy producers, with own production capacities are evolving. This increases competition and results in a higher degree of required communication and a more complex and interactive network within the market environment [66, p. 7].

However, the status quo of the market situation has to be described by a concentrated degree of market power. The four major utilities, E.On, RWE, EnBW and Vattenfall account for most of the overall electricity production and end consumer sales and also operate the geographically subdivided grid. Besides, these companies pursue the goal of vertical integration by continuous acquisitions of stakes of local and regional providers. In addition a comparison of the largest European electricity companies illustrates the international market power, as all four big German utilities are ranked under the top eight positions, according to their consolidated sales volume. [77, p. 49][80, p. 115]

2.2.1.2 Market Places and Pricing

Market Places and mechanisms for power trading are an essential component in liberalized energy markets. In general power trading has to be separated into wholesale and retail markets. Wholesale markets trade large volumes between producers, retailers and brokers as well as businesses.

Figure 2.2 illustrates the concept of wholesale markets. Electricity is traded either in Over-the-Counter (OTC) deals or on power exchanges. OTC trading represents a bilateral deal between two entities that is basically independent of any official exchange institution. Currently 80% of power-trading is done by OTC arrangements, most of which are long-term contracts [81]. In these contracts, energy suppliers sell power to either power-resellers and brokers or directly to larger companies that consume it [64].

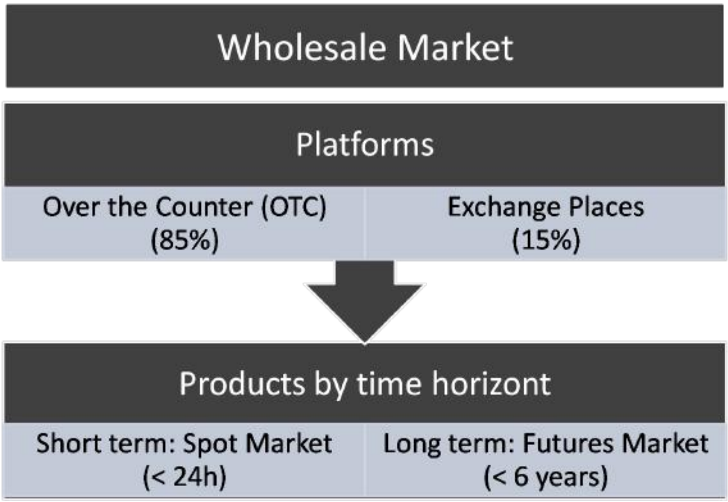

Figure 2.2: Concept of electricity trading on wholesale markets
Source: Adapted from Ockenfels et al. [81]

On energy exchanges marginal power, which is not covered by OTC deals, is traded. In 2008 the German-based European Energy Exchange AG (EEX) had a trade-volume of 1319 TWh [68, p. 3][81, p. 7-9]. Power exchanges are of fundamental importance to the market, because their trading prices are signals to the market and adjust conditions for OTC deals. In Europe the EEX is the most important power exchange by trading volume and participants among seven others [107]. The EEX runs two types of market places: the short-term spot market (154 TWh in 2008) and the long-term futures market (1165 TWh in 2008) [68, p. 3]. Based on demand and supply, market clearing prices for electricity are determined. The spot market is used to cover short-term needs, as energy is traded up to 24 hours in advance to physical supply [94]. Prices are set for every hour of the next day. Figure 2.3 illustrates the resulting high volatility of prices according to daily load curves. In the futures market, energy supply is traded for up to six years in advance. Prices are set for monthly, quarterly or yearly periods reflecting long-term expectations and coverage. This results in less volatility according to figure 2.4. [94, p. 42-46]

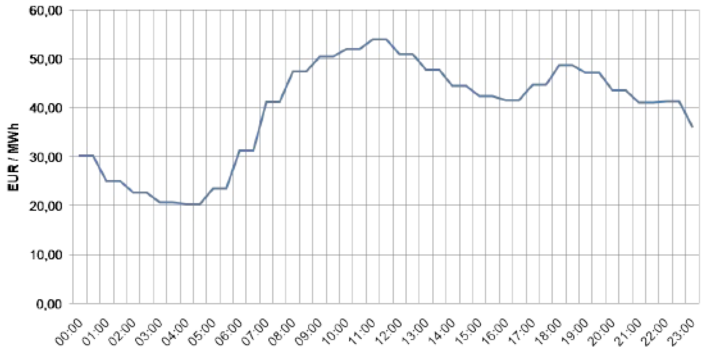

Figure 2.3: Hourly price (average of data 01.01.2009 - 03.09.2009) on EEX spot market

Source: EEX [65]

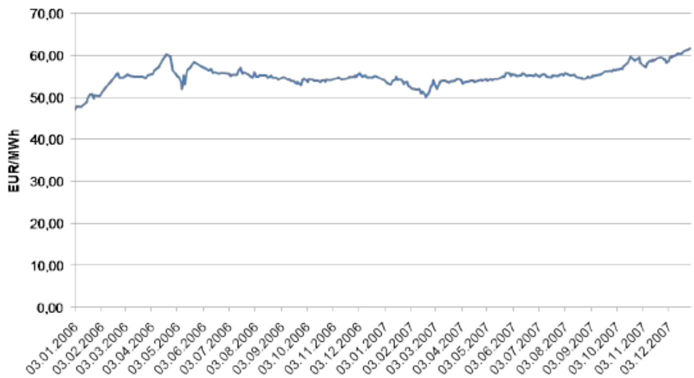

Figure 2.4: Average daily price 01/2006 to 12/2007 for power supply in 2009 at EEX futures market

Source: adapted from Electricity Exchange AG [89]

On retail markets power is sold to either private households or businesses that do not have OTC contracts. Looking at the electricity prices for a German household with an average consumption of 3500 kWh/a, the price for power is 21.65 ct/kWh (2008). Figure 2.5 illustrates the composition of electricity prices. The wholesale price contributes 34% of this price (7.36 ct/kWh) whereas governmental charges combined account for 39% of the amount (8.44 ct/kWh).

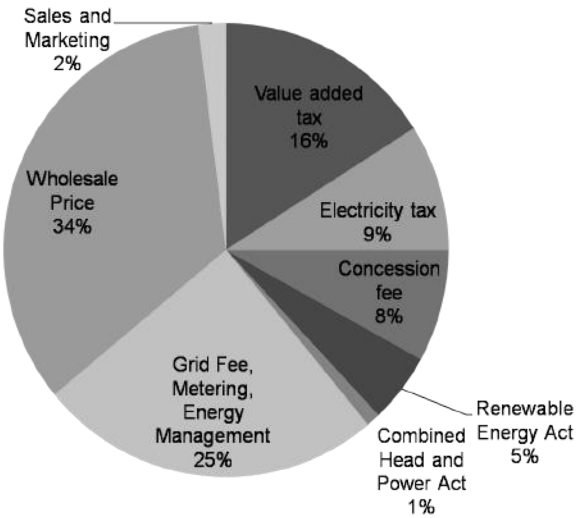

Figure 2.5: Composition of energy price for private households with average consumption of 3500 kWh/a in 2008
Source: mRW [80]

As figure 2.6 shows, after the liberalization in 1998 private end consumer prices went down only for some years. Compared to 1998 power prices went up by 26.4%. This is due to an increase of tax and governmental charges (104.8%), as well as increasing fees for production, transportation and sales (0.7%).

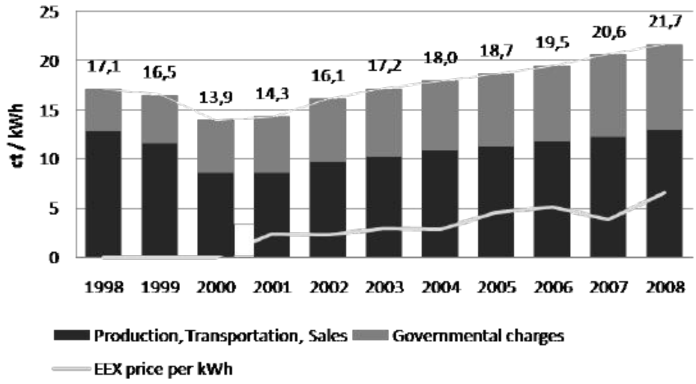

Figure 2.6: Development of electricity prices for private households with average consumption of 3500 kWh/a
Source: VdEW - Verband der Elektrizitätswirtschaft BW [111]

A comparison of the price development of private retail prices to wholesale prices from the EEX shows that they share a common trend on a yearly basis. But still there is no dynamic adjustment of retail prices to wholesale prices.

2.2.2 Consumer Segments

The market of the electrical energy consumption in Germany is subdivided into four different sectors: private households, manufacturing industry, business and transportation. Besides their unequal amount of consumption these four sectors vary in their energy demand over time of day. The next chapters give an overview of the four consumer sectors and explain their different behavior.

2.2.2.1 Private Households

Germany has around 38.6 million private households with an average of 2.13 residents each. In 2008 this sector had an electrical energy consumption of 146 TWh [76, p. 23]. With 69%, process heat and mechanical energy account for the biggest share [102, p. 10]. Based on the load curve, there are mainly two energy peaks across a day. The first one usually arises at noon between 12pm and 2pm and the second one - even higher - in the afternoon between 7pm and 9pm caused by people coming home and starting to do housework.

A closer look at the German households shows that 79% of the consumers of the private households do not have either the personal initiative or the disposable income available to change their previous behavior in order to reduce their energy consumption. This group of people can be found in the darker colored part of figure 2.7. Around 70% of them can be characterized by acting with short-term view in regards to further developments in the energy market, relatively low interest in energy usage and a passive attitude towards providers' services and products. Due to this passivity they are hardly willing to change their life-style in order to make a contribution to reducing their energy consumption. Even though 90% of all consumers state that they pay attention to their energy consumption, only 24% are aware of their precise amount of energy consumption per year. [97, p. 7-8][105, p. 7-8]

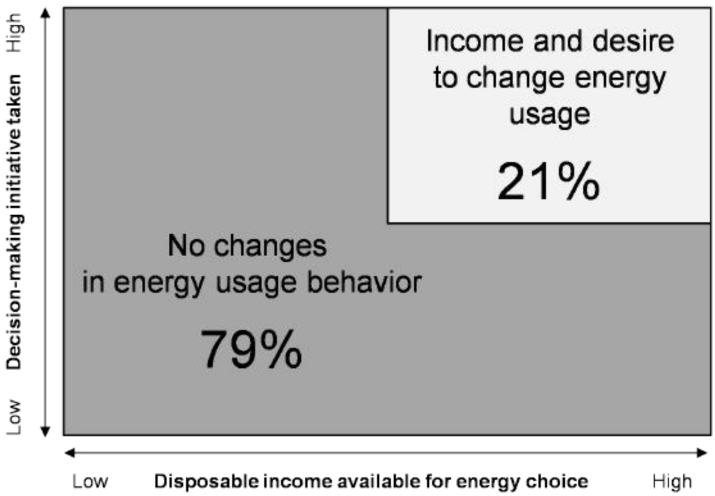

Figure 2.7: Characterization of the private consumer
Source: Valocci et al. [97]

Due to their low interest, the price for energy is the most powerful motivator to change consumers' mindsets. Due to 48% increase of costs in the last twenty years, price is the most perceived criterion for electricity as a product. However, only 14% of all private consumers changed their providers in the past and just 10% are planning to do so in the next two years. Although most of them complain about suppliers' offers and services, the private costumer has the impression that switching would be too complicated and not result in a significant cost reduction. In addition providers are perceived as not differentiating enough among each other. [105, p. 7][**?** , p. 4][76, p. 40]

Furthermore, people expect more transparency in the field of energy costs and tariff models and request a better overview of their actual electricity consumption. Besides these requirements the private households demand more support from supplier side in order to reduce their energy consumption.

2.2.2.2 Industry

The second customer segment is manufacturing industry with a power consumption of 233 TWh in 2008. Power consumption and load curves vary between different kinds of industry as every industry has different equipment and manufacturing processes. Cost intensive load peaks caused by run-ups of heavy machines have to be considered. Some industries, especially metal production, chemical and automotive industry, produce a significant part of their required power themselves. Figure 2.8 shows consumption and self production of electrical energy in German industries. [80, p. 7]

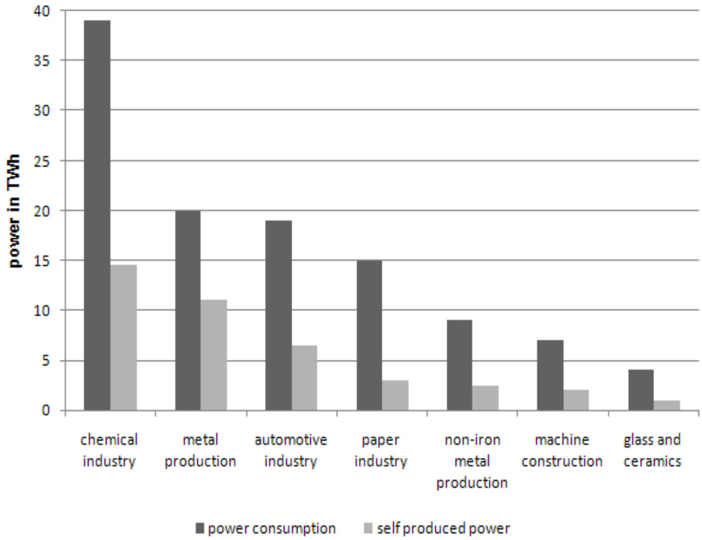

Figure 2.8: Power consumption and production of German industries in 2007
Source: RWE [107, p. 7]

Industrial companies put pressure on energy providers by demonstrating independency from a special provider, like they are used to handle their usual suppliers. 52% of industrial enterprises have switched providers and 48% have negotiated new contracts with their power providers since 1999 [80, p. 121].

Industries need reliable power supply as well as low and predictable prices to run their business. Therefore, industries conclude individual OTC contracts including load depending tariffs with their power providers [83, p. 6].

2.2.2.3 Business

Business companies consumed 146 TWh of electrical energy in 2008. They vary a lot in size and power consumption. The biggest shares in power consumption have commercial enterprises, office businesses and restaurants. An overview of regarded business companies and their power consumption is given in figure 2.9. [109, p. 15]

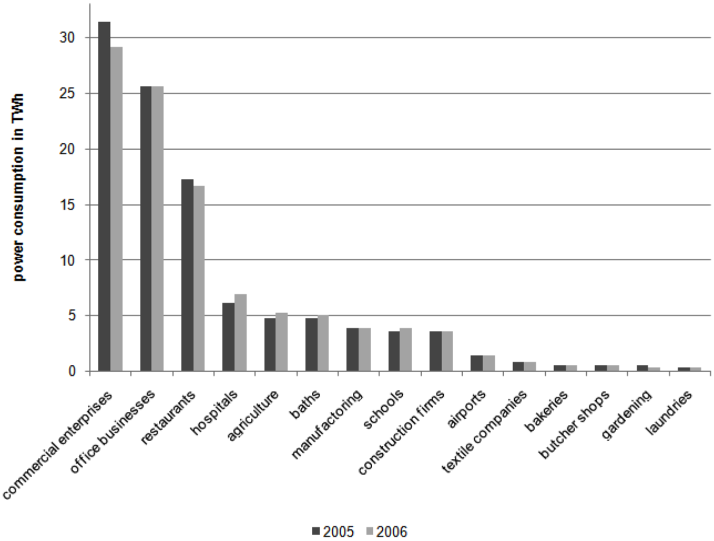

Figure 2.9: Power consumption of business companies in 2005 and 2006
Source: Schlomann [109, p. 15]

Switching behavior concerning power providers is noticeable different depending on the size of the company. While a 37% of small companies have not even changed their agreement about power supply, 52% of the bigger businesses have switched providers since 1999. [80, p. 121]

The specific needs of business companies are very different, depending on the field of business. For example restaurants have very simple power requirements while hospitals or finance companies need services to keep up steady power supply, even in the case of a blackout.

2.2.2.4 Transportation

Transportation in Germany has with 16 TWh in 2008 only a small share of 3% in power consumption. As most vehicles are based on combustion engines, rail traffic is the only section which plays a role in the field of transportation today. In 2008, 2.3 billion people went by train and 371 million t of freight were transported. [115, p. 441]

Railway companies need power providers who are able to handle immense load peaks caused by starting trains. In Germany, DB Energie is the quasi monopolist of railway energy supply. DB Energie allows a 14% discount on power prices for Deutsche Bahn AG. As small railway companies have to pay the full price, they have difficulties to fulfill their need of cost-efficient energy supply. [95][110][106]

2.3 Trends

The status quo shows that there is an asymmetry between the evolutionary stage of the macro-market environment and customer wants. Paired with the enabling technology infrastructure that E-Energy provides, there is large potential for market changes. Consequently the general energy market will develop into a consumer oriented decentralized system. Consumers will produce energy themselves and even sell parts of it which then requires efficient market places. Driven by that, market places will gain further importance as an integral part of coordination in the energy system similar to the financial sector. Market prices will be a leading indicator for all market participants to change their behavior accordingly. Moreover new markets at the intersection of energy and ICT will develop as E-Energy uses intelligent systems and ICT to improve the energy market. In the future both sides will see this merged sector as a major opportunity for business growth.

2.3.1 Changes and Trends in the Electricity Market

Currently the electricity market is affected by pressure from different external sources. Some of them are continuous developments based on the liberalization, others add completely new perspectives to the market. Altogether, they lead to three major trends for the market and its mechanisms.

2.3.1.1 Decentralized Energy Production Requires Efficient Market Places

According to the International Energy Agency the world's primary energy demand will expand by 45% between now and 2030 (1.6% per year) [70, p. 2]. Apart from that, studies indicate that although the energy consumption for final usage in Germany will decline, consumption of electricity will experience a slight growth in demand of approximately 4% by 2030 [103, p. 165]. Considering the planned incremental nuclear phase out in Germany, a gap in electricity production capacity is expected to evolve [80, p. 91]. To ensure long-term security of supply, energy policy is focusing on energy efficiency programs and an intense expansion of renewable energy production capacity. Renewables will have an empowered position in upcoming years. Figure 2.10 considers investments in renewables and efficiency measures and explains the potential of this energy sources, as they are expected to contribute about 50% to the gross electricity production in 2030.

Furthermore investments in research and development of new technologies aim for reducing the dependency on imports of the German energy supply [77,

p. 50]. In combination with the described liberalized electricity markets, an increasing number of small energy producers will emerge in the market.

The trend for renewables leads to a decentralized system of electricity supply. The downside of this changes is the strong dependency on external environmental factors resulting in a intermittent energy supply. In order to effectively manage energy bottlenecks and shortfalls, electricity exchange becomes even more important. For instance market coupling supports efficient cross-border trading. Consequently the intensification of international trading is an important step towards the integration of the EU electricity markets. [91, p. 19]

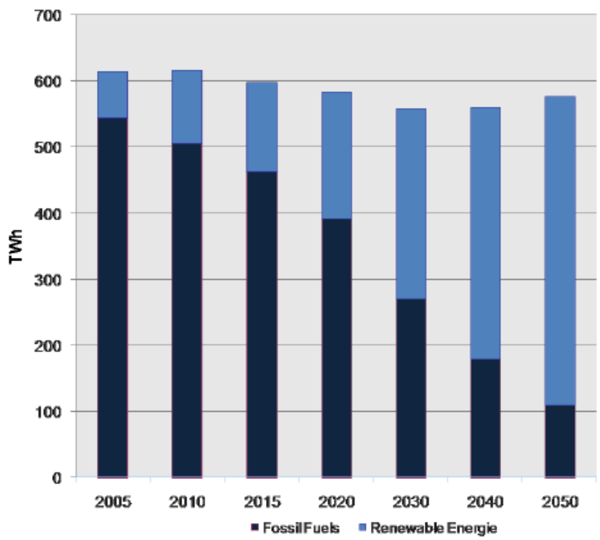

Figure 2.10: Development of the gross electricity production according to BMU scenario 2008
Source: adapted from Dürrschmidt [112, p. 12]

The trend for renewable energies requires investments in the grid to adjust flexibility for the new challenges of decentralization and increase cross-border capacity which is a limiting factor of electricity exchange today. Apart from that ICT takes an increasingly important role in the electricity market, as intelligent grid control and management is required [85, p. 10]. Due to the increasing importance of energy trading and electricity exchange, the described investments have an essential role for the new market structure. Furthermore until 2020, at least half of the installed national power generation capacity has to be replaced or upgraded [116, p. 7].

2.3.1.2 Emerging Role of Market Places as Efficient Coordinators

In a system of decentralized energy production traditional consumers can evolve into energy producers [85, p. 22]. According to their individual benefits they are willing to sell parts of their energy. Consequently the role of power exchanges will gain importance alongside current feed-in tariffs [100, p. 61, 74, 75]. Business models that enable consumer electricity trade on exchange places are examined in chapter 5. As a result the number of market players as well as market dynamics will increase.

In addition Demand-Response-Programs (DRP) will be another major sign for the grown importance of liberalized market mechanisms. DRP's are separated into price-based and incentive-based programs, both trying to optimize consumer behavior in order to reduce load peaks.

Incentive-based programs subsume models for compensating consumers for their commitment to reduce or postpone power consumption according to supplier instructions. For instance a supplier could give compensation payments to consumers for not using energy in peak load times to balance their production. In contrast to that price-based programs focus more on creating efficient market mechanisms. They enable consumers to adjust their consumption based on the current market price of energy. Consumers will have dynamic tariffs that reflect the variations in power production costs instead of the fixed price tariffs currently used. This effect is of crucial importance to price transparency. With dynamic tariffs consumers can decide whether to purchase power or not and even to sell some of it based on price signals. For example in the evening when power demand increases, rising prices will work against that as consumers reduce their consumption on high prices. In this context prices fulfill their role as indicator of the actual supply of power in the market. As of 2011 variable tariff systems will be forced by law.

These mechanisms are beneficial for all market participants although consumers and suppliers most likely have contrary interests. Figure 2.11 shows the potential of price differences between base and peak load as traded on the EEX with an average difference of 7.2 EUR/MWh and a variance of 16.8. In 2009 the daily volatility of average hour prices (base and peak load combined average) at the EEX was more that 42%. [65]

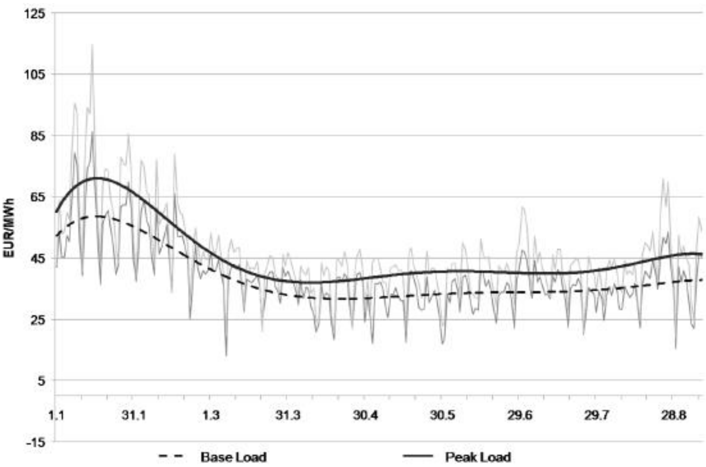

Figure 2.11: Base and peak load on spot market 2009 with 6-times polynomial smoothing
Source: adapted from EEX [65]

Consumers are likely to reduce their consumption during expensive peaks. The resulting load curve is more balanced and enables producers to run their production more cost effective. In addition, they can reduce the production of cost-intensive peak load which is, due to its inefficiency, also the most harmful way of production for the environment. [90][99][101, p. 73-80]

As a result, price-based DRP's will lead to more efficient market structures, higher transparency and overall lower costs. Supply and demand are better aligned because both energy consumers and suppliers have their best interest in maximizing their individual benefits. [108, p. 11]

2.3.1.3 E-Energy Creates New Markets by Merging ICT and Energy

E-Energy implicates a merge between two markets: energy and ICT industry. This leads to new technical opportunities and product applications, as well as new ways of business collaboration. Especially ICT as an interface is bringing together traditional electricity market participants with players who have competencies in other markets. The potential and offerings within the ICT industry can leverage the energy market by already existing conceptual solutions for upcoming technological challenges. Software providers can develop applications for the new system, hardware manufacturers can equip their products with smart intelligence to be used within the E-Energy system and service providers can adapt their business models to a new market. Consequently the E-Energy market gives incentives for innovation. [76, p. 7]

Establishing an E-Energy system in an efficient way requires heavy investments in building up and managing the infrastructure. Due to that, energy related products for private and industrial end consumers as well as value-added services like energy usage optimization create a stable market growth for manufacturers and service providers. In addition supporting service companies apart of the value chain like financing, consulting or project management will adjust their range of products. Furthermore new software to manage data and establish data security is important. [101, p. 7][98, p. 22]

The merger of markets created by E-Energy will not only lead to synergies but also to fundamental changes. Companies on both sides have the opportunity to extend their portfolios and to make the sector a pillar of future business growth.

2.3.2 Changing Customer Needs

As stated in chapter before, the market and its structure will change dramatically, even new markets will develop. These effects result in a new environment for consumers who will need to adapt to it in order to fulfill their needs. Thereby, each customer sector will have unique opportunities as well as challenges. As a result there will emerge major trends in customer needs and behavior. The private customers will be more involved by managing their energy consumption due to dynamic tariffs. The industry as well as businesses will have to concentrate on energy efficiency because of increasing energy prices. The transportation sector will grow due to the increasing railway traffic as well as the emergence of E-Mobility.

2.3.2.1 Increasing Involvement of Private Consumers

Looking at the private customer in 2015 there will have been a change in behavior and involvement concerning energy consumption. This process will be caused by increasing environmental awareness as well as growing cost pressure due to high energy prices. Because of these impacts, most of the private households will be willing to take action to manage their energy consumption based on individual goals. [105, p. 14]

Due to this effect, consumers can be segmented by two dimensions. First of all customers are distinguished by their decision-making initiative which will increased in general compared to 2009. Secondly there is a distinction based on disposable income available for energy choices (figure 2.12). The upper left segment shows active consumers with limited resources but nevertheless strong intention to change the way of energy usage. On the other hand, there will be a group with the necessary personal initiative and the disposable income for making high investments like solar panels.

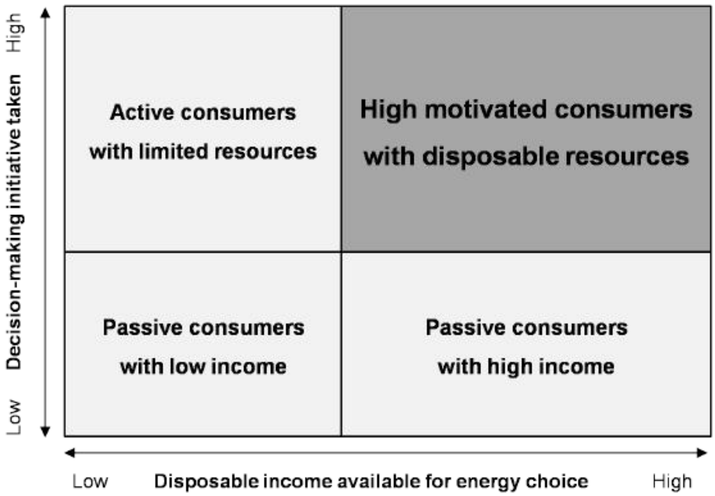

Figure 2.12: Characterization of the private consumer in 2015
Source: Valocchi et al. [97]

Looking at consumers with low decision-making initiative some consumers are indifferent or unable to take responsibility, there will be a group with low personal initiative, but comparably high income. The barrier of these customers to reduce their energy consumption is the lack of motivation to change their behavior by lowering costs as well as quality of life-style. Nevertheless they possess more knowledge about their provider and options than any other group. The installation of new energy-consuming devices into their homes with low impact on current life-style will turn them into more involved consumers. As a result more governmental incentives are necessary to move both active and passive consumers with limited resources to the upper right segment of figure 2.12. Through governmental incentives consumers with limited resources will be motivated to get active as well. Consequently, in the next years, customers will be prepared to get more involved in the energy market. [105, p. 9][97, p. 7-9]

In 2015 consumers will be accustomed to having high transparency concerning their energy usage and pricing. Dynamic tariff models in combination with ICT, such as smart meters, will be necessary to enable short-time insight into electricity supply and demand. Being aware of their usage around 84% would shift their energy-consuming housework, such as washing, to more favorable time slots in order to reduce peak usage and save money. [67, p. 22][105, p. 10]

The requirements for such a smart meter solution are mostly the same: easy and intuitive usability, manageable user-interface, no influences on current life-style and short-term control of success. Around 63% say that they prefer an indicator in the living room in combination with a smart meter showing the current electrical energy price as well as the personal energy demand. While the younger generation is more likely to accept this product. The skepticism of ICT controlling their energy supply increases by age especially with people older than 60 years. Their aversion to modern ICT is based on usability issues and fear of subjective control by data abuse. Therefore, the implementation of data security directives will be necessary. [82, p. 4,6][71, p. 2][105, p. 12-13]

Despite the concern of data abuse, 70% of German consumers would make their electricity usage information available to qualified providers in order to promote greater competition. This shows that consumers value costs and transparency higher than data security. Resulting consumer acceptance coupled with governmental regulations will lead to market penetration of approximately 55% by 2015. [113, p. 10][67, p. 32][101, p. 38-39]

Over the next six years this development will be supported by an up-growing new generation. These young people are usually defined as those born between the late 1970s and the 1990s. The so-called millennium generation [97, p. 4] has grown up with technology being part of their lives. They possess a distinct environmental awareness and are willing to pay more for energy services and products than any other group. In this age group 68% are willing to pay extra for a smart meter in contrast to just 45% of consumers over 65. This millennium generation is moving into adulthood and will influence their fellow men who might be more skeptical, thus changing their behavior in regards to their openness towards new technologies. [97, p. 4, 10]

To sum it up, the consumer of 2015 will have been more involved and will consequently get more power in the energy market.

2.3.2.2 Companies' Growing Attention on Energy Efficiency

Due to high competition and energy costs, companies will pay attention on their saving potential regarding energy consumption. This trend can be observed in the sector of industry as well as in the sector of business.

Industry

Although industry is already aware of energy efficiency, this issue will become even more important in the future. By 2020, yearly energy consumption of industrial companies could be reduced by 59 TWh. Several studies of the German Energy Association (DENA) indicate that the main reason for establishing energy efficiency measures is cost. Because of increasing energy prices and cost pressure 84% of managers in industrial enterprises state that increasing energy prices are relevant for their company. Therefore, 87% agree that energy efficiency has to be implemented to decrease unnecessary consumption in their company. [96, p. 16][119, p. 3][117, p. 2-3]

Surprisingly, only 42% of industrial enterprises took energy efficiency measures so far. However, further 19% are planning to do so in the near future. Companies explain that there are barriers, mainly concerning lack of financial resources, knowledge and time, to take measures. Furthermore, many companies still underestimate the benefits of energy efficiency measures. Until 2015, barriers will be likely to become smaller because of governmental support for energy efficiency measures. [117, p. 5][118, p. 2][120]

Main potentials for future improvements in industrial companies can be found in production, heating and lighting. In order to increase efficiency, energy management systems and energy consultancy will have a great impact [96, p. 16][119, p. 15-16][120]. As industrial companies are already quite familiar with the management of energy consumption via IT, they have the chance to become E-Energy outriders.

Business

Due to huge saving potentials, energy efficiency is a significant trend for business companies, too. By 2020, 19 TWh of energy can be saved in the business sector every year. A study of the Fraunhofer Institute together with TU Munich indicates that 57% of business companies already realized energy efficiency measures while further 29% see a necessity to take action. Governmental support for the mostly small sized business companies will break up the biggest barriers: financing and lack of knowledge. Companies will be likely to use energy efficiency for image purposes as 25% of them already do so today. [96, p. 13][119, p. 3][109, p. 7, p.29][73, p. 12]

Effective energy efficiency measures tackle infrastructure as well as the behavior of employees. On the infrastructure side, most companies already recognized that lighting has the biggest potential. Besides efficient lamps, electric ballasts will be introduced in business companies. Green IT will be another important topic for business companies, because especially IT departments are under pressure to reduce power consumption at the moment. A further study indicates that there are also great opportunities to reduce power consumption in the field of air conditioning. The introduction of E-Energy systems will create synergy effects. [96, p. 29][88, p. 22-23][73, p. 7][96, p. 13]

Today, business companies already try to decrease power costs by switching off lights or machines when they are not needed. However, further changes in employee behavior will be necessary. For instance, the PC Energy Report shows that people at home are more likely to power down their PC than at work. Examples for big improvements by quite few efforts, like the campaign for sustainability at Harvard University, will make their way to business companies in order to save significant amounts of cost and energy. [109, p. 29][92, p. 4][63]

2.3.2.3 Increasing Railway Traffic and Rising Awareness for E-Mobility

Drivers for railway traffic are liberalization, environmental issues, the globalization of transportation and high fuel prices. Although freight transportation went temporary down due to the financial crisis, studies predict, that railway traffic will increase by 0.7% every year until 2050. Thereby, power consumption of the transportation sector will increase slightly. [114, p. 2,4] [72, p. 4-6]

Far more important is the emergence of E-Mobility, because this could increase the electricity consumption of transportation significantly. Due to increasing fuel prices and environmental awareness, people are looking for efficient alternatives to the traditional combustion engine. A study, carried out by TNS-infratest, shows that awareness level and consumer acceptance for cars equipped with hybrid or electric engines are increasing significantly. The same study shows that through governmental subsidies the willingness to buy such cars can be raised by more than 50%. As the German government declared a National Development Plan for E-Mobility, upcoming hybrid and electric cars can cause a drastic change in the sector of transportation and become an important pillar of the E-Energy system. [74, p. 11- 35][84][87]

2.4 Conclusion

Increasing energy demand, scarcity of resources and the development of prices lead to a period of change in the European energy markets. Liberalization, expansion of renewable energies and the process of decentralization in the German energy sector require comprehensive ICT penetration as well as a dynamic and interconnected system in all parts of the value chain. The trends in the electricity market result in a significant increase in market activity, competition and communication. In the E-Energy market, exchange places for electricity trading are pillars of the system. Moreover, price signals will be indicators for the whole energy ecosystem and lead to efficient allocation. Due to the increasing degree of efficiency, higher consumer involvement and adjustment in consumption behavior, benefits for all market participants are created in E-Energy market. These developments go along with the increasing consumer's demand for transparency and optimization of energy usage. Furthermore, the intersection of the energy and ICT market will develop new markets and opportunities. Consequently, the electricity sector has huge growth potential in utilizing smart technology and expanding product portfolios.

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3 Chapter 3

Politics and Legal Trends

Jelena Frtunik, Miriam Al-Ali, Felix Binder, Felix Jung

In the evolving sector of E-energy political decisions and legislation play an important role in future development. The on-going liberalization of the market for electric energy supply is still about to be completed with respect to consumers' rights. Political incentives for the introduction of certain technologies that are already in place will be taken further in areas such as renewable energies, smart trans-European grids and smart metering. Concerning the political system a shift in power from national governments to the European Union can be expected to take place.

3.1 Introduction

Electric energy has attracted significant attention over the last years from politics as well as from consumers. Rising prices, environmental issues and new technologies as well as scarcity of energy resources are consequently calling for a comprehensive energy policy.

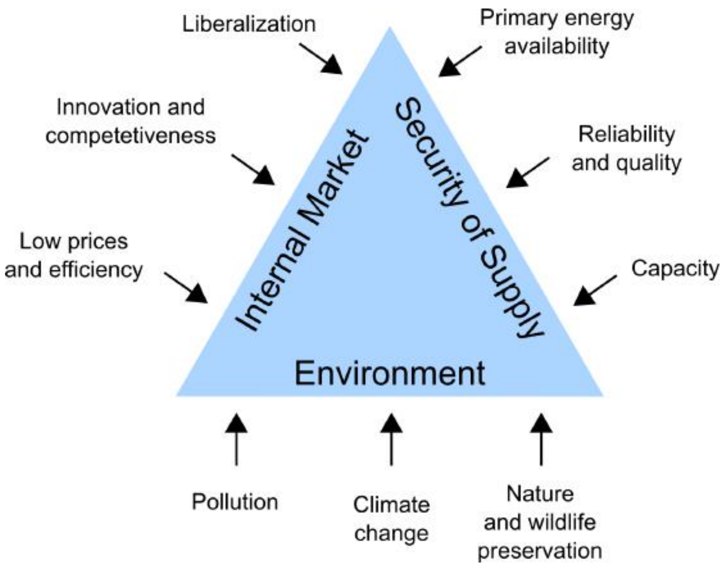

Figure 3.1: Political goals
Source: adapted from European Commission [160]

The focus of these policies lies in (1) the security of energy supply, (2) environmental issues, and (3) implementing an efficient internal market within the European Union (EU) (see figure 1).

These goals are implemented on an international level by the EU with its Commission and Parliament, and on a national level through Germany's Bundestag and Ministries. At this point it must be mentioned that legislation is also affected by other non-institutional stakeholders such as company and consumer lobbies (see figure 2).

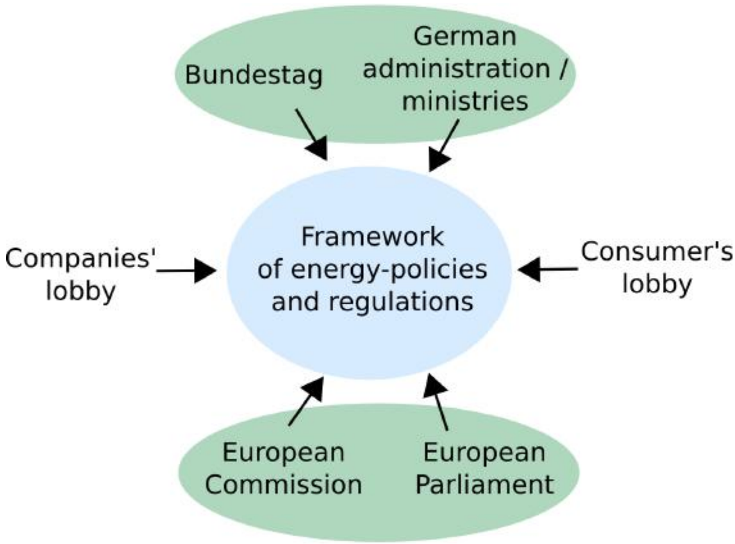

Figure 3.2: Political actors

Up to this date, harmonization efforts have not yet managed to fully install a standardized European internal market for electricity. Moreover market structures within individual member states have only partially been liberalized. Further legal action must be undertaken in order to reach the goals set forth by the EU and Germany. Based on this, political trends can be extracted and identified.

The report is divided into the analysis of the current legislative situation and the collection of anticipated trends in energy policy. Both parts follow along the energy value chain in order to display the complex topic in a structured and comprehensible form.

3.2 Status Quo

A comprehensiv energy policy is responsible for the long-term security of energy. But this should not be at any cost, instead energy must also always be affordable and sustainable too. The following part identifies the current status of energy policies in Germany.

3.2.1 Generation

Generation of energy represents the first part of the value chain. Depending on the type of source used in the production of energy there are different legal frameworks that already exist. The national energy mix is not solely determined by the German government. It is a result from the decisions taken by the actors that are responsible of the legal frameworks that have been and are put in place at the national and European levels.

In 2000 the German government agreed on the orderly phase-out of nuclear generation, which was incorporated into the Atomic Energy Act in 2002. To each nuclear plant roughly 32-year lifetime are allocated, thus requiring all nuclear plants to be closed by the early 2020s. This act also covers waste management. Furthermore, the operators are obligated to erect and use interim storage facilities for spent fuel rods at the location of the nuclear power plants. [164]

The phase out of coal mining was introduced by the government in February 2007. This will result in the shut-down of the remaining eight plants in North Rhine-Westphalia and Saarland by 2018. [158]

There are two important laws that promote electric energy-production using renewables by offering financial incentives:

- Renewable Energy Sources Act (EEG in German) [167]
- Law on Combined heat and power (KWKG in German) [173]

The EEG specifies annually decreasing feed-in-tariffs that grid-operators have to pay to other energy producers that induce power from renewable sources into their grid. The induction of power under terms of the EEG has priority over power from convenient energy sources.

The Law on Combined Heat and Power supports the operation of (old and new) existing plants, through a fixed financial add-on that varies by size and type of installation.

In the field of environmental protection, the German government has issued regulations that aim at cutting greenhouse gas emissions by 40 % by 2020 (compared to the 1990 baseline level) [162]. Emission trading plays a big role in the reduction of greenhouse gases. As far as energy production is concerned, every power plant that emits CO2 is obligated to buy emission certificates. This reduces margins of power plants using fossil sources. [176, p. 9]

The federal funding for energy research and development (R&D) in Germany is formulated in the Fifth Energy Research Program. Within this program, the federal government has provided almost EUR 1.7 billion that will be used by the universities and research centers for R&D in the area modern energy technologies. The largest funding was for biofuels and renewables. Apart from renewables, the energy efficiency received the largest share of total R&D funding. [168]

3.2.2 Storage and Transmission

Concerning storage of electric energy no regulatory framework has been put in place neither on a European nor on a national level in Germany other than support for research programs.

At the moment the legal framework for electric transmission grids is mainly given by the Energy Industry Act (EnWG in German [336]).

The EnWG aims at liberalizing the energy market as required by EU-regulation [124]. To do so it first requires vertically integrated companies in the sector of electric energy to unbundle their company along the value chain if they serve more than 100.000 customers. Unbundling implies that a company's different activities along the value chain have to be separated operationally and legally.

As a second measure the EnWG demands grid operators to let other companies use their grids without any discrimination in price. Usage fees are set by the network operator under conditions defined by an additional regulation (Stromnetzentgeldverordnung [140]) and controlled by the Federal Network Agency (Bundesnetzagentur).

Additionally network operators are monitored by the Federal Cartel Office and the European Commission.

Grid operators also have to take into account that they have to pay fix feed-in-tariffs to producers that induce power from renewable sources as required by the EEG as mentioned before.

These circumstances result in stronger competition between transmission network operators.

3.2.3 Distribution and Retail

Liberalization of energy distribution was primarily initiated by the European Commission in order to expand the single European energy market and to secure the supply of energy to consumers with transparent and low prices [125]. Distribution network operators (DNOs) have to unbundle the same way as transmission network operators do according to the EnWG [169, 137, p.23].

The cost of energy is composed of the price for energy supply which is subject to competitive energy trading and auctioning on the European Energy Exchange (EEX). On the other hand there are costs for network access regarding the use of network-infrastructures to transport electricity from the power station to the consumer, which in Germany also underlies the regulation of the Federal Network Agency [172, p.96ff]. Additionally there are contributions to local authorities, licensing fees and various taxes on energy which are regulated by the Federal Ministry for Finance. For many of these aspects laws exist in Germany regulating the price distribution network operators have to pay. Therefore they also regulate the fee at which they can offer electricity to the consumer. In Germany the Federal Cartel Office is empowered to prevent market-dominating suppliers from demanding prices that disproportionately exceed those of comparative firms [135].

In 2009 the Incentive Regulation Ordinance was enforced, replacing the former

"Netznutzungsentgelte" defining revenue caps for each DNO. These are based on benchmarks set by the most efficient companies [137, p.30], and can only be fulfilled if the DNOs manage to reach the efficiency goals and reduce costs.

Retail of electricity has also been strongly affected by liberalization as new regulations have increased competition and transparency between providers. German legislation (Energy Industry Act) has given consumers the opportunity to switch between electricity suppliers in order to find the most fitting and cheapest tariff. Additionally pressure and competition increases on DNOs through the low-voltage-directive [128] and the provision of basic electricity supplies [129] enforced in 2006. The main objective was not only to intensify competition, but also to guarantee retailers offered fair comparable prices and that new retailers can enter the market unobstructed which is additionally monitored by the Federal Cartel Office.

3.2.4 Consumption

In the last part of the value chain, there is the interaction between distribution entity and end-consumer. On EU-level and on the German national level there are strong efforts to increase macroeconomic energy efficiency [147, p.25], which is reflected in all parts of the consumer-related issues. The European guideline on energy efficiency and energy services (EDL-RL) from 2006 and the vertices for an integrated energy and climate program (IEKP) from the Bundesregierung in 2007 lay out the framework [184, 3]. The EDL-RL, which stands in line with the third plank of the 20-20-20 policy [154, p.28], has the goal of increasing the end-energy efficiency within the European Union within all areas of consumption by energy services and efficiency measures. The public sector is intended to serve as a role model. The EU guidelines require the members for national action plans on energy efficiency. So far, even though guidelines exist, there is no far-reaching legal certainty in many areas. Customers so far do not know what their actual consumption looks like as with billing no individual reference is created to the point in time of consumption. For a successful roll-out of smart-grids and smart-metering in Germany, a legal framework fostering investment, defining parties to cover implementation cost, and defining laying out standards for application, is needed. [170, p.100-101]

3.3 Trends

Energy policies are subject to dynamics in the economic and regulatory environment. Although the introduction of new regulations strongly depends upon the decisions of national and international political parties as well as lobbying groups, there is a general direction in which policies are moving. These are mainly based upon the political goals of enforcing the internal market, securing energy supplies and protecting the environment. In the following part the near future legal trends will be highlighted along the energy value chain.

3.3.1 Generation

Reduction of greenhouse gas emissions and acceleration of the process of penetration of renewable energy sources, diversification of Europe's energy mix and enhancement of the competitiveness of the European industry are the main objectives that the EU Commission and the German government have in the area of energy generation. Therefore all the actors involved in the process of energy generation will enforce many investments in this research and development area. The main trend will go towards an increase of renewable energy generators and replacement of inefficient coal and lignite-burning power stations with highly efficient new power stations. [159]

What is worth to mention is that, although phase-out of nuclear power plants has already been legislated by the German government there might be a change in this area. This is due to the fact that the period of 32 years will result in increased reliance on coal and lignite for power generation over the coming years, with the result that carbon dioxide emissions may be higher than they would have been otherwise [176, p. 153].

3.3.1.1 Reducing the Climate Impact of Fossil Power Plants

Coal-fired and lignite-burning power plants will only have a future if they become less harmful to the climate. The main trend in achieving this goal goes in the direction of Carbon Capture and Storage (CCS) power plants. The technical, environmental and economic feasibility of them is to be confirmed by demonstration power stations. In April 2009 the Federal Cabinet adopted the draft act on capture, transport and permanent storage of carbon dioxide in deep underground rock formations. According to the act operators are granted the necessary planning and investment security for pilot and demonstration plants. However, the operators are obligated to prove, that for an unlimited period of time complete retention of CO2 in the storage site is guaranteed. [165]

The two running research programs Cootech and Geotechnologien [175], which are funded by the German government and cover the reduction of the emissions of fossil fired power plants and CO2 storage show a trend in the R&D investments in this field of energy production.

The upper limits for emissions of carbon dioxide, which have been reduced in the Second Allocation Act, will help Germany to meet the national climate protection targets. Due to technical limitations the first national allocation plan did not succeed at taking advantage of joint implementation (JI) [182] and the clean development mechanism (CDM) [183]. Through these mechanisms a country or operator will be able to purchase emission permits or credits from the international market, which count towards the country's own Kyoto target. Under the rules of the second national allocation plan, individual installations that exceed their emission allowances will be authorized to purchase an equivalence of 20% of their initial allocation from the JI/CDM market. The 20% limit is a consequence of the European Commissions decision to reduce the overall allowance cap.

Considering the trend that is going on in this field, the German government itself will not be purchasing from the JI/CDM market as it forecasts that its policies and measures will fully achieve the target without relying on the international market[166]. In the future the upper limits for emissions of carbon dioxide are expected to further be reduced in the third European trading period that will begin in 2013. [163]

3.3.1.2 Promoting Modern Renewable Energy Technologies

In reaching the global climate protection goals research and development play a great role when it comes to increasing the use of renewable energies in Germany. This allows renewables to continue their success story on the market by continuously advancing technological development and steadily reducing prices for manufacturing and application. Many public R&D groups from across Europe are active in research, development and demonstration of renewable energy technologies. [161] All investments that are going on in the field of renewable energies (solar and wind power, hydropower, biomass and geothermal energy) show the continuing trend in this field.

3.3.2 Storage and Transmission

Concerning storage of electric energy, the main trend in the future will be increased spending on research and development by the EU and national governments. The EU has put in place the so-called Strategic Energy Technology Plan (SET Plan [131]) which calls for a common European research program including research in storage of electric energy and guarantees a budget for this research.

On a national level there are calls for increased spending especially on the development of fuel cells as well as the setup of a nation-wide hydrogen-network in Germany in order to create an infrastructure for the usage of fuel cells [142].

What concerns the legal part of the transmission of electric energy the major trend is the creation of a common European structure for power grids.

The Federal Network Agency has recently expanded the Energy Industry Act in coherence with the European Commission to complete ownership unbundling of energy networks [137, p.17]. This process is yet to be fully accomplished. As parties in the European Parliament support the liberalization of the energy market it can be expect to be driven even further

3.3.2.1 Interconnecting Power Grids within Europe

A strong trend goes toward the enhancement of European high-voltage grids. The EU is taking an increasing part in the decision-making. The main focus in political support lies on the integration of smart grids that enable the induction of decentralized generated power from renewable energy sources [131].

There is a strong call for the realization of an interconnection of European power grids by creation of European transmission networks (ETN) in the near future. A decision by the European Parliament aims at connecting remote parts of the EU, central grids as well as connecting grids to some of the neighboring countries. The EU wants to support these projects by identifying priorities, coordinating ventures, stimulating technical cooperation and helping in acquiring necessary funds [156, 121]. The development might further be stimulated as some political parties call for ETNs that directly connect North-Western Europe to the continent, the Central European grids to the Southern European ones as well as connections to Northern Africa [150, 146]. Within Germany the federal government and its ministries aim at creating further connections within Germany and to its neighbors [142, 130].

A separate project has been launched by the eight Baltic Sea member states which intents to strengthen the electricity infrastructure in the region including grids that allow reverse flow [157].

The European Union is striving for a bigger impact on the planning and risk-management within the electricity infrastructure as a regulation on the transparency of investments shows [145].

As the European Union aims at providing as little financial support as possible for the actual erection of the networks it can only set priorities for construction ventures and can, together with its member states, try to create a supportive environment. The actual timescale of the construction process depends on the companies involved.

3.3.2.2 Implementing Smart Grids and Data Management

The introduction of smart grids will be accelerated by the setup of the European Technology Platform Smart Grids [160]. With the establishment of these networks there will be an increasing need for communication and data transmission.

Political regulations can be expected to be established in the area of EU-wide norms and standards concerning communication protocols. Whilst there are EU-wide standardized protocols for one way communication in electricity grids, norms for two way communication which will become necessary with the introduction of smart grids are yet to be defined. The EU Commission is currently working on this. [136, p.28]

The second area where regulation is likely to be established is the exchange of data between grid operators and the publication of information. These regulations would ensure a safe and reliable power supply whilst consumers can inform themselves about where their energy comes from. [132]

3.3.3 Distribution and Retail

As consumer grow more aware of prices and environmental issues regarding electricity supply and consumption and distributers are aiming at maximizing their profits, governments are faced with near future trends that call for necessary regulations to protect and inform the consumer and secure the energy supply in a liberalized energy market.

3.3.3.1 Liberalization of Measurements and Information Requirements

Beginning 2010 the mandatory use of digital smart meters regulated in the Messzugangsverordnung will facilitate the visualization of energy-consumption and sensitize consumers to the associated prices [336, §21; §40]. DNOs will be in charge of installing and controlling the smart meters. They will then be obligated to provide consumers with better information and more transparency on their actual usage and usage times. An EU directive on Energy End-Use Efficiency already installed will additionally require new legislation for providing customers with accurate data (e.g. information on consumption profiles) [155]. Based on the disclosure requirements currently outlined in the EnWG, distributers will also be obligated to exhaustively publish information regarding network-fees, network shortages and network-structures to further enable consumers to compare the distribution operators [138]. Also regulations are planned that will request invoice and advertisement material to include information on the environmental effects of the energy production [179]. Although a regulation by the EU to inform consumers in real-time with usage-information is already implemented [127], it has not yet been taken over by German law. The implementation can be expected to happen in the near future [144, p.52]. Additionally, new legislation is likely to change the existing calibration regulations which are currently still hindering the implementation of smart metering. This will include abolishing discrimination of electronic meters based on their calibration validity period and its harmonization [144, p.85].

3.3.3.2 Flexible Tariffs in newly regulated EEX

With the liberalization of the energy market opening up to competition, Germany with its fixed pricing is getting under pressure to let market forces decide price. Therefore, as of 2011 it will be mandatory for energy suppliers to offer variable electricity prices intended to motivate consumers to save energy [336, §40, 3]. This calls for the realization of load-variable or time-of-day-depended tariffs [178].

Currently the EU is striving to give consumers access to market prices by introducing dynamic tariffs. Assuming that in the near future renewable-energy prices will also be based on the market prices of the EEX in Germany, the importance and power of the exchange would increase and therefore require a more extensive regulation and legislation to protect consumers, investors and traders alike while guaranteeing price stability [144].

With increasing liberalization and unbundling the Federal Cartel Office is expected to implement more measures to increase competition, reduce energy prices to consumers and integrate all European markets. There is also a trend expected to reduce network-access costs in order to promote competition in the end-consumer market. [174]

3.3.3.3 Securing Data Storage and Privacy

Critical at this point is the relation between the design of the protection of privacy in smart meters and an exhaustive regulation of reading and usage right given to distributers and network operators [139, p.11]. As smart meters and flexible pricing requires customers to share private and sensitive information with the distributers. Not only does this provide room for misuse but it also raises questions at how data will be stored, used and protected. Privacy regulations are also vital in order to avoid acceptance barriers from consumers as their consumption habits become transparent [170, p.37-39] as well as negative media attention. National legislation is therefore expected to build a clear and transparent legal framework to protect sensitive data and regulate access rights [153, p.29].

3.3.4 Consumption

An EU-wide harmonization for energy efficiency is intended for 2010. Germany is to set up national plans, called NEEAPs for 2007, 2011 and also committed to certain stopover goals which the BMWi is responsible for implementation for [177, 134, 147, 133, p.8-10; 58-61; 25-26; 19-20] Member states are required by the EDL-RL to ensure transparency and to promote energy end-use efficiency, e.g. by implementation of smart meters and further measures [134, p.62-63]. Experience within other EU-states during the last years shows, that for rapid implementation a strong legal framework has to be set [123, p.2].[122, p.12].Stronger national legislation, initiated by the federal government, can be expected to come shortly. During early stages, EU-guidelines will have a big influence. Nevertheless, a total harmonization will not take place, as until today there are only few legal guidelines while some countries are at the implementation stage already.

3.3.4.1 Regulating Consumption and Measurement

With the EDL-RL guideline and the German Energiewirtschaftsgesetz a legal framework for measurement is set. With installation of individual counters, end consumers will be informed on their actual energy consumption [152, p.17]. New markets for measurement and billing-enterprises are created [170, p.100-101], allowing further consumers to participate in the market and allowing further for stronger price competition due to new and more flexible tariff structures[170, p.139-140]. The law for liberalization of electricity and measurement effective 2010 requires implementation of smart meters, offer load-dependent or variable tariffs and to offer during the period billing with the aim of providing transparency of consumption, allowing for efficiency gains and incentivizing consumers for more economic energy usage. A steadier and reduced consumption in turn further increases energy efficiency. This is also in line with the EU 202020 targets and also anchored within the EnWG [151, 143, p.1-2; p.10] [136, p.8-9]§21b EnWG. Not only private households, but also the industrial area offers interesting fields, as foreseeable energy efficiency potentials and innovation potential can be found. We expect stronger legal obligations which grant more rights to consumers to a very detailed extend.

3.3.4.2 Introducing Load Management Regulations

With liberalization, suppliers will be required to offer load-dependent tariffs. This serves for incentivizing consumers to save energy (EnWG) and provides efficiency, transparency and creates legal certainty. The intention behind is to let customers choose and to provide them with price advantages, while also educating them for intelligent energy use. In order to facilitate this, consumers will be granted the right for choosing the provider who sets up and services the meter. [136, 180, 149, p.8-9; 11-13][184, p.7 and EnWG §21b][180, p.11-13]. For the future, more narrow regulations can be expected. With the legislative proposal for the Bundesrat for opening of measurement from June 2008, there is the obligation to offer measurement appliances reflecting actual consumption beginning 2010 and in addition to offer load-depended tariffs effective 12/30/2010 [151, p. 17]. In the long run, the EnWG will be amended and, together with other laws, set a even more precise standard for measurement and information to be provided to customers. The customers will, besides existing general data privacy regulations, get a legally anchored right for detailed information related to their actual consumption.

3.3.4.3 Establishing Privacy Regulations

There is a trade-off between information-sharing for enabling a working grid and privacy concerns of users. A sensitization of users for the new technology is needed. Consumer protection has a critical view, as there is danger of a vitreous customer [181]. Similar to the German Telekommunikationsgesetz (TKG, §88ff), consumer data can be protected. In accordance with this law, personal related data of consumers can only be collected and used for contract-related affairs with consumers and needs explicit agreement by the customer [171, p.38-39]. Even though politics initially have been against information sharing for smart metering, implementation of smart meters is explicitly included in the EnWG now, indicating that legislative efforts are taken to promote smart meter use. For acceptance of new technologies, a transparent legal regulation of access authorization and restrictions on data access on measurement and usage entities will create the necessary acceptance for new technologies [136, p.29-30]. While fears on privacy regulations will play a prominent role in the future, we expect that EU and national governments will set strong data privacy restrictions, allowing information exchange between distributing entity and consumers within narrow boundaries.

3.3.4.4 Educating Consumers

Load tariffs help to provide transparency and for educating customers for intelligent use of energy. There is a trend towards education of, and dialog with customers [139, p.23]. Also bonuses for low energy usage or feeding back from emission revenues are in discussion [139, p.32]. Customers shall be sensibilized and develop sense for ecologic responsibility [180, 148, p.11-13; 56]. Governmental programs contribute significantly for promoting the usage of technologies and efficient energy usage habits. Electric automobiles are a promising way for reduction of emissions within the area of traffic. The German government clearly commits to electromobility with its "national development plan for electromobility[136, p.32]. Currently, it can be assumed that the large political parties in Germany will strive for a framework which incentivizes consumers to revise their consumption patterns by new tariff structures.

3.3.4.5 Technology Regulations and Device Standards

Within the EU SET-plan, as well as the German parties general opinion, it is intended to bring to the mass market more efficient energy conversion especially within end-use devices and systems.[122, p.4][141, p. 6-7] The national energy goals of energy efficiency, including energy efficiency action plans (EEAPs) until 2014, are now anchored within the EDL-RL. The general trend is towards a top-runner appliance standard on an EU basis, making the best technique on the market a minimum standard [180, p.15-16]. Standardization on national level is excluded but there are national rights by implementing European guidelines [180, p. 8-11]. Another major trend is towards building services engineering improvements. Amendments to the ENEG and EnEV which will foster further building efficiencies and energy saving services. [180, 141, p.3-7 and 14-15; 7]. While the EU does not dictate implementation of smart meters, the political will for comprehensive roll-out exists in Germany [152, 141, 148, p.17; 6; 56]. Yet, implementation costs range within millions of EUR, but still there are no guidelines for cost transfer, which still causes strong legal uncertainty detrimental to roll-out, as experience in European countries gave the insight that a strong legal framework is needed [151, 152, p.7; 9-10]. However, we expect a politically driven roll-out of smart-metering as the public opinion is about to notice the importance of energy policy, which is clearly reflected within current political discussion and programs of the parties. Within appliances and devices, the EU will have a stronger impact in the future towards a harmonization of appliance standards and within subsidizing energy projects on EU wide level.

3.4 Conclusion

Summing up the findings three major trends can be identified.

In the area of legal regulations and administrative control there will be an increase in legislations giving more rights to the consumers. Laws granting more privacy protection for consumers will be introduced as well as a legal framework that strengthens consumers' negotiating position. Political efforts that contribute to the liberalization of the electricity market will continue. Transparency requirements and market price orientation will lead to price-reductions for consumers as competition between energy suppliers will increase.

Apart from regulating, politics will also take part in promoting certain technologies by investing in research, offering fiscal incentives or coordinating efforts towards their establishment. Support for renewable energies will continue whilst new transnational high voltage grids will be promoted that enable decentralized induction of power from renewable sources. The usage of fossil energy sources will be influenced by the political support for research on CCS-technologies. On the interface to private consumers the mandatory introduction of smart meters will shape the future.

Concerning the political system there will be a shift of power giving the European Union more influence. This is due to changes that are currently occurring within the political system of the EU as well as the matter of policies concerned, such as trading of emission-certificates or construction of high-voltage grids.

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4 Chapter 4

Market Players and Value Chain

Emanuel Breitsameter, Julien Donat, Tobias Schneiderbauer, Adrian Sennewald

E-Energy will have an impact on the value chain of the electricity market. Its phases and their orientation will change drastically. Bi-directional connections between phases allow for new business models drawing companies into the market. That along with consumers taking on new roles suggest a major shift of economic relevance for current market players.

4.1 Introduction

Nowadays electricity is available almost everywhere. Everyone is used to accessing it by just plugging something into the power outlet on the wall. However, several activities have to be performed in order to provide the consumer with electricity. The process starts with the different energy sources that can be used to generate electricity and the actual process of energy production itself followed by the transportation to the consumer. The various steps needed in this process are summarized under the term value chain. Market playeres in the energy sector are the companies that are involved along this specific value chain.

This part of the trend report on E-Energy deals with value chain and the market players acting within it. The chapter is divided into the two sections: status quo and trend. The status quo passage explains the current steps of the value chain followed by a description of the different market players and their role in the value chain. The manner in which the trend towards E-Energy influences the value chain and the market players is subject of the subsequent trend section.

4.2 Status Quo

In order to provide an understanding which steps electricity passes on its way from the natural source all the way through to its consumption, the following section deals with the value chain of the energy market first. Afterwards the market players of the different steps are identified and classified depending on their place in the value chain.

4.2.1 Value Chain

The value chain concept which was first introduced by Michael E. Porter, is in its original sense meant as a way to describe all strategically relevant activities a company performs. In this section the activities performed by the whole energy industry are of concern. Michael E. Porter titels this stream of embeded value chains as a "value system" [208, p. 34], but nowadays literature refers to both, activities within a single company as well as the stream of activities along vertical related companies [210, pp. 9 - 13] as a value chain. The latter is the way the term is used in this chapter. In this section different steps in the value chain shown in figure 4.1 are explained.

Figure 4.1: Status quo of the electricity value chain

4.2.1.1 Energy Source

Variouse types of energy sources can be used as an input for power plants to produce electricity. Hence these sources are the first important step in the value chain. These sources can be devided into fossil fuels and renewables. Table 4.1 shows the reserves, the amount of energy stored in the reserves, the price and the global consuption per year of the most important fossil energy sources. It has to be considered that these source are not only input to power plants for the production of electricity but also used to fuel cars, heat homes or produce goods.

Source	Reserves	Winnable Energy	Price	Consumption/Year
Crude Oil	163,5 Gt	6.835 EJ	70 $/b*	3.882 Mt
Uranium	1,77 Mt[1]	725 EJ	46 $/lb**	64.615 t
Natural Gas	183 T.m³	6.948 EJ	2,80 $/MMBtu*	3 T.m³
Hard Coal	602 Gt	17.638 EJ		5.523 Mt
Lignite	110 Gt	3.214 EJ		978 Mt

1)Category < 40$/kgU
*) http://yahoo-rohstoffe.customers.solvians.com/
**) http://www.uranium.info/

Table 4.1: Overview of the fossil fuels
Source: adapted from Rempel et al. [209, pp. 11 - 12]

Most deposits of these energy sources are not located in Germany resulting in a dependency on foreign countries. Where the different sources are located and the sources on which Germany is most dependent can be seen from figure 4.2 and figure 4.3. Part of this value chain step is also the extraction and the transportation of the different sources. Covering this in detail would however go beyond the scope of this report and is therefore not further explained.

Unlike fossil fuel deposits renewable energy sources are not limited. Renewable energy sources currently used are: sunlight, warmth, wind energy, hydropower, biomass and geothermics. Due to the fact that these energy sources can not be transported (except biomass), they are accessable in Germany but depend on local circumstances [189, p. 9].

4.2.1.2 Generation

The generation of electricity is the process of creating electricity from other forms of energy. The net capacity of electricity generated in Germany by the entire energy industry in 2007 was 635,8 TWh [215, p. 1] wich puts Germany

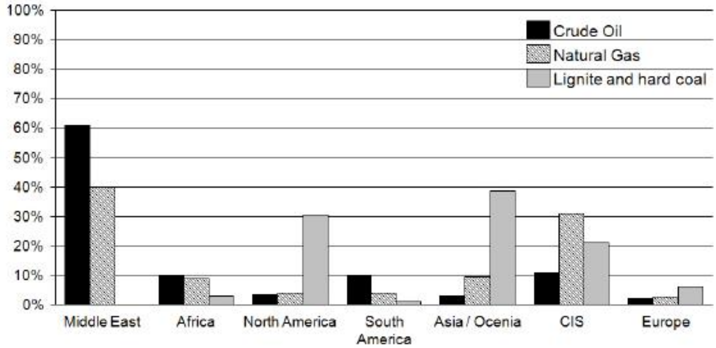

Figure 4.2: Overall percentage of fossil fuel reserves per region
Source: adapted from Bundesministerium für Wirtschaft und Technologie. [192, p. 8]

to the top of the cart for European energy consumption [207, p. 7]. Figure 4.4 shows the currently used sources of energy production according to the Bundesministerium für Wirtschaft und Technologie [213, pp. 13 - 14].

Depending on the type of power plant the electricity produced can be classified in three main categories: base load, middle load and peak load. Base load is the minimum amount of energy that must be produced at all times. Lignite fired or nuclear power plants are devoted to baseload production. Hydroelectric, geothermal and OTEC also often provide base load power [185]. Base load plants typically run throughout the whole year except for during repairs or scheduled maintenance. A key feature is their very large fixed cost and very low short-run marginal or variable cost [196, pp. 75 - 77]. Middle load is the capacity of energy provided on top of the baseload which primarily occurs in the daytime. In Germany hard coal fired power plants are most commonly used for this purpose [187, pp. 16 - 18]. Peak load describes the additional load that is expected to be provided for a sustained period of time at a significantly higher than average supply level. Power plants providing peak load show a high reacivity but also have relatively low fixed cost and high variable or marginal costs [196, pp. 75 - 77]. Pumped storage hydroelectricity, compressed air energy storage and combined cycle gas turbines are usually devoted to peak load. Photovoltaic arrays and wind turbines are also often used for this [195].

The value added by the generation phase consists of turning different energy sources into a specific form of energy: electricity.

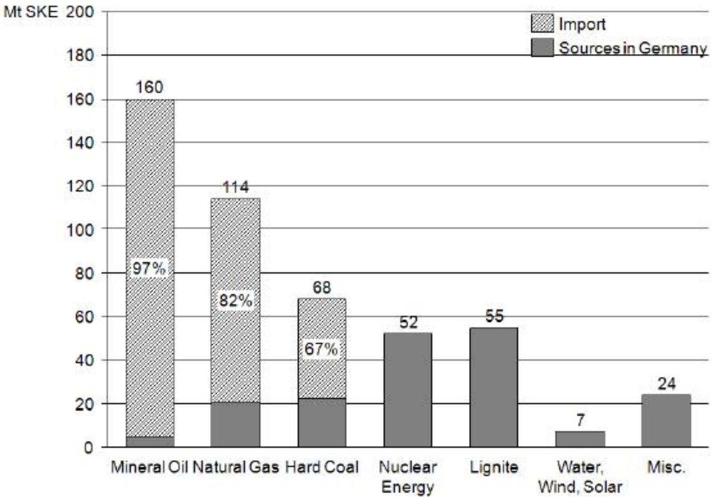

Figure 4.3: Dependency on energy sources of Germany
Source: adapted from Rempel et al. [209, p. 7]

4.2.1.3 Transmission

Electric power transmission is the way to transfer electrical energy in bulk a process in the delivery chain of electricity to consumers. Power transmission networks usually connect power plants to multiple substations near a populated area. The wiring from the substations to the customers is referred to as electricity distribution. Electricity transmission takes place at highest voltages (110 kV or above) in order to reduce the energy loss over long distances.

A power transmission network is referred to as a grid. Multiple redundant lines between points on the network are provided so that power can be routed from any power plant through a variety of paths to any load center. These networks use components such as power lines, cables, circuit breakers, switches and transformers.

In addition to the transmission itself, load management is also part of this phase of the value chain. Load management is the process of balancing the supply of electricity on the network with the electrical load by adjusting or controlling the load rather than the power station output. This task may involve sophisticated load analysis and include scenarios influenced by factors such as weather forecasts or network maintenance [186, pp. 44 - 48]. Load Management could be achieved by using a wide range of tools and programs including demand side management programs as well as demand response programs.

Both transportation at high voltage and load management make the guiding

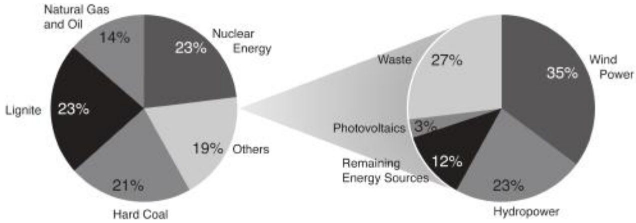

Figure 4.4: Gross electricity generation of Germany
Source: adapted from Thomé and Weirich [213, pp. 13 - 14]

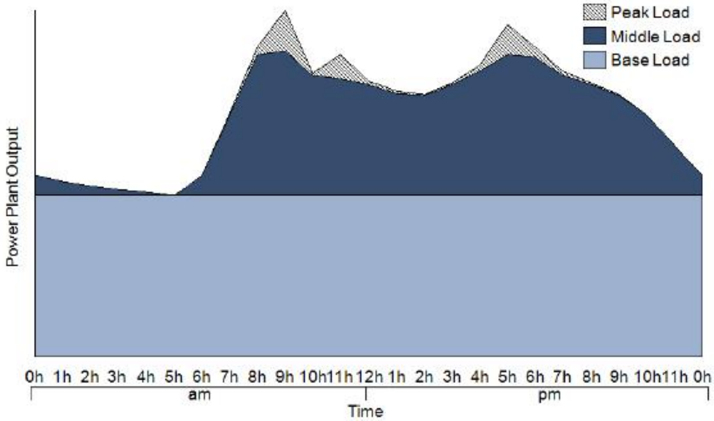

Figure 4.5: Load curve

principle of this phase of the value chain

4.2.1.4 Distribution

This part of the value chain is the physical link between the transmission network and the consumption. The distribution network in Germany consists of three layers: the high voltage (36 – 110 kV), the middle voltage (6 < 36 kV) and the low voltage (0,4 < 6 kV) grid [187, p. 28 - 29]. This grid is run by the owner of the concession for the respective part of the grid. These are called the distribution network operators (DNOs). DNOs are obliged to provide power plants access to the grid as a reward they get fees for the usage. DNOs do not compete against each other as the distribution network is a natural monopoly and competition is therefore not economically reasonable. That is why these operators are not that much affected by the pricing pressure caused by the

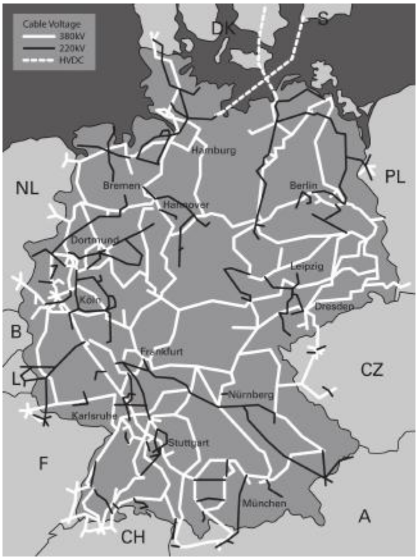

Figure 4.6: German transmission network
Source: adapted from Deutsche Energie-Agentur GmbH [199, p. 82]

liberalization of the energy market since 1998 [204, p. 3.24 - 3.30] [187, pp. 28 - 30]. However, the operators have to grant energy suppliers and dealers non-discriminatory access to their networks and since 2003 their business has to be legally separated from other activities. This is supposed to help so-called independent power producers to access the market [213, pp. 21 - 26]. Moreover, the DNOs have to make high investments for construction and maintenance of the networks. The Federal Network Agency limited the interest paid on equity for new construction projects from 2009 onwards to 9.29% (pre tax) and for the older ones to 7.56% (pre tax) [194, pp. 38 - 41].

To recap, this value chain step is the physical link between the transmission network and the customer. Value is created by providing the grid and ensuring its quality.

4.2.1.5 Retail

Retail companies are the actual contractual partner of the consumption party. These companies buy electricity on the EEX or OTC and sell it to the customers. Liberalization mainly affected this stage of the value chain. A liquid trade of electricity and the possibility for consumers to change their retailer whenever they want is suppost to lead to more competition. Since most of the electricity bought by retail companies is still subject to long term OTC contracts this goal is not fully reached yet [203, p. 71] [200, pp. 78 - 79].

4.2.1.6 Consumption

Consumption is the final stage of the value chain. This is where electricity is transformed into other forms of energy.

4.2.2 Market Players

As the market players differ in their coverage of the electricity value chain, they can be distinguished into major utilities, regional and national distributors, large municipal utilities and local utilities as shown in figure 4.7.

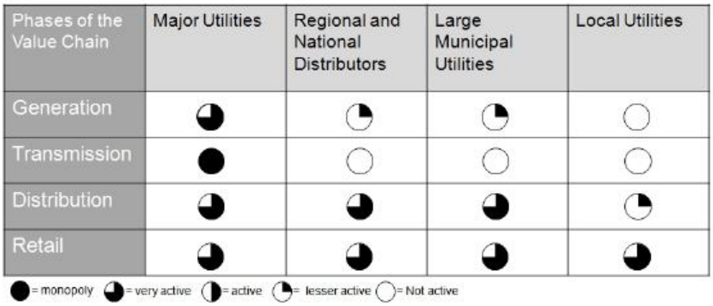

Figure 4.7: Matrix of the market players and their activity along the value chain

4.2.2.1 Major Utilities

In Germany there are four major utility companies (E.ON, RWE, EnBW, and Vattenfall) which are active along the whole electricity value chain: generation, transmission, distribution and retail. Theses four companies dominate the generation with a market share of over 85%, while the remaining share is covered by municipal utilities, regional and local producers. Each of the four companies owns and operates their own transmission system via legally unbundled companies E.ON Netz, RWE Transportnetz, EnBW Transportnetze and Vattenfall European Transmission, with the country divided into four large zones. The four transmission system operators (TSOs) must provide nondiscriminatory third-party access to their networks for all generators and they must coordinate their operations under the term of the Union for the Co-ordination of Transmission of Electricity (UCTE) [205, pp. 127 - 132]. In addition to this the major utility companies are responsible for the cross-border transmission and the allocation/supply to the regional and national distributors

[193, p. 7]. In the distribution and retail market, the major utility companies are active by having subsidiaries or large stakes in municipal and local utilities [190, pp. 17 - 20]. The following description of E.ON and EnBW gives a better understanding on how the market players are structured.

EnBW is a major utility company focused on providing electricity, gas and environmental services. It operates in Germany and other parts of central and Eastern Europe. The company operates through three business segments: electricity, gas, energy and environmental services. In the electricity segment, the company covers all stages of the value chain from the generation to the sales via electricity trading, transmission and distribution [197, pp. 5 - 8]. Here EnBW operates through subsidiaries, EnBW Kraftwerke, EnBW Kernkraft, EnBW Trading, EnBW Transportnetze, EnBW Regional, EnBW Vertriebs und Servicegesellschaft and Yello Strom as shown in figure 4.8.

Figure 4.8: Electricity value chain of EnBW
Source: EnBW Energie Baden-Württemberg AG. [201, p. 2]

Due to legal issues the other three major utility companies are structured in a similar way.

4.2.2.2 Regional and National Distributors

The regional and national distributors supply the electricity which they produce in their power plants to local utilities or to the end-customer. In addition they also deliver some of the electricity generated by the major utilities or other companies. Currently about 60 companies are active on this level of the value chain. These companies are present in the generation, distribution and retail phases. To generate electricity they operate medium sized and decentral power plants [205, p. 135]. Mergers and acquisitions which underline the consolidation in this segment are having a strong effect on the market environment for regional and national distributors. The major utility companies and the regional and national distributors are closely linked by capital participations and supply contracts [190, pp. 19 - 22]. The most important market players in this segment are MVV Energie AG, EWE AG, Evonik Industries AG, Rheinenergie AG and badenova AG & Co. KG. The following gives a short insight into MVV Energie.

MVV Energie is one of the many energy distributors and service providers in Germany and acts as a holding company that operates a network of companies within the Mannheim region and also in Poland and the Czech Republic. MVV operates through six business segments: electricity, district heating, gas, water, value added services, and environmental energy services. The electricity business segment is involved in the generation, trading, distribution and retail phases. The company sells its electricity to industrial and commercial customers [198, pp. 5 - 7].

4.2.2.3 Large Municipal Utilities

In Germany 24 large municipal utility companies operate. These companies are active in the generation, distribution and retail phases. They generate electricity by operating both medium sized and decentral power plants. In addition to that they concentrate on the operation of the distribution grid. While doing so they are obliged to provide third-party access to their grid. The major utility companies have stakes in a large percentage of these companies [67, p. 135]. The most important large municipal utility companies are Stadtwerke München, Stadtwerke Köln and Stadtwerke Leipzig.

4.2.2.4 Local Utilities

More than 700 local utility companies are currently operating in Germany [191, p. 36]. These companies are most active in the distribution and retail phases of the value chain. Some of them are also present in generation phase by owning and operating decentral power plants. Within the distribution phase they are mainy responsible for the low voltage grid and in some cases partially for the middle voltage grid as well. The cooperation between local utility companies rose in the past in order to cope with the higher competition [202][194, pp. 34 -35]. The major utility companies also have stakes in a large percentage of these companies.

4.3 Trends

Though there has been much debate over the exact definition, E-Energy actually compromises a broad range of technology solutions that optimize the energy value chain. Depending on where and how a specific utility operates across that chain, it can benefit from deploying certain parts of the E-Energy solution set.

4.3.1 Evolved Value Chain

E-Energy is characterized by a two-way flow of electricity accompanied by information to create an automated, widely distributed energy delivery network. It incorporates the benefits of a data management system into the grid in order to deliver real-time information and enable the near-instantaneous balance of supply and demand at the device level. This leads to a bi-directional value chain as shown in figure 4.9.

Figure 4.9: Evolved value chain

4.3.1.1 Data Management and ICT

Data management predicts, organizes and systematizes the generation, allocation and usage of energy while aiming to achieve ecological and economical goals. Taking the importance of the predictive, organizing and systematic handling of energy into account the great value of the information allocation, transmission and processing becomes clear. ICT will allow for real-time-pricing to reach the consumer which would result in a direct or indirect control of energy consumption [188, p. 10].

An ICT-System covering the whole value chain will transform the electrical system into an E-Energy system in which all existing actors get new roles [188, p. 10]. In the center of this system the energy trading, data management, load and demand management and all similar processes will be controlled by the exchange agent. Its role to trade and organize information will be of benefit for all parties. This can allow for markets to open for players in the value chain all the way down to the consumer.

The communication and networking capabilities of the data management layer offer potential to optimize the grid while bearing risks at the same time. If for instance the protection of data privacy is not managed properly it could result in an entry barrier for consumers. Regulations such as the German telecommunication law (TKG) would be required to create a standard for data handling and privacy [188, p. 38].

4.3.1.2 Energy Source

The tendency towards renewable energy sources makes the generation very dependent on a smart grind in order to operate efficiently. Solar and wind power for instance are very close linked to weather conditions. This limits its local reliability and makes the long distance grid an important factor for an efficient usage of this source.

Smart Grid deployments may represent the largest single information technology investment that can be made to reduce CO2 emissions, as electricity generation is the number one source of greenhouse gases (GHG) [206, p. 8].

4.3.1.3 Generation

E-Energy's new technologies and applications are intended to facilitate and integrate sources of generation that are both intermittent and distributed. As a result E-Energy is going to offer huge opportunities in terms of renewable energy [206, p. 17].

Here communication with the other phases also becomes a crucial topic: The generation domain must communicate key performance and quality of service issues such as scarcity (especially for wind and sun) and generator failure. This communication may cause the routing of electricity onto the transmission system from other sources. A lack of sufficient supply may be addressed via the data management layer.

New requirements for the generation domain include green house gas emissions controls, increases in renewable energy sources and a provision of storage to manage the variability of renewable generation. The choice of energy source will depend on the cost of CO2 emissions [216, p. 55].

4.3.1.4 Storage

Storage is a vital phase of the E-Energy value chain as it plays a key role in flattening the load curve and decreasing the need to build new power plants and transmission lines. Energy storage could assist in making small scale distributed generation a viable alternative to large centralized power stations since it acts as a buffer in down times. This will help these "green" power plants to retain their produced energy until it is needed [206, p. 18].

Distributed storage options which would be located near the consumption end of the grid – will provide localized power where it is most needed. The customer could store his own energy without requiring the grid to access it [206, p. 17].

4.3.1.5 Transmission and Distribution

Transmission and distribution offers a very steady yet limited revenue streams at a low risk. Expansions require high investments while they then last for decades [188, p. 15].

Since generation inputs feed into the grid at different voltages, depending on the generation facility, transmission and distribution phases become alike. Combined they could be referred to as the Grid, a place where most of the smart-meters are to be implanted and is therefore expected to undergo a massive change. E-Energy technologies may allow for:

- faster diagnosis and reaction to distribution outages, reducing overall outage times with major economic benefits
- a better utilization of transmission paths, to improve long distance transfers
- a reduced transmission congestion by using synchrophasors [Report of the Electricity Advisory Committee, 2008]
- direct operating costs to be reduced, using advanced metering technologies (AMR/AMI) such as connects/disconnects, vehicle fleet operations and maintenance
- an optimized asset utilization and operation efficiency. In this case routine maintenance and self-health regulation abilities would allow assets to operate longer with less human interaction [216, p. 30] [212, p. 21].

4.3.1.6 Retail

The bi-directional orientation of the energy market allows not only for flexible pricing, but for additional products such as feed-in tariffs. Retail will create new and innovative services and products to meet the new requirements and opportunities presented by the evolving smart grid. Services may be performed by the electric service provider, by existing third parties [206, pp. 49 - 50], or by new participants drawn by the new business models. Emerging services ranging from traditional utility services to enhanced customer account management represent an area of significant new economic growth. All parties can have an active role in retail domain to trade and sell their electricity.

4.3.1.7 Consumption

Advanced metering and network communication lets the consumer become an active participant of the smart grid. The energy consumption could be controlled by preference. The smart grid consumer is informed, modifying the way they use and purchase electricity. They have choices, incentives, and disincentives to modify their purchasing patterns and behavior. These choices help drive new technologies and markets [216, p. 29].

Actors in this segment now not only act as consumers but often play roles in generation and storage. This leads to new sub-network and islanding possibilities making the complete value chain to still exist without a connection to the nationwide grid [188, p. 98].

4.3.2 Impact of E-Energy on the Market Players

The following section deals with the expected impact of E-Energy on the market players. The advantages and disadvantages as well as the arising conflicts are described briefly.

4.3.2.1 Power Plant Operator

Due to the better coordination possibilities between generation and demand, the power plant operator will be able to run the power plants in a more efficient way and will have a better planning reliability. However, the power plant operator will not be able to sell the profitable peak load anymore. As this trade-off shows the current market players will not be a main driver for E-Energy. The phase-out of nuclear power plants will lead to a need for other types of electricity production. Therefore new and existing market players, especially in the sector of renewables, will gain more importance. Additionally, the quantity of decentral power plants (e.g. PV) will grow. Virtual power plants will give these small decentral operators the ability to increase their market power. As a result the importance of the existing power plant operator will decrease [188, pp. 90 - 92].

4.3.2.2 Network Operator

The most important impact of E-Energy on TSOs and DNOs will on the one hand be reduced peak loads brought upon by the smoothing of energy consumption and on the other hand a constraint to invest big sums of money for the extension of the grid in order to enable a more decentralized generation of electricity [199, pp. 70 - 79]. Also, distribution companies' activities will not anymore be limited to the transportation of electricity but also the distribution of information [214, pp. 27 - 28]. This has all to be considered while taking the ongoing liberalization in the energy sector into account (see chapter 3). As a result network operators will have to deal with the provision of a stable grid without the possibility of an integration along the value chain. Even moreso than they do currently. Thanks to reduced peak loads and a lower need of “Regelenergie” they will be able to save maintenance costs [188, pp. 90 - 92].

4.3.2.3 Retailer

E-Energy will have a very big impact on market players acting on the retail phase. The variety of potential services is growing tremendously due to the new possibilities enabled by ICT. Market players will be effected by each other in many ways. On the one side there will be a growing number of possibilities to differentiate themselves and on the other side a lot of new companies will enter the market and may lead to more competition. Current market players will have to invest in ICT while risking a tendency towards decreasing turnovers. Conflicts between retailers and customers may also arise. The detailed private data collected from the consumer through smart metering could create a such conflict [188, pp. 90 - 92].

4.3.2.4 Customer

In the future the active customer will be part of the market players in the field of generation due to the decentralization of electricity production. In addition they will possess a lot of storage capacity (e.g. electric cars). Furthermore, these market players will shift their consumption according to price signals as soon as they are able to monitor them leading to cost savings. Customers will supply and receive information on energy. By doing so they as well as other market players will benefit economically or in terms of convenience [299].

4.3.2.5 Market Players in Data Management and IT

The following gives an overview of the market players with a brief explanation for each segment within the data management and information technologies:

- **Networking/Communication**

  Competitors within the Networking and Communication domain are Current Group, Eka Systems, Silver Spring Networks, Smart Synch and Trilliant. Silver Spring Networks is a leader for AMI networking solutions in North America. The company is focused on providing two-way real time communication between the end-user's smart meter and the utility's control and management systems. This is how Silver Spring Network enables utilities to achieve operational efficiencies, reduce carbon emissions and offer their customers new ways to monitor and manage their energy consumption [206, pp. 106 - 113].

- **Demand Response**

  In the Demand Response sector Converge Inc. and EnerNoc Inc. are important market players. EnerNoc Inc. is a demand response solutions provider focused on the commercial, institutional and industrial market. The company uses its Network Operations Center to manage and reduce electricity consumption across a network of commercial, institutional and industrial consumer sites to allow for a more information based, responsive and intelligent electric power grid [206, p. 114].

- **Grid Optimization/Distribution Automation**

  The competitors in this sector are mainly ABB and SEL. ABB is a market leader in power and automation technologies and is very active in integrating distribution management systems into advanced utility control systems. The company provides several E-Energy applications like fault location, unbalanced load flow analysis, restoration and switching. These solutions are mainly located between the distribution network and the utility control room [206, pp. 116 - 117].

- **Software, Solutions and Application**

  In the software, solutions and application segment many companies with different approaches are active like Aclara Software, Ecologic Analytics, GridNet, eMeter, Gridpoint, OSlsoft and Ventyx. Aclara Software focuses on meter data management, network planning, load forecasting, and customer information systems. The company works currently with over 95 energy companies on a global basis. GridPoint is a software company that develops modular systems and applications for utilities to improve and implement for energy efficiency, load management, renewable energy management, energy storage management, and electric vehicle management. In addition GridPoint also offers consumers online energy management portals for greater efficiency, reliability and savings [206, pp. 118 - 126].

- **Home Area Networks and Energy Management Systems**

  Competitors in this sector are Control4, Gainspain, Google, Microsoft, Tendril and Onzo among others. Google PowerMeter is a web-based home energy management system which receives information from utility smart meters and energy management devices. Additionally it provides the access to their home electricity consumption right on their personal iGoogle homepage for the customer. PowerMeter will be an open-source platform, and offers therefore the possibility for third-party developers to add more specific applications. The German retailer Yello Strom is one of the partners of the Google Powermeter project [217]. Microsoft will also be active in the home energy management market with MS Hohm. MS Hohm will allow consumers to monitor and manage their own energy consumption online [206, pp. 127 - 130].

- **Other major players**

  Cisco Systems Inc. announced recently that they want to become active in the following market segments: AMI networking and communications, distribution and transmission automation, data storage and home/ building energy management. IBM competes in both the services and software sector of Smart Grid. The company is able to serve utilities by providing trusted expertise as an intermediator between distribution utilities and IT providers. On the software side, IBM will offer both systems architecture and enterprise applications for market sectors like AMI demand response, distributed generation and storage. Oracle announced that they will offer grid optimization, demand response/load analysis, work and asset management, meter data management and the integration of renewable energy [206, pp. 137 - 143].

4.4 Conclusion

All phases of the E-Energy value chain interconnect through the data management systems that meter, process and allocate information. This makes new products and services possible that generate value in both directions horizontally. Alongside electrical energy the information becomes a commodity through the economical benefits it generates. Although market players will be presented with new possibilities and new players will be drawn into the market it is questionable if liberalization is able to break the historic monopolies of existing companies. More so generators running on renewable sources as well as information based services can clearly be recognized as a trend that is already beginning to grow. Whoever wants to become or stay a big player in the market will have to pay close attention to the active consumer though.

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5

Chapter 5

Emerging Business Models

Joshua Cornelius, Thomas Hopf, Rodrigo Rivera,
Moritz Winter

Upcoming changes in the energy sector due to the increasing relevance of information and communication technologies (ICT) raise the question how these technologies could be employed to develop new business models. On the long run, these models will have substantial influence on the future development of the energy market. Based on a common framework, business models are analyzed. Starting with current models which are built on the traditional value chain, this paper shows four major areas in which new business models could evolve: energy supply, grid operations management, user side demand management and complementary applications. Concrete business models for each area are defined. It is found that a variety of innovative new models will evolve.

5.1 Introduction

The energy sector of the past has been subject to major changes in recent times. Liberalization of energy markets was initiated by the EU in 1996. Since then, the formerly existing monopolies have evolved into a multitude of various business models in a market with increasing competition. The results of the process of deregulation with regard to business models are described in the section "Status Quo". The second wave of change will be brought to the energy sector through the introduction of ICT, resulting in a substantial shift to the pillars on which the entire industry is built. New business models will emerge. They are topic of the section "Trends".

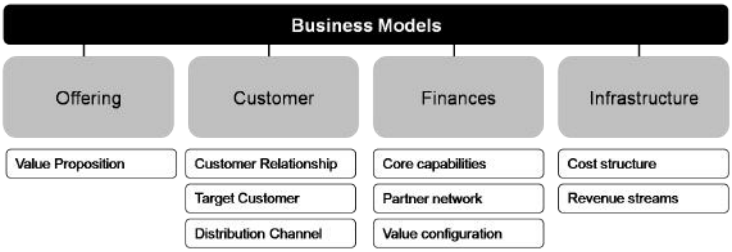


Figure 5.1: Central pillars of a business model
Source: adapted from Osterwalder [240]

Throughout this paper, business models are discussed based on the framework proposed by Osterwalder [240]. It defines four major aspects which describe a business model (figure 5.1). A certain added value is proposed to the customer by means of a product or service (Offering). The company aims to sell the offering to a certain group of customers (Target Customer). To provide the offering, certain capabilities and assets are necessary (Infrastructure). The cost structure and the revenue stream determine the profit and thus the ability to survive in the market (Finance).

5.2 Status Quo

The most important business models shaped through regulations are: International and national as well as regional and municipal supply, generation, transmission and distribution, and finally resell. Moreover, the models of trading and bundling can be named. They are, however, of minor importance in Germany and are therefore not discussed. The models can be separated into two major groups, integration and specialization. Adding up to these current models already a couple of E-Energy applications, which have the possibility to change business models in the future do exist[1] [219, 228, p. 39].

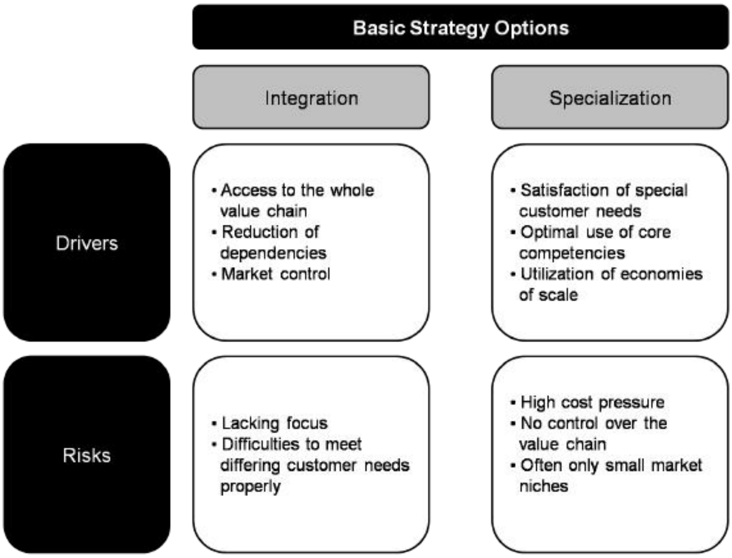


Figure 5.2: Basic Strategy Options

5.2.1 Integration

The business concepts that will be introduced in the following have evolved from a former monopoly market. The basic structures of these time-proven models still exist today [221, 219, p. 179]. The models have in common that the corporations based on them are active along the whole value chain.

5.2.1.1 International and National Supply

Typical exemplary companies are E.ON, EnBW, RWE and Vattenfall Europe.

Usually these kinds of corporations operate their own power stations and electricity networks. To run the infrastructure assets properly expertise staff ranging from production to disposal is needed.

E.ON and others have gained a dominant market position through their integration along the whole value chain and thus were forced by the legislation to carry out their business through independent companies. Consequently, a special focus of the process management lies on the coordination of the single business units to ensure a smooth production flow [218].

[1] Zoltan Elek, CEO of Landwärme, personal communication

The full integration along the value chain enables E.ON and others to operate independently. Nevertheless, power can be bought from generation sources as well as it can be transported and distributed for other energy supplying businesses. The main focus, however, lies on the provision of electricity. The retail sector is therefore usually divided in private and business customers. In this area it is especially important for big companies to keep a keen eye on specific customer needs and their fulfillment. Considering that these corporations supply huge markets it can be challenging to meet the varying needs of different customer segments [228, p. 42f].

For a long time the electricity sector was a mainly static market and so far only Yello was successful to increase its numbers of customers through investing big numbers into a marketing strategy offensive [243, p. 152].

The power transportation and distribution sectors are characterized by stable margins. Profits are limited through legislation. However, higher margins are possible in the retail sector. Moreover, aiming for economies of scale and scope is a possibility to decrease variable costs [228]. This is especially true for large companies such as E.ON, with an annual turnover of nearly 87 Billion Euro [224, p. 4].

5.2.1.2 Regional and Municipal Provision

A very similar business model to the international and national supply is applied by SWM or Harz Energie. The difference is that here only a specific city or region is provided. The disadvantage of this model is that most regional suppliers are not able to bear the cost pressure. On account of this alliances with other companies are common. Associate companies are engaged in sewerage, supply of water and passenger transportation, for instance [222, p. 57].

The regional energy suppliers are also mainly offering power provision. However they are not able to produce enough power and are therefore forced to buy additionally from external power producing firms. To stand out from the competition, regional suppliers offer special product and service combinations offered in cooperation with the associated companies [222, p. 57]. Another possibility to satisfy various customer needs are diversified bargains. Bringing added value to the end user in such a manner is essential for the company's success, since regional limitations make the loss of customers hard to compensate [228].

Target customers are both private and business purchasers. Within the target region a strong market presence as well as a popular brand name are crucial for the success in customer acquisition.

A major cost factor is purchasing the electricity. Therefore power fluctuations and the resulting volatile prices play an decisive role. Furthermore, a possible way to lower the cost of distribution is E-Commerce [228, p. 43].

5.2.2 Specialization

Deregulation efforts and increased competition in the sector in the last years have forced the incumbents to specialize on certain links of the value chain. Hence, companies based on the emerged business models are not active along the whole value chain anymore. The most important models will be discussed below.

5.2.2.1 Generation

About 85% of the power is generated by companies being part of the four big players E.ON, RWE, EnBW and Vattenfall [220].

In order to be succesful it is required to count on infrastructure such as power plants and an expert staff. Moreover, companies which are specialized in the field of renewable energy most face the problem of being dependent on factors they cannot control such as wind and sunshine. Therefore, cooperation with other companies is recommended in order to be able to deliver electric power during critical situations, especially since power is not storable. Furthermore, these companies need to be capable of forecasting the demand as exactly as possible to prevent supply problems [246, p. 42]. In the end the offered product is electricity from specific energy sources; this is worth mentioning, as support for the supply of green power has been steadily increasing in recent times.

Various groups of customers have to be considered. On one hand there are power resellers as well as regional and municipal suppliers. On the other hand there are bulk customers in the industry [228]. Anyway, it makes sense to have local customers to avoid transportation costs.

The main idea of the concept is reducing costs by creating economies of scale through specialization and high efficiency [222]. Currently the problem is that the technology is not fully developed, which results in high R&D costs. Moreover, for international operating companies the missing natural hedge could lead to an inescapable loss.

Therefore, Government authorities promote renewable energies by financially subsidizing companies under the law of renewable energy. This law guarantees attractive and profitable green energy prices.

5.2.2.2 Transmission and Distribution

The next part of the value chain is power transmission and distribution. It is served by companies like E.ON Netz or RTE EdF transport. In Germany, almost all of them are part of the big integrated enterprises. They own the grid and perform maintenance tasks.

In the course of market liberalization, the obligation to offer discrimination-free access to all users of the grid was introduced (EnWG). Hence, the possibility to shape the transportation and distribution business of the grid owner is restricted.

Customers of power transporters and distributors are all types of energy utilities which are dependent on transporting their electricity from one place to another, but do not have their own grid [248, p. 5].

Costs originate from grid maintenance and the coordination of feed-in and demand [248, p. 5]. Due to the monopoly of the net owner, revenue is constant, but the margin is constrained by law (incentive based regulation). Consequently, earnings can only be increased by optimizing the net load [222, p. 58].

5.2.2.3 Resell

It is also possible to just buy and resell power, like Lichtblick does, for instance. ICT based platforms are necessary, since resellers trade without power plants and grid. Emphasis is put on sales management and the build up of a service network.

Resellers create value through very specified and diversified product offers. Although the business model itself does not command a certain specification, the focus is put mostly on renewable energies. Furthermore, added value can be achieved through additional customer services [222, p. 58].

Especially private customers create a demand for environmentally friendly energy sources. It depends on the design of the business model, whether emphasis is placed on big marketing campaigns or on mouth-to-mouth propaganda.

Costs arise from both buying power, especially green power, and from maintaining the ICT infrastructure. Costs, emerging from customer services, can be lowered quite successfully via proper E-Commerce. Simultaneously, the revenues per unit are quite high, since customers are willing to pay a markup [228, p. 45].

5.2.3 Existing E-Energy Implementations

E-Energy arrives in many little steps. A few increments have already been made and may change existing business models or even lead to new ones. By means of Vattenfall a couple of E-Energy applications will be introduced.

Vattenfall is one of the four big players named above and already offers a broad range of services and platforms based on ICT, which might be considered as E-Energy implementations. A few will be outlined below.

Besides several different tariffs, Vattenfall offers private customers energy consulting to reduce their energy consumption and energy analysis with lend able devices. Furthermore, a counseling is offered for new home appliances. All services are offered free. Business customers can choose from an even bigger variety: energy profiles, load management and energy controlling, for instance. Additionally, the internet based platform, PowerPricer, not only provides business clients with real-time price information, but also allows them to buy electricity at all time. Click&Trade enables municipal utilities and industrial customers to participate at the energy exchange without being accredited [249].

5.3 Trends

As the complexity of the smart grid rises it becomes more difficult to carry out all the steps along the value chain as one single integrated company. The one integrated company that offers all services will vanish due to more specialized ones along the value chain. The existing market players therefore have to double-check how the framework conditions and parameters defining their competitive space will evolve and how they in return can react to carry their business model successfully over into a new decade in the energy timeline. An overview of upcoming business models is given. Major changes have been indentified in the areas of energy supply, grid operations management, user side demand management and complementary services. Hereby, ICT plays a major role in the emerging business models.

5.3.1 Energy Supply

There is broad concensus on the necessity of restructuring the current network towards a more efficient grid with the possibility to integrate renewable energies [246, p. 41ff]. In the following, business models in the the areas of distributed generation and storage are introduced.

5.3.1.1 Distributed Generation

More efficient renewable energy resources will lead to a higher degree of distributed energy generation in the future. Small scale distributed energy generation will meet two main barriers. First, only considerable large capacity generators will have direct access on the various energy markets[2]. Second, a utility scale generator will have advantages when it comes to terms of flexible system control as well system quality assurance [230, p. 9].

These barriers can be handled by virtual power plants, which have the task to aggregate distributed and central energy sources to profit from economies of scale and scope. Through controlled decentralized contracting it is possible to balance the network load. According to the ownership we can distinguish two different business models [225, p. 4.8ff].

[2]for example transaction costs, information asymmetry, regulatory barriers

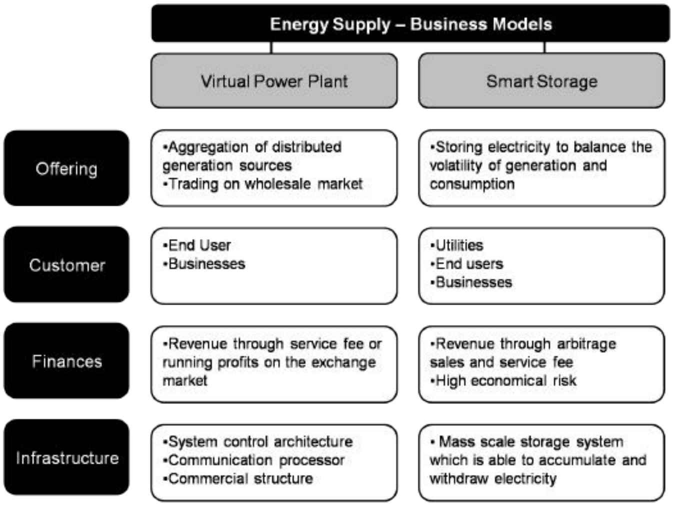


Figure 5.3: Business models in the area of energy supply

Virtual Power Plants – End-User Ownership

A third-party aggregator pools together various distributed generation sources, which are owned by the end user. In the following the aggregator forms a selling coalition [229] and acts as a trader in the wholesale market.

The added value that is offered to the network company, through contracting, is quality assurance and reliability. It is moreover possible to control the net load in the transmission and distribution network more steadily with decentralized generation [380, p. 22ff]. As main infrastructural devices a virtual power plant (VPP) needs a distributed system control architecture, an information and communication processor and a supporting market and commercial structure [231, p. 111]. In relationship to the construction of a central stationary power plant, a VPP can be setup quickly in small increments by adding new supply sources into its agglomeration power. A VPP has consequently relative lower investments and therefore a lower financial risk [380, p. 22]. Moreover the aggregator earns its revenue by a fee it levies the end user for it services. The customers are typically early adopters, attracted by the green footprint, energy independence and technological progress. Though the homeowners get state rebates, the financing of the system contains potential for additional financial offers by the aggregator [225, p. 4.9ff].

Virtual Power Plants – Third-party/Utility Ownership
The main difference of VPP with third-party/utility ownership lies in the customer base and the revenue flows. Here, the third party shoulders the high up-front costs of setting up the system. Thus the financial risk transfers from the end user to the third party. The third party now earns their revenues as a trader on the exchange market and pays the end user a rental fee. A risk free rent on the other side is earned by the customer, who can probably be considered as early majority - even though aspects like green footprint might still play a role [225, p. 4.8ff].

Concluding one can say that the third-party/utility ownership model is probably a development of the end-user ownership model, since it hands over the financial risk from the relative risk avers consumer to the relative risk neutral company and therefore achieves a more efficient solution [227]. The third-party ownership model additionally opens up the market for a bigger number of customers and therefore can profit from network effects. Furthermore, the third-party ownership model could be a very profitable business model for utilities, since they could easily use the customer base to include demand response management to make the process as a whole smarter [225, p. 4.6ff].

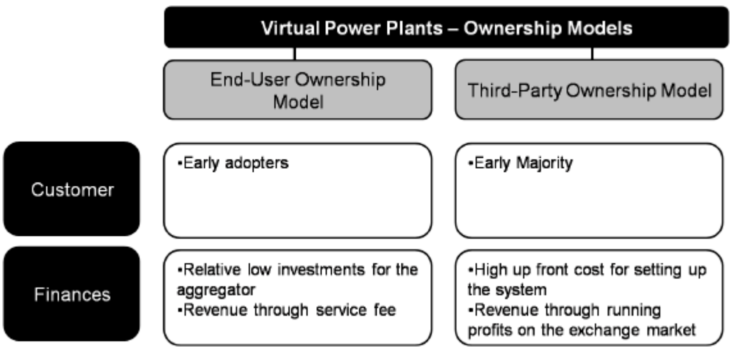


Figure 5.4: Virtual Power Plants - Ownership Models

5.3.1.2 Integration of fluctuating power sources

With its ability of flattening the peaks of energy supply storage is often referred as the missing link for a complete successful integration of the volatile renewable energy resources [372, p. 9].

Smart Storage and Transformation
The special value, storage can offer is that energy can be stored when the prices of energy are low and be fed back into the grid during rising prices. Storage

is therefore able to smooth fluctuating power [234]. It offers the possiblity of absorbing energy in times of overflow, so that cost ineffiecent shut downs of powerplants can be prevented [236, p. 54].

Larger storage sizes are more favorable, with a higher price volatility and an advanced technology [244]. Most storage systems have very high initital investment costs, but low operating costs [236, p. 51]. As in the case with distributed energy generation a smart grid itself is necessary to ashure that devices like storage and plug-in hybrid electric vehicles can run properly. The economical risk has to be rated as high since the future development of demand and competitive technologies are hard to predict. [3]

The storage systems could be setup by a third party. The revenue can be earned through abitrage sales on the exchange market or lending out the storage place. In case of utitility ownership the benefit would result in an improvement of the load managment system and would result in higher overall profits. Target customers are the utilities themselves or through a VPP either third party or in case of distributed storages the end users.

Plug-In Hybrid Electric Vehicles

A plug-in hybrid electric vehicle (PHEV) equipped with a battery to store energy could provide a similar way of smoothing fluctuating power as storages do. According to a US-study cars are only used for around one hour a day [234]. The opportunity of vehicle to grid thus lies in the time it is not used and still plugged into the electric grid.

The great business potential hides in the fact that PHEVs can be financed through two ways. First, money is earned for PHEVs through usual car sales. Second, PHEVs yield profits as storage devices. Furthermore, state subsidies are possible[4]. The goal of the German government is to have 1 million cars running on the streets by 2020 [380, p. 26].

The system behind the PHEVs is rather complex. A network of companies would probably have to carry out the task of building up the necessary technical infrastructure. Three main business models are possible:

- A local electric distributor which would gain system reliability could offer free charge of the cars at stationary places. It would earn no revenue but gain storage capacity which would yield to increased profits in the core business [236, p. 34].

- An automobile manufacturer providing car rental/sharing services. This would create a higher demand for cars and leads to additional revenue through the car sharing.

[3] A european-wide long distance load managment network could for example be viewed as competitive technology. Already today high voltage dc power lines make long distance distribution costeffecient possible. (vde energiespeicher p.53)

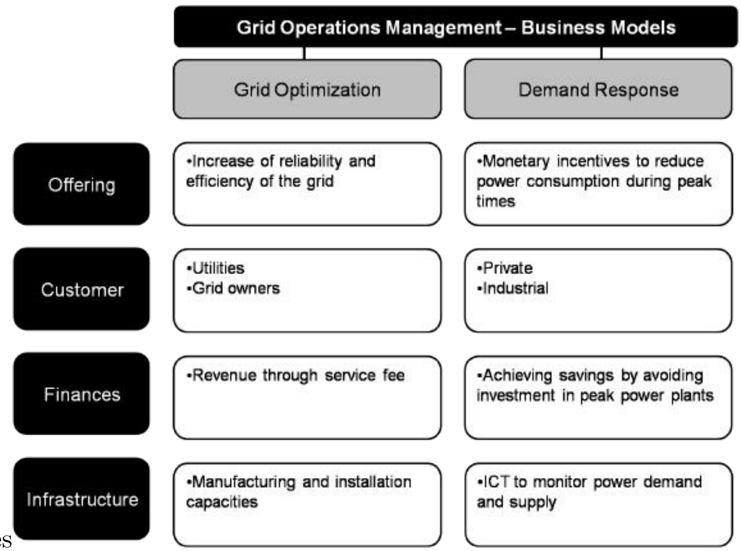
[4] Nationaler Entwicklungsplan Elektromobilität der Bundesregierung (August 2009)

- A system operator that sets up the telecommunication network and infrastructure and furthermore handles the electricity billing and complementary services. Money is earned through transfer payments of the electric distributor and the automobile manufacturer [233, p. 19ff].

Target customer, shortly after introduction of PHEVs, would be the early adopters and people that use their second car as city car[5] [236, p. 33]. It would be important to aim towards the mainstream customer, as soon as possible, in order to reach a critical mass which is necessary to cover the high up front R&D and infrastructure costs to set up the system. The main parts necessary for the technical infrastructure are a smart meter to measure the power flow and an unique identifier device on the vehicle [233, p. 18ff].

5.3.2 Grid Operations Management

Several business models on the grid operator scale open up through the introduction of smart technology.



References

Figure 5.5: Grid Operations Management - Business Models

[5]Without fuel PHEVs have a reach of 30-70 km (VDE-Energiespeicher 33ff).

5.3.2.1 Grid Optimization and Distribution Automation

In their current form, electrical grids are a one-way system, where power flows to the customer, but no information about the process is returned to utilities or grid owners. The goal of grid optimization and distribution automation is to develop, add and use digital sensor, control and communication technology to improve the reliability and efficiency of the grid [372, p. 16]. R&D, manufacturing and installation capacities are necessary for a company providing such products and services, e.g. ABB[6].

Availability of the optimization and distribution system offers several benefits to the owner of the grid as well as the feeding suppliers of electricity. As power flow is monitored in real time, faults and outages can be immediately detected and resolved. Efficiency of the grid is increased automatically by routing electricity in a more directed manner. This leads to a substantial reduction of losses and augmented grid capacity, allowing the utility to sell increased amounts of energy to customers and yield higher revenues [372, p. 16]. For development and installation of the technology, grid owners pay either on a fixed amount basis or by regularly giving a share of the savings from optimization and automation.

It would also be conceivable to outsource the operation of the grid to specialized companies, opening up the opportunity for more advanced business models on grid optimization and distribution automation.

5.3.2.2 Demand Response

Demand response aims to solve the problem of energy consumption at times of peak demand. Instead of supplying additional energy from cost-intensive peaking plants, utilities offer incentives to consumers to reduce their energy consumption. This practice has been exercised for years in a conventional manner by explicitly requesting a decrease in demand from large-scale users. With the onset of smart metering and communication technologies, all users of electrical energy could participate in demand response [245].

This model targets any consumer of electricity, from private to industrial, who is willing to temporarily reduce power consumption in favor of monetary or other forms of compensation. Moreover, peaking plants have a higher grade of pollution compared to base load plants, adding another incentive aspect for the environmentally aware. Both customers and utilities benefit from demand response. The customers can earn additional income by adjusting their energy demand, while the utility does not have to resort to peaking plants which are expensive in construction and operation, not in use for most of the time and putting weight on the companies CO_2 balance [238, p. 135f].

ICT and personnel is needed for customer management and monitoring of power demand and supply. Customers have to be contracted and rules

[6]http://www.abb.com/

must be defined covering when to reduce demand at which degree of incentive. During operation, real-time registration and analysis of each customer's smart meter data, including which smart devices are running and could be preferably switched off, has to be performed to allow appropriate control in situations of peak demand [226, p. 187f].

While the needed infrastructure seems to favour utilities as executors, at the moment the smart metering version of demand response is primarily performed by third party companies like Comverge and EnerNoc. They aggregate the load potential of customers and offer peak power reductions to utilities [372, p. 23].

5.3.3 User Side Demand Management

Determining how to properly balance the cost of energy and the pricing for the final customer by using various measures in proper combination is called Demand-Side Management (DSM). Hereby, smart meters play a pivotal role behind the new business models. They bring significant cost reductions and added value for both providers and customers. Furthermore, they allow the introduction of new pricing models and premium added value services as well as applications [241, p. 143].

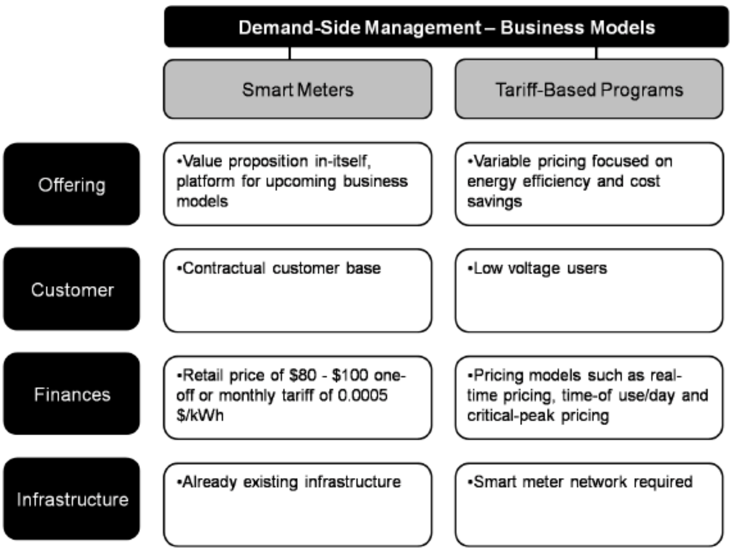


Figure 5.6: Demand-Side Management - Business Models

5.3.3.1 Smart Meters

Smart meters enable the creation of new business models either by reducing the costs of electric utilities or increasing their revenue through new pricing strategies and additional premium services. Electric utilities count already with the needed infrastructure to deploy a full coverage of smart meters. Likewise, their contractual customer base allows economies of scale for the acquisition and production of such devices. Furthermore, smart meters are a value proposition in itself enabling the possibility of differentiation among a commoditized electricity market [239, 237].

The path to profit is therefore clear: Smart metering can enable customers to realize greater value from the investment in the electric system and provide ways to reduce bills. Smart metering operational savings are measurable reductions in the cost of providing customers with electric service [239, 242]. These savings include the reduced labor and transportation expenses associated with the conventional practice of on-premise metering reading. Another source of operational savings are reduced levels of the equipment and materials required to operate and maintain the electric system and an extended lifetime cycle. Furthermore, the institution argues that all of these operational savings reduce the net cost of the utility to deploy smart metering. Galvin and Yeager [226, p. 187] argue that increasing the price of the kilowatt hour by $0.0005 would be sufficient to cover the cost of equipping every household in the United States with a smart meter. Other sources of financing could be selling the device itself at a retail price of $80-100 according to a study[7].

5.3.3.2 Tariff-based programs

As previously mentioned smart meters allow for a series of business models previously unknown in the industry, one of them are tariff-based programs. Most low voltage users (target customers) pay the same flat price for each unit of electricity they use during the year. These users have no incentive to use less electricity at times of the day when production costs are high and have little incentive to reduce their overall consumption according to the Irish Commission for Energy Regulation [232]. Thus the current metering arrangements and therefore structure of electricity prices do not provide customers with an incentive to better manage their use of electricity and do not allow for a differentiation among electricity providers. A tariff-based program would serve therefore as an ideal value proposition and provide greater efficiency, system security and market benefits among others. Once the network of smart meter devices is deployed electricity utilities have the needed infrastructure to implement the business model. The Irish Commission for Energy Regulation [232, 223] proposes three different pricing models as potential revenue streams:

[7] http://www.iom.bwl.uni-muenchen.de/aktuelles/allgemeines/neuigkeiten/smart_meter_studie.html

- **Time-of use/day**: Tariffs reflect daily and seasonal variations based on estimated costs. These tariffs reflect expected costs during peak and off-peak periods of the day. Customers are hence informed of the different time periods and prices on their bills and on their meter display.
- **Real-time pricing**: Customers pay in each half hour the actual cost of electricity. The half hour price is known when customers use electricity. They are alerted of these prices through the meter display. This form of pricing is already in use in Norway.
- **Critical-peak pricing**: A business model already in use in France, where the customers pay a time of day price most of the time and a high critical peak price at times when it is important to reduce demand.

5.3.4 Complementary Services

On top of the business models based on smart technology a multitude of complementary services can be offered.

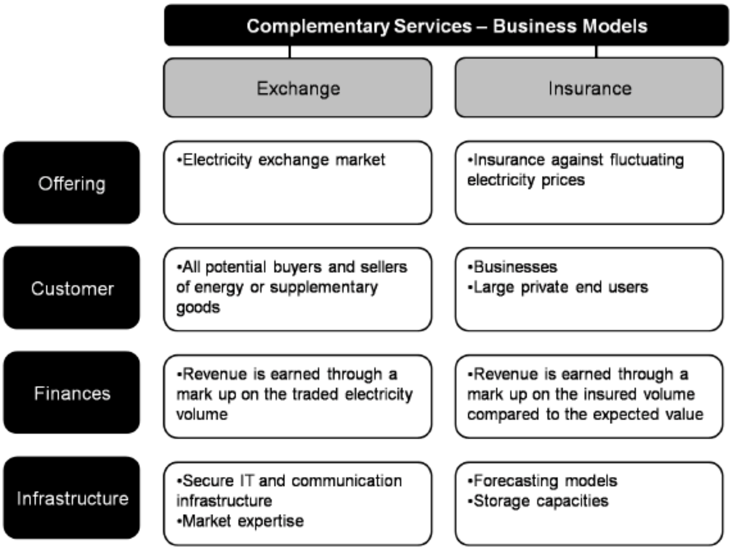


Figure 5.7: Complementary Services - Business Models

5.3.4.1 Exchange

The importance of markets will increase in the future, requiring the formation and operation of new, probably specialized market places in addition to big, central exchanges like the EEX.

Players from the energy sector, but also from conventional exchanges, own the expertise necessary to successfully run an energy exchange [380, p. 23]. In addition, they must supply secure IT and communication infrastructure to allow for smooth real-time trading. Independency of the exchange operators has to be ensured, to guarantee a transparent and reliable transaction process.

The exchange is of interest for all potential buyers and sellers of energy or supplementary goods within the intended reach of the exchange who want to trade in an open market. In the future, this can also involve end users. The traders are given a platform for transparent business and in return pay for the offered service by a percental share of transactions values or a fixed flatrate amount.

5.3.4.2 Insurance

The free trade of energy and the rising influence of renewables might lead to fluctuations in energy prices. This could develop into a disadvantage for users relying on large amounts of energy at a fixed time. From this perspective, energy insurances against changing prices are a possible business model [380, p. 23].

With their integration into the energy markets by means of ICT infrastructure and access to various data sources like energy consumption profiles or weather forecast, insurances can build models which predict fluctuating energy prices with high confidence. Additionally, storage capacities to correct wrong predictions could be employed. The prediction model is used to offer consumers a certain amount of energy for a guaranteed price at a certain point of time. Customers can range from large industrial to larger home users.

The insurance generates revenue by either charging the difference compared to the actual price at delivery time, gets a share of this difference or charges a fixed fee in advance.

5.4 Conclusion

The energy sector will experience a drastic change in its current revenue sources and business models. The market is shifting from a one-product market to a market with a focus on differentiation. Moreover, customers will change from being passive users to being prosumers. The energy sector will melt with the ICT Industry around the core product (electricity). The traditional business models will remain; however, new business models will arise targeting the following areas: transparency, convenience, cost reduction and environmental friendliness.

The upcoming business models seek to provide new revenue streams by bringing for example more transparency in the billing process for end-users through offering services such as Internet-based real-time consumption reports. Moreover, both customers and utilities have greater incentives to reduce their costs by optimizing their appliances and infrastructure using peak load management devices and smart meters. Likewise, they make life more convenient for users with services around the smart home such as remote control and surveillance of appliances. Finally, they promote environmental friendliness by enabling profitable distributed generation and storage with a focus on the integration of renewable energies.

Consequently, it is possible to conclude that the business models of the incumbent players will shift from simple electricity suppliers to information service providers. These changes will have strong impact on both consumers and utilities.

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Part II

Scenarios and Business Ideas

Chapter 6

6 Smart Private Home

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Smart Homes are a major part of the E-Energy concept as they connect users to their home environment, enable distributed generation and can lower energy consumption. Future home technology is characterized by intelligent devices which provide comfort, safety, entertainment and energy efficiency.

The goal of this scenario report is to come up with an E-Energy product idea for Smart Homes in 2025. In order to know about future conditions, a scenario planning methodology is executed. This methodology is based on a driver analysis, to get an overview of how certain factors could influence future developments.

Based on this driver analysis, three different scenarios can be distinguished. The first scenario, called **Ubiquitous Unity**, is based on the assumptions of extensive international efforts, technology affine customers and the introduction of user friendly smart appliances. This leads to the full interconnection of devices enabling an independently acting high-tech home. The scenario of **Missing Market** portrays a restraint environment with no governmental efforts and customers preoccupied with more urgent problems. Smart appliances stay underdeveloped and do not achieve mainstream status. Therefore these homes do not differentiate greatly from current standards. Finally, the **Isolated Islands** scenario emerges from national governmental efforts, environmental aware customers and affordable smart appliances that have improved in usability and energy efficiency. Smartness in homes is wide-spread. However, missing standards lead to communication problems between devices of different brands.

The first scenario is based on almost optimal conditions for a fast spread and development of Smart Home products, while the second scenario deals with very low customer acceptance. Therefore, the third scenario of **Isolated Islands** is the most likely one to occur. Thus, the product idea, E-EnergyOS, is based on this scenario.

The E-EnergyOS is a cloud computing operating system which connects the island solutions of different manufacturers, in order to realize overall energy management. Furthermore, a service platform is included which can enhance the system through various add-ons developed in-house or by third-party developers. The system seeks to bridge the gap and achieve interconnectivity between home appliances in heterogenic Smart Homes.

6.1 Introduction

The idea of a Smart Home revolves around intelligent technology which supports users and is imbedded within various home devices that can communicate with each other. This includes easy to use systems fulfilling customer needs for comfort, safety, health and energy efficiency [262, p. 8]. A variety of sensors and smart appliances can detect the needs of inhabitants in order to support them in their daily life and to make them feel comfortable [267, p. 10]. However, it is more than just a composition of separated smart devices. A high degree of interconnectivity provides synergies and increases the functionality of connected appliances, creating a whole smart living environment as illustrated in figure 6.1. Simply said, homes are made smart through interactive technologies.

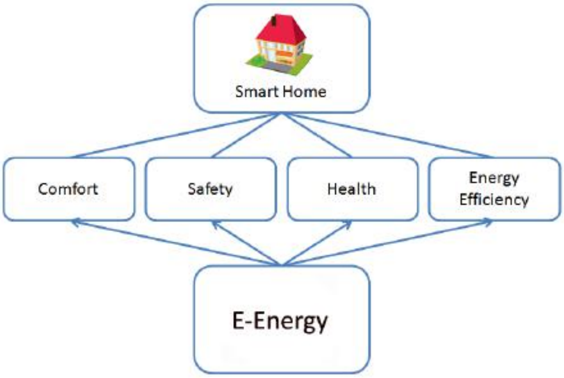

Figure 6.1: Basic Smart Home Model

As all of these technologies are in the need of energy, Smart Homes form an important part of the E-Energy approach. In such a smart house with a high degree of connectivity, E-Energy could create synergies in order to optimize energy consumption. Intelligent energy management systems could adjust energy usage to reduce overall consumption and to increase efficiency. Furthermore, Smart Home technologies are necessary to realize methods like demand-response energy consumption.

Although Smart Home technology has been developing since the 1980s, it has not been implemented on a large scale as prices are too high, implementation difficulties exist and handling is still complex [262, p. 8]. However, this could change in the future because of the vast introduction of information and communication technology (ICT) into houses and appliances, increasing usability and cost-efficiency.

In order to come up with a product idea for Smart Homes in 2025, this scenario report will first give an overview of the developments and implications of ten drivers expected to push or impede the development of Smart Homes in the future. Afterwards, according to the possible outcomes of the drivers, three different scenarios of Smart Homes in 2025 will be described. Finally, based on the third and most expected scenario, the product idea of the E-EnergyOS, will be introduced and described in detail.

6.2 Driver Analyses

In this section, ten drivers are analyzed which will influence Smart Homes in the future. Their development will have significant impact on technical progress, customer acceptance and introduction of Smart Home products and therefore be the basis for the three scenarios described later in this report. The drivers are divided into certain and uncertain drivers according to the reliability of their future development shown in figure 6.2.

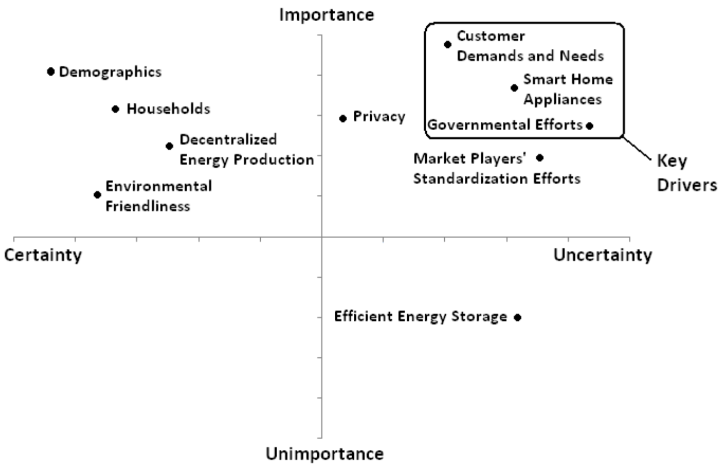

Figure 6.2: Importance and Certainty of analyzed Drivers

6.2.1 Certain Drivers

Drivers are certain if their future development is sure. Thereby, their implications on the development and introduction of Smart Home technology are foreseeable and have to be considered in all three scenarios.

6.2.1.1 Demographics

Germany's population is aging. This trend has not only one but three dimensions. First, the sector of people above 65 years of age will increase from 20% of all people to almost 30% in 2025. Second, the ratio between older to younger people will grow. Third, the number of very old people will rise as the share of people above 80 years is the fastest growing share of population [262, p. 14-15] [260, p. 9]. Getting older is for most people affiliated with physical, mental and social constraints [260, p. 12]. Decreasing sensorial and motor abilities make independent living difficult. Therefore, the demographic changes will strongly influence the development of Smart Homes [262, p. 14-15].

The integration of ambient assisted living as a part of Smart Home technology could assist elderly people living in their homes. Thereby, safety and independency could be increased so that people could live longer in their own homes. Such ambient assisted living systems have to be easy to use and adapted to the needs of elderly people [262, p. 17-19]. Moreover, scarce care resources make it necessary to shift care and medical services from stationary institutions towards the homes of elderly people. Thus, services could be optimized and a share of people can live longer in their own homes. For complex medical services, especially via telemetry, a reliable technical infrastructure within the homes would be necessary [262, p. 15-17].

Altogether, innovative solutions to supply the growing number of elderly people are necessary. Matured Smart Home technology could help to satisfy the needs and to keep the independency of elderly people in the future.

6.2.1.2 Households

Regarding households, two aspects have an impact on the success of Smart Homes in the future: Household composition and household wealth. For both aspects clear trends are determined making this driver certain.

The benefits households could gain are dependent on the people within a household. Therefore, the uptake of Smart Home technology depends on the size and type of household, including the division of labor, family set-ups and stage in the family lifecycle. Due to the described demographic development, households consisting of elderly people will increase. The group of older people has a higher household-to-population ratio than any other age group creating a need for individual solutions, in order to assist them in their daily life [250, p. 12]. This need could be satisfied through Smart Home technology. Apart from households in which both partners are working and highly mobile single-person households especially households with elderly or disabled people could benefit most from an adoption of Smart Home technologies [268, p. 32].

A study of McKinsey indicates that this development of household composition will result in decreasing household wealth accumulation and savings, with a negative impact on living standards and long term investments [250, p. 12-

18]. History showed that rich households are the first to adopt new household technologies, because they are more likely to substitute labor cost, like time spent on chores, for capital costs like Smart Home appliances. However, over time, as technology usually becomes more affordable it eventually spreads to poorer households, too [268, p. 66-69]. So in summary, the decreasing wealth of households could slow down the broad introduction of Smart Home technology in the future.

6.2.1.3 Environmental Awareness

Smart Homes can provide several environmental benefits. For instance, intelligent control systems could switch electrical devices off when they are not needed. The energy consumption of heating systems could also be optimized this way [262, p. 20-21]. Smart meter systems will offer transparency of power usage to the customer and thus create incentives to reduce usage. Furthermore, Smart Homes which could handle demand-response could foster intelligent load management. Thereby, the shape of the daily load curve could be formed in order to avoid and expensive load peaks and to adapt to fluctuating feed in fees of renewable energies. All those measures would also lead to a reduction of consumer energy costs. [262, p. 10-14]

Environmental issues, for example power consumption or energy efficiency, have become a hygiene factor of home appliances. This means, that energy efficiency or environmental friendly production are no major reasons for buying a certain device but expected features [265, p. 37-38]. Therefore, the image of Smart Homes will benefit a lot from the rising environmental awareness of customers due to their environmental advantages.

6.2.1.4 Decentralized Energy Production

In Germany, there is a trend towards renewable energies. Research, development and operation of photovoltaics, thermal solar collectors and wind energy plants are fostered by the state [258]. Due to rising efficiency, competitiveness of those technologies is increasing. In the future, small combined heat and power systems are also likely to spread [262, p. 20]. An increasing number of consumers will therefore become prosumers in the future which means that they will produce energy on their own, through the installation of decentral power generation appliances.

Decentralized energy generation systems provide a certain degree of self-sufficiency to equipped houses. However, Smart Home technologies can offer additional benefits. Efficiency can be increased in general by adopting consumption to production of energy. If the Smart Home gathers statistical data about the production and consumption of energy across the day possible synergies could even be increased, by an accurate adjustment of energy consumption. In the future it could also be possible, that the Smart Home automatically decides if it should consume, store or feed in produced electrical energy according to the actual consumption, energy price or grid workload, in order to achieve higher benefits.

All in all, the exact future development of decentralized energy production, like used techniques or efficiency, is dependent on policy and technical progress. But a trend towards decentral energy production in general is certifiable making it a certain driver.

6.2.2 Uncertain Drivers

Drivers that have an impact on aspects like technology, spread or customer acceptance of Smart Homes depending on their future direction of development are uncertain. Therefore, possible outcomes are separated into different projections for each driver. Within uncertain drivers, governmental efforts, customer demands and needs and Smart Home appliances are the three key drivers as they have major influence on the future development of Smart Homes.

6.2.2.1 Efficient Energy Storage

Through storage technology, electrical energy can be stored locally for later retrieval. Today, storage, especially for large amounts of energy, is quite expensive and difficult due to lacking efficiency. Therefore, efforts are made to increase the efficiency and cost-performance ratio of storage applications. In addition to that, Smart Storage is a topic for Research and Development (R&D) as it could help to smooth the load curve [263, p. 48-69]. Future Smart Homes do not rely heavily on storage technology. However, the development of matured storage technology is an important issue regarding E-Energy. Thereby, interesting synergies between Smart Homes and the E-Energy concept could be created which will be described in the first of two projections below.

In projection one, storage technology could develop quickly and spread, resulting in cost-efficient mass-products. This would especially foster the development of plug-in hybrid electrical vehicles (PHEV) or plug-in battery electric vehicles (PBEV) which could create synergies together with Smart Homes as they could provide the required infrastructure to charge and discharge the car batteries according to the load curve. In the same context, houses could also be equipped with stationary storages in order to increase the cost-efficiency of self produced energy from renewable sources or small combined heat and power. Within both possibilities, energy could be stored to be fed in during peak load times. Providers offering flexible energy tariffs will reward this approach because it helps them to flatten the load curve. In addition, those storage devices would also increase self-sufficiency [271, p. 7-8]. Finally, matured storage technology could facilitate the development of autonomous household appliances that can operate without steady power supply.

Within the other projection, technical development of storage devices would not increase as fast due to technical difficulties and high development costs. So storage would still be pricy and not very efficient in the future. Self-produced energy would have to be used or fed in instantly. Thereby, customers could not increase the cost-efficiency of their energy generation appliances as they could not help providers to smooth the load curve.

6.2.2.2 Market Players' Standardization Efforts

The cooperation of market players regarding standardization will influence the future development of Smart Home technology. Since the beginning of Smart Home development, an environment of many different market players has been established including manufacturers of white goods, consumer electronics, information technology as well as telecommunication providers and media providers [272, p. 8]. In the future, the increasing digitalization and integration of Internet services will lead to a convergence of former independent markets [272, p. 10-11]. Especially the broad introduction of ICT to Smart Home appliances offers various possibilities for service providers and ICT companies to enter the market [268, p. 250-253]. For the success of this technology it will be of major importance for those providers to agree on common communication standards for their products and services [272, p. 29-33]. According to manufacturers' efforts to introduce a common standard, two projections can be distinguished.

In the first one, suppliers would cooperate in order to create a common standard for Smart Home technology. This would lead to positive net effects as compatibility would be enforced. Furthermore customers would accept and adopt early Smart Home technologies because they would not have to fear settling for a decaying standard as for example in the HD DVD versus Blue-Ray competition. In summary, the introduction of a common standard would increase interoperability, the market volume, credibility and the probability of success of Smart Home products [272, p. 29-33].

On the other hand, suppliers could fail to introduce a common standard due to company policy and in order to maximize their own benefits. Due to the heterogeneity of devices, probably no company has the power and the expertise to enforce its own standard. Therefore, various proprietary standards of different companies or consortia would emerge. Competitions for a predominant standard are in most cases hard, long and expensive, leading to a high financial risk for involved companies. Moreover this would lead to slow customer adoption of Smart Home technology, as they would be afraid of settling for a standard that could not prevail [272, p. 31-32].

6.2.2.3 Privacy

Smart Home technology will rely heavily on data exchange via ICT. Information sharing will increase even without a large adoption of Smart Home technologies due to the mandatory introduction of smart meters defined in the German Energiewirtschaftsgesetz [266, p. 38-39]. Therefore, it may be possible that companies such as power suppliers and Internet providers or, even worse, hackers could gather private information about customers. Private information and data security, is a very sensitive and popular topic, as in the past years data scandals such as those of Telekom, Deutsche Bahn or Lidl attracted considerable attention. Both politicians and the public were outraged over the behavior of the related companies [264]. As customers expect data security as a natural feature, privacy is a hygiene factor for the introduction of Smart Home technology. Depending on future political efforts for this topic, two different developments are possible [272, p. 53].

Within the first, policy would quickly establish a transparent legal framework including strong data privacy restrictions, allowing information exchange between providers and customers only within well-defined boundaries, similar to the German Telekommunikationsgesetz. People would have few worries about data security to adopt Smart Home technologies as they would know that there is a comprehensible legal framework to protect their sensitive data from abuse [261, p. 29][266, p. 38-39].

Another development could be that policy failed to establish an overall legal framework about data security within Smart Homes, because technology is developing and changing too fast. Therefore, customers would have mixed feelings because they would know that they would pass their privacy, at least to some degree. So a fast spread of Smart Home technology would be rather unlikely as customers would fear the abuse of their private data [266, p. 38-39].

6.2.2.4 Governmental Efforts

At the moment, the German government fosters renewable energies and energy efficiency. Accordingly, the federal funding for research and development mainly funds projects for renewable energies and energy efficiency [252]. The European Union (EU) also strives for EU-wide harmonization of energy efficiency, especially within end-use devices and applications [254].

Policy also forces energy providers to offer variable power tariffs. This development is accompanied by the mandatory introduction of smart meters [253]. Future regulations for variable tariffs or concepts like demand-response are important drivers for the Smart Home technology market, because sophisticated applications are necessary to fully exploit the benefits of flexible power tariffs.

Eventually, policy tries to educate the customer. Thereby, promotion campaigns, incentives and bonuses, especially for renewable energies, take place [257, p. 15-21].

However, policy as a driver is insecure. While it is certain, that some technologies, e.g. renewable energies, will still be fostered in the future, the degree of engagement is quite uncertain. Efforts concerning Smart Homes are possible but they are not determined yet. In addition to that, policy is influenced in many ways. For instance the economical situation, the composition of governing parties and the interest of the people have a direct impact on the political direction. Therefore, depending on efforts and international cooperation, three possible projections for Smart Homes have to be considered.

The first projection would be continuing international cooperation, including a push towards Smart Home technology as a way to improve energy efficiency in private households. The international aspect in this projection is very important because policy could provide platforms encouraging manufacturers to implement international standards regarding Smart Home technology. Furthermore, R&D funding, incentives or promoting campaigns, fostering Smart Homes, would be more likely if international policy agrees that Smart Homes are an important topic. This would on the one hand accelerate the technical progress of Smart Home products as new providers could enter the market fostered by R&D funding and the possibility to use common standards in order to connect home appliances. On the other hand, customers would become more aware of the possibilities Smart Home products can provide and equip their houses with this technology as they are encouraged by policy.

Another projection could be limited, isolated and mainly national efforts for Smart Home technology. Some governments would recognize the benefits of Smart Homes regarding energy efficiency and consumption. In this projection national R&D funding, incentives or promotion campaigns regarding Smart Home technology are imaginable but the enforcement of a common international standard would be rather unlikely. Thereby, standardization would be a regional issue or left to manufacturers. A common international standard would be rather unlikely and therefore technology would develop regionally different. Furthermore customer adaption would differ from country to country as promotion campaigns and incentives would only take place in few single countries.

Finally, a policy that does not foster Smart Homes at all would be the third projection. Governments would miss the chance to accelerate the development and spread of Smart Homes because they would not recognize their benefits. Therefore, standardization efforts are not that likely, as companies would hesitate to push that issue themselves. Customer awareness would stay on a low level, too as there would be no governmental support or promotion about the benefits of Smart Homes.

6.2.2.5 Customer Demands and Needs

People have many wishes what their future Smart Homes should offer. Regarding the infrastructure, they want autonomous lighting, heating, air conditioning, ventilation and gardening systems in order to improve comfort. Smart white goods which assist their owners in doing their housework are also of high interest.

Customers want to use their different entertainment devices to fully enjoy their media, for example MP3s or photos on TV. They are interested in the Internet and new technologies like video telephony or downloading movies for the TV. Furthermore, there is an increasing number of customers who want to consume actively the different types of media like TV, Internet, photos or radio. This also includes personalized content as well as participation. Especially in the entertainment sector, user friendliness is very important because of the growing complexity. In addition to that, customers want future Smart Homes to have security systems. Fire, water damages and burglary should be detected. When owners leave their homes, power of certain devices should be switched off and the house should report open doors and windows. Their home should also have a “holiday mode” to prevent burglary [267, p. 12-18].

As most of the mentioned systems already exist, it is quite interesting why Smart Homes have not spread already. Besides cost and implementation, the complexity of technology is a main reason [262, p. 8]. So the ease of use of future Smart Home technology will be of high importance for customer acceptance. To create real value added, the handling of Smart Home technology has to be easy to learn. Systems have to be fail-safe and efficient in order to offer real added value to the customer [272, p. 11-12].

The driver of customer conception is a crucial one, because in the end it is the customer who decides whether he equips his home with Smart Home appliances or not. As it is not sure if manufacturers will meet customer’s conceptions, two projections can be distinguished.

In the first one, customers would accept future Smart Home products because manufacturers would fulfill their wants and needs. Therefore, Smart Home appliances would create on the one hand a clear value added while on the other hand they are easy to implement and to use. The rising customer acceptance would significantly foster the spread of Smart Home technology as many customers would like to equip their houses with it.

By contrast, in the second projection customer acceptance for Smart Home products would be on a low level, similar to today, because manufacturers would not manage to create significant advantages through Smart Home products. They would be just too difficult to use and not really meet customers’ conception. Therefore, only few customers would buy Smart Home appliances which would encounter a fast development of Smart Homes.

6.2.2.6 Smart Home Appliances

Appliances that are able to work independently or that react autonomously to the environment are referred to as Smart Home appliances. They are in need of ICT, using sensors to analyze their environment or to use information provided by a person. As Smart Home appliances are the most important feature of Smart Homes, their development and spread will shape its future.

In the next years, developments in the fields of housekeeping, home entertainment, home security, home energy management, home communication and home healthcare could make living more comfortable and safe through Smart Home technology. Thereby, ICT will merge more and more with common appliances. This could improve functionality and could add new features to usual appliances and furniture [267, p. 6, 19]. Nevertheless, to be successful, Smart Home appliances have to fulfill customers' conceptions and have to be affordable. However, most manufacturers still pursue the "technology push" instead of paying attention to the needs and wants of customers [268, p. 22, 23, 29].

According to that, the two dimensions of customer benefit and price create four different projections for the scenarios as shown in figure 6.3.

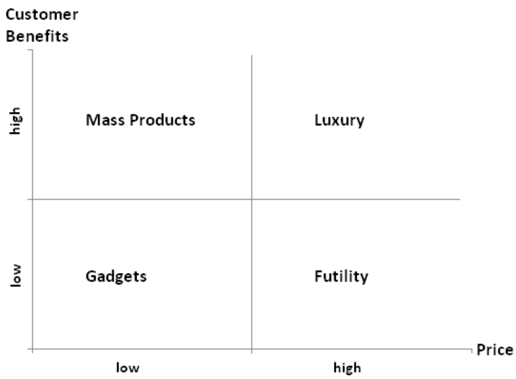

Figure 6.3: Projections of Smart Home Appliances

The projection of cheap Smart Home mass products with big added value to the customer could lead to a fast spread because customers could fulfill their wants and needs by equipping their homes with affordable Smart Home appliances. Moreover, network synergies could be achieved and Smart Home technology could develop further as there would be a big market demand.

Smart Home appliances that are expensive but offer great benefits to the customer would rather stay luxury goods instead of spreading fast. Nonetheless, wealthy households could adopt their houses due to the additional comforts Smart Home technology would provide. Thereby, manufacturers could probably try to expand their market by advertising or eventually lowering their prices.

Within the third projection, the cheap Smart Home technology with little benefits could not get real interest of house owners. Techies could introduce some Smart Home gadgets but the big mass would not consider spending money for equipping their homes with technology that does not offer any advantages. Manufacturers could finally recognize the need to pay more attention to customers' conceptions. However, a fast and big spread of Smart Home projects would be rather unlikely within this projection.

Finally, the last projection of pricy Smart Home products which offer no real added value would probably lead to almost absolute customer neglect. Development of Smart Home technology could stagnate as it would seem impossible to fulfill customers' wants and needs in a price efficient way.

6.3 Scenarios

The three main drivers which have been identified lay out the general framework for the most likely future scenarios for Smart Home living to occur. Namely, Governmental Efforts, Customer Demands and Needs, and Smart Home Appliances, strongly shape the scenarios **Ubiquitous Unity**, **Missing Market**, and **Isolated Islands**. In addition, the seven beforehand illustrated drivers further influence the scenarios but have a lower impact. An overview of the characteristics which are described in the following three scenarios in detail is provided by illustration 6.4.

	1: Ubiquitous Unity	2: Missing Market	3: Isolated Islands
Governmental Efforts	Early standardization; International governmental cooperation	No standardization; Market left to run freely	Consortia; → Many different standards
Customer Demands and Needs	High acceptance throughout public; Focus on entertainment, health care & security	Low acceptance & disinterest; Doubts regarding data security; Focus on feature improvements	High acceptance; Focus on health care, house security & energy management
Smart Home Appliances	Mass Products; Ubiquitous computing & smart devices; Automated household: self-monitoring & self-repair	Single (smart) devices, not connected; Marginal enhancements only	Many islands of smart devices; Connections between islands & devices partly possible
Equipment	Smart sensors, smart effectors; Invisible to user	Improved standard devices	Gateways, sensors; Visible to user
Communication with Smart Home	Holograms, no interface needed; Verbal Commands or movement recognition; "invisible communication" with one integrated system	Manual inputs and programming of single devices	Communication possible, but manual inputs via interface necessary; Verbal commands; Visible interaction with device system
Communication between Devises	Smooth and standardized communication	Rare communication	Difficulty of communication protocols of different manufacturers/consortia
Home Automation	Home acts itself, needless of user's input; Full personalization; Home "knows owner" and reacts	No smart home, independent devices	Home creates smart people and needs their input to act; Owner tells home what to do
Development beyond 2025	Consumers highly dependent; New issues in data privacy; More human-like robotics	Real smart homes as luxury; Improved devices for everyone	Necessary standardization to come; Less consortia

Figure 6.4: General Scenario Overview

6.3.1 Scenario 1: Ubiquitous Unity

What had often been considered a dream or science fiction has in 2025 become reality thanks to fast and innovative technological development and strong governmental efforts. Intended primarily to make living at home more convenient, comfortable and safe, homes have been converted into independently thinking, smart automated homes with smart appliances and smart sensors.

Consequently, manual inputs have become redundant as ubiquitous computing allows home devices to communicate with each other, hidden from the view of the user which has led to high customer acceptance (figure 6.5).

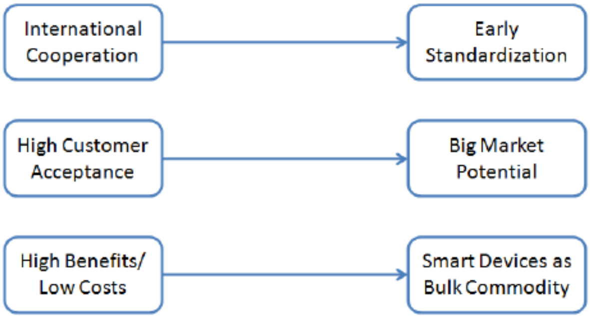

Figure 6.5: Key Driver Projections and Implications for the Ubiquitous Unity Scenario

6.3.1.1 Early Standardization Enables Success of Smart Homes

Due to the energy efficiency potential of Smart Homes, they have become of high interest to the European Union and thereby promoted substantial international efforts. Incentives, special regulations and investments had been promoted very soon to increase the use of Smart Home applications as well as set forth the standardization of hardware and software regarding Smart Homes. Global standardization has been accepted by all big market players and thereby increased the confidence of users in the technology from a very early point on.

A Smart Home budget had been implemented by the German government to support universities in research on the field of energy efficient and safe Smart Home applications. Additional efforts had been set by heterogeneous national legislation to promote R&D within companies and other research institutes. Likewise, the German government had implemented incentives to help introduce the devices to the public, helping even those with lower income attain a minimum standard Smart Home to give them the same home security and health care support. These incentives are mainly financial in terms of subsidizing to a certain extend the costs of the products, as well as reducing the sales tax and allowing tax deduction on any products considered Smart Home energy efficient standard applications. Loans given at special discounted rates for the upgrade and new construction of Smart Homes have been issued by banks. The previous financial incentives to equip houses with energy production appliances such as solar and wind mills have been implemented widely within Germany. The consequent increase in home energy production has turned consumers into prosumers who produce a significant part of the energy they need themselves.

Considering the aging society and the German government's limited personnel resources to support them, the need for automation and security of homes has been emphasized. To make Smart Homes more attractive, a comprehensive legal framework has been adopted early to protect users' privacy and data.

As a result of early governmental policies and efforts, production and sales of Smart Home appliances increased highly, as it reaches a broad public and is affordable to many. There is an entire home automation industry ready to supply gadgets that can be integrated. Also, the possibility for various devices to be connected independently of their brand has allowed many new competitors to enter into the market and further reduce prices. The resulting Smart Home hype has turned applications into a bulk commodity, while at the same time promoting the variety of functions and services. Advertising has correspondingly focused on and reached all user groups, ranging from young to old as well as targeting single and multi-person households. The customer has been comprehensively educated of the benefits of Smart Home appliances from an early point on. Therefore the technology is not unfamiliar and users have shown wide acceptance and high interest in the various functions. User's high technology affinity has added to the fast acceptance and spread of Smart Homes, as has the increased wealth of the population.

Apart from standardization, automation and affordability, the wide acceptance has been led by the products functionality and user-friendliness, as Smart Home appliances can be used intuitively without prior knowledge or training. Special characteristics include simple learnability, high error robustness and self repair as for instance on damages within the house. This is very important regarding the scope of the technology, which now serves a wide spectrum of users. Especially with regards to the older population, the fast setting of standards and early confrontation with the technology has persuaded them to try and hence accept the technology. High competition and advanced production technologies have also reduced the prices of sensors and detectors. The implementation and installation is simplified as standardized plug and play modules allow for a full compatibility of devices. These standards also include communication protocols used between other devices and external service operators. Devices and applications can be installed and bought by the user himself, either per Internet order or in a typical building supplies store, as the installation and implementation is simple and mostly conducted by the intelligent home networking system itself. Therefore applications are rather small and specialized to individual functions, but can be combined into a whole integrated system of Smart Home appliances. The user can decide individually how smart his home should be and can always add-on new applications and functions at a later time, without needing a specialized provider.

6.3.1.2 Ubiquitous Homes are Fully Interconnected and Automated

Smart Homes are the normal home of the future. Thanks to a comprehensive framework of subsidies and financial incentives, income plays an inferior role when it comes to whether Smart Home appliances will be used at all. Differential will only be the extend and intensity to which houses will be made smart, as those with more disposable income will naturally spend more on Smart Home appliances and seek for premium products.

The **Ubiquitous Unity** scenario represents the most technologically advanced and independent Smart Home. Using Universal Plug and Play (UPnP) as a protocol, a smooth wireless connection among house-automation devices and applications is possible. For the realization of a smart automated home, the basic equipment installed within the walls and ceilings includes various combined sensors and detectors. Similar to human senses that continuously feed the brain with information to ensure the best decision is made, sensors of Smart Homes will receive many inputs and signals, process them and give commands to a variety of subsystems and devices. Sensors gather information on motion, temperature, brightness, air and gas, and can be expanded with various other sensors or hardware such as pressure sensors added to doorknobs and floors through a plug and play system.

Based on the concept of ubiquitous computing, ICT is fully integrated in connectable household devices and sensors. This is done through integrating countless little connected microprocessors enabling them to collect information of their environment such as where they are, which other devices are nearby and what has happened in the past.

High end products on the market have integrated the different detectors into one application to enhance functionality and guarantee a smooth interaction [270]. The communication protocol sensors use to exchange data is standardized. Thanks to ubiquitous computing, combined sensors are also capable of efficiently processing information and performing variance analysis, whereby gateways with the purpose of controlling mechanisms and processing data have become obsolete. It is therefore possible for smart sensor networks to control end-devices and make automated decisions [278].

Based on individual needs and wants, software applications can further personalize the Smart Home. This information includes for example age, job, weight, existing children and other personal preferences manually inputted. Habits and daily routines, including sleeping hours and meal times, are recorded and analyzed by the Smart Home itself and added to the inhabitants' profile. By this the system is able to identify every person and can react to him individually. The inhabitants' data is stored within a house database that can be accessed only by the sensor network to avoid simple data security breaches.

The communication between the user and the devices is embodied by a smart robotics system (SRS) [277] equipped with a vast memory and connected to the sensor network. SRSs are either in the form of a hologram interface module displayable on room wall or a high end luxury mobile robot capable of moving, which both react to hand gestures, body movements or verbal commands. This allows users to easily control home appliances from anywhere within the house without separate remote controller for each appliance or visual wall displays.

Personification of the SRS and sensor network has occurred over the last years allowing it to detect and interpret human intensions through for example its sensors for facial expressions. Smart Homes have thereby gone a step further than simple home automation and approached an independently acting house devoid of manual input. The house knows its users, offering the highest level of individuality and comfort. ICT interconnection of all home devices has enabled automation, self-monitoring and self-regulation. A central independent control unit is used to guarantee a smooth coordination between devices, software, users and external service providers.

Almost all homes in Germany are considered smart, but still vary in intensity. While not all homes are updated to the level technologically possible yet, many already include very innovative applications, and tendencies show that smart, self-automated homes are finding increased popularity among the public. Robotic Systems are very popular, especially for automation and facilitation of routine duties within the house. Ubiquitous computing allows Smart Homes to recognize the needs of users and make decisions on their behalf [278]. How well equipped and smart these systems are mostly depends on the income and comfort desire of the user.

Housekeeping

Comfort and convenience are important not only in the sense that users are relieved of housework, but generally also their sense of wellbeing is important. Smart Homes can adjust the room temperature according to the preference of the individual owner. For this function to work, the user installs software to combine the temperature sensors within the room with the windows, heating and air-condition system in order for them to communicate with each other. The individual user's preference is also transferred via a powerline-technology, where data is communicated over an existing electricity grid, from the centralized data storage unit to the SRS. Comfort and wellbeing are easily enhanced without any assistance from the user.

In upper class households, the demand for movable robots, taking over undesirable consumer tasks, is constantly increasing. A thirsty user for example gives a verbal standardized command to the robot to bring a glass of milk. Due to the robots constant knowledge of the fridges inventory, it can immediately state whether the requested product is available. Robots use onboard sensors, cameras and laser scanners to gather information of their surrounding and continually adapt to it [251].

Home Entertainment

Entertainment systems are connected with the Internet and have access directly to the centralized data storage unit allowing for the personalization of contents based on the user. Smart bed pressure sensors communicate to the TV who is lying in bed to adjust the TV accordingly to preferences and viewing habits. The multifunctional robotics system acts as the communication device for users giving verbal commands for channel changes, light reduction or similar.

Ordinary sound systems are interconnected with the smart house's motion detectors and sensors. When a user is walking through the house, the speakers will only be activated in the room he is currently in and follows him to any other room. Verbal commands given through voice recognition for example to change the channel or lower the volume can be given anywhere and are transferred directly to the sound system which then fulfills the order. Other home entertainment features such as television can be connected to a hologram system. This enables various users to be entertained within the house wherever they wish, as TV images can be projected onto any wall, without disturbing anyone. This is further enhanced by directional loudspeakers which pin-point a beam of sound in only the direction of the user, so that more than one user can be in the same room, while they may all be watching different shows on TV.

Health Care

By 2025 Smart Homes have been adapted to include medical sensors and devices mandatorily for elderly and invalids to enable them to stay independent within their homes. Past developments have focused on equipping robots with blood pressure meters, blood test and urine tests it takes of the user in regular intervals [259]. The information gained is sent via Internet to an external medical service provider, where it is analyzed and the required medication prescribed.

Furthermore, an automated electrocardiogram measurement device can be installed upon request that takes tests while the user is in his bed without his knowledge and without using body surface electrodes. Also, body weight can be monitored by the toilet. To evaluate these automated health monitoring systems, overnight measurements have been performed to monitor the daily health status of both young and elderly subjects. Many high-end health care systems have been enhanced so that external services are redundant as home-internal mini computers of sensors and detectors are capable of finding abnormalities and risks.

Work at Home

Working at home is not only for self-employed or outworkers, but is possible also for any employee preferring the comfort of his own house. Even employers have recognized the potential of relocating workplaces to Smart Homes. Not only are costs of offices reduced, but employees are more productive if they are in an environment and climate they personally feel most comfortable in.

A home office is made possible with a secured, high power Internet connection to transmit data and connect to other employees. Anywhere within the house laptops can be used, while holograms additionally project data or phone conference partners. Combined with the installed entertainment system, the loudspeakers are used for telephoning and also follow the user.

Security

Besides comfort aspects, homes can be equipped with security applications to enable them to automatically notice damages and abnormalities. Theft and trespassing is reduced and the house inhabitants can feel safer. The Smart Home recognizes its owner based on the interconnection of surveillance camera data, infrared scanners, voice recognition and habitual actions. Information about user's daily living activities 24 hours a day, seven days a week are collected and stored. Over time, this sets a baseline of normal habits so that an alarm triggers if the normal routine is broken. It is programmed to know the user's schedule while at the same time being connected to the car to find out where a person is. By this, the home can tell whether it is the owner or a stranger trying to enter. Door and window control via finger scanner can be added to further increase protection. Also, fire or gas leakages are immediately identified by the house and any dangers communicated to the user while at the same time help is called for. Methane sensors signal if gas leaks out of defect pipelines within the house [270].

Energy Management

The consumer is also a prosumer producing energy, because almost all houses are equipped with very efficient solar panels and small home wind turbines which provide almost all the necessary electricity needed. The home energy production devices are personally installed at low costs to the user, thereby still further promoting their use and installation. Any excess energy is rarely fed into the grid, but rather stored in vast house-internal efficient storages as energy feed-in rates are so low, due to excess supply, that it is not of peculiar interest. Only in very rare cases is energy taken from the grid to overcome shortages in production.

For houses which produce large excess capacities of electricity, limited E-Mobility is realized. With local home docking stations for private households' cars, car-batteries are charged. Since energy feed-in rates are very low, cars are not used extensively for mobile storage. Energy is transferred only in a one-way direction from the house to the car. Cars have passed the stage of being used as storages.

Because of consumer's own production capabilities, energy efficiency in products has become less an interest as there are hardly any costs for energy consumption. As an effect, energy consumption has risen not only due to the high energy consumption of the full interconnection of the Smart Home and its devices, but also due to the indifference of users to save energy. Former technological approaches that automatically switched home appliances on or off have thereby lost relevance and are not found in Smart Homes anymore.

Integration into the Environment
In general, standard-setting and the Plug and Play (PnP) concept allow for a rapid implementation of Smart Home technologies. Implementation of sensors and smart technologies in new buildings is quite standardized and easy. But the apprenticeship of pattern recognition of systems and of users to the system at first time takes time. Afterwards an extension of the house with PnP devices is very rapid and easy. In addition, connection to the public energy-grid and metering is done easily due to the standards laid out before. The excessive bandwidth available within broadband connection infrastructure further facilitates remote access to the Smart Home.

Weak Signals
There is a noticeable trend for standardization efforts either through governmental efforts and collective agreements between firms. Therefore it is very likely that a rapid technological development and in consequence an acceptance of Smart Homes takes place. Additionally, widely communicated road maps laying out the next steps to develop Smart Homes, increase the probability of occurrence of this scenario. The same applies to indications that ICT firms are beginning to cooperate with established producers of Smart Home appliances. The more consumer advocates are satisfied with the implemented data protection regulations, thereby also signaling their approval to consumers, the sooner Smart Home appliances capable of communicating with each other are becoming a bulk commodity.

6.3.2 Scenario 2: Missing Market

Within this scenario a general framework for Smart Home implementation is nonexistent. Despite provider-driven advances in smart technology, governmental efforts were too low and consumers were not interested in smart technology as the benefits of a coordinated interconnected Smart Home did not provide sufficient additional advantages to those of advanced single devices (figure 6.6).

6.3.2.1 Missing Customer Acceptance Hinders Smart Home Success

Due to a longer prevailing difficult period within the political and economical environment in Germany, policy focused more on accelerating economic performance, not only in Germany but also within other EU-member states. Initiatives focused on solving unemployment and supporting existent industries, as well as creating a long-term basis for economic growth and prosperity, which was achieved by further investments in education. Because politics didn‘t manage to steer in one common direction in terms of concerted actions, efforts took place on a national level rather than on international or EU level. Nature of

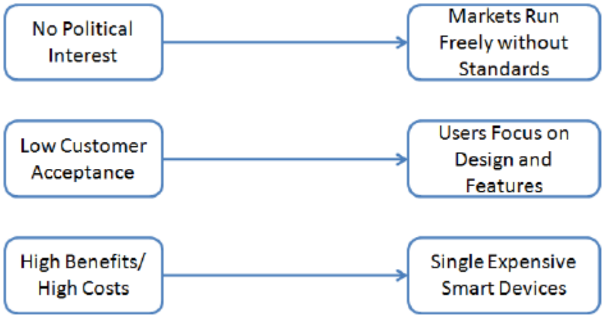

Figure 6.6: Key Driver Projections and Implications for the Missing Market Scenario

election turnus and constant pressure for ruling the parties made it difficult to foster Smart Homes as prioritized directive. In consequence, almost no efforts were taken by the German government to incentivize R&D of Smart Home technology. Hence, also no efforts were taken to standardize devices, as a roll-out on a large-scale basis was not in sight, which made the providers of smart applications niche providers. Missing standards and problems with implementation, e.g. missing energy storage technology, were further reasons for a delayed roll-out of a Smart Grid, making roll-out still a work-in-progress.

In general it can be observed, that environmental friendly energy production, e.g. fostering solar or wind energies has higher public awareness, leading political parties to focus on the production of energy. Thus, on the consumption side there was also no drive for manufacturers to establish common standards for Smart Home communication as Smart Home solutions were most-likely tailor-made for specific usage. Green policy stayed an argument for social acceptance of political programs but did not become a core element within economy; hence the industry was not promoted.

Within Smart Home appliances, no real coordination of players took place. More specifically, market players could not manage to agree on common communication standards. Hence, no coordination for standard setting took place. Standards and smart device solutions only existed within different single product categories but not for the interconnection of devices from different manufacturers. While the large consumer electronics and digital home equipment manufacturers as well as the scientific community took strong R&D efforts in order to develop real interconnected and coordinated smartness among several devices, these advances were not transferred to consumers' households at large numbers. Therefore, the benefits to consumers with smart appliances stayed limited due to missing connectivity of devices.

Technological innovations concerning smartness and efficiency were most often incremental and a roll-out was very slow as no attention was drawn to these new developments. In consequence, complex autonomous appliances are rare and remain relatively expensive. Households equipped with simple smart devices as technological developments are not revolutionary advanced. More importantly, it can be observed that different devices are aggregated and boundaries among devices vanish. As before, for instance a television can have Internet access, hence be used in sense of a PC terminal.

For those users innovative enough to equip their homes with smart technology, data scandals and digital technology abuses raised further trust and reliability issues, hence were detrimental to market penetration and roll-out of the Smart Home concept. Forecasted convenience scenarios remained outstanding research projects, rather than being put into practice, due to skepticism from the broad public and data sharing opposing institutions. Hence, the future smart devices are not available at hardware concept-stores but only with highly specialized providers.

Focusing on energy consumption of smart devices, an increase occurs, as those smart devices, even if not equipped with sensors like for instance in the first scenario, have many functions in standby which consume energy. Smart interfaces, which adapt to the user, for the single devices consume increased amounts of energy, as no coordination among several devices, which would have provided energy saving potential, took place.

As customers were increasingly interested in saving money directly or receiving direct incentive benefits for using energy efficient devices, the smartness of the devices was not commercializable on large scale and stayed an individual product feature. Overarching connected smart device solutions are seen as luxury goods and not affordable for large parts of society. As from governmental side, due to limited funds, no subsidization took place, consumers have no awareness for Smart Home technologies even though the general affinity to use digital devices and ICT-supported applications rose to an elaborate level. As the implementation of a Smart Grid still is not finished and so far no bi-directional information exchange over the grid is possible, the potential of intelligent energy consuming devices is strongly limited. Next, due to the governmental focus on alternative energies, consumer‘s environmental awareness was increasingly focused on getting green energy, rather than getting intelligent green end-user devices. However, consumers use single smart applications. These single smart applications have yielded sufficient benefit, i.e. convenience, and can be implemented independently, so that there is no need for a smart network within the household.

The living standard within Germany today is already at a very sophisticated level. Therefore people have striven only marginally for further convenience. In addition, German consumers have a rather conservative attitude fearing short half-value periods of products and technical obsolescence. Therefore, consumers saw no need for a real Smart Home, because further benefits were not recognizable. Furthermore, consumers faced a very difficult and expensive implementation as the communication technology was not mature yet. In addition, consumers in general, but especially elderly people had a good portion of skepticism towards data-protection as further data scandals might have occurred.

6.3.2.2 Disinterest and High Prices lead to Sporadic Smart Devices

The Smart Homes in 2025 offer only marginal improvements compared to today‘s home environment. Hence, a Smart Home in 2025 cannot be considered a Smart Home to the definition set beforehand. The majority of common houses in Germany look very similar to today‘s homes. The development of home appliances and environment was driven more by design aspects than by revolutionary technical improvements. A Smart Grid is still not fully working in Germany, hence a bi-directional data transfer between homes and grid is not warranted. The convenience- and personalization aspect of homes is represented in design elements and incremental technological improvements. Hence, appliances have improved mainly in efficiency and individual handling. Instead of an ongoing development many innovations didn‘t establish themselves, which can be explained by the average end-consumer not being technologically addicted.

In general, the focus of technologies lies on single appliances. Single appliances have the possibility to customize individually their interface, including the possibility to change their input masks accordingly to the user, e.g. for elderly people or kids, or running programs according to the customer using the device. Improvements, like washing machines which can be programmed to run in the night, save power costs for instance by taking advantage of load-tariffs. Users have remote controls for most appliances, but as there is no standard, every machine has to be operated individually or within a constrained network of appliances. Also speech recognition can be a feature but is limited to the single device and still lacks full reliability of voice recognition.

Most importantly, appliances don’t communicate with each other. Therefore, the synergies of Smart Home technology cannot be exploited, as the technology simply does not exist. The technological advances made within research have not been able to be marketed to end-consumers. Reason for this is also that average available income and high living expenses lead to consumers which weigh strongly the benefits of an appliance which provides marginal advances in convenience, compared to today‘s standard or for instance book a holiday instead.

Housekeeping

As with other scenarios, comfort and convenience are the most important issues of housekeeping. This is represented in new products which are complemented by new functions and design. For instance due to the increase in single-households and new working habits of people, there is a higher number of convenience-appliances for preparation of high-quality fast-food, similar to the coffee-pad development. However, adjustment of homes and housekeeping appliances takes place on the application level, not a network of applications. The user remains an active part and is to enter much data locally on which an appliance relies on. This data in many cases is not personalized but simply fit to standardized user profiles which the appliances are optimized for. Household appliances have more remote-control possibilities but are not fully automatized. Existing technologies like vacuum cleaning robots which automatically clean up floors have become much cheaper and widespread. Extensive and coordinated usage of sensors, evaluation and storage of generated data and use for several appliances does not take place. Some middle-class households have central systems, e.g. home-servers which centrally regulate opening/closing of windows at fixed times, or heat the house following defined timing rules. In consequence, even though smart technologies are available, the benefits obtained by an individual solution will not fully pay the appliance cost as it would with techniques available on large scale.

Home Entertainment

Even though home entertainment systems reached a very sophisticated level of technology and quality, connectivity among several devices and manufacturers remains expensive. As far as interconnected network products exist within the house, there is no automated connection to user-actions or day-situations as implementation proved to be viable but very individual.

Smartness for entertainment devices consists of incremental enhancements which facilitate usage. The convenience increased also by improvements of device design. Standards like MP3 and other formats have increasingly replaced traditional media formats. For instance with a hi-fi system which has direct access via Internet connection to a selectable music-provider, users have the possibility to download directly to the device. Nevertheless, in general home entertainment systems have become cheaper and better value for money is provided, as turnover within entertainment devices is high.

Health Care

The most important factor which influences smart healthcare is the aging population. Elderly care has proven to be problematic, as care and medical services and products are very expensive, hence healthcare for the lower societal layers has become a problem. In consequence, single devices like call-for-help devices or the possibility to transmit information have become cheaper and therefore more widespread, but real smart and automated devices are predominantly found at specialized healthcare centers where elderly people are cared for. These remain expensive and thus exclusive to well-off people. For the latter, home-appliances for single plusser households have features which ease the daily use, e.g. signal adapting or adapted interfaces. Connectivity is highly difficult, as complexity increased which elderly still often don‘t manage to understand.

Work at Home

The tendency towards work at home increased, as more people are enabled to work from their homes. Technologies existing today, e.g. software for remote-access or devices which are constantly synchronized are widespread. Hence, there is a majority of population working from their homes using a bunch of technological devices and an Internet connection. The remaining problem is that the transmission of data over the Internet connection remains a bottleneck as amounts of transferred data have strongly increased, because more and more users require access to wireless data networks.

Security

Data security is highly valued within society. From an appliance perspective, as long as they are not connected to the Internet, there are no issues as the majority of devices does not need to transmit information. With increasing amounts of transferred data, critical incidents within data protection have increased and in turn deterred users from providing data.

Besides data security, the technological advances are also used for a more extensive surveillance of homes, e.g. with webcams more prevalent due to a better interaction of software. Furthermore, integrated home security and alarm systems are more common within households.

Energy Management

Management of energy usage is local and limited to single devices. Overall energy profiles for households exist, but adaption is done manually by switching devices on/off or by implementation of more efficient devices. As the intelligent grid roll-out within Germany did not advance as expected, smart-metering is also not working properly within all areas. Hence energy management is somewhat limited. With cheap night-tariffs a general shift of energy consumption can be done by energy management systems. As such, centralization of energy management is still underway.

Integration into the Environment

The realization of a Smart Home within this scenario consists in implementing the improved single devices into the household while ensuring that devices are not too complex to handle and besides no overload of functions exists, otherwise consumers would not derive benefits from. Integration is mainly done individually by each subject alone. Only real Smart Homes have to be implemented by specialized vendors in order to ensure operational capability.

As Germany has no grid considerable as smart there is no need for integration, i.e. connection to the energy grid and bi-directional information exchange.

Weak Signals

Several signs indicate developments resulting in the above scenario. With the prototyping and testing of technologies in Smart Home testing centers several data privacy issues have come up. These have been collected by consumer data protection organizations. Due to the extensive communication and rising of consumer fears, Smart Home technology was left far behind from what it could perform. Hence, demand potential was reduced even before the advantages could have been communicated to consumers. Despite government investment into energy efficiency measures and R&D development, financial limitations of the public limited the level of awareness and interest. Besides, the ICT industry faced a strong recession with the economic downturn, which was further aggravated with the German "bargain-hunter"-mentality. Therefore, only single outstanding devices found entrance to customers' homes. Therefore, we see a slow but still very constant development within home appliances that is in most cases, e.g. induction stoves, technical developments simply supplemented existing products. Also design aspects, for instance a kitchen in Porsche design at an affordable price are no innovation but provide great convenience and benefits to consumers. This can be expected to represent the further development. Consumers have no need for further automatization within households at large extend, rather are afraid of losing control of how to handle the appliances. Besides, the broad public already keeps a high living standard. Autonomous smart appliances are not self-evident. Therefore, real Smart Homes will stay a luxury good for the very wealthy people. Implementation is done by highly specialized companies, which have the knowledge about adapting appliances to a communication network. In case Germany manages to run a Smart Grid, it can be expected that several devices will be able to communicate.

6.3.3 Scenario 3: Isolated Islands

This scenario focuses on a common Smart Home equipped with independent smart appliances as well as customized isolated appliance systems. The house itself is not considered to be smart though, it merely creates smart people by providing data whenever decisions can be made. Smart Homes are used to teach and inform instead of being fully automated to decide for themselves. Smartness at this point is still very much dependant on the individual user, his financial situation and desires. Although technology has made frequent innovative steps forward, many products are still not installed in the common Smart Home and their inclusion is subject to the relevance given to them by users (figure 6.7).

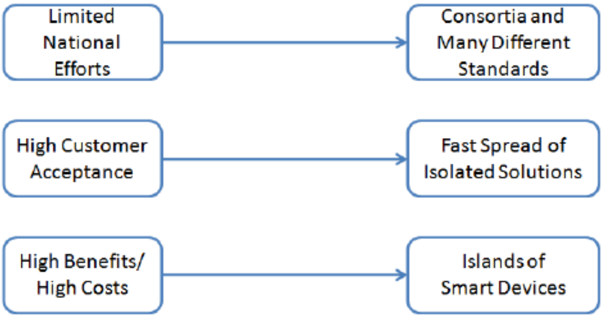

Figure 6.7: Key Driver Projections and Implications for the Isolated Islands Scenario

6.3.3.1 Consortia Create Island Solutions

Due to different crises, partly similar to the financial crisis, EU politicians focused mainly on economic recovery. Therefore, they only proposed a legal framework and single guidelines concerning Smart Homes and energy efficiency. Standards regarding smart appliances, which would allow different appliances and devices to be connected independent of their brands, have not been set. Although the EU tried to incentivize companies to establish an open Internet Protocol (IP) Standard recommended by many experts, two different problems occurred: Either standards could not handle the complex technical and usability issues or they could not get past competitive commercial interests. Each of these consortia uses its own standards and interfaces trying to secure its dominant market position. Hence, new as well as small and specialized companies can hardly enter the market, since on the one hand their devices are not compatible with existing appliances and on the other hand they cannot withstand the cost pressure. Most of their service and product ideas get either bought by the consortia or do not get implemented at all.

Nevertheless, the national government tried to foster the implementation of energy efficient applications to finally lower Germany's overall energy consumption. They also put money into the revision of the grid and the research and development of possibilities to generate renewable energy, as fossil fuels will come to an end and the last nuclear power plants will be shut down in near future – beforehand the operating time of nuclear power plants was extended. This incentivized named companies to rather concentrate on making former existing smart appliances and energy generation applications such as solar panels and wind turbines more efficient, than to spend a lot of money on developing new technologies.

The home appliances available in the market offer quite great benefits to the customer being easy to understand and use. Achieving user-friendliness was a long process, as providers had to deal with: Functionality, ease of use, reliability, adaptability, upgradability and flexibility. For that purpose customers were actively involved in the development process and providers figured out that consumers rather want appliances easy to use and control than pure automation. However, the customers are still limited, since applications and devices of different brands can neither be connected to each other nor be connected to external service operators. Customers either have to buy everything from one provider or they have to abdicate a connected home; that means appliances and devices are not able to communicate with all the other technologies in the house or apartment, but at most with those from companies of the same consortium. Moreover, the focus was lying on making smart appliances suitable for mass production, instead of creating exotic ones and thus, technical developments have only been insignificant, comparing to the home appliances drafted 15 years ago such as programmable washing machines and refrigerators with permanent inventory reports. The products became inexpensive and most people can afford to buy smart appliances. Wealthy people can additionally choose from a variety of add-ons regarding media entertainment, home security, home energy management, etc. At the same time providers also managed to lower the initial investment required from the customer as well as costs to adjust existing, not smart houses. But still implementation and installment depend heavily on the appliance and on the provider. The customers themselves can easily install some products; others require time-consuming installation procedures done by experts. Likewise, there is no single network solution. The consumer is confronted with mixed networks, including both wired and wireless technologies. Prerequisite for almost all smart appliances and services is an extended broadband-infrastructure, expanded by consortia.

Through political efforts and even more through media people were educated on ecology and on topics regarding energy consumption. Moreover, several environmental disasters reminded people of the consequences of climate change and raised their environmental awareness. Therefore customers appreciate energy saving appliances as well as advanced generation applications enabling them to generate power at home efficiently which then can easily be fed into the revised grid. Beforehand, transmission and distribution systems were made capable of transmitting and distributing power bi-directional by a publicly financed project. This is a very important step, as large-scale power storage is still inefficient and thus electricity generation by private households would not be worthwhile, if electricity could not be fed into the grid. Since customers became familiar with the technologies in the market, comfort and convenience applications as well as applications increasing home safety are common. Even though more than one third of the population is older than 65 and elderly people do not want to adapt to a high-tech environment, providers managed to inure them to smart appliances, using mainly user-friendly or old technologies. Moreover, the elderly are even willing to deal with technologies they are not used to, since they enable them to stay at their homes safe and secure. Overall people do not only accept smart appliances, but are strongly used to them.

Before accepting this change in lifestyle, people and customer protection called for strict and transparent laws dealing with privacy and data security. Governments reacted and created a framework trying to satisfy both parties. Laws were passed, governing access authorization and restrictions on data access and affecting not only energy suppliers and Internet providers, but also service providers and companies offering health care – since they can get a thorough health profile of their customers. Still, not all customers were completely satisfied with the results and therefore continue to have doubts.

Finally it is worth mentioning again that due to a growing income gap the purchasing power as well as the disposable income of people varies strongly. Hence, households defer in respect of the appliances used; poor people either have no smart appliances at all or only very basic ones mostly not even connected; whereas wealthy people can afford many different, connected appliances, devices and add-ons. Very rich people can also get a customized, fully connected and centrally controlled high-tech house.

6.3.3.2 Gateway Systems Provide Limited Connectivity

Primary focus of Smart Homes lies in health care especially for elderly, house security in terms of theft and damages, as well as in energy management. Meanwhile, smart entertainment devices and housekeeping facilitations are still considered less important and more a luxury than a necessity.

One of the central aspects which describe the purpose of all smart appliances is that of empowering people, hence improving and equipping people with smartness provided by several smart technologies.

As policies have lacked behind in creating a standard for Smart Home appliances, the resulting consortia have implemented their own standards. While devices and sensors within one consortia can communicate smoothly with each other, the installation of foreign devices is hindered, forcing users to decide early on which manufacturer they will become dependent on. This additionally hinders residential gateways from processing all sensor data correctly and controlling various devises efficiently. To overcome the consortia constraint additional gateways must be installed to understand the varying protocols of the single devices. Still, there is only restricted communication between the different gateways within the house, disabling potential information combinations. Instead, many isolated smart systems and networks are found in homes.

Quite a few sensors have become necessary for Smart Home devices to work, such as motion detectors, temperature and light sensors. The individual single smart networks within the home are easily created and expanded by little slots with which devices are equipped. A box can be connected via the slot and functions as a transmitter connected to the power outlet. Users have access via a windows-interface and can thereby control any appliance even from outside of the house. As gateways have difficulties understanding the different protocols correctly, vital information still gets lost on the way.

The number of different separated networks within the house is reduced to two clusters, one for infotainment and one for control. Within the infotainment cluster devices such as PC, Internet, television, multimedia and mobile devices are covered while the control cluster monitors networks for heating, ventilation, light, solar, window as well as security systems like video surveillance, alarms, biometric access controls. Installation bus systems are used to try to ensure the integration of all devices, but technology is not advanced enough yet for a smooth process. Both are based on the IP-protocol and communicate via UPnP, which allows for docking of new devices and docking to the Smart Grid. The communication between internal and external networks is then handled by the residential gateway. Applications are set for a standardized platform which has yet to be implemented fully.

In order for applications to do what is needed, users have to give them manual inputs or set upper/lower limits. This is done within the home through an interface such as a PC-tablet storing the data in a centralized PC. The transmission technology is based on power line communication (PLC), where data is transfer through the existing power grid. Once the user leaves the house, a smart phone connected to the Internet can communicate with the gateway via an individual web site or through downloaded application software. This enables users to request information on the status of any connected home appliance and control it for example by turning an appliance on or off [276]. This is intended to inform users and give them control over the house from anywhere.

Smart Homes are able to identify abnormalities independently through their sensors, communicate status messages and execute orders. But in order to make this possible, gateways have to be comprehensibly programmed with extensive software systems, as they cannot learn or make decisions on their own. They can only perform previously defined concrete actions. This enhances the importance of external service providers to additionally control connected devises where software or manual input is not sufficient and automation is missing. These service providers are provided with the necessary data sent to them from the gateway directly through an Internet connection. However, as the amount of different protocols and standards still raises many problems, only few providers have managed to offer their service and establish themselves.

Housekeeping

Due to low prices for matured household appliances, autonomous vacuum cleaners and lawn-mowers have found their way into many homes. But even after being programmed by the user, the appliances still need manual decision-inputs from users in order to work, as they are not able to perceive the environment fully as they can only communicate their status to the gateway for the user to see. Energy intensive appliances, like fridges, freezers, washing machines and dryers are programmed through easy to use interfaces such as touch screens. Energy consumption for example is scheduled in order to benefit maximal from the variable power prices across the day. Thereby, the gateway is told when to operate appliances according to the actual energy price quoted by the energy exchange.

Additionally, specialized companies offer efficient room climate systems. By interconnecting the air conditioning, heating and ventilation devices with temperature, air, humidity and CO2 gas sensors, an optimal climate is achieved. Customization is enabled as the demanded temperature and air humidity are entered manually into the centralized PC connected to the gateway. The gateway in turn compares the settings of the user with the data from the sensors and based on this communicates commands to the devices. Individuals, despite all the offered convenience, still have a lot of work and an increased stress level. Optimally, a RFID-driven (Radio Frequency Identification) reminding and scheduling system provides the possibility to, dependent on context or time such as different zones at home, be reminded or receive scheduling messages when entering certain areas. When several subjects enter one zone, for instance the mother receives the reminder to cook or kids are reminded to do their homework.

Entertainment

It is not only possible to buy single entertainment devices but also complete ready to use entertainment systems. In addition to that, these entertainment systems are embedded invisibly into the homes. TVs look like picture frames and speakers are hidden in furniture. Expensive entertainment systems have a multi room audio and video function, which means that audio and video contents can follow the user through the house. Therefore, media systems are equipped with different types of sensors such as motion detectors and acoustical sensors.

As different users have different needs, context-aware media personalization allows personalizing the user's media experience based on his changing context. Unlike traditional personalization systems that are merely based on user preference, a context-aware personalization system takes information ranging from user preference and situation to device/network capability as input for both content and presentation recommendation [269, p. 360].

Healthcare

The demographic changes make it necessary to continuously react to the growing population of elderly people. As nursing staff is limited and people want to live in their own homes as long and safe as possible, healthcare technologies are more comprehensive. The focus of these technologies is not full home automation, which results in lethargy, but instead in assisting in medical issues.

Therefore, one of the most desired functionalities of Smart Homes is ensuring the safety and enabling an independent life at home for elderly and disabled. Smart Homes are equipped with advanced security systems to find out what users are doing, where they are within the house and whether they are in distress. Such devices include cameras in the ceiling and trip sensors in doorways. Motion and medical sensors as well as smart medical devices provide the necessary infrastructure for remote care.

Regarding elderly people, the major domain is Ambient Assisted Living [260]. Monitoring systems continuously measure physiological parameters and then analyses the collected data. Where possible, a noninvasive method is preferred to monitor vital signs without attaching sensors to the body, which is done for example during sleep [269, p. 7]. This enables telemedicine for patient in residence such as remote monitoring of vital data by doctors [269, p. 74].

Of course, healthcare technologies are a delicate topic. Data security is an important issue and devices have to be reliable and secure. But successful examples which demonstrate the benefits of Ambient Assisted Living will resolve doubts as benefits in terms of physical security help outweigh dangers from data fraud. Elderly people will accept the technologies because they favor independency, security and living at home. However, in 2025 only a few companies will exist which have on the one hand the necessary expertise and on the other hand the confidence of the people.

Work

Basis for the increased work at home is the transfer of data over the expanded broadband connections available. Most profiting from smart workplaces at home are the self-employed people as well as freelancers due to the increased communication possibilities, speed, and flexibility provided by the new smart Internet technologies and possibilities.

Employers would prefer relocating workplaces to Smart Homes to reduce costs and productivity. Nevertheless, social interaction still remains one of the most important factors for business, which hinders the acceptance of virtual work places by employees. Handicapped people are enabled to work independently as Smart Home work places adapt to their individual capabilities and needs via intelligent interfaces and stored personal information.

Security

Home security has reached quite a sophisticated level as a majority of households are equipped with devices for protection and surveillance due to affordable prices and user acceptance. Entry to private homes is done either by security cards which contain RFID or similar techniques, or by finger print scanners, hence no traditional keys are needed. This means that the technology is still visible and function depends on active interaction of the respective subject with the smart device. Due to the closed-system character within security, except a connection to a central server or an external security contractor via the gateway system, hardly any data privacy issues arise. Further techniques comprise common GPS-tracking applications, e.g. child surveillance via mobile phone and GPS signals.

A strong integration of service providers into home-security and home systems via contracting services can be observed. This is important as houses have no own regulation but rather can only send automated warnings to react to. Users or service providers for a building have remote access to standard functions e.g. security control mechanisms, important electrical appliances and air-conditioning systems, for instance via their mobile phones based on easy adaptable programs. In addition, within the home, technologies are more and more brought to perfection, e.g. smoke detectors which give alarm only when real fire is present and which are connected all over the house, giving alarm within several security-levels.

Energy Management

Continually increasing environmental concern leads to a progressive sustainable mindset with consumers, enhancing actions to act eco-friendly, and therefore raising the demand of various energy efficient products. But as financial limitations of many potential customers hindered the purchase of technologically advanced energy efficient products, the focus now is also on domestic energy production technologies such as solar and wind.

Intelligent appliances with integrated information and communication technology can measure their actual consumption and transmit the data via power line or wirelessly to the gateway. Still, due to a failed common standardization, gateways encounter many difficulties when connecting data of different protocols.

The gateway also controls the solar panels on the rooftop, depending on whether excessive energy should be stored in small home emergency storages or sold to the market. This is based on a combination with real time pricing and a secure Internet connection, as well as manual inputs of the user stating upper limits for prices and entering certain actions for the gateway to trigger, such as switching devices on and off according to energy prices. The gateway can also be told when energy must be produced and used, produced and sold and when to additional energy should be bought. For this to function, the user must program the gateway extensively beforehand via the PC-tablet storing the data in a centralized PC. This is further hampered as the different brands use different interfaces making it complicated for the user to connect devices and appliances.

Also, local energy production entities such combined heat and power can be added. Cogeneration of energy is very efficient as about 90% of the fuel is exploited while environment is protected. For private homes this is done on a micro level. Condensing boilers, installed in the cellars of homes, contain a stirling-machine heated with gas which creates electricity from the temperature difference of water, which can then be fed into the grid. Hence, consumers have their own micro block heat and power plant covering a major part of the electricity needed. This also provides the benefit of an emergency power unit, e.g. for lighting or the fridge in case of an electricity grid outage [275][278]. In addition, modern heating and climate systems provide not only for comfortable climate but lower energy consumption e.g. by earth-recuperators. Air-diffusion-stacks secure constant air-conditioning, including the filtering of air within the home. Generally the former available technologies for business buildings are now present in private homes.

Energy management also includes the intelligent steering of sensors. At night sensors deliver less data or only within longer periods or are in standby mode [278]. Houses and apartments can basically exchange electricity and data with their environment. Starting with the electricity exchange, two major changes occurred: Besides being supplied with power from the socket-outlet, people can easily feed power into to grid themselves. The new grid is able to handle a bi-directional electricity flow and thus enables distributed generation. Normally many small-scale generators are aggregated in virtual power plants, allowing them to withstand the cost pressure. Moreover, many people use PHEV or PBEV. The vehicle-to-grid system uses the vehicles' excess rechargeable battery capacity to supply electricity to the grid during peak load times. PHEVs and PBEVs can then be recharged in off-peak hours at cheaper prices while helping to use excess nighttime production. Cars are used as a distributed battery storage system to buffer electricity, so to speak. Nevertheless, this is not sufficient to balance load curves. The broadband-infrastructure, supporting the Internet and telephoning and additional services, is used for data exchange. Again, the only problem, prohibiting a smooth data transfer, is missing standards.

Weak Signals

Several factors indicate that the **Isolated Islands** scenario is likely to occur. While standard-setting is vital for Smart Home penetration, standardization does take place but nevertheless many large manufacturers set their own distinguishing device standards in order to limit compatibility, hence forcing customers to stay with their technology. Besides, ICT manufacturer and electricity providers started very early to cooperate and to foster research, which is very beneficial to the rapid development of Smart Home applications. Governmental efforts taken within increasing energy efficiency and incentivizing R&D, also with the E-Energy program in Germany, are beneficial to Smart Home advancement. Also steady recovery from the economic crisis is conducive. Data protection is still an issue but consumers are increasingly willing to provide data as they see benefits for themselves, hence consumer advocates' influence is reduced. In addition, prototyping and testing shows lots of interesting technologies, but still many are ill-conceived or lack feasibility on a large scale.

People are already used to live in more or less smart houses. Not only young but also elderly accept and appreciate their Smart Homes making everyday life easier and more convenient and enabling them to actively contribute to environmental protection. It can be assumed that the consortia cannot withstand the pressure from society much longer. Finally they will have to establish standards enabling people to connect appliances and devices independent of their brand.

In the following, many different small companies will enter the market offering innovative products and services. In addition, standards, enabling people to market new ideas and technologies a lot faster than before, could lead to successive progress of technologies. Overall development could be similar to the development of the Internet, which faced a rapid progress, after standards were set.

6.4 Product Idea: E-EnergyOS

The E-EnergyOS is a cloud computing operating system (figure 6.8) based on the scenario of **Isolated Islands** and focused on efficiently and proactively managing energy consumption in a Smart Home. It also offers an open platform to leverage the power of the system and to offer applications, which complement and expand its core functionalities. By using the E-EnergyOS household owners do not need to think how to appropriately setup their Smart Home appliances in order to reduce their utility bills. Likewise, they only need to be familiar with one unified user interface and set of features in order to control their Smart Home energy consumption.

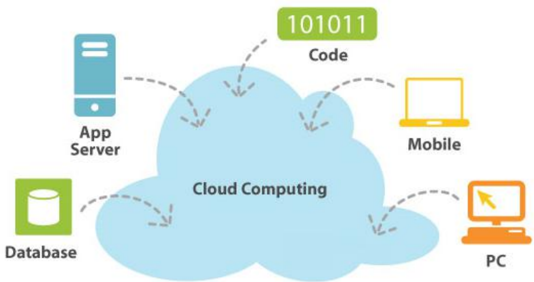

Figure 6.8: Cloud Computing allows to host and deploy all type of application on the Internet
Source: adapted from RCl [256]

The operating system is more than a simply upgraded smart meter, because it can control all energy sources in a household such as heating and cooling, but out-of-the-box it is optimized only for electricity consumption. In order to achieve this, a fine-grained level of control is deeply implemented in the

E-EnergyOS enabling the operating system to visualize, how and where the energy comes (e.g. renewable, atomic, coal, self-generated etc) from and to decide how it should be used. However, the customer may decide to deactivate this feature and manually control the system. The subscriber is therefore able to determine what decisions the operating system is allowed to make.

The system on its core has two main functionalities: Communication with the outer world, communication with every household appliance and with the household inhabitants.

First, it serves as the gate connecting the inner ecosystem of a household with the outer world. One example hereby is the demand side management. During peak times electric utilities are able to exert control over the system and define how much power a given appliance may use or even if it is allowed to consume power from the grid. The suppliers have the added advantage that they do not need to deal with different protocols or Application Programming Interfaces (API). Next to demand side management the demand response concept is implemented. The system reacts to expensive electricity prices by turning high-consumption devices off. However, subscribers may override this option if they see fit. The major advantage hereby is the optimal combination of demand side management and demand response.

It is important to point-out that the E-EnergyOS is software, which expands the common found gateways and control stations found in most Smart Homes. Therefore, it is capable of fulfilling the functionalities of such hardware but it goes beyond it and solves other problems commonly found in the energy management of such households.

The communication to the outer world is not limited to just regulating consumption. Some Smart Homes are able to generate electricity, if equipped with the appropriate devices, and most household owners are interested on selling their oversupply to the markets. Therefore, the E-EnergyOS acts as a broker. The system detects the eventual existence of oversupplies (electricity locally stored and not to be consumed by the household inhabitants) and automatically starts looking for potential buyers. It offers the generated electricity to the different electricity trading markets for residential customers. Under the E-EnergyOS household owners do not need to care about the offering, selling and billing process. They only specify some constraints about the lowest selling price, the markets where it should be offered, etc.

In order to appropriately regulate the communication with the outer world the operating system has a firewall built-in. Just like regular computer operating systems with Internet access, the E-EnergyOS needs to control the flow of information going to the outside. This has been motivated by privacy concerns expressed by Smart Home owners and potential buyers. Without a firewall such as the one included in the E-EnergyOS a user is unable to know if a home appliance is trying to send information about the use behavior without his consent. The firewall enables users to visually select what kind of data should be blocked or allowed. It ensures a complete privacy control and can be considered as a holistic solution to protect users against data misuse. Its functionality is exactly the same as a traditional computer firewall. As home appliances adopted the IPv6 protocol and they connect to the gateway using defined ports. Their behavior is similar to traditional computer programs, which can be controlled using computer firewalls. (figure 6.9)

Figure 6.9: E-EnergyOS user interface Mockup

Second, the operating system not only optimizes the energy consumption of household appliances but it is also capable of communicating with its inhabitants. As previously mentioned it works on pilot mode out-of-the-box but if users decide to change to manual mode the system limits itself to only make recommendations. By having complete access to all devices and appliances in the household, including the smart meter, the system is able of making concrete recommendations about energy optimization. The system goes as far as saying ”Your washing machine should only be used at a certain time with self-generated electricity”. This can be achieved by tracking behavior patterns of the Smart Home inhabitants and combining it with public released data mined information from other users. Hence, the main premise behind the E-EnergyOS is to take the complexity from Smart Homes and make them accessible to people familiar with neither technology nor electricity tariffs (figure 6.10).

However, the system is also able to display extensive information of electricity consumption. It has become a standard that household appliances can report their current consumption if requested. Hence, it informs real-time about

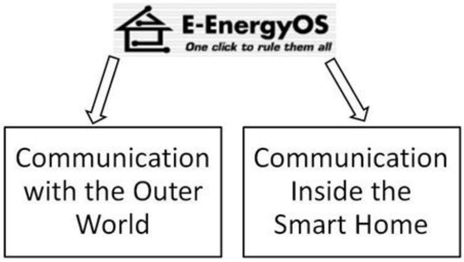

Figure 6.10: E-EnergyOS Communication

the exact consumption and it converts this information into a currency value. Therefore, users have a clear overview of the cost of running a certain appliance each day. It is also possible to display the cumulative consumption and have an overview of the weekly, monthly or yearly bills.

Under the premise that technology should be easy to use, the operating system uses a pervasive approach to display its data and be controlled. Therefore it communicates with the inhabitants using multimedia methods such as pre-recorded voice messages or visual alerts on the users' mobile phones. By using common established protocols such as Bluetooth and WiFi the system is able to communicate with devices, which are not under its command (e.g. mobile phones). Common situations that trigger this notifications are emergency situations or if the system faces a situation, whose response has not been defined by the user. However, other possible uses for this notification system are for example customized recommendations for home appliance buyers.

A unique user interface is one of the biggest value propositions of the E-EnergyOS. Currently most home appliance providers and other incumbents offer their own operating systems hardcoded for concrete hardware and software specifications. Most household owners are not familiar with the functionalities, user interface and features offered by other products in the market and some of them differ greatly from each other. They desire interoperability between their heterogenic household appliances but products currently offered do not solve this problem.

Finally, the feature that differentiates the system from similar products is its open nature and platform. The system contains an API, which allows third-party programs to be developed and to be able of leveraging the power of the O.S. Similar approaches were already common in the past. As in the first decade of the 21st century Internet companies such as Facebook or Salesforce opened their products and allowed other programmers to develop applications, they extended and leveraged the host platform. Nevertheless, the previously mentioned examples were applications confined to the browser, which were not able to go beyond the browser and make use of the computer hardware.

However, in the year 2025 we have gone far beyond that and the platform offers third-party developers partial access to concrete household appliances. To avoid malicious use, the O.S can block program requests that seem suspicious (e.g. they try collect customer information without his knowledge) or completely forbid them. However, most of the quality assurance process is done before the application is released on the marketplace. Each application available on the online platform must be certified by a developer body, the O.S only monitors for suspicious behavior. The use of an API as an abstraction enables programmers to concentrate on developing applications. Likewise, it avoids having to get familiar with concrete hardware specifications and proprietary APIs as well as testing a program with a multitude of heterogenic systems and appliances. The applications are hosted in the servers of E-EnergyOS and before their public release they are tested to ensure safety and compliance with the company politics.

Multiple modules were developed in-house and are available as a premium add-on to the E-EnergyOS for example modules for total energy management, where the system is not limited to only optimizing the electricity bills. These modules allow for the complete control of the heating and cooling of the household. The system can therefore operate without trouble with the air conditioner and central heating of the Smart Home. But it is also capable of regulating the temperature and humidity by opening or closing the intelligent windows of a home or just by reducing the power of the heating or cooling system. The E-EnergyOS is therefore a holistic solution for the intelligent energy management of a household.

The operating system is foremost an online platform hosted on remote servers. Interested users subscribe themselves to the service and start profiting from it immediately. The E-EnergyOS installation process works very transparent. Once a user has allowed the E-EnergyOS access to his home gateway by giving his user credentials, the operating system is able to access the gateway through the IPv6 Protocol. By using the API of the gateway it installs the needed firmware in order to gain full compatibility with the hardware. Subscribed users of the E-EnergyOS see in their control touch screens the standard user interface of the operating system but customized to the characteristics of the subscriber's Smart Home setup. Moreover, subscribers do not need to care about learning the use and functioning of proprietary solutions. An inconvenience commonly seen in a landscape, where there are multiple suppliers with their own programs and user interfaces.

However, the company behind the operating system acknowledges that some household owners do not have a gateway device where the E-EnergyOS can be installed but they might be interested in making savings and supporting sustainable environments by optimizing their energy bill and home. Therefore, it can be offered a rent-a-gateway program. Customers receive a full-compatible gateway with the E-EnergyOS already installed and they only need to pay an affordable fee per month. If during the first six months they are not satisfied with the service or product, they can cancel it and send the gateway back. However, if after this time period they decide to continue using the service, then they commit themselves to a 1-year contract until the device has been paid. Afterwards, they do not need to continue paying the monthly fee but may continue using the service.

The E-EnergyOS is based on the concept of early alternatives in the Home Energy Management Software landscape such as Microsoft Hohm or Google PowerMeter, both online software, which allowed back in 2009 households and businesses to track real time their energy spending and to receive recommendations on how to optimize their consumption. Likewise, following the trends of other industries such as the computer industry or the mobile phone industries most incumbents in the Smart Home sector started to be less interested in developing the software for its gateway devices. Moreover, residential clients demanded a solution, which allowed heterogenic Smart Homes equipped with appliances from multiple providers but kept a consistent look and feel as well as a common set of features. Furthermore, the cloud computing trend of the first decade of the 21st century enabled the possibility of offering Platform as a Service (PaaS) solutions such as the ones already available by major software companies.

6.4.1 Business Model

The E-EnergyOS follows the trend of the software industry, which changed from a complicated license model and physical media distribution to a transparent subscription model with virtual media distribution. Furthermore, its value proposition is offering free products and services, which could be complemented with premium add-on services for a fee. The so-called freemium model is a viable alternative for start-ups desiring to reach a broader audience but lacking the needed marketing budget. The company behind the E-EnergyOS has learned from the positive and negative experiences of using such business models and decided to implement the freemium model but it has slightly modified it.

Basic users do not need to make a big financial commitment in order to start using the operating system. They can subscribe to the service and start using it immediately. However, the system is not a freeware. The user pays 15% of the savings he made by using the service. This can be calculated by letting the system consult previous utility bills and compare it with the current monthly consumption. If the system is not able of bringing tangible savings the user does not need to pay for its use.

Add-ons which complement the functionality of the system are offered but are not required for achieving tangible energy savings. An example are the complete energy management modules, which as previously mentioned can manage all energy sources in a household such as heating and cooling. Another interesting add-on is the comfort program, which controls lighting, alarms and the correct behavior of the home during the presence or absence of its inhabitants. The optional add-ons have a monthly cost. Its pricing model can be compared with a-la-carte offerings available for mobile telephony. Likewise, users have the possibility of immediately canceling the service and there are not minimum stay contracts. These pricing strategies have proved to be useful to attract new customers desiring to try the product without having to commit themselves to a long stay contract. Furthermore, the add-on services have a very affordable monthly fee.

The operating system counts with a virtual marketplace for third-party applications. The E-EnergyOS offers developers a platform to release their software applications for Smart Homes. However, it is important to guarantee both the quality of the released applications as well as a smooth installation and buy process. Furthermore, it is important to motivate developers to release their applications for the E-EnergyOS. Therefore, developers do not need to get licensed or authorized in order to have their applications published for the E-EnergyOS. Every approved application is automatically added to the virtual store. Moreover, developers are capable of defining the price for their application or if they want to release it as a freeware. There is a commission of 15% for every sale. If developers release new versions or update their installed application of their customer base, they do not need to pay additional fees (figure 6.11).

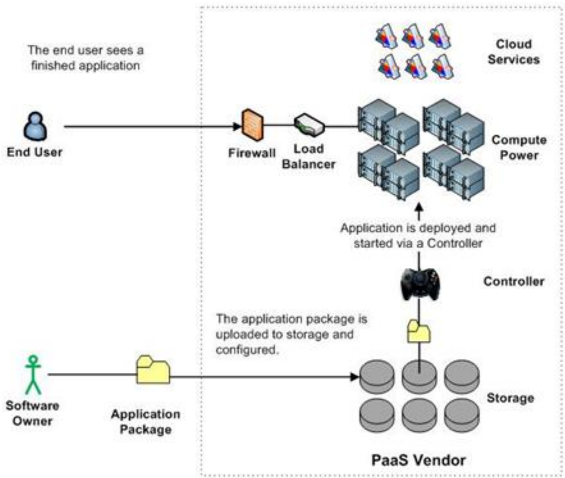

Figure 6.11: E-EnergyOS PaaS architecture
Source: Pijanowski [273]

6.4.2 Customers

In general the E-EnergyOS caters two different types of customers: Private and business customers. Private customers are in this context considered as people using the operating system at home, regardless of the applications, which reach from saving money to the control of private data. On the other hand, for business customers the operating system is essential to fulfill their business. They use the E-EnergyOS to connect their products or services with devices and appliances using different standards. Although the product is focused on private customers and their needs, business customers' needs will also be mentioned (figure 6.12).

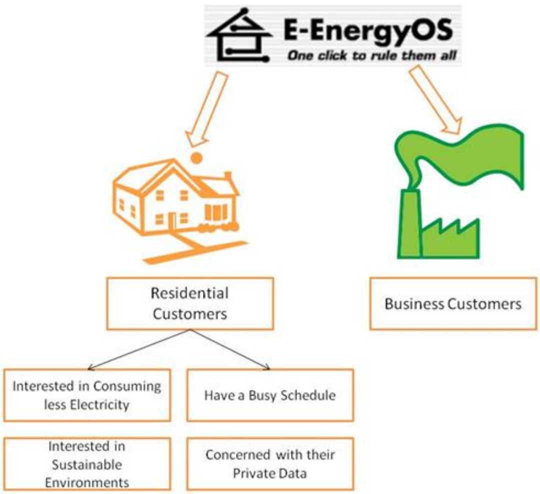

Figure 6.12: E-EnergyOS customer profile

6.4.2.1 Private Customers

Four different types of private customers can be identified. First, customers interested in consuming less electricity. They want to save money by optimizing their energy consumption and electricity feed-in. Such consumers do not only want to get the information gathered by the smart meter, but they also want the information analyzed immediately to take maximum advantage of it. However, some of them do not want a device to make decisions on its own and hence, they seek to have a system giving recommendations on how to optimize their electricity consumption. Others do not distrust technology and prefer as much automation as possible; they rather need a system acting independently. Additionally, customers who want to minimize their costs would like to have a system adjusting the feed-in of electricity generated at home to the power supply and consumption. Hereby, the system should decide, whether it is better to use the energy generated at home or the energy provided, depending on the prices.

Second are customers with a busy schedule, who do not want to spend time on domestic work, as well as convenience oriented customers in general. They want their house to relieve them of as much work as possible. These potential customers commonly request possibilities to adjust appliances and devices of different brands; they are also interested in allowing the home equipment to work together efficiently without their interference. Moreover, they would appreciate a device able to communicate with the power provider autonomously and thus enabling them to save money via demand response, etc., in spite of being passive. Again, potential customers who want to stay in control co-exist next to potential customers interested in complete automation. Therefore, a device or system with different settings that either operates on command only or independently is required to address both types of customers.

Third, customers interested in protecting the environment. They are interested in reducing their energy consumption to preserve the environment and even further, they want to base their everyday decisions on knowledge about environmental related topics. Therefore, on the one hand they want to know what kind of energy they use as precise and up to date as possible. On the other hand they ask for an information tool which can advice its owner, for instance which new appliance to purchase.

Last are customers concerned with their personal data and their privacy. These customers do not want appliances and devices such as the smart meter to sent private data to the outer world, since they would like to restrain third parties to gather their private information. Therefore, they are in need of the possibility to tell appliances and devices, which information to send and which not. Ideally, most of them want to setup the system once and then it should sort out the information accordingly, so that they do not have to control the data stream constantly.

The E-Energy operating system described above is designed to meet all of those demands at once. Further, the system addresses a couple of general needs shared by these customers. It enables the customer to interact with the house proactively and very simple, since the system can be controlled in various ways described above and being a universal system the customer only has to deal with one interface. In addition, it can exchange messages with portable devices such as the cell phone. Accordingly, it addresses both young as well as elderly people, being very easy to understand, use and control. The overall benefit to private customers is generated through the combination of a control, information and communication tool, which simplifies customers' lives, optimizes their electricity consumption and enables them to save money. Moreover, by offering many different add-ons, it is possible to offer a customized solution for every single customer.

6.4.2.2 Business customers

They are mainly service providers and small electrical equipment suppliers, who are in need of a system enabling them to connect to appliances and devices using different standards. Such a system would allow them to build their own services and products upon it. As already mentioned, until now there are only proprietary solutions available, this situation hampers independent service providers and small electrical equipment suppliers to sell their services and products. The E-EnergyOS allows them to address new customers and markets hassle-free. In the process of time energy suppliers might also become business customers. At first they might probably compete with the new operating system (see 6.4.3), yet, it might be cleverer to offer the E-EnergyOS to upgrade their own offer. In that case, energy suppliers can focus on their core products and services.

6.4.3 Market

The ICT market merged with many parts of the former energy market. Therefore, a lot of different potential competitors and partners need to be considered. Markets around the Smart Home sector are highly competitive, since Smart Home appliances, devices and services are very attractive and the market as a whole has a high revenue potential. Hence, many different companies from sectors such as electrical equipment and ICT try to achieve a leading market position. This situation applies to energy management operating systems as well. Companies offering products and services competing directly with the basic product can roughly be categorized in established operating system developers, big electrical equipment corporations, established power suppliers and finally small and independent software companies trying to act as a link between different established standards. In contrast, a potential provider of the E-EnergyOS needs to enter partnerships with device manufacturers only. Other strategic partnerships can only be entered with service providers active in the energy market.

6.4.3.1 Competitors

Companies offering operating systems for computers such as Microsoft and Apple have also developed operating systems for Smart Homes. These operating systems are the next generation of PaaS products such as Microsoft Azure. However, they stick to their own standards trying to drive out competitors and to gain supremacy in the market of Smart Home operating systems. Microsoft software, for instance, always carried a high level of vendor lock-in, based on its extensive set of proprietary APIs. Moreover, established operating system developers do not focus on energy consumption specifically; they rather try to develop and establish a completely integrated operating and control system for Smart Homes. Therefore, energy consumption management, control and information are only small parts. The E-EnergyOS focuses on energy management and related services. Thus, it is able to meet the specific needs of customers concerned with their energy consumption and further, it is not linked to a certain brand or consortium.

Electrical equipment suppliers rely on two different strategies. The first strategy is applied by home appliance companies which are part of a consortium. They are not direct competitors, but the software developers of the corresponding consortia might be competitors in the way explained above. The other strategy is applied by companies operating independently. They try to make their appliances smart enough, so that they do not need additional adjustments. Their appliances try to optimize energy efficiency through coordinated communication with each other. Some companies even offer additional sensors, e.g. to measure the temperature, and market them as performance improvers. Further, appliances similar to the Energy Management Enabled Appliances introduced by General Electric in 2008 can exchange information with the electricity providers. Nevertheless, the system applied by electrical equipment suppliers cannot replace the E-EnergyOS, since it does not offer a feature to connect home appliances of different brands and hence cannot enable interconnectivity among devices.

The next group of competitors consists of established power providers. They argue an energy management operating system is useless due to the various functions of smart meters. Indeed, smart meters combined with gateways and additional Internet-based services can potentially do everything the E-EnergyOS standard offer does. However, minor disadvantages of this competitive system might be a lacking usability and lower communication capabilities between customers and the gateway. Since these additional services do not belong to the core competencies of power suppliers, focus was not placed on improving them. Further, due to the open-nature of the E-EnergyOS, innovative applications are expected in the following years. In addition, there are two big issues energy suppliers cannot solve. First, utilities make money from customers having a higher and less-efficient consumption. Second, by ignoring privacy concerns energy suppliers can greatly profit from using their customers' private data. To sum it up, they are not independent and thus, customers will never trust them completely.

Finally, the last competitor segment contains small and independent software developers. They are direct competitors working on the same challenges an E-EnergyOS provider faces: Energy management systems enabling customers to link different devices and appliances independently of their brands. Hence, a couple of good proprietary systems exist as well as gateways allowing communication between appliances of certain brands and consortia. Until now, however, no one has managed to develop a universal system like the E-EnergyOS.

Besides these rival products, different services similar to the E-EnergyOS add-ons are provided by the big players previously named as well as by independent service operators. Some of them offer for instance a shopping assistant for household appliances. Yet, single services cannot compete with a universal, customized operating system such as the E-EnergyOS.

The reasons for adopting this operating system are very clear. It offers at least the same features, some of them without cost, and advantages as other similar products. Further, a E-EnergyOS provider has an interest in safeguarding user privacy, since it is part of the value proposition and allows customers to choose which information should be transmitted to the outer world. Finally, the E-EnergyOS is expected to develop rapidly and an attractive set of features is anticipated in the upcoming years due to the aggressive business model. To put it in a nutshell, the E-EnergyOS has the potential to outperform competitive systems and solutions available in the market (figure 6.13).

Figure 6.13: E-EnergyOS competition environment

6.4.3.2 Partners

Since customers, who do not already have a control device such as a gateway, are supplied with one, it is necessary to cooperate with device manufacturers. The most important characteristics of a potential partner company are reliability and the production of inexpensive as well as high quality gateways. Device manufacturers from Asia may be a good choice, since their quality increased in the past years, but their offers are still inexpensive.

In the course of time, different partnerships, especially with service providers building their services on the E-EnergyOS, will become interesting. Consequently, the focus would increasingly lie on the core products, namely the software and computer programs. Once a secure market position is attained, earnings can be increased by such outsourcing measures. In the beginning and as long as the market share is small, however, the combinations of software and additional services are an important part of the competitive advantages. Other potential partnerships are with local authorities, which might be interested in complying with supranational regulations such as the environmental goals of the European Union. They might decide to subsidize the needed hardware or cover the user fee for residential customers. In order to achieve this, it is important to start a lobbying campaign to make politicians and decision-makers aware of the potential savings and advantages that the E-EnergyOS offers to both customers and governments (figure 6.14).

Figure 6.14: E-EnergyOS strategic partnerships

6.4.4 Financial Viability

The E-EnergyOS has a tremendous market potential. The mandatory implementation of smart meters, national governmental efforts and low price offers fostered the spread of Smart Home appliances and devices. Hence, about 60% of German households consider their home as smart up to a certain extent. In 2009 the German Federal Statistical Office assumed that there will be 40.5 million households in Germany in 2025 [274]. Their assumption proved to be right and thus the E-EnergyOS has 24.3 Million potential customers in Germany, equaling 60% of 40.5 million households.

In the information age services and products that offer new and tangible benefits spread very fast. For example Bitcom declared that the number of households using a broadband Internet access increased from just a third to a half in only three years from 2006 to 2009.

Still, only very few people really understand new technologies according to a study published by IT-Fitness, an initiative founded by Bill Gates, in 2009. Therefore, the handling needs to be very simple. Moreover, most people do not buy technical products, which correctly fulfill their needs. They merely buy those products they are familiar with or have heard of. This customer behavior, among other things, made Microsoft achieve a market share of more than 90% in the market of operating systems for personal computers in the first decade of the 21st century. Hence, a rapid spread of the E-EnergyOS is likely, especially since no comparable product is on the market. Once the system is established, people will probably remain recurrent customers just as it happened with Microsoft's Windows. Therefore, it is possible to assume the possibility of achieving a market share of 60%; that equals around 14 Million customers.

It might be relevant to acknowledge the potential of such a solution by rough calculations based on estimates and numbers of 2008 and 2009. However, due to their nature they should be considered as slight indications only, since many additional factors were neglected: An average household spent about 870 € on electricity in 2008 [255]. Even if the system can only achieve savings of 5% of the total consumption and if the requested monthly fee is 15% of the resulted savings, the yearly revenues would equal more than 91€ million for the basic offering. Furthermore, it can be assumed that one out of two customers subscribes to an add-on service provided for 10€ per month on average. This would generate 840€ million additionally. On top of that, the E-EnergyOS provider earns about 15% of every third-party application sold. It is not possible to make exact calculations about potential revenues, which can be generated under this scheme. However, the success of the Apple iTunes store and its third-party applications can lead to believe that this scheme might become a notable source of income.

However, it is important to consider the costs to mount such an infrastructure. Servers, maintenance, R&D, electricity and labor costs should be taken into account. Nevertheless, they only sum up to a fraction of the revenues. The major challenge is that high expenditures are necessary up front: A big marketing campaign must be launched and the supply of gateways must be acquired in advance.

6.4.5 Market Entry

The market entry strategy consists of two different stages. During the first stage the objective is to gain end-user awareness and brand recognition for the E-EnergyOS. In the second stage, once the E-EnergyOS is prevalent, it should be sold to energy and electrical equipment suppliers, which should offer it in product bundles. This measure will consolidate the market position. Nevertheless, the objective of the first phase will be pursued during stage two as well.

6.4.5.1 Stage 1 – Market Introduction

The product offered contains the software, hardware and the additional services described above. The focus is on the one hand placed on the E-EnergyOS and its main advantages: cost reduction, energy management, improved convenience, appliance connectivity and user data privacy. On the other hand it is placed on the most important additional services such as the control system.

Mass advertising is used to promote the product. No matter if on TV, on posters or on screens in the subway and in inner cities, in the first stage as much publicity as possible is needed to make the product known. Yet, the content of every advertising measure has to follow a consistent strategy: At first the major advantages of the core product are outlined briefly. Thereby, the needs of the different customer segments need to be addressed. Then customers get informed about the pricing structure and the major savings they can make. Finally, the Internet address of the E-EnergyOS provider is shown. Customers should become curious about the product. Nevertheless, concrete information about the product is kept brief, so that they feel compelled to visit the home page. A similar marketing strategy was successfully pursued by Sky, a pay TV provider, in the first decade of the 21st century.

One of the major marketing hooks is that the E-EnergyOS cannot be bought immediately. This creates greater expectations and curiosity. Information and service hotlines are set up to answer questions of potential customers. Finally, E-Commerce is the only distribution channel available and hence no additional distribution fees apply.

6.4.5.2 Stage 2 – Bundling Strategy

Once the E-EnergyOS is established, other companies such as energy suppliers and electrical equipment providers may want to bundle their products with the E-EnergyOS to upgrade their offers. That might be a very effective possibility to distribute the operating system, since money spent on promotion and advertising can be saved.

6.5 Conclusion

Recapitulating it can be concluded, that there will be a trend towards smart appliances and automated homes in the future. The extent and speed at which this will occur though is strongly dependent on the interaction of the named drivers. All scenarios predict alike that there are for certain many potential advantages to users living and working in Smart Homes which are primarily safety, comfort, entertainment and energy efficiency.

But there is always a reverse side to new technologies. With increased amounts of data sent between devices, gateways and the outer-world, the risk of potential data misuse is raised. And as connections are becoming progressively more complex and incomprehensible to users, they lose oversight of the amounts of sensitive data and the hands it gets into. Besides that, Smart Homes could possibly be hacked and any security protection be disabled. Also, full automation and independently acting homes and devices make users dependant on them as they forget how appliances work. Finally, people could lose control of their houses and apartments. To avoid a loss of control the goal of Smart Homes should be to make devices intelligent, but at the same time let the user be smart, too, which basically means that the user should still have monitoring and controlling power and is informed of what is and how it is happening within the Smart Home [269, p. 3-6].

A system such as the E-EnergyOS could be used to achieve that. And once such a system is in use Smart Homes can foster distributed electricity generation, support the smoothing of the energy demand curve and optimize energy consumption as well as energy efficiency. That means Smart Homes equipped with an energy management operating system can contribute a lot to the idea of E-Energy.

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Chapter 7

Business Solutions

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Environmental challenges require efficient solutions in the area of E-Energy. Hereby the exploitation of untapped energy saving potential of businesses plays a decisive role. Businesses need to seize opportunities in order to combine sustainable economic activity with profitability. Energy becomes a strategic factor and contains the potential for firms to create a competitive advantage. Decisions of crucial importance have to be based on uncertain factors. Within a comprehensive approach, three scenarios in the area of energy efficient business solutions were shaped through the interaction of main drivers.

The **Low Hanging Fruits Scenario** describes a world in which firms implement the most profitable efficiency measures without taking high risks. In contrast **Optimax** pictures a scenario which is shaped through a high degree of firm owned electricity generation sites, favored by the fact that large storage possibilities exist to balance the volatility of renewable energy sources.

Think Globally Act Locally was defined as most the likely scenario. Firms follow the approach of intensive usage of strategic cooperations to balance risks and pursue structural changes within their processes to increase energy efficiency.

A service idea which addresses the needs of firms in 2025 was developed and shows how firms can differentiate from competitors through a coactive partnership. The product idea hereby builds on the fact that the conditions shaped through technological progress, electricity prices and public awareness level the ground for firms to set up own electricity generation sites and join forces to implement a higher degree of energy efficiency. The service idea, ECOperation manages energy related questions within a network of firms and enables companies to enforce their energy strategy and benefit from complementary competencies.

7.1 Introduction

Global energy demand on the rise, progressive impacts of climate change and fossil resources becoming scarce create crucial challenges for humanity. In Germany, both prosperity and competitiveness increasingly depend on our ability to use energy as efficient as possible. This is true for private households and even more for companies. The fact that businesses consume 73% of the overall electricity in Germany undermines the relevance of efficient business concepts. Figure 7.1 illustrates that efficient business solutions have a leverage for energy savings, which is emphasized by the development over the last 20 years.

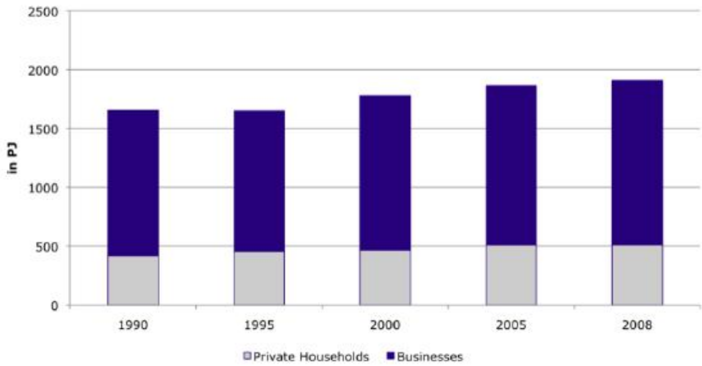

Figure 7.1: Electricity consumption in Germany
Source: Adopted from BMWi [285]

Fostered by technological progress companies are required to modify their planning and develop comprehensive strategies in order to drive more energy efficient operations. Thereby the challenge for businesses lies in the creation of solutions that combine sustainable economic action with profitability. The first step in accomplishing this goal is the implementation of smart efficiency technologies. Great understanding of ICT infrastructure, energy efficient building technologies, smart offices and processing technologies are the basis for improvements. Furthermore entities have the possibility to invest in energy production capacity to achieve self-supply. Supported by the governmental programs this can lead to structural changes within the business environment. However, changes should also account for the stakeholders, who play an important role in the whole process. Especially the environmentally friendly general public expects corporations to transform their structures and processes in order to increase performance and to be more ecologically effective.

On a macro-level the efforts and developments have to add up to advocate climate protection, economic growth, employment and security of supply. Key components of the developments concentrate on an expansion of renewable energies and an enforcement towards energy efficiency. Throughout this part of the scenario report, possible future scenarios for a more energy efficient business environment in 2025 are discussed. The chapter is divided into three main sections: driver analysis, scenarios and product idea. The driver analysis passage elaborates the ten main drivers that educe three different scenarios, which are described in the subsequent section. The last part illustrates the product and service idea ECOperation. This innovation will be developed in order to match the needs of corporations with the efficiency requirements of 2025.

7.2 Driver Analyses

Scenarios represent different stories about how the future might evolve. Figure 7.2 illustrates that the development of scenarios follows a clear methodology and is based on a profound analysis of drivers.

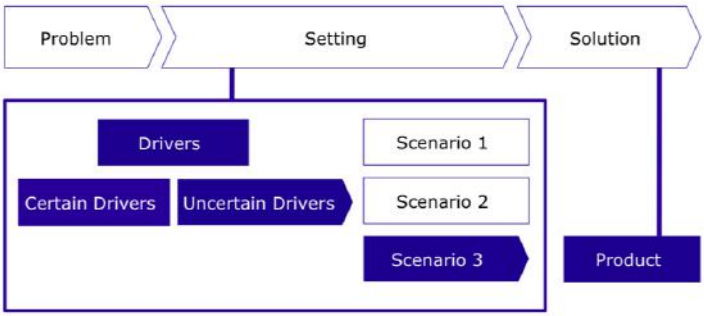

Figure 7.2: Scenario planning process

These drivers have important impact on shaping the future. According to their potential development, drivers have to be distinguished either as certain or uncertain. Certain factors related to energy efficient business systems are the scarcity of fossil resources, environmental awareness, product varieties, or the profitability of technologies and investments. In addition uncertain drivers characterize the future business environment. The volatility of renewable energies in combination with the question of storage, as well privacy sensitivity issues and the influence of fiscal policy have vital effects. However, three indentified key factors have the potential to introduce fundamental changes in the business environment. New efficient consumption technologies in the areas of efficient buildings highly contribute in an decrease of energy usage. The second key driving force, technological progress for efficient energy production will also be of a great importance in the transformation process. Lastly, strategic networks for energy efficient cooperations, are a step towards collective and more efficient energy usage. Figure 7.3 gives an overview of the relevant drivers. The key drivers are marked by high degrees of uncertainty and importance and therefore have the potential to compose three relevant scenarios. The concrete and comprehensive pattern of the scenarios is formed by the underlying projection bundles and the interrelation and interaction between the different driving forces. A clear understanding of future developments and their implications enables companies to transform the information to strategies. Thus the findings of scenario planning have to be incorporated in innovation management. Accordingly, product ideas can be developed on the basis of the most likely scenario. Such innovative solutions fit the needs and requirements of the world that is projected by the scenario. Consequently the scenario methodology enables strategic decision-making and creates opportunities to obtain competitive advantages.

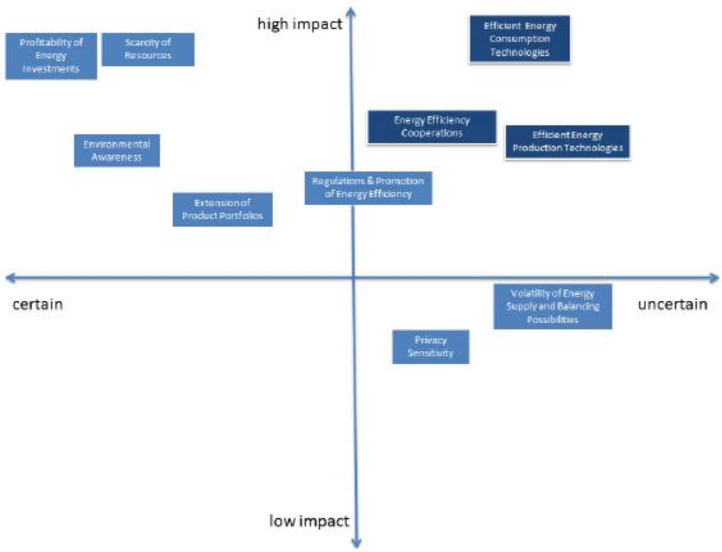

Figure 7.3: Driver matrix

7.2.1 Certain Drivers

A definition and analysis of probable scenarios has to include an evaluation of influencing parameters that are of certain nature. Such factors create the framework for the evolution of all scenarios that paint the picture of the future.

7.2.1.1 Environmental Awareness

Environmental awareness describes the understanding and consciousness towards the environment and its problems, including human interactions and effects. The outcomes and effects of environmental challenges result in an interactive process where mutual opinions generate the overall environmental awareness. Environmental awareness is affected by various influencing factors. Global warming has radical direct and indirect impacts on each member of the society. Especially the various results of climate change lead to awareness of problems and risks on a global scale. Sustainable activities for climate issues, as well as nature conservancy and protection of the biological diversity are in the field of interest. Apart from that the correlation of environmental awareness with increasing awareness of health issues is an important driving force. Another parameter for shaping environmental awareness is the level of specific information available for the general public. In this regard, media information systems have a special role. In particular information systems like the internet function as a public education tool and have a leveraging effect when it comes to information distribution and mobilization of public participation.

As a consequence, these developments create high public sentiment towards environmental protection within the German society. In general, the driver environmental awareness can be projected and described with a high level of awareness [292, p. 33]. With industrial countries being the main causer, the environmentally aware general public requires Germany to foster its leading role in the renewable energies sector. Furthermore industrial sectors and branches are requested to take special responsibility and engagement [304, p. 17]. Thus energy efficiency and renewable energies are a relevant topic of the agenda in public debate and policy. Environmental awareness creates demand on politics and lobbies to establish systematic actions for modernization and sustainability on a long-run perspective. Thus the public priorities for sustainability and environmental protection rely on efficient use of energy, increasing use of renewables, promotion of environmentally friendly products and reduction of climate gases. Thereby problems with the acceptance of measures only exist, if deficits in justice and fairness of policies are directly perceived [292, p. 33] [281, p. 219].

Many consumer segments follow ecologically sensitive guidelines. Behaviour is focussing on purchasing energy efficient products. In addition there is an expectation for environmentally friendly processes within corporations, as well as sustainable and responsible energy balances. This creates standards for companies and increases their environmental awareness, too. The general public is stakeholder of all businesses and takes an essential role in the economy. Therefore social developments and changes of public opinions are of crucial importance for all market participants. Consequently the high level of environmental awareness can express its direct power in multifarious forms. Organizations and interest groups as stakeholders have incentives and sanction possibilities, like consumer-boycotts, protests or strikes. In summary the high awareness and sensitization for environmental developments has potential to create pressure for efficiency measures on politics and businesses.

7.2.1.2 Scarcity of Resources

The demand for energy has been on the increase across the world through the years which contributed in increasing use of fossil fuels. As a consequence the raw-material reserves that have remained [291] are dwindling (figure7.4) and therefore the energy costs are climbing dramatically. Even though it can be expected that unused fields with fossil fuels will be discovered, it will still not be enough to meet the energy demand. This trend will lead to a rising development of energy prices of approximately 6% by the end of 2020 [286]. However, it has to be mentioned that the scarcity of resources is not the only influencing factor that shapes the energy price, but other elements e.g. governmental charges play an important role as well.

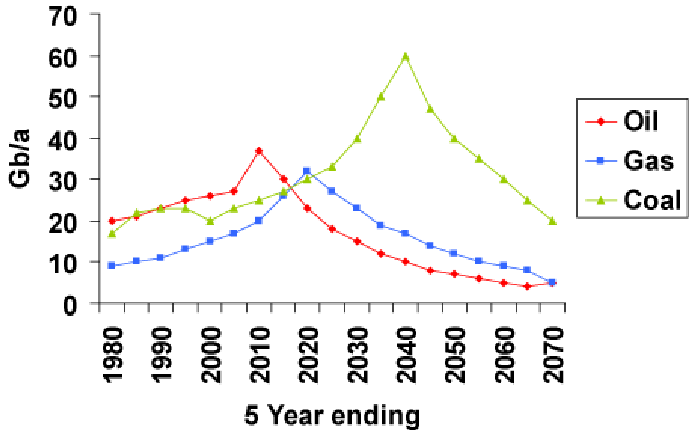

Figure 7.4: Fossil fuel production
Source: adapted from John Busby Limited [291]

This development shows the relevance of the scarcity for each consumer and therefore creates high political concerns especially in countries that have to import most of their energy resources. As one of those countries, Germany wants to decrease the national dependency on energy imports and guarantee stable energy supply. This is why, for several decades now, Germany has turned the focus towards the development of renewable energy technologies in its various forms. Wind and solar energy, hydropower, geothermal energy and bio energy are available in almost unlimited quantities and moreover are environmentally friendly. Larger deployment of renewable energy sources ensure greater independence from energy imports, greater security of supply and additionally strengthens the domestic economy.

Consequently, the scarcity of resources acts as a driver to increase consciousness within the business environment. In order to secure the supply of energy and decrease the external dependency of third party suppliers, many companies invest in building up their own energy generators especially from renewable resources. Moreover scarcity of resources emphasizes the requirement of action, which directly implicates a need for efficient energy usage by all individuals in an economy.

7.2.1.3 Extension of Product Portfolios

The progressive liberalization activities in the European energy markets over the first two decades in the 21st century show crucial effects on the structure of national and international markets. As the number of market participants in the energy sector is increasing, the overall market competition remains on a high level and the status of the value network is marked by high complexity. Apart from that, E-Energy represents a merger between the energy sector and the ICT industry. Levered by this, new market opportunities and business models apart from the traditional system appear for established companies, as well as start-ups [283, p. 6]. New technologies like smart metering and bi-directional communicating equipment thereby create new levels of transparency and opportunities.

In general, the projection of this driving force results in an extension of product portfolios Seher [299, p. 14]. Technological innovation is the solution to many energy related problems and a significant share of the augmented product variety focuses on energy efficiency technologies. Especially the development of innovative cross-sectoral products has high potential and supports the new power network. Such solutions focus on efficiency for defined processes, which are relevant for companies of all industries and businesses. As any economic sector uses specific technologies, individual solutions for single branches are particularly attractive for energy-intensive facilities and equipment. The new technical products, in turn, also have to be installed, maintained and serviced, which is offered by different approaches. Integrated processes for information, communication and transaction within energy markets enable real-time interaction of business and technology operations and enhance the new service world [280, p. 5]. A companies ability to adapt to the new framework conditions and develop new business models will be determining for their competitiveness. The use of new services can enable entities of all sizes to review the origin and price of the electricity, determine the individual energy mix and have an immediate impact on the marketplaces. Other business models result in new tariff systems and diverse pricing alternatives. Therefore, this parameter is a certain driver that enables a business focus on cost efficiency and optimization.

Accordingly, a wide range of services is developed and offered in the E-Energy system. The availability of this product variety drives the awareness and decisions within companies whether to enhance their energy efficiency. Overall, the extended product portfolios form a broad range of opportunities for efficiency measures. This aims at making use of energy-saving potential and the mitigation of impacts of environmental problems and climate change. In addition this driver increases the number of involved parties, complexity and possibilities in the market environment and thence fosters a need for transparency and guidance. Together, the higher competition and the potential of cooperative energy and ICT markets give incentives to foster innovation. At the same time the new business models demands and endorses consistent standardization of communication protocols and data privacy regulation

7.2.1.4 Profitability of Energy Investments

Energy efficiency projects reduce energy consumption and increase efficiency for end users. A profound examination of the future value and risk of projects, as well as the liquidity impacts of such opportunities is essential for all decision makers. As investment opportunities are competing for limited capital resources, managers have to compare risk-return-profiles of efficiency investments with potential returns from other investment alternatives. The tools of First Cost, Payback and Internal Rate of Return (IRR) are the main approaches that drive the decisions regarding energy investments within businesses. Profitability is usually measured by a project's IRR, which is the interest rate that generates a Net Present Value[1] of zero. Liquidity effects are analyzed by First Cost and Payback, the amount of time necessary for future revenues to cover or return the initial investment. The latter is the dominant method used for efficiency investment analysis, but has the downside that it does not consider the time value of money and savings beyond the payback period. The fact that available investments require profitability and nedd to meet specific hurdle rates as condition to be implemented by corporations is a certain driving force. [289, p. 3]

Companies use profitability analysis to assess the cost effectiveness of investments. Profitability of energy efficiency measures is influenced by various factors. At first the initial investment requirement is a significant burden for many companies. But while efficiency measures experience higher market penetration, the increasing production volumes have the potential to reduce technology costs. Through economies of scale and learning effects, these developments lower initial

[1] Present Value of an investment's expected future net cash-flows minus the initial investment requirement

financial barriers for investors. Apart from that, companies that are willing to invest need to determine future cash flows and project energy cost savings. Cost are generally recovered from energy savings and technology performance [296, p. 20]. Thereby energy rates, technological efficiency, as well as operating hours and schedules play a major role. Moreover factors like enhanced corporate image show financial advantages too, but are hard to quantify. In general and within the projection, the technology efficiency factors and productivity are increasing, but to a different degree for the specific technologies. Hence, profitability of energy efficiency upgrades is defined through different rates of return for the various efficiency measures.

However, investment risk is a crucial coefficient for profitability and differs between the typical technologies and project characteristics. This is due to uncertainties that make a classification of risk levels difficult. Although energy efficiency technologies are showing increasing cost-effectiveness and are widely considered as being of low risk levels, their potential is dependent on additional parameters. For instance financial incentives have to support financing activities [296, p. 20]. In addition, the specific analysis method used for investment decisions is determining. Furthermore, a combination of measures or rather packaging of upgrades by firms may lead to a maximization of energy efficiency [279, p. 4]. Providers of technologies and services have to account for the implications of the described decision-making criteria and processes within businesses. In the end, energy efficiency is pushed by different factors and the final decision about proftability and whether to implement efficiency upgrades stays with the firm. This driver is significant for the success and market penetration of the efficiency technologies used in the business environment.

7.2.2 Uncertain Drivers

Key characteristics of the drivers in this section incorporate substantial factors of uncertainty and risk. The implications of these factors can be defined through different possible projections, which are highly important and crucial for outlining their possible future developments within scenarios.

7.2.2.1 Efficient Energy Consumption Technologies

Development of technological solutions for efficient energy usage is of vital importance for the changes within the energy sector, as it addresses fundamental challenges. Increasing power consumption has a high impact on both environment and businesses. Environmental impacts include the greenhouse gas emissions from power generation plants, which greatly contribute to climate change. For businesses the coherence between energy consumption and electricity costs is obvious, too. More efficient consumption technologies carry the potential to reduce costs and CO emissions significantly. The uncertain nature of this driver is emphasized by the dependency on the progress of research and development activities. Hereby ICT, building technologies, smart offices and processing technologies domains imply the greatest savings potential for businesses. Within these domains success can generally be achieved either through the elimination of unnecessary energy usage, efficiency upgrades of current technologies or implementation of new and innovative solutions.

Concerning the ICT dimension, data centers have a high impact on the energy consumption. According to a report of the BMU, German data centers had a power consumption of 10.1 in 2008, totalling in 1.1 billion Euros [287, p. 7]. Furthermore, the ICT costs for businesses are also affected by the employee's computers which use additional 6.8 TWh resulting in 0.7 billion Euro [302, p. 14]. Since the two major ICT cost factors account for total 1.8 billion Euro and under consideration of the strong growth of this segment in the future, the role of efficiency measures is essential. The easiest way to achieve an immediate impact in the field of ICT lies in the replacement of old hardware with more efficient one or in the replacement of specific hardware parts. Thereby, company's servers hold an even higher potential for reductions of energy usage. Since the average work load of a server is just around 30% a lot of energy is wasted through idle times [302, p. 88]. In order to prevent this, the consolidation of servers to "green data centers" is needed. These centers will include technologies for virtualization and simulation of many different systems on one system, dynamic identification of running applications, energy saving IT hardware and highly efficient cooling systems. By relying on these technologies, energy can be used much more efficient by achieving higher work loads while consuming less energy. The third ICT projection is the complete outsourcing of the ICT infrastructure and computing power into the "cloud", which is explained in the section of E-Energy technology trends. As a result, energy costs and energy savings are handled by a provider which operates more efficiently.

In the area of building efficiency two projections can be determined. First, upgrading existing buildings towards higher energy efficiency and second, new buildings that are tuned for efficiency and target for maximum savings. For the upgrade approach there are different possible measures like improved insulation, energy monitoring and efficient light control systems in combination with new light bulbs or LED light sources. Furthermore, the replacement of current heating, cooling and ventilation systems with new and more efficient ones contribute greatly towards energy-cost savings of 20% - 30% on average [294, p. 4]. Constructing new buildings offers the chance of implementing an larger variety of technologies with optimized packages of upgrades. For heating a compact whole-design of buildings and new measures for heat insulation, like special wall construction techniques or insulation materials can be mentioned as examples. Cooling includes ways of sun protection and heat dissipation in comparison to highly power draining air conditioning systems. Ventilation relies among other things on highly efficient aeration systems. For lighting, clever architectural solutions are essential in order to harness daylight at a maximum.

Moreover efficient light control systems in combination with low consuming light sources and energy monitoring greatly support efficiency.

Smart offices will also play an important role for business energy efficiency in 2025. Thereby an interconnected system enables efficient dissemination of information within enterprises and coordinates information transfer processes. The system controls different technologies and devices in a energy efficiency favoring way. One projection is the use of automated offices. These can support the employee in energy saving matters, as for instance automatic switching of light, computers and printers. One step further is the second projection of personalized offices. These solutions build on the automated system and manage the office environment in order to allow consideration and adjustments to employee behavior and personal preferences.

Especially for industrial corporations and their factories energy saving manufactoring processes or upgraded ways of processing are vital for the reduction of energy costs and CO_2 emissions. When less energy is consumed, for example by assembly lines, less power needs to be bought or produced. In general there are cross-sectional technologies that can be used in different industries to lower power consumption. These include appliances as improved compressed air systems, new electric motors and pumping systems with higher degrees of efficiency. Additionally, heat as a by-product of a process can possibly be reused via waste heat recovery and therefore save energy and money. Concerning this aspect, two main projections arise. First of all, upgraded facilities with minor optimized processes, for instance through the usage of upgraded equipment and components in energy intensive processes, enhance efficiency to a certain extent. Secondly, more optimized processes, which make use of highly developed and efficient technologies in the assembly process, raise the efficiency to a higher degree. Moreover, the combination of structural changes, results in even higher efficiency grades for this projection. In this case structural changes can be sector-specific like special heat exchangers for metal processing.

The potential for improving the energy profiles of the various technologies that consume electricity within a company is diverse. There are a multitude of approaches for increasing efficiency on the business level. As a consequence, the possible combinations of measures are broad and also dependent on the specifications of other drivers. Based on the characteristics of the technologies used the overall efficiency factors vary strongly across the board.

As mentioned before, when less energy is consumed, less energy has to be produced. Therefore, this paragraph described more efficient possibilities in consumption and the following deals with the production side.

7.2.2.2 Efficient Energy Production Technologies

Energy self-production is one significant way for businesses to increase energy and cost efficiency. This approach is heavily pushed by investments in a modernized smart grid system that facilitates the concept of distributed generation. The most suitable energy production technologies for office buildings and production facilities are solar cells, wind turbines and combined heat and power solutions which are described in detail within the technology trend report. For instance, the dependency on technological progress and estimated economic potential relates to the uncertainty of this influencing parameter.

For scenarios in 2025 there are three different projections dealing with distributed generation within companies. In the first projection most businesses rely on external power sources from the grid instead of using their own production sources. In this case, distributed energy generation is only performed on low scale. The second projection is marked by a constellation, where many companies invest in renewable energy production capacity, but still depend on external supply. Companies are thereby prosumers, which are energy consumers from the private or commercial customer segment, who actively participate in the energy market place and both produce and consume energy. Possible technologies for the own generation are foremost combined heat and power systems, intelligent photovoltaic systems and small wind electric systems. The third projection extends the second one to a more autarkic solution, which is basically an approach where a certain degree of companies manage to generate their individual energy supply. Zero energy buildings, highly efficient technologies and further scientific breakthroughs foster such a development.

As the degree of distributed generation is important for the reliability and stability of the overall system, the influence of this driving force is represented by its change potential. The goal of long-term sustainability through energy efficiency is only possible if there is a sufficient degree of energy contribution on the micro-level. A further implication of an increasing number of power producers via renewable energies is the creation of network effects and cooperative forms of collaboration between entities, as for example the establishment of micro-grids and virtual power plants.

7.2.2.3 Energy Efficiency Cooperations

Strategic cooperations among businesses enable firms to introduce energy efficiency measures across the board. There are different possible forms of cooperation, but in particular their development and characteristics is an uncertain criterion for the world in 2025. The basic form of cooperations is an energy efficiency network. Here a platform, which aims at improving the energy strategy of its member firms is created. The cooperation can have regional character or focus on a field of competence. During an as-is analysis of participating companies, consumption profiles and drivers for energy consumption are determined. On this basis individual energy optimization concepts and performance targets are created. This includes investment measures and organizational arrangements which are designed to contribute to the group efficiency target. In this regard entities benefit from concept evaluation and know-how transfer within a learning network [282]. A second form of cooperation is concentrating on the energy demand side. The price volatility of the whole sale market will foster the formation of consumption cooperations, which act as aggregated force to optimize profits through demand response systems. Hereby companies try to reduce energy consumption in periods of peak demand through curtailment or load shifts [300, p. 1]. The firm which operates with the lowest profitability at times of peak demand of the grid is then required to lower its energy consumption. This cut-back option provides energy suppliers with a good planning horizon and decreases the need to operate expensive and inefficient peak load plants. It is consequently honored through rebates given to the firms by the electricity providers. Apart from that, firms can cooperate in terms of production cooperations. Thus their focus lies on the supply side, as they are formed with goal to support the development of distributed generation sources. Here, the efficiency gain lies in the reduction of high transportation losses and the aggregation in form of virtual power plants [290, p. 111].

One can conclude that cooperations play a decisive role in enabling energy efficiency measures taken. Through the above described efficiency networks, a platform is created to exchange expertise about efficiency implementations. Coordinating consumption with production cooperations builds the basis to introduce self owned production plants and integrate those optimally into the firm and market structure [290, p. 70].

For the scenarios, three projections are of major importance. First, cooperations between companies are uncommon and play a minor role across the board. Only a limited number of firms are willing to aggregate to efficiency networks to share expertise in the innovative field of energy efficiency. This leads to a relative low overall degree of measures taken in the field of energy efficiency since single firms lack the capabilities to do so. Second, the formation of local storage clusters helps to push storage as mass scale balancing device which has far-reaching effects on the overall energy system. The formation of storage clusters implies a decreased tendency within businesses to apply energy efficiency measures and shifts the focus to use storage as way to smooth consumption. Third, in the absence of storage, virtual power plants shift the concentration of cooperations on the electricity supply side. Consumption cooperations are created in response to the inefficiency of peak demand power plants. In general, strategic cooperations play an important role in improving the firms planning process [290, p. 81]. Aggregating to cooperations gives firms the necessary certainty and assurance to pursue long term investments in increasing energy efficiency.

Lack of detailed information and missing market knowledge are the main qualitative constraints for companies not to invest in new technologies. The establishment of networks therefore can have a levering role and is an important driver for the developments in the energy efficiency sector. The advantages of those networks consequently range over a continuous improvement of energy balances through an exchange of experiences in a coactive cooperation and competition to meet the agreed objectives.

7.2.2.4 Regulations & Promotion of Energy Efficiency

In times of scarce fossil fuel resources and continually rising energy prices, economic prosperity and competitiveness depend more than ever on the ability to use energy more efficiently. The use of innovative technology holds enormous potential for energy conservation in every field of application. Therefore, the German government focuses on establishing energy policies and financial programs that support investments in strategies which create saving of energy. Although the introduction of new regulations strongly depends upon the decisions of the political parties that are in power, there is a general direction in which policies are moving. These are mainly based upon the political goals of achieving independency of energy imports, encouraging security of supply and fostering environmental protection.

Due to the fact that the governmental regulations and promotion of energy efficiency influence the development and the changes of the business environment, they are of a great importance for companies. Therefore, the tree potential ways of development of this driving force play a big role for companies. In the first projection, as a result of the shifted focus of the government on other fields of responsibility, the energy efficiency incentives and programs are not successfully promoted. Hence, the lack of knowledge about the energy efficiency incentives and the lack of legislative pressure lead to very low penetration rate of the energy efficient technologies in the business environment. The second projection, which is characterized by high governmental focus and strong monetary incentives, especially in the field of decentralized energy generation bring to high usage of efficient energy technologies and mini power self-generators from companies side. Moreover, together with improved technological solutions, subsidies for cooperations foster efficiency. The establishment of this type of system, has a levering role for the formation of production and consumption networks. Compared to the second projection where the fundamental changes of the business infrastructure also depend on the willingness of many companies to be energy efficient, in the third projection, the high legislative pressure plays the major role in the modification of the business environment in which companies have to fulfil certain standards that are assigned by the government.

The importance of this driving force is crucial for the overall energy system. The right combination of governmental measures includes an optimal allocation of public finances budgets. Besides the improvements of operational performance, this can turn energy efficiency into a competitive factor for corporations.

7.2.2.5 Volatility of Energy Supply

Along the way of guaranteeing a secure energy supply, Germany will face two main electricity balancing issues in future. First, the share of renewable energies will rise and leads to a stronger dependency of the energy supply on external environmental influences [295, p. 4][290, p. 75]. Second, a strongly variable load curve results in a need for running expensive peak load power plants. The ability to balance the variability of the renewable sources as well as the power to smooth energy demand will consequently determine the uncertain degree to which renewable energy sources will be used within businesses solutions.

In order to achieve a balanced load curve, instruments like demand response solutions and real time pricing play an important role. Thereby the electricity price is correlated directly to current market conditions. As a result businesses manage their energy supply in a market-oriented way and have incentives to aggregate and cooperate in networks with the aim to optimize profits through shared and hedged risks [303]. While cooperations have the ability to smooth demand and reduce the degree of needed peak load supply, renewable energy sources still rely strongly on environmental influences. The situation of the volatility of energy supply could be changed through the introduction of larger storage capacities. While there is broad consensus that the usage of storage would foster the share of renewable energies, opinions differ if storage will take the form of large scale centralized storage or distributed storage, like within electric vehicles [298, p. 55,57]. Based on that, three different projections can be determined. First, there might be different approaches of companies trying to balance the load curve. However there will not be an effective tool to mitigate the influence of external factors [290, p. 81]. Therefore businesses will hardly install own electricity generation sites. Second, due to the availability of mass scale storage the ups and downs of renewable sources will only play a minor role. Distributed generation and usage of renewable consequently will experience strong growth. Third, storage capacity will not be available to a sufficient extent but international joint networks, as well as emerging cooperations function as a natural balancing device, resulting in feasible degree of volatility in the energy supply [298, p. 38ff, 57] [290, p. 122]. This implies that business are increasingly willing to invest in own electricity generation sites.

Volatility represents a factor of uncertainty that directly interrelates with the risks associated in renewable energy sources. The ability to balance volatility, hedge against fluctuations or store electricity on mass scale is therefore of crucial importance for the further integration of such energy sources within the business environment.

7.2.2.6 Privacy Sensitivity

Through technological progress, for example in the field of ubiquitous computing, new opportunities to collect data and location information are available. This information can be used to optimize processes and coordinate individuals within a system more efficiently. The intensified use and storage of data however carries the risk of data misuse and hence erects systems of control especially when corporations have the chance to exchange data to create detailed user profiles [284, p. 168]. Society is consequently facing a trade-off between managing processes more cost and energy efficiently, as well as securing the freedom of information. On the one hand, technological progress resulting in real benefits might shift society's opinion about the benefit of a more liberalized dealing with personal data [301, p. 8][293, p. 3ff]. On the other hand, data scandals could raise publics' privacy concerns, resulting in increased requests to ensure informational self-determination [301, p. 14]. As further influencing factors socio-demographic developments could play a crucial role. Younger generations as well as a stronger international orientation could for example shape the public opinion in favor of less privacy concerns [297, p. 531 ff]. According to the unstable influencing framework, the data privacy parameter is classified in the group of uncertain drivers.

From an energy efficiency aspect, two dimensions characterize the projections of this driving force. The first dimension is expressed through the degree of privacy concerns related to personalized office systems. The second dimension represents the firm's willingness to outsource information systems, which has a tremendous effect on cost reduction. On basis of the dimensions, two projections concerning privacy issues arise. Firstly, decision makers will face the challenge to moderate efficiency measures that involve personalized office systems that allow for example local tracking of employees in order to increase efficiency [301, p. 4]. Secondly, under the trend of cloud computing, choices have to be made about the degree to which the company shall outsource their information system which contains confidential and sensitive company data. Hereby the dependency on a third party is deterrent [284, p. 201].

In conclusion the willingness to share data will present a driving influence on how well energy efficiency measures are being implemented in the office environment. The degree to which firms will outsource their information system can be viewed as a similar important factor, since it contains a huge potential cost saving and creates flexibility.

7.3 Scenarios

Considering the effects that the driving forces have in shaping the business environment, three possible scenarios arise. Each scenario is an abstraction of a possible future, representing the relationship and interaction between influencing factors and parameters of uncertainty. The developed pictures of the future furthermore outline how energy efficiency within the business environment could develop and emphasizes the challenges and the need for a transformative approach.

7.3.1 Scenario 1: Low Hanging Fruits

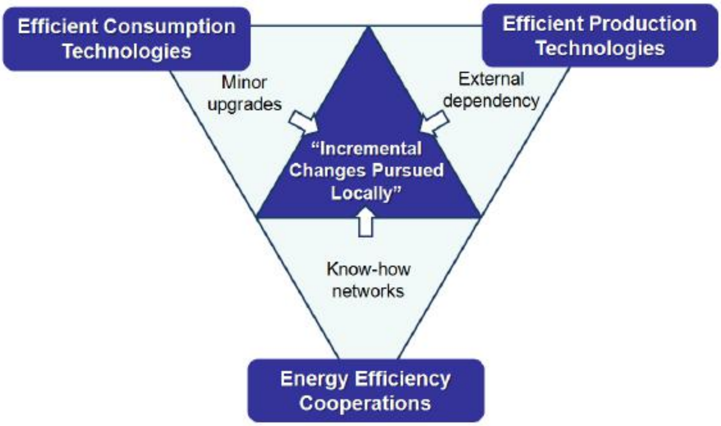

Figure 7.5: Incremental Changes Pursued Locally

Energy efficiency is becoming a more important topic for many corporations. But as efficiency technology generally requires substantial investments and holds factors of uncertainty, companies mainly focus on incremental improvements on the way to more efficient buildings (figure 7.5). Especially energy intensive corporations try to optimize processes in areas, where minor changes have strong impact on energy and cost savings. Early success of components interconnecting ICT and efficiency technologies through automated control systems creates the basis of a smart office to some extent. Generally speaking there is almost no cooperative work between companies. But to some extent small regional efficiency cooperations are built up. These cooperations focus on know-how exchange between companies with same fields of activity, in order to compensate lacking information about better energy efficiency measures and technologies. In terms of power supply, self-production through renewable sources does not achieve the mass-scale breakthrough on a micro-level. Purchasing energy through external supply is still the most convenient way for companies to secure their energy provision.

7.3.1.1 Scenario Description

The energy supply system in Germany is in a situation of change. The measures taken for amending the structure of the German energy mix are increasing the share of renewable energy on the macro-level shows success. A significant part of the national energy supply is covered by renewable energies. Thereby the relevant sources used are wind energy, bio energy and water energy. Especially large electricity producers are hereby important. As the transportation of electricity over long distances is still a fundamental problem due to losses, the lack of sufficient storage-capacity on a large scale to support the system is polarizing the situation. Although coal-burning power plants produce with high efficiency factors, the dependency on imports of the German energy system is still serious. Therefore the extension of renewables is important. This requirement is also enforced by the gradual process of nuclear phase-out.

Although, renewable energies increase their share in the gross energy production, on the micro-level the majority of companies across the board are hesitant to invest in own energy production capacity. Self-production of energy is efficient due to significantly lower transmission losses and stronger independency for companies. Distributed generation is gaining higher importance, but in general, companies rely on external supply. Yet, it is not profitable enough for many companies to use own renewable energy production capacity. Furthermore firms stay inactive due to a lack of information. Therefore the mass scale break-through of energy self-production by usage of renewable sources is not achieved. Efficient energy production technologies for facilities require relatively high investments. In addition technological limitations undermine the situation. Deficient financial incentives by the government, as well as limited technological efficiency result in long pay-back periods. Thus entities focus on investments which optimize short-term profits, rather then on the search for alternative investments. The risk and uncertainty associated with this dependency on external factors is influencing the managing decision-makers in the corporations.

However, the moderate growth of renewable energies increases the volatility of the energy supply. In order to coordinate the fluctuating electricity supply and demand, the betimes investments in grid, equipment infrastructure and modern information and communication technologies build the basis. Automated control supports a system where energy is used in a demand-oriented way. Intelligent smart meters, which act as an interface between the digital data network and the power grid, play a pivotal role and are widely-used by individual households and companies of all branches.

In addition to this, the processes of the modern energy system rely on an increasing relevance of new market places and market appliances. Flexible and load-dependent tariffs are examples for opportunities, how businesses of all sizes and branches can improve their cost efficiency and external supply of electricity. Energy intensive corporations from industry and service sector are trying to improve their energy management by a minor rescheduling of energy intensive processes, according to price signals.

The merger of the energy and ICT industry, in combination with the stronger competition within the value chain enables established utilities and start-ups in these sectors to extend their range of products. This is supported by a high level of environmental awareness and an intensive discussion of environmental problems and developments within the general public. Energy providers, vendors of services and manufacturers of devices (e.g. energy efficient consumer electronics) are active by offering new products and business models - addressing corporate, as well as end customers.

Thus, new technologies in the area of efficient processing and building efficiency in the business environment are available. At first the focus of energy efficiency activities on the corporate level lies on the elimination of unnecessary use of energy. Building technologies is a field of activity, where high potential for energy efficiency exists. Companies owning big facilities and operators of office buildings rely on efficiency measures, where minor changes have the most impact. Hence the installation of more efficient lighting systems for example LED and measures for reducing heating and cooling, like improved insulation, tackle the main causers of energy consumption.

As far as the efficiency measures concerning the IT technology are considered, they do not exceed the replacement of old equipment. In particular energy-saving hardware and data-management systems are of interest in this area and companies are continuing to use own calculating capacity. Apart from that, automated systems contribute significantly in decreasing energy usage, as they are able to monitor energy consumption, interconnect the energy efficient equipment and control the activities. Such systems form the framework for smart offices, which in turn could be even more efficient with a comprehensive restructuring approach. Hereby it is important to mention that privacy concerns of employees are high and the willingness to provide personal data to automated systems is a restrictive factor.

As a result from these developments, in most cases company specific infrastructure is not ready for the product variety and possibilities created by the merger of ICT and Energy. As a consequence, re-design of whole buildings and systems are rarely seen across the board. On the other hand large corporations of the industry sector, as well as energy-intensive medium industrial firms are willing to undergo successive steps for energy efficiency regarding their production processes. In this regard not only the investments in lighting, heating, cooling or above stated cross sector technologies are relevant. For instance motor systems and compressed air machines hold many industrial processes alive and therefore represent potential for technological improvement.

Overall, the technical potential that enables increase in energy efficiency is by far not used enough. The reason behind that is that the fundamental structural changes require high investments in expensive technology and contain risk and uncertainties. Organizational measures are cheaper and in most cases easier to implement. Although energy policy should be on top of the political agenda, there is still a lack of governmental activity in this sector. The allocation of the limited national budget is also needed in other fields where governmental support is extremely necessary to stabilize national economy. The distraction of fiscal policy to some extent is visible due to insufficient communication and promotion of efficiency measures. Companies focusing on incremental changes with high potential are underprovided with detailed information about the running programs and monetary incentives.

However, generally speaking there is almost no coactive collaboration between businesses or strategic networks. The success of efficiency measures depends on specific branches, combination with other efficiency technologies and the regional circumstances. Only a small share of firms is willing to take more action in the efficiency question. So to some extent, mostly firms with similar needs, operational background and regional characteristics group up as cooperation with the aim of increasing efficiency. They set up a pool of know how and learn from each others experiences. Moreover efficiency targets are determined on group and individual level. Due to the establishment of such networks and the technological progress, new data privacy concerns arise. However confidential information is kept on cooperation level, the willingness of companies to provide useful information highly depends on the expected value.

7.3.1.2 Weak Signals

There are different factors indicating the occurrence and characteristics of the “Low hanging fruits” scenario. Firstly the high penetration of installed smart meters at households and corporate level shows the development towards transparency and represents the ability to have direct impacts through changes of usage behaviour. Especially real-time pricing models build on this requirement. Secondly, an unfavourable development of national economy can indicate a distraction of fiscal activity on non-energy related topics, or rather a loss of governmental focus within the energy system, so that running programs are not sufficiently successful. This can be initiated by a crush of oil prices, market collapse, terror attacks, epidemic diseases or social problems of national impact. Since there will be no sufficient incentives for the companies, companies will have to find another way in order to address the energy efficiency problem. The know-how cooperations between firms can become a major tool to solve this problem. Lastly, although data scandals lead to a higher degree of data sensitivity among employees, companies that are part of the know-how cooperations share their data on very high level and in that way avoid the high privacy issues with the employees.

7.3.2 Scenario 2: OptiMax[2]

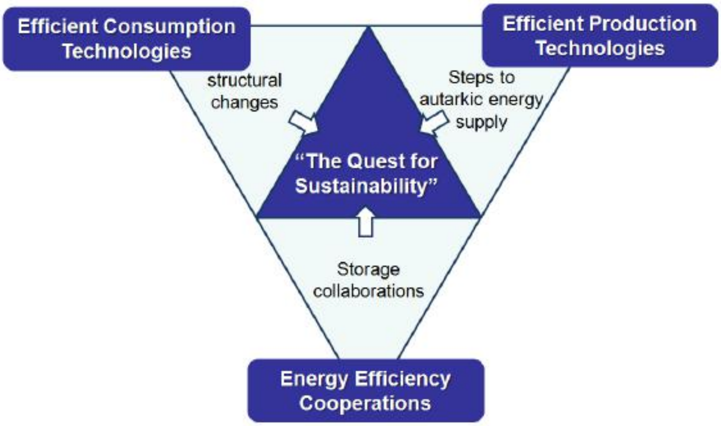

Figure 7.6: The Quest for Sustainability

Since decisive factors play together sustainability is reached in scenario 2 (figure 7.6). Technological progress, together with the implementation of storage leads to a major boost of renewable generation sources and structural changes in the business environment. Cooperations among companies are focus on the formation of storage clusters. As a result higher energy efficiency is achieved.

Energy efficiency is an important topic for companies. This development is closely linked with the increasing autarkic character of some businesses concerning power generation via renewable energies, which is strongly supported and demanded by the government. These incentives and demands also enforce several developments in consumption technologies. ICT systems and data centers are outsourced into the cloud and smart offices which implement personalized systems are introduced. Additionally, office buildings and processing facilities are greatly improved in area of energy efficiency. Nevertheless, the importance of smart storage systems, which allow highly efficient energy consumption leads to a decline of the prevailing efficiency, consumption and production cooperations. As a consequence the OptiMax scenario is based on favorable combination of driver outcomes.

7.3.2.1 Scenario Description

The scarcity of resources has a considerable impact on businesses. The increasing lack of fossil resources results in rising energy prices. Hence it is essential to use the generated energy more efficiently, decrease consumption and focus

[2]Neologism for the combination of the words optimization and maximization

on electricity generation from renewable energy sources. Furthermore it is not surprising, that the rising prices directly affect the company's stakeholders, especially the government. The administration thus wants to decrease the national dependency on energy imports in order to avoid the risk of becoming victim of supply boycotts or arbitrary pricing. In addition, the legislative body has to guarantee a constant energy supply for its citizens and industries. As a result Germany continues to greatly invest in power generation technologies based on renewables and particular focuses on raising the degree of efficiency. Consequently, the already high share of renewable energies in electricity production experiences a strong and further growth.

Unfortunately the energy supply from renewables is volatile, due to the fact that the power of sun and wind is not constantly available. This problem has been addressed via real time power pricing. Here prices vary according to the time of the day and the amplitude of the load curve. On this way the power demand could be influenced. The goal is, to decrease the expensive and inefficient peak in demands. With the integration of mass scale storage the balancing problem can be addressed directly. As a consequence real time pricing looses in importance as balancing device. Furthermore, the influence of renewable energy volatility is lowered on the industry's micro and macro level.

In addition to these measures, German government greatly funds research projects, which are dealing with efficient energy use. Since private households have been most inefficient in energy use, the government has already started programs with subsidies and monetary incentives in the past. Furthermore laws have been passed in order to enforce significant changes in consumption behaviour. These efforts are starting to pay off, leading to increasing private distributed generation, energy exchange in micro grids and more efficient energy usage. Similar measures have been taken for medium to large scale businesses and industry, but as a matter of fact, these ambitious energy efficiency measures have not been implemented as fast as in private households, due to necessary investments and lack of know-how. As a result, companies are encouraged to extend the usage of distributed generation sources through monetary incentives. Furthermore the government uses the tool of legislation more intensively to push structural changes, mandatory efficiency plans and standards. This leads to an increased penetration of efficiency technology and decreases the influence of profitability as single decision criterion for firms.

A combination of factors like environmental awareness, scarcity of resources as well technological progress in the area of energy efficiency have great impact on people's opinion how social responsible companies should behave. Together with governmental legislation this obliges firms to actively invest in advanced technologies. Companies are hereby using new approaches and know how in the area of efficient office buildings, processing in production facilities and distributed generation. Consequently structural changes and major upgrades are introduced. Main driving factors are the elimination of unnecessary usage of energy, optimization of processes and improved energy efficiency across the board.

The external dependency on third party energy supply and the rising prices lead to a “sustainability thinking” in the business environment. In order to secure their supply more and more companies start to build up own power generation facilities, mainly based on renewables. As a result distributed generation is not only driven by private households, but is strongly enforced by businesses, showing the success of the governmental actions. Thanks to a technological breakthrough which has been achieved in the field of distributed electricity generation, investments in firm owned generation sites are easier to finance. This effect is strengthened through a higher efficiency of renewables and leads to an increased number of distributed generation among firms. This development is not limited to specific branches but predominates in business sectors across the board. Furthermore a significant number of companies are getting close to operate autarkic and therefore independently of centralized power plants.

This progress is also levered by network effects that help to hit a critical mass for successful cooperations. These cooperations are divided into three categories: efficiency, consumption and production cooperations. Efficiency cooperations aim at a more efficient energy use within companies. To achieve this, the involved companies assemble a kind of taskforce, which deals with the exchange of know-how between the members. This institution plays a vital role for the participating companies, due to the social responsibility and governmental incentives and regulation. In contrast to that the consumption cooperations, which for example allow cheaper energy purchases, are hardly represented, due to the very high degree of distributed generation. Therefore power is already generated “for free” and does normally not have to be bought on the market. Considering the production cooperations, many companies are part of virtual power plants to secure the supply among each other on the one side and sell possible surplus power on the market. These cooperations are situated within a strategic network of the participating businesses, allowing them to gather more incentives and benefits from the state and the public. With the implementation of mass scale storage the other forms of cooperations loose in importance.

Regarding energy storage, the intense research in the field of energy storage shows progress. Small capacity storage systems are already on the market and are partly used in private households and micro grids. In addition large scale storage systems suitable for medium- to big sized companies are currently introduced and will have a major impact on the current strategic networks in the future. The intermittency of renewable energies is decreased to a level in which it does not represent a serious barrier for their wide spread use anymore. Therefore the characteristics of cooperations are about to change and the importance of production and consumption partnerships will decrease greatly.

Instead, local storage clusters are emerging, which are either shared among cooperation partners or are restricted to one business. Furthermore, storage greatly contributes to the companies urge for sustainability.

The issue of efficiency in combination with computing and data processing influences companies, too. Data centres and information systems, which represent a considerable large cost factor, are outsourced into the cloud. These factors include labour, hardware and maintenance costs as well as high energy consumption. Further optimization done by companies includes the established personalized offices, which are able to adapt to the personal preferences and behaviour of the employee. At the same time personalized systems use that information for a more efficient power use of every employee.

As a result of the high penetration of ICT and computing power throughout the business environment, public discussion of ubiquitous computing versus data security and privacy arise. Since businesses share and have been sharing information within their cooperations, companies have relative low data concerns. Due to the high energy and cost saving potential, more advanced encryption methods are available as a result of intensive research on data security in smart grids. In contrast, the general public's and the employee's opinion is differing. Younger generations tend to share private information more willingly, whereas employees from older generations are sceptical towards the privacy loss.

Concluding, the environment for new products and services is prosperous. High governmental support, acceptance of ubiquitous computing and the restraint on companies to become more efficient are factors which furthers innovative research. The merging of the energy industry with the ICT sector creates new business opportunities. This leads to extended product portfolios for existing companies and a variety of new services offered by start-ups.

7.3.2.2 Weak Signals

There are several factors that indicate the occurrence OptiMax scenario. First of all the raising popularity and success of the cloud computing paradigm clearly points the way to the willingness of individuals to hand over information to a third party - to increase convenience and save costs. This is illustrated already today through the growing demand of businesses for scalable IT infrastructures that are very cost effective and high performing. Closely linked signal is the intensification of outsourcing activities, since cloud computing usually is viewed as outsourcing of information systems and data canters. This however is not limited to the ICT sector but can be found in all parts of the value chain.

7.3.3 Scenario 3: Act Locally Think Globally

As shown in the figure above (figure 7.7), scenario three describes a possible world in 2025 in which firms find the necessary requirements to pursue fundamental changes within their business structures. Firms furthermore actively follow the approach of intensive usage of strategic cooperation to balance risks.

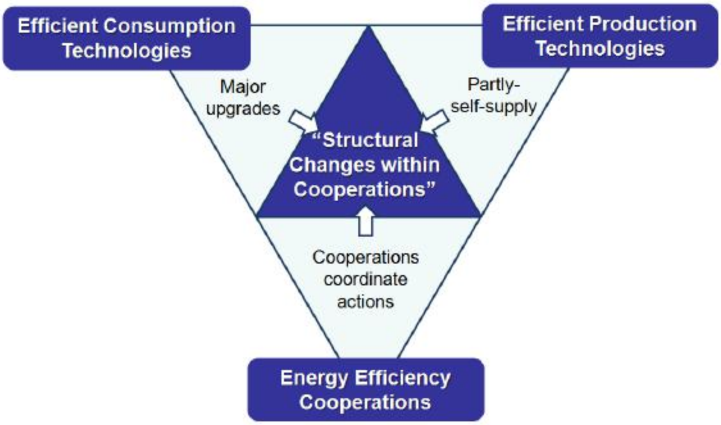

Figure 7.7: Structural Changes within Cooperations

Energy efficiency measures hold substantial untapped saving potential for small energy intensive and medium sizes firms or larger corporations. Technological progress in the fields of efficient electricity consumption and efficient electricity production enables firms to restructure processes and business on goings. In the area of consumption technologies emphasis is put on the implementation of efficient applications, which are connected over an ICT network to create an automated system. This kind of system is able to effectively control efficiency technologies and integrate those into the restructured processes. So called "green data centers" evolve and foster the restructuring of the IT. Furthermore facilities are redesigned with the goal to increase efficiency. New constructed buildings circle around the idea to build the facility according to efficient manufacturing processes. Additionally companies install firm owned power generation capacity. This can be seen as a clear trend to a higher degree of sustainability. However, firms are still dependent on external power providers. The formation of cooperations is interrelated with the evolvement of distributed generation sources as well as the willingness of firms to share information among a company networks. On the supply side virtual power plants act as method to balance the intermittent renewable energy sources. The scarcity of fossil resources and continuously rising energy prices impose strong cost restrictions on firms across the board. These developments consequently create high concerns in the business environment. The rising prices furthermore directly affect the firms stakeholders like the general public or the legislative body.

Taking everything into account, companies act locally, by implementing energy efficiency measures and think globally by aggregating in networks and cooperations.

7.3.3.1 Scenario Description

Companies are willingly restructuring core processes since taken energy efficiency measures create real benefits. Those lie either in the fields of increased monetary profitability or a raised firm friendly attitude of various stakeholders. High environmental awareness of the general public animates companies to have an eye on the carbon footprint as well as increase efficiency. Companies hereby take into account that the broad public has a major influence as a stakeholder. As a response emphasis is laid on implementing environmental friendly applications. The usage of renewable energy sources makes a valuable contribution to environmental protection and is subsequently deployed to promote the achievements through an eco-marketing effort. While the ability to use eco-marketing represents a considerable positive side effect of introducing efficiency measures in the business environment, the main decision criteria for investing in new technologies remains the profitability.

As mentioned above, important stakeholders, like the general public for example, are very important to the companies. The reason for that, is that they can have a major influence on firms through two possible channels. First, they directly affect the businesses in deciding which goods to buy or to boycott. Second, the public applies indirect pressure in form of governmental action. The government hereby has several options to take action. First, it uses rather soft tools like increased investments in R&D or energy efficiency consultancy. Hereby, efficiency advisory through governmental bodies proves to be especially popular among small and medium sized firms. Second, the administrations apply monetary incentives which can however be viewed as critical in terms of European competition law, and therefore can only be used to limited extent. As ultimate measurement the government is able to enforce standards through legislative pressure.

Companies are however eager to avoid strong legislative restrictions and therefore pursue a change of strategy beforehand. Consequently, energy intensive small- and medium-sized companies as well as larger corporations start optimizing their assembly processes and improve the efficiency quality of their respective buildings. Besides the elimination of unnecessary usage of energy, firms are furthermore willing to introduce structural changes and major upgrades.

These upgrades include renewable energy sources, leading to an increasing share of distributed generation. Further firms follow this trend and install renewable energy sources to reduce the dependency on third party suppliers in the long run and to avoid large transportation losses, as well. Since a distributed generation system requires relatively high up-front investments, renewable generation sources are mainly installed by medium sized companies and larger corporations, which fully profit from technological progresses in recent years. However, also small energy intensive firms start to invest in own production sources. Here, the actions of the government to provide the small firms with sufficient financial resources through the financial markets, falls on a fruitful ground. After a certain number of distributed generation sources are installed, a critical mass is reached. From that point on the energy production from renewable technologies is on a larger scale, which results in lower prices. Furthermore network effects start to come into play. It is now easier for firms to join strategic networks. Both consumption cooperations and production cooperations have a higher number and greater variety of firms, which leads to a greater balancing power and smoothing of the load curve. This attracts even more firms and lowers the barrier to invest in renewables since cooperations provide its participating companies with a more stable planning horizon. Consequently the risk of investing in a technology is lowered.

Since, production cooperations are in vogue, the number of virtual power plants rises. The main goals include to aggregate distributed generation sources and to better balance the volatility of renewable energy sources. Consumption cooperations are present as well and aim at shifting consumption away from times of peak demand. With the help of a comprehensive plan, these cooperations manage to balance the energy load curve by adjusting energy intensive processes according to the electricity price. This decreases the number of expensive and inefficient peak power plants. Cooperations furthermore create a platform to exchange knowledge about efficiency potential and represent a pool of information all participating firms can profit from.

The strong exchange of knowledge implies an intensive exchange of information for strategic cooperations. Thus new privacy issues and questions arise. Firms are increasingly willing to share internal data related to energy and efficiency improvements as long as the information is kept on cooperation level. Among employees different attitudes are present. While most workers are still reluctant to share information others are willing to contribute work related data to increase energy efficiency across the board.

But not only efficiency cooperations are enjoying increasing popularity. Two technically important features are developed and provide the ground for the flourishing growth of consumption and production cooperations. First, an improved two-way communication grid allows a full integration of self-production systems. Second, the sophisticated support of the ICT enables a comprehensive strategy which coordinates sudden changes in supply or demand.

Since renewable energy sources undergo a rather strong growth, increased problems with volatility arise. Together with the fact that the load curve has high altitudes, making the use of expensive and inefficient peak power plants inevitable. Consequently the government has introduced a mandatory usage of real time pricing models and demand-oriented usage of electricity to give consumers incentives to shift electricity usage to times when it is abundant.

Another way to address the volatility problem would be the use of large-scale energy storage systems. Unfortunately, with the lack of mass scale storage other ways have to be found to balance the load curve. The most promising one for companies lies in the creation and extension of joint international networks. Here, energy providers make use of the fact that there are randomly the same weather conditions across the European continent. This is taking into account that advanced technology is able to reduce electricity transportation losses for longer distances. This consequently enables a strengthening of security and stability within the net among neighbouring countries. Hence this progress results in a higher degree of electricity imports and exports.

Due to the indispensable investments into renewable energies, firms choose renewable generation sources which best fit into their requirements and objectives. To have a hedge against the intermittency of electricity generated by wind turbines and solar heating systems, biogas power plants and hydraulic turbines are used to guarantee a basic load supply. Firms are increasingly trying to use the by-product of industrial production to generate electricity e.g. through the recovery of waste heat. Additionally vice versa is done in using the by-product of electricity generation for example for heating.

Furthermore significant energy conservation potential is revealed through enhancement of facilities. Hence, many companies consider changes of building characteristics and are willing to introduce major upgrades. Emphasis is put on improvements through the installation of advanced technologies. Innovative solutions for insulation and effective ventilation are used to create more efficient heating and cooling processes. Further examples are energy-saving lighting technologies, which are combined with automated systems for optimized exploitation of daylight like modern facade technologies. In addition, sensor networks enable the optimized control and adjustment of the light- and air-conditions. Thereby, an automated system is managing the processes within the facilities of several corporations. Even more improvements of energy conservation in the offices environment are possible through personalized systems. Hence, the integration of employees and their interactions among each other as well as with the efficiency appliances are needed. Consequently privacy concerns of employees come into play and act as a restrictive factor. From an employee's side of view, automated systems are therefore preferred compared to personalized systems. Since most employees are unwilling to provide private data, personalized system are rarely seen. Nevertheless some companies manage to convince their employees switching to new systems. Reasons include for example, that these are able to adapt to the user's preferences and behavior, thus enabling more comfortable workplaces. Due to that, people perceive real benefits of the new approaches and are thus willing to share more personal data. Furthermore, younger generations give up data more easily, which also contributes to the slow but steady development towards personalized smart offices.

As described, a large number of technologies and devices show high efficiency factors and involve low-operating costs, which lead to shorter amortization periods. A vital factor for the ongoing implementation of efficiency measures through companies moreover is a sufficient, timely and stable governmental program funding. Mechanisms are created that increase incentives for business customers to take lucrative opportunities of energy efficiency, for instance by special financing mechanisms. Moreover, taking into consideration economies of scale, modern energy efficient technologies appear to be more financial acceptable for the business environment. Therefore, particularly large and medium firms, but also small energy-intensive companies of all industries are willing to invest in efficiency measures that require structural changes.

As soon as it comes to the most expensive, but most efficient way to introduce structural changes, the whole-building design represents a comprehensive approach, aiming for implementation and automation of complementary building technologies. Buildings with low stand-by energy and increased life-cycle are resulting of such energy face-lifts. Above all, most newly built facilities follow new standards and are optimized concerning their energy consumption profile. Thereby overarching building solutions increase both the efficiency and the value of buildings. These solutions furthermore contribute greatly to the reduction of greenhouse gas emissions. The public opinion and eventually the end customers honour the efforts that companies take upon them to mitigate the effects on climate change.

A good addition to the above optimizations can be found in operational processes, which are a field of activity where especially industrial corporations focus on optimizing their assembly processes. Under consideration of production planning and scheduling, processes are tuned for efficiency. This is done by including advanced components as for instance better controllable motors, pumping systems with higher coefficients or utilization of recovered waste heat.

Moreover, the deployment of innovative processing technology contains enormous potential for energy conservation. Therefore, the installation of shared green data centers is a step further to collective and more efficient energy usage. The shift of the companies from local computing to centralized green data centers involves two great advantages. First, there is a major technical benefit since a highly scalable architecture is offered. The high performance enables a centralized processing solution for a wide range of software related tasks. Second, substantial cost savings are possible. High competitive pressures in the various sectors lead to the importance of just-in-time processing. Companies are adopting this approach in combination with their own green data centers, in order to gain a competitive advantage on the market. This fusion enables a significant acceleration of the internal processes and the mutual interaction between them. In order to switch to this new approach, companies are re-arranging their business processes that are not in direct interaction with the customer - like procurement and marketing or sales. The rearranging is done around a high performing and interconnected IT infrastructure which is provided by their data centers. Furthermore, other parts of the value chain, like suppliers are moving closer. Hereby transaction costs are reduced. Furthermore suppliers are in some cases even fully integrated into the businesses through connection into the companies' information infrastructure. This results in a strongly improved level of communication between the entities.

These new models enrich the business environment, leading to new products and services in energy efficiency. Through the merger of the energy industry with the ICT sector new business opportunities are created. Extended product portfolios and a variety of new services addressing end customers and companies arrive on the market. Due to a high number of cooperations among firms from different areas of expertise, innovative cross-sectoral services arise. Those new products are fit to be easily embedded in the infrastructure. This in return helps companies to save costs, enhance productivity and increase efficiency.

When looking at this scenario, it becomes obvious, that four major needs are driving the companies. The first factor is the need for sustainability. In order to reduce the dependency on third party energy suppliers and the rising energy prices, companies have the following possibilities: The partly self-supply with energy through renewable energies and a more efficient energy use. A firm's image, as a second need, is also very important. For a good image, companies have to satisfy their highly environmentally aware stakeholders, with eco-friendly measures and products. Moreover, the own reputation is vital for successful interactions on the market. A third factor is profitability. In order to raise it, companies need to gain competitive advantages. This can be achieved with the help of the new services and products within E-Energy. A further obvious way to receive a higher profitability is to lower the own costs. Finally, a company has to deal with the existing consumption, production and efficiency networks and has to figure out, how to benefit most from them. Last but not least, the need for convenience is a forth factor. This factor is especially important, because on the one hand the market situation is very complex and on the other hand they want to focus on their core business. Due to the complex situation, transparency of the market is essential in order to successfully act in it. Therefore, consultancies support the companies by giving them orientation for the market, in order to make it possible for them to focus on their core business. Nevertheless, a lot of know how is required when a business tries to act in a new market, which lead to a quite high chance of failure.

As a result of these four factors and needs, companies badly need support to maximize benefits within this scenario. The presented product idea is a service platform that perfectly addresses these four issues and supports businesses to act locally and think globally.

7.3.3.2 Weak Signals

There are several arguments, that indicate the occurrence of the act locally think globally scenario. The greater standardization in ICT and energy industry allows an increasingly eased connection of both fields and consequently levels the ground for a successful merger between both industries. This can be seen in a rising number of publicly announced cooperations or joint networks between firms from both areas. The energy sector furthermore picks up the speed of innovation of its ICT partners. This in consequence leads to a modern bi-directional energy grid which allows the full integration of distributed power plants. Firms are increasingly willing to form strategic alliances and cooperations in order to join forces. Thus the number of third party firms that offer services for efficiency- consumption- and production cooperations raises.

Moreover energy efficiency remains a frequently discussed topic in the general society as well as in journals of leading research institutes. This fact is also expressed in the strong attention governmental bodies dedicate this subject. Furthermore partnerships between governmental sponsored activities and businesses emerge. As an example the model regions across Germany could be named. The need for environmental actions is widely accepted across all German parties and broad consensus exists that improvements of the energy grid in a concentrated European action are necessary. Consequently a country overarching joint network is the aim to better balance the volatility of renewable. This can be seen in the strengthening of country connecting transmission lines. Unified governmental actions within in the European Union lead to efficiency standards for businesses and therefore takes disadvantages for specific national firms away. Last but not least, a high amount of monetary subsidies flows into R&D. This additionally fosters the exploration and implementation of energy efficient technologies and facility appliances.

Concerning future developments, the lack of mass-scale storage will play an important role. Since there will be no sufficient possibility to store generated electricity, another way has to be found in order to address the volatility problem of renewable energies. Therefore, cooperations between companies will become a major tool to solve this problem. Moreover, the high environmental awareness of the general public will gain more and more impact on businesses. Due to the fact, that they encounter a high pressure from their stakeholders to be more ecological, companies have to optimize their processes and products towards energy efficiency. As a result, this leads to the implementation of new technologies and the upgrade of old ones, in order to achieve the efficiency goals. Last but not least, the rising energy prices encourage the firms even further to be more energy efficient. But furthermore, as companies are dependent on third party suppliers and their prices, they start to invest in own sites of distributed generation. This will lead to a major growth of market share of renewable energies, leading to lower prices of the technologies and as a result attract even more businesses. Consequently, cooperations become more important concerning the volatility problem. Nevertheless, this development leads to a new problem: the adjustment, balancing and controlling of energy related topics inside the cooperations, which can be solved with the ECOperation service idea.

7.4 Service Idea: ECOperation

ECOperation manages energy related questions within a network of firms. While using the tool of forecasting it estimates the electricity demand as well as the supply. Furthermore it analysis the load curve of single firms, to reveal energy efficiency and cost saving potential. The detailed knowledge of the load curve is applied in negotiations on the energy exchange market and additionally used for an effective and efficient coordination of the network.

7.4.1 Matching of the Service Idea with Scenario 3

Basis of ECOperation is the world described in scenario 3 - think globally act locally. Here medium sized companies and larger corporations have started to produce their own electricity through different generation possibilities. Firms concentrate on the production source that is most profitable, for their requirements. This approach however has the disadvantage that the firms are exposed to the intermittency of the renewable energy sources. With a lack of efficient mass scale storage companies try to balance the volatility of the renewables through the formation of cooperations.

The need to cut costs as well as pressure of various stakeholders has induced most firms to actively implement energy efficiency measures. As a result, automated systems have been installed. Those are capable to control efficiency technologies, meter the electricity consumption and store the information in a database. ECOperation builds on this infrastructure, to estimate the load curve and to follow through with the analysis. Firms and employees are moreover willing to share information with a third party if the perceived benefits are real. The high environmental awareness of the general public calls for business solutions which continuously increase energy efficiency. ECOperation therefore aims in this direction and consults companies how to raise efficiency and more importantly helps firms to concentrate on their core businesses.

7.4.2 Service Description

The value proposition of ECOperation consists of a core service and value added services which act as complementary force. Both the core and added value services rely heavily on a working infrastructure which enables data gathering and data analysis.

7.4.2.1 Core Service

ECOperation builds its core service on three main pillars, as shown in figure 7.8. The first competency of the offer lies in load curve forecasting. Here the service idea tries to estimate the firm's electricity demand over the day and compares the load curve to the estimated supply from the firm's generation site.

As a result ECOperation, gets active on the energy exchange market and buys electricity contingents for a long run - according to the estimated aggregated undersupply of electricity. ECOperation is able to bargain at the exchange market or sign long term OTC's under favorable conditions since it is able to provide the energy contractor with certainty of planning. It can guarantee that it will not exceed an agreed level of electricity demand and furthermore buys long in advance.

The second main competency lies in the field of quick reaction to sudden changes. In case of an unexpected undersupply ECOperation has two possible options. On the one hand it can get active on the short term market, to buy electricity contingents in addition. On the other hand it can regulate down the aggregated demand, through cutting down the energy usage of single firms. This will be done in a predefined way so that firms will not be taken by surprise. Which ever option it chooses, depends on the current prices of the electricity spot market as well as on the profitability of the firms.

The third field of expertise lies in energy efficiency consulting. From analyzing the precise load curves of every firm, ECOperation can derive individual recommendations, and reveal potential energy savings. It can furthermore demonstrate how cost efficiency within the networks can be raised, through an increased coordination of working hours of the participating firms. Here the focus lies on the question how single load curves can be shifted to achieve an optimal network load curve.

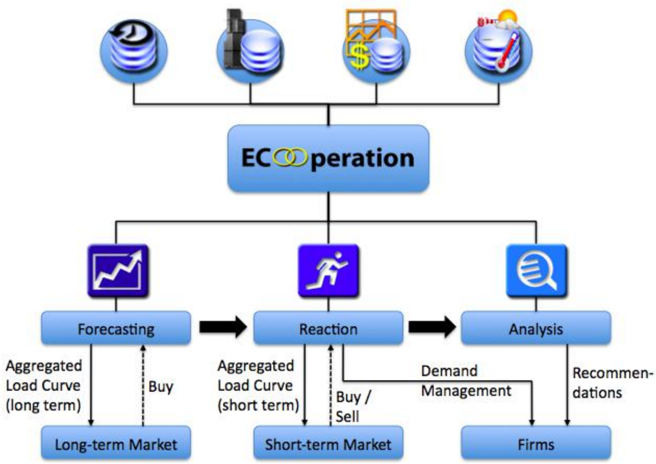

Figure 7.8: ECOperation's core service

The core service therefore lies in managing electricity supply and demand of the participating firms within region wide networks. ECOperation furthermore increases energy and cost efficiency through coordination and consultancy. The firms of the networks are therefore enabled to concentrate on their core business. As an advisory house close contact to the customer firms is very important for ECOperation. To support communication to and among customer firms, ECOperation can install an online platform.

Figure 7.9: ECOperation Mockup

Here the participating firms gain detailed access to the analysis and recommendations made by ECOperations. They furthermore have the possibility to contact other firms of the network. Decreased costs, energy efficiency and convenience are however not the only value, ECOperation is able to offer. Adding up to the core business idea, are the value added services.

7.4.2.2 Value Added Services

ECOperation combines a variety of firms in its network. All of those firms have made different experiences with energy efficiency measures. It is consequently, a worthwhile plan to enable an exchange of expertise from which all members of the network can profit. Furthermore ECOperation could create a strong brand name and start a nation wide marketing offensive from which all regional networks could profit. Thereby it would give its member firms a platform to market their energy saving achievements to a wider public. For the firms this can be a decisive factor to differentiate from their competitors – especially in times of high environmental awareness. Within the cooperation it would furthermore be possible to create a sort of competition among the member companies. The top ranked firms could use the results to increase the attractiveness towards employees and customers. The amount of overall saved energy could flow into the network wide marketing strategy.

Summing up, ECOperation can create complementary services, to increase the value of its core offer, through setting up a nationwide marketing campaign and through promoting a knowledge exchange among the member firms. After having explained what ECOperation offers, the question what technologies and processes are necessary to make the service idea run, are discussed.

7.4.2.3 Data Gathering and Analysis Infrastructure

Collecting and analyzing data forms the basis for load curve forecasting. In order to react quickly on sudden changes in the energy supply, an effective data gathering system and an appropriate infrastructure for data analysis is an essential part of the service idea.

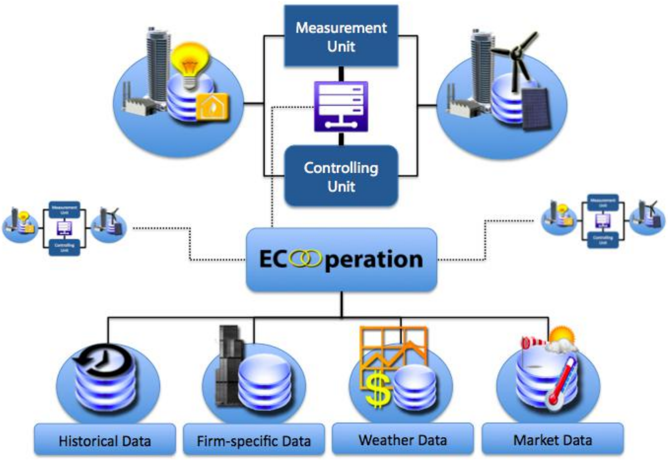

Figure 7.10: ECOperation's data gathering and analysis infrastructure

As seen in figure 7.10, data gathering takes place at different locations and levels inside ECOperation. First of all, data is collected internally from the customer firms via specialized sensor networks and smart metering. The level of detail, meaning the size of the monitored areas, depends on the size of the building or production facilities in correlation with the desired rate of measurement and analysis. Hence, a balance has to be found between the accuracy of measuring energy consumption of as many devices and rooms as possible and the increased costs for metering. The accuracy can furthermore be raised through including employee related data. As an example the number of absent workers in an office or more detailed information about production processes of industrial companies can be mentioned. As a result ECOperation tries to collect as much data as possible to enhance the prediction model. As a result, the trade-off has to be determined on a case by case basis. To gain the necessary information the service relies on an automated system for energy related data acquisition within the firms. Different lighting, heating and ventilation devices are connected within this automated network to a smart meter combined with a sensor network. The collected data includes information about power consumption of the specific efficiency technologies used, as well as office devices like computers, printers and copy machines.

In addition to the general data, more specific information are part of the model calculations. These information covers three different domains. The first one is company external data, including weather forecast and energy market information. The weather information includes insulation, hours of sunshine, cloud movement, as well as direction and speed of wind, for example. The market data analysis prices and their development on both OTC and energy exchange markets. The second domain handles company specific and general historical data. The business related data contains historical consumption or production information that can occur under certain social, economic or environmental conditions. These information are also vital for the further development of ECOperation's prediction model due to the learning effect. Additionally, external general influences on the company's power consumption and production are taken into account. The third domain deals with current firm specific data, which is updated in short intervals, in order to ensure ECOperation's quality of service. These data includes specifications of the customer's energy production technology, like the degree of efficiency, amount and duration of power consumption within production processes. Furthermore information about production planning, design and profitability is needed.

All this information is analyzed within the ECOperation's infrastructure. The system is highly interconnected with the infrastructure at the customer's site via high speed data connections. The portfolio company's architecture includes measuring and controlling units, which collect the businesses' internal data and provide information to the intelligent systems that are able to control general efficiency technologies production processes. The customer's data centers are used as intermediary systems in two ways. Firstly, they store and forward the measured information from the according units, flowing from the customer to the service platform. Secondly, they manage the delivery and execution of the control commands to and at the controlling units, coming from the service platform. Consequently the prediction and the resulting actions are calculated within the service platform and are based on statistical and mathematical models, interpolated and augmented information, specific and general internal data from the companies and external information, that is acquired via interfaces and connections that are situated between ECOperation and the according providers.

7.4.3 Customer

While a good service idea is the basis of a running business, the customer relationship is the key to succeeding in a competitive environment. Below, an overview is given on which customers ECOperation should concentrate what customer desires are addressed and how a successful relationship could be build up.

7.4.3.1 Target Customers

ECOperation manages a network of regional firms. Fundamental for the success of the cooperation is the right combination of companies. Goal is it to create a portfolio of firms which have complementary characteristics. Firms are selected on the basis of three main criteria.

A first selection criterion is the ability of single firms to contribute to the construction of a load curve, which is optimal for the entire network. Hereby a variety of firms, from the service sector over to the manufacturing industry are feasible customers. When determining the target firms, it is furthermore important to keep in mind, that the tool of demand management to balance the load curve can be used effectively. Hereby the company's potential, to shift or cut energy consumption in times of peak demand is crucial. A second decisive point is the aim to create a levelled electricity consumption to soften the effects of intermittent renewables. This is especially important since companies will focus on building up only that generation source which promises the highest profits for their requirements. Answering the question of how to segment the right target group, a third crucial factor plays a determining role. Especially for building up a nationwide brand, which stands for environmental energy savings, the companies' respective internal eco-culture and the products offered to the end customers are important.

The size of the networks is limited due to two constraints. First, the distance between the companies of the cooperation is restricted through an upper limit - at the point where transportation looses exceed a critical value. Second, the number of firms within the regional networks is bound to the operating performance of the service platform.

Concluding, one can say that ECOperation will focus on medium to large sized firms which have set up own electricity production plants and which are willing to join forces in order to increase profits. Furthermore the ability to contribute to an optimal load and demand curve plays a crucial criteria. After finding the target customers the next step for ECOperation is to indentify benefits and customer needs to position the service idea promisingly at the market.

7.4.3.2 Benefits and Customer Needs

Looking into 2025, scenario 3 describes a world in which the competitive situation demands from most firms, to combine sustainability with profitability. Firms will increasingly face decisions on energy related questions, which are outside the field of internal expertise. Energy efficiency measures contain considerable large cost reduction potential, but firms lack the knowledge of how to skim the savings. Companies increasingly feel the urge to work together in networks, however fear to loose sensitive data. Furthermore stakeholders pressure companies to operate environmental friendly and to pay close attention on their carbon footprint. After eco-friendly goals have been achieved, companies feel the need to communicate their accomplishments to the public, however many lack the resources of doing so.

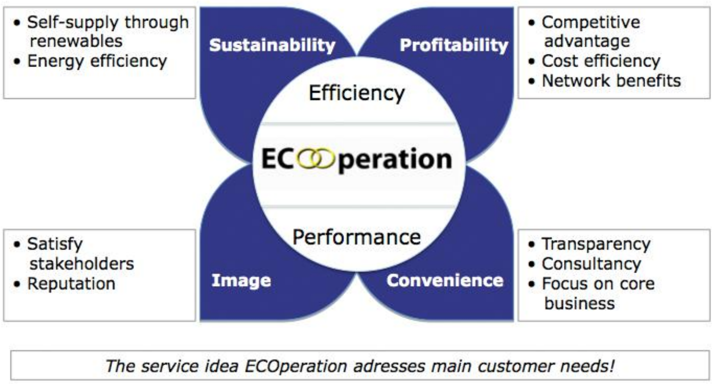

Figure 7.11: ECOperation's Power-Flower to address customer needs

One can argue that ECOperation offers participating firms four main benefits, which directly address the identified customer needs. First, substantial cost reductions will be possible through a several ways- as shown in figure 7.11. Through aggregation of firms economies of scale and scope arise. Cooperating within in a network furthermore increases the market power, reduces risks and ensures a secured planning horizon. Recommendations, which build on detailed analysis of a firm's consumption behaviour, reveal untapped efficiency potential. Second, a consultancy which works out individual solutions provides businesses with the convenience to concentrate on their respective core competencies. Third, sustainability is furthered through enabling the expansion of renewable energy sources and the promotion of energy efficiency. Fourth, ECOperation creates a positive image in building up a strong brand promoted through an offensive marketing strategy.

While cost reductions and a higher degree of sustainability lead to an increase in efficiency, the convenience to focus on the core business as well as a positive image among the stakeholders of a company, result in better performance. Overall the value of a company rises.

7.4.3.3 Marketing Messages

To successfully convince potential target customers of the service idea, this paper suggests ECOperation to use the following key marketing messages, as seen in figure 7.12.

Figure 7.12: ECOperation's marketing messages

Besides customers, other players considerably influence the action of a company. The following part describes the roles of competitors and business partners and how those interact within the value net of ECOperation.

7.4.4 Coopetition

ECOperation moves within a value net, which builds on the Co-Opetition framework by Adam M. Brandenburger and Barry J. Nalebuff Hayon [288]. This addresses the possible duality of cooperation and competition in markets. Within this model the company, its customers, competitors, suppliers and complementors are mutually linked, as seen in figure 7.13 below. Furthermore the actions of the net's participants are influencing and depending on each other, although no explicit cooperation has been agreed on. As customers have already been described in the previous section, the focus of this subchapter lies on the other parties.

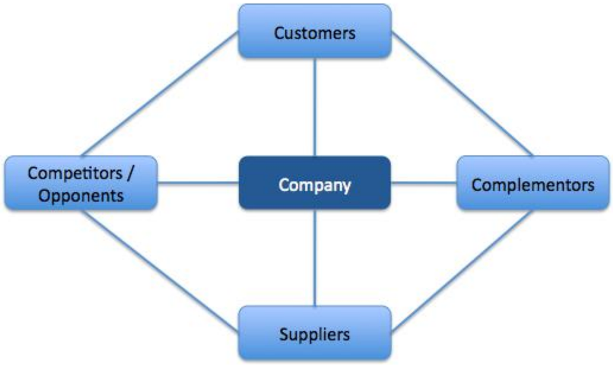

Figure 7.13: ECOperation's value net
Source: adopted from Hayon [288]

7.4.4.1 Competitors & Opponents

ECOperation's service platform has several competitors. At first there are virtual power plants, which aggregate decentralized energy producers and approach the volatility of renewable energies. In terms of security of supply, insurance companies are competing against the ECOperation platform, as they provide payment in case of a damage event. For instance, potential customers insure themselves against system failures or blackout situations. ECOperation's service lowers the probability of blackouts, as continuous power flow and energy exchange among the cooperating participants is guaranteed and dependency on purely external supply is reduced. In general, it is more valuable for companies to count on stability and security, than to get compensation payments from insurances

Further rivals include consumption cooperations, which strive for better conditions on the market when buying electricity. Admittedly, price cuts are gained by aggregating short-term power demands and receiving volume discount. In this case, long-term deals suffer from roughly estimated energy predictions and therefore further transactions are needed. Since they are missing an automated platform, a high effort has to be put into the adequate energy distribution, depending on customer specific load curves. Furthermore, consumption cooperations not offer comprehensive service as ECOperation does. Finally, consultancies are another imaginable competitor concerning advisory and guidance for energy efficiency measures. As a matter of fact, the consultant approach is focused on short-term success, does not benefit from a network learning effect, and is typically not including monitoring activities. In contrast, ECOperation's service is long-term oriented and continuously supporting customers in consulting and implementation.

In addition, opponents are existing as well. In particular companies covering the retail section of the energy value chain oppose the ECOperation service, since they face a potential loss of customer segments. Secondly, the companies developing large-scale electricity storage are against the ECOperation platform. Nevertheless, the development of a competitive storage system is not achievable within the product scenario, considering short- and medium-term perspective. Lastly, big utilities and energy generators that run centralized power plants will disapprove the service, as the ECOperation solution creates a more efficient energy usage and encourage firms to start their own independent electricity generation.

7.4.4.2 Business Partners

ECOperation's partners can be divided into complementors and suppliers. On the one hand energy providers are opponents of the service, but on the other hand they represent partners as well. In this regard the ECOperation service enables precise load forecasts, better production planning, as well as stable planning horizon for internal and external energy supply processes. If ECOperation manages to state that its service, offers an improved planning horizon and therefore clear advantages to the energy providers.

Additional partners are weather forecast agencies and IT companies, that are responsible for the communication and analysis infrastructure. Furthermore strategic cooperations with technology providers do exist. Within these partnerships, long-term agreements with producers of energy efficient technologies for consumption and production play major role. Further affiliates are research institutes, providing mathematical and statistical input for the calculation and prediction model. Finally, long-term collaborations with energy traders and brokers on exchange markets can be important, as they level the ground for better conditions and prices.

7.4.5 Financials

An evaluation of ECOperation's strategic plans and activities allows to give financial projections. First, it is important to analyze and define costs that arise from the business model. Moreover the assessment of potential revenues is essential in order to determine whether or not a business idea is viable.

7.4.5.1 Potential Costs

Establishing the ECOperation system requires initial investments in different fields. At first investments in the hardware infrastructure and the data center are of particular interest. Moreover expenses for setting up the ECOperation model are parameters that have to be considered. This includes efforts in research and developing the software for forecasting and analysis processes, as well as the system management. Further cost factors are created through hiring and employing highly skilled staff. Expenses for market access play a vital role when it comes to the roll-out of the system.

In addition the operation of a system like ECOperation depends on a continuous improvement and expansion of the software to achieve a sustainable competitive advantage for the participating portfolio companies. This creates ongoing expenses as for example the maintenance of data centers. Furthermore the assurance of system stability and reliability is of crucial importance for ECOperation. This entails sustainable costs. Moreover, charges for data gathering and data management are required to support the system. Creating a strong brand is a vital part of the offered value added services of ECOperation and therefore calls for an offensive marketing strategy with the resulting involved cost.

7.4.5.2 Revenue Stream

As client companies are provided with substantial services by ECOperation, the pricing model is compounded out of three parts. First component is a fixed fee which is charged for standard processes. Second, two variable components are priced on top of the fixed levy. One variable element results out of services for load forecasting and quick reactions on sudden supply changes. The other variable element follows from recommendations in order to increase energy efficiency.

The variable element resulting from load forecasting can be depended on the time taken to complete the service, the degree of complexity and level of expertise required to complete the service, as well as potential risks associated with providing the service. As energy consumption and production profiles as well as behaviour differ among the participating companies, the varying individual contribution to the value for the cooperation requires further differentiation and has to be considered, too.

Energy efficiency consulting (e.g. through installation of advanced technologies) is the second element priced according to a variable scheme. Here the decisive pricing criterion is based on success participation. Thus the degree of profit sharing is dependent on the performance of implemented energy efficiency measures.

ECOperation will furthermore aim for collaborations with providers that offer efficiency technologies, in order to achieve favorable conditions in form of commissions for intermediation. Apart from that, cooperation agreements with energy providers are advisable, as ECOperation achieves planning security and stability on the supply side, as well. In the world of scenario three, fiscal activity regarding environmental issues and energy efficiency is high. Hence, ECOperation is likely to benefit from governmental support through subsidies. Furthermore advantages like special tax deductibility conditions are likely.

One can conclude that high initial costs are equalized through a stable income stream. Hereby a high customer satisfaction and loyalty is of crucial importance. The overall financial aspects look promising since the importance of ECOperation will increase strongly in the time period from 2025 on, when distributed generation plays an increasingly strong role.

7.5 Conclusion

This paper has identified three main drivers that will shape the future in the area of efficiency solutions for businesses. Depending on uncertain projections of each main driver three scenarios have been developed. These scenarios describe how efficiency solutions in the business environment could develop in 2025.

The "Act locally think globally" scenario, hereby describes a constellation of parameters which is considered to be the most likely one. This scenario pictures a world in which individual firms and countries have come together to take unified action. Companies realize that in a globalized world only firms which are interconnected to their stakeholders will have successes. Substantial opportunities for energy efficiency are available in virtually all sectors. Thereby firms develop comprehensive strategies addressing the upcoming changes and challenges.

Based on the characteristics of the scenario, a service idea that focuses on customer needs was developed. This service idea is called ECOperation and already merges two of the key characteristics in its name: ECO-efficiency and Cooperation among firms across the board. Focus hereby is laid on managing energy related issues within a network of companies. For the evolvement of the scenario and thus for the described service idea, two major challenges might appear. First, the merger of the ICT and energy sector contains potential to create an innovative field in which every side of the partnership contributes to solve the problem of sustainable energy management. However the risk remains that players from those two strongly differing fields do not find a common language. Second, the behavior and number of companies that understand the necessity of joining forces is crucial as it determines the success of cooperations on a global level. This is emphasized by the fact that sustainability requires not only green technologies, but also the consideration of companies' economic, social and cultural impact.

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Chapter 8

8 Smart Storage

Birgit Braun, Dominik Facher, Tobias Schneiderbauer,
László Vidos

Renewable sources are perceived as an integral part of future energy mix as they are an option for cleaner and more sustainable energy production. From a technological perspective solar panels would be able to supply the worldwide electricity demand. However, renewable sources account for less than 10% of the energy mix as their dependency on external environmental factors complicates a reliable energy supply. Storage could solve that problem by capturing energy to compensate fluctuating output. Despite that potential, storage is currently no viable solution and on top its development looking at 2025 is highly uncertain. To account for that, this report shows three possible scenarios and their impact on Germany. The first scenario, **European Grid**, is shaped by low storage usage but instead uses advanced transmission technology to balance supply throughout Europe. In the second **Central Storage** scenario large facilities can be used to store energy from renewable sources. The third and most likely **Integrated Green Future** scenario reflects both central and decentral storage as an important component of the energy system. Consumers have own renewable sources to produce their energy themselves cheaper than electricity from the grid. As they are not willing to take high initial investments in own storage capacity but still want to use as much of it as possible, the product idea of a **Storage Cloud** could be developed. By providing storage as a service for a monthly fee consumers can store and receive their energy at an external storage service provider. With the stored energy, revenues are generated through trading activities on energy market places.

8.1 Introduction

Energy topics have every reason to be in focus of politics, public concern and observation by businesses. Increasing damage to the environment, scarce resources and increase in worldwide energy demand call for new ways of producing and using energy. Renewable energy technologies like windmills and solar panels could be adequate solutions to address this problem. Although the efficiency of renewables is increasing, they still face the problem that they are dependent on external environmental factors which prevent a stable power supply. The missing link to this issue is storage. If it is possible to store excessive energy from renewable sources and use it in other periods, it would be possible to solve their energy production problems. Therefore, the expansion of renewables is a driving force for the advancement of storage. Storage plays currently an inferior role because it is too expensive. Nevertheless, its development will be a decisive factor for the future. Governments and industry are aware of that and intensive research is done to develop storage solutions as an integral part of the future. Sophisticated and cheap storage solutions are the critical force to not only change energy production but also make electric vehicles a mass market product. Besides economic potential, electric vehicles would have a positive effect on the world's climate. Certainly the role of storage will shape the future of energy and humanity. Governments, private households, utilities, and other businesses have to be aware of the high impact and the uncertainty. Especially for E-Energy and intelligent grid networks, storage could be a valuable addition as it makes energy production and transmission more flexible and efficient. Locally produced energy can dependent on certain criteria like price either be stored or transmitted. For instance with dynamic price tariffs consumers could decide to store their energy when it is cheap to sell it during high-price times. Among other benefits, utilities could balance their production by being able to store excessive energy that can then be distributed during peak load times.

The scenario report deals with the topic smart storage. The report is divided into three sections: Drivers, Scenarios and Product. The drivers section explains the ten most important influencing factors for the scenarios. The outlook into the year 2025 with the different possible developments is described in the scenario section. The different possible developments are characterized in the three scenarios. Within the product section a business idea for the most promising scenario is explained in detail.

8.2 Driver Analysis

The scenario planning for the topic of smart storage is based on the selection of ten relevant drivers. They describe the most important influencing factors from the political, economic, socio-demographic, technological, legal and environmental side. Figure 8.1 shows the classification of all drivers according to their degree of impact and level of certainty.

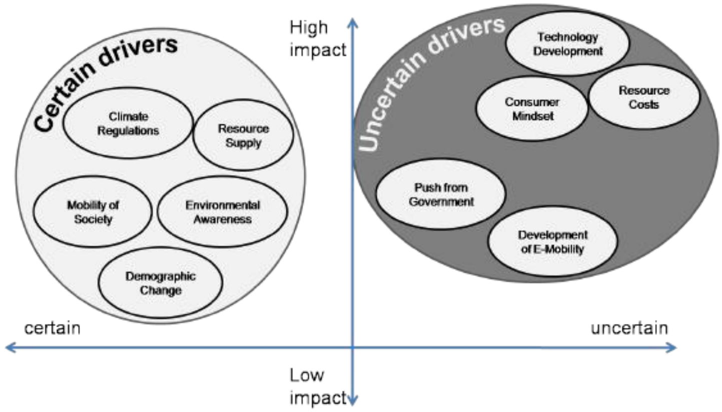

Figure 8.1: Overview of the Certain and Uncertain Driver

The driver can be distinguished into five certain and five uncertain drivers. The certain drivers are the so called stable drivers and build the basic principles of each scenario, whereas the remaining drivers are uncertain and their different possible developments (projections) shape the characteristics of the three scenarios.

8.2.1 Certain Driver

The five certain drivers are demographic change, mobility of society, environmental awareness, climate regulation and resource supply. The drivers are arranged according to increasing impact and decreasing certainty, starting with the lowest impact and the highest certainty. Their most likely development until 2025 can be deduced from trends that are currently active or at least show distinct signs.

8.2.1.1 Demographic Change

The demographic change describes the shift in human population. Relevant factors are life expectancy, birth and mortality rate within a country. Hence, the development of population can be predicted in a long term view.

The demographic change of countries of the Organization for Economic Cooperation and Development (OECD) is different from the development in the remaining countries, such as China or India. Althoug life expectancy all over the world grows, the development of birth and mortality rate shows differences. Industrialized countries show a shrinking population due to a higher mortality rate than birth rate in contrast to other countries [307, p. 5-7].

Compared to other OECD countries the shrinkage of the German population is especially distinctive due to the low birth rate since 1972 [329]. This process can hardly be compensated by immigration. Moreover, the improvement in health and the related rise in life expectancy will lead to a population aging in Germany [308, p. 3]. While in 1950 only 10 percent of the German population had an age over 65, nowadays this age group accounts for 21 percent of the German population. According to predictions of the German federal statistical office they will represent 25 percent of the German population in 2025 and 33 percent in 2055 [328]. Figure 8.2 shows a comparison of the German population age structure in 2009 and 2025.

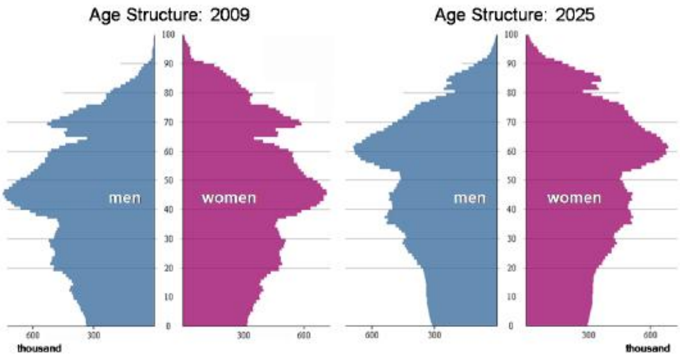

Figure 8.2: Comparison of the Age Structure of the German Population on 2009 and 2025
Source: Statistisches Bundesamt [328]

As a result of the German demographic change, the working population will decrease. This influences the economic power of Germany. Governmental response to the population aging will be longer working life, longer working hour, increased labor force participation and utilization rates and immigration of workers from other countries [319, p. 2-3].

8.2.1.2 Mobility of Society

The mobility of the German society is growing and can be differentiated between long-term urbanization and growing daily commuter traffic. These increasing movements begun in the last years and will proceed further due to the urban economic growth.

Urbanization is defined as a movement of people from rural areas to cities and their suburbs. Mostly working people moved from the newly formed German states to city regions of the old West German states. As a result, Germany has an unbalanced regional distribution of population. While the younger working population lives in the closer region of metropolitan areas, less and mainly older people can be found in the rural areas of the newly formed German states, such as Saxony or Saxony-Anhalt [308, p. 8, 16-19, 24-25].

Besides urbanization, the daily mobility of working people who travel from nearby regions to inner city working places is increasing. Due to this development, the traffic volume on the road and the rails will increase in the morning as the people move in to the city and in the evening as they move back home [311].

The process of urbanization and the daily travel into the centers influences the economical development of metropolitan areas and increases the gap of rural and urban regions. The process will continue in the next years and lead to the people's need for mature mobility options in metropolitan areas, such as public transportation and taxis.

8.2.1.3 Environmental Awareness

The environmental awareness of the population is rising which results in a changing consumer behavior towards renewables and more efficient technologies.

In the last decades, there was a relatively consistent interest in environmental issues. However, the environmental consciousness of the population is growing currently. This can be predicted by the increasing presence of environmental issues in the press. Due to climate change and the relating natural catastrophes, the environmental consequences are visible to the general public. Therefore, the environmental awareness increase and more people are willing to change their behavior to make a small contribution to improve the situation. Even though most people are unlikely to limit or change their living standards, they implement renewables and more efficient technologies in their homes [310, p. 10-11]. The political effort to run a more efficient environmental policy supports the current development of the private consumers and helps them to become prosumers by giving subsidies and incentives.

The increasing environmental awareness will lead to a growing amount of private investments in decentral solar panels. Due to the German goal to enlarge the share of renewable energy, these private investments in renewables are needed.

8.2.1.4 Climate Regulations

The quantity of regulations concerning greenhouse gas (GHG) emissions on the international as well as on the national level is increasing steadily. The main goal behind these treaties is to avoid further climate changes and the related global warming.

The causal correlation between carbon dioxide (CO_2) emissions and global warming has been widely accepted. Therefore, an international agreement, the so called Kyoto Protocol, which is linked to the United Nations Framework Convention on Climate Change, was enacted in 1997 with the goal to achieve stabilization of GHG concentration in the atmosphere. The Kyoto Protocol sets binding targets for 37 industrialized countries for reducing GHG emissions. It accounts for an average CO_2 reduction of 5.2 percent against the levels of 1990 in a five-year period 2008-2012. The protocol placed a heavier burden on industrialized countries. The European Union (EU) has to reduce the GHG emission by 8 percent and Germany had to achieve a reduction of 21 percent [311, p. 13]. In contrast to other countries, like Luxembourg, Austria and Spain, Germany already accomplished the Kyoto target. In 2008 the German CO_2 emissions were 1.9 percent below the Kyoto target [314, p. 45]. The next international climate conference will take place in Copenhagen with the target to enlarge the Kyoto Protocol in December 2009. The main goal will be to commit emerging nations, like China and India, to meet defined target emissions to reduce the worldwide GHG emission [317].

Beside the worldwide climate regulation, the European Union agreed on a new climate deal in 2008 by reducing the European CO_2 emission against 1990 until 2020 by 20 percent. Within the climate deal the German government committed to achieve an emission reduction of 40 percent by 2020.

In order to reach the international binding target of CO_2 emission reduction, the German government has to introduce some national regulations. Most of the GHG is generated by the production of electrical energy. Therefore, the share of renewable energy has to increase. In order to accomplish this, the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz (EEG) in German) was passed in 2000 to support the electrical feed-in of private households with renewable technologies. [312, p. 12-13] [314, p. 14, 34-35]

Due to the pressure of the general public, the German government passed the Atomic Energy Act (Atomausstiegsgesetz in German) in 2002 to realize the nuclear phase out by 2022. Although the production of nuclear energy does not cause any CO_2 emission, the risk of an atomic catastrophe and the problem of nuclear waste disposal are too high. [312, p. 14-15]

Because of the international as well as the national regulations Germany has to reduce the GHG emission by 40 percent until 2020. To reach this ambitious target, Germany will have to increase the share of renewable energy in a large scale.

8.2.1.5 Resource Supply

The supply of resources for energy production and battery related resources is limited. Due to the economical dependency on these resources, the worldwide competition for resource supply is rising.

The available resources can be differentiated into reserves and reserve base. Reserves are the part of the reserve base which can be economically extracted or produced and include only proved recoverable materials. Reserve base is the geological resource and is defined as the part of identified resources that meets specified minimum physical and chemical criteria related to current mining and production practices. Thus the reserve base includes resources that are currently economic (reserves), marginally economic (marginal reserves) and some of those that are currently sub-economic (sub-economic resources). At some point sub-economic resources might become available if prices rise sufficiently [330, p. 4].

By worldwide comparison of fossil fuel and battery related resources, Germany has no significant reserves apart from lignite. Natural gas and petroleum comes mainly from Russia, Norway and OPEC countries. Lithium, which is used for lithium-ion batteries, is imported by South America and Tibet. Only coal is currently a sub-economic resource and would become available if worldwide prices rise. Due to that situation, the German government and economy is highly dependent on the import of such resources [321][330, p. 9][314, p. 15-17].

The demand of resources, like lignite, coal, natural gas, petroleum and lithium, increases steadily due to the upcoming nations, like China and India. This development leads to the scarcity of these natural reserves and forces to exploit other reserve base.

In the future the secure supply at stable prices cannot be guaranteed in the long term. Therefore, the conflict between high demand and limited reserves will result in continuous tension on resource supply. Advanced renewable technologies and batteries have to be developed to ensure long term energy stability.

8.2.2 Uncertain Driver

The uncertain drivers have a significant impact on the future development. According to their further progress the world of energy storage in 2025 could look different. The uncertain drivers are push from government, development of E-Mobility, consumer mindset, technology development and resource costs. The drivers are sorted according to increasing impact and rising uncertainty. In the following sections, the uncertain drivers, their feasible future development (projections) and the resulting consequences are described.

8.2.2.1 Governmental Push for Technology Innovations

The governmental push towards technology innovation is directly and indirectly done by subsidies, incentives and taxes to influence the process of development and market penetration of supported technologies. It is uncertain which technology the government decides to stimulate in the upcoming years until 2025.

Subsidies are a form of financial assistance paid to a business or economic sector by the government to make domestic goods and services competitive against imports. In the course of governmental aids around 60 million Euros will only be spent in the development of lithium-ion batteries in the next years[315, p. 14]. Whereas, incentives and taxes are instruments to enable or motivate a particular course of action and count as a reason for preferring one choice to another. Due to the EEG inducements and supplemental rewards for renewable sources are currently offered by guaranteeing feed-in-tariffs for power from renewable sources[312, p. 12-13]. Moreover, reduction of taxes by driving carbon dioxide friendly vehicles will stimulate and motivate the consumer to buy alternative technologies.

The technological innovation in the field of energy that can be supported are mainly research and development of fully electrical vehicles, alternative technologies, such as hybrid and fuel cell vehicles and renewable technologies. To influence the market penetration of these technologies incentives and taxes can help to establish an infrastructure of electrical vehicles equipment, like charging stations and enlarge renewable technologies in private homes.

In the future mainly two different projections can be taken by the German government: On the one hand, it could almost stop making financial aids in the field of energy and could concentrate on other topics, like education. On the other hand, it could enlarge the amount of financial aid and emphazise energy issues. These two projections are shown in figure 8.3.

Both ways could be possible and would influence the further development of Germany as a precursor country in energy issues.

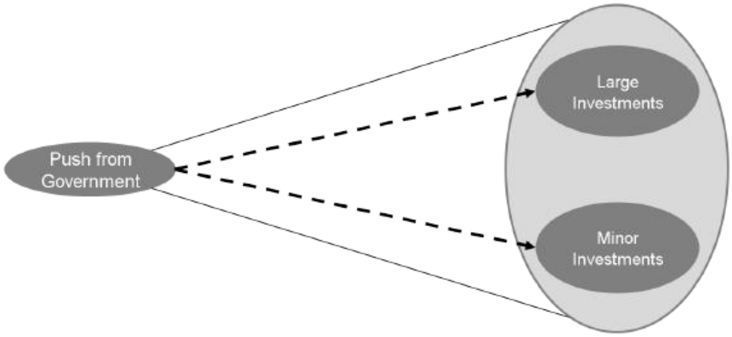

Figure 8.3: Projections of the Driver Push from Government for Technology Innovations

8.2.2.2 Development of E-Mobility

Electrical mobility is based on electrical vehicles and electrical public transportation. Its realization on a big scale would solve several technical and environmental problems. But to what extend electrical vehicles will have penetrated the market by 2025 is highly uncertain at the moment.

Due to governmental pressure on the automotive industry to reduce their vehicles' CO_2 emission, they are working on the development of fully electrical cars whose propulsion technology depends solely on electricity. The implementation of this technology would have several advantages. Beside the reduction of CO_2 emission, the electrical car technology means an independency of fossil fuels as propulsion of cars. Moreover, they could be used as decentral electrical storage capacity by integration in the electrical network. This could balance peak demands and lead to a more efficient energy consumption [316, p. 8-9].

To meet the challenge of electrical cars, several problems have to be solved. Beside control electronic, improvements in high-capacity battery technology have to be achieved. Price reduction, short recharging time, high safety even in the case of an accident, long durability and high energy density are neccessary. Moreover, the infrastructure of energy supply for electrical vehicles has to be built. Only if the penetration of charging station is high enough, it will be possible to adequately replace combustion engine cars. If all these problems are solved electrical cars can become widely accepted [323, p. 2] [325, p. 77].

By 2025 mainly three different projections will be possible as shown in figure 8.4. Firstly, the electrical vehicles could not have the potential to replace alternative technologies, such as the internal-combustion engine (ICE), hybrid, plug-in hybrid, range extender and fuel cell vehicle. In contrast, the electrical cars could replace other vehicle technologies only for short distance use. Low energy density of batteries results in only short distance travels that make inner cities the main application area for electric vehicles. At last, short and long distance electrical cars for inner city as well as long electrical driving ranges could be developed on such a high level that complete replacement of other technologies is possible.

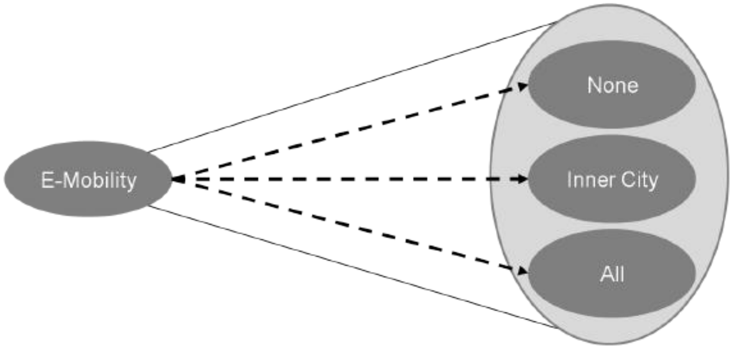

Figure 8.4: Projections of the Driver Development of E-Mobility

The development of electrical mobility is highly uncertain. The success of electrical cars will largely depend on how efficient and cost-intensive alternative technologies will become. Figure 8.5 shows the electrification path from advanced ICE to fully electrical vehicle and explains their technological definition and CO_2 reduction.

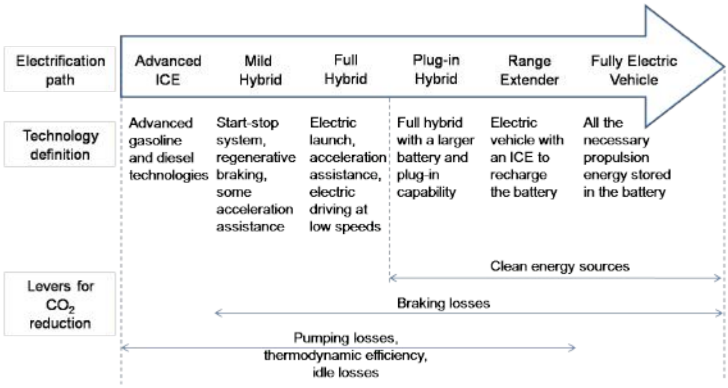

Figure 8.5: Electrification Path of the Automotive Industry
Source: Book et al. [323, p. 2]

8.2.2.3 Consumer Mindset

The mindset of consumers determines their needs and wants as well as their attitude concerning a specific product or service idea. It is important to look at the world from the consumer's point of view in order to comprehend the process of buying decision and predict the success of new technologies.

Arising consumer enthusiasm for special products can be realized by different factors. The most important ones are price-performance ratio, convenience and environmental impact. Current and future price-performance ratio is the most significant criterion for buying decisions. Consumers are looking at the total cost of ownership (TCO) that assesses both direct and indirect costs and benefits related to the purchase. In contrast to low TCO, the other two criteria – convenience and environmental impact – are differently pronounced by every consumer and influence the buying decision in a more subjective way. The consumer demand on convenience can be satisfied by avoiding wasting time or effort and offering more comfort. In addition, the environmental impact of products is another criterion more and more people look at due to the increasing environmental awareness in the last years.

Figure 8.6 shows three possible projections concerning consumer mindset. In each projection the three factors – price-performance ratio, convenience and environmental impact – influence the consumers to a different extent and build their mindset accordingly. While convenience stay in every projection the same, price-performance ratio and environmental impact are different among every projection. In the first one price-performance ratio is the most significant factor.

So, most of the people are looking at the price of a product. In the second projection the three factors are balanced. However, in the last one environmental impact build up the most important basis of consumer decisions and therefore the environmental awareness of the consumer is especially increased.

	Price-Performance Ratio	Convenience	Environmental Impact
Projection 1	●	◐	○
Projection 2	◐	◐	◐
Projection 3	◐	◐	●

● = high ◐ = moderate ○ = low

Figure 8.6: Projections of the Driver Consumer Mindset

8.2.2.4 Technology Development

The changes in the energy industry are mainly dependent on the technological development in the field of renewables, storage and transmission technology. Nowadays, these technologies are a limiting factor. Development in these fields is an enabler for possible energy solutions in 2025 and therefore has major influence on how the energy market could look like then.

Mainly two factors influence the level of technological improvement: the spectrum of application areas and advancement in efficiency. These factors have a remarkable impact on products deciding whether they will reach a critical mass or not.

In the energy mix the share of renewable sources will increase in the next years. Due to its dependency on external factors, such as wind or sunshine, solutions to handle fluctuating output will be neccessary in order to guarantee sufficient supply of energy at any time. This depends on development particularly in the fields of central and decentral storage, grid and transmission technology and renewables.

Renewable energy is generated from natural resources and can be classified into solar, wind, hydro and geothermal energy, biomass and biofuel. In Germany biomass, solar, wind and hydro energy are the most important sources for renewable energy. It has the world's largest installed capacity of both solar and wind power. But to reach the German target share of 30 percent of renewable energy until 2020, the efficiency as well as the technical standard of renewables has to be advanced [312, p. 12-13] [313, p. 53, 68].

To accommodate the increasing penetration of intermittent renewable energy supply, energy storage – central and especially decentral – is expected to play an increasingly important role in the development of the upcoming years. The most important attributes of storage technology are costs, safety, power and energy density. Further factors that characterize central storage technologies, such as pumped hydro and compressed air energy storage (CAES), are time period of storage, degree of efficiency and rate of availability. For batteries, especially lifetime and charging time are a decisive quality factor. From today's point of view most seminal battery technology is based on the lithium-ions. To become a mass application requirements like high storage capacity and short charging time have to be met [322, p. 21-36].

In Germany the grid and transmission network is currently in a tolerable condition but has to be expanded in load capacity. The goal in development is to minimize degradation of energy and to guarantee sufficient supply of energy.

The level of development of renewable energy, storage and transmission technology by 2025 will decide which solution will handle the intermittancy of renewable sources and will be mature enough to supply the energy in Germany safely and in a long term perspective. In each of the projection the development of the three fields are differently sophisticated. In the first projection the renewable energy as well as the transmission technology is highly advanced. However, in the second projection the development of renewable energy technology is on a high level but the storage as well as the transmission technology is moderately advanced. In the last projection both renewable energy and storage technology is sophisticated while the grid technology could not developed. The composition of the three projections is shown in figure 8.7.

	Renewable Energy Technology	Storage Technology	Transmission Technology
Projection 1	●	○	●
Projection 2	●	◑	◑
Projection 3	●	●	◑

● = highly advanced ◑ = advanced ○ = not advanced

Figure 8.7: Projections for the Driver Technology Development

8.2.2.5 Resource Costs

The costs of both fossil fuel and battery related materials are subject to uncertain price developments and volatilities in the future. These resource costs have large impact on the price of energy and battery products and consequently influence the German economic.

Particularly the price of fossil fuel has a high impact on the costs of energy production and propulsion for fuel-powered cars. The supply of battery materials, like lithium or alternative metals, will play a major role in the future due to the increasing share of renewable sources. The market prices result from the balance of demand and supply on the world market. The demand of fossil fuel arises out of international economical situations and technological developments. However, its supply is mainly defined by suppliers, like Russia, Norway and OPEC states. These three groups satisfy 70 percent of the current demand of natural gas and petroleum in Germany. Due to political instabilities, the power of the OPEC and speculations on ressource exchange markets the prices for fossil fuel can hardly be controlled. The price of batteries and their resources is currently also uncertain. Due to the lack of knowledge what battery technology will meet the technological requirements, it is unknown what battery materials will be needed and what the demand and supply will be. All these factors influence the uncertain current price situation of batteries and their resources. [309, p. 10] [314, p. 15-17]

The price development and volatility of fossil fuels and battery materials could mainly develop in the following projections: While the resource price could stay moderate, increase or decrease, it would be possible to have low or high price volatility. So, there are six possible projections which are demonstrated in figure 8.8 by connecting lines.

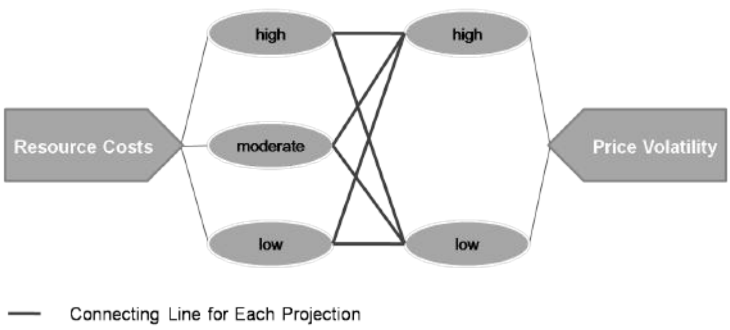

Figure 8.8: Projections for the Driver Resource Costs for Energy Production and Storage

In the scenarios just three possible projections of the price progress of fossil fuel and battery related materials are considered and shown in figure 8.9.

	Price Development	Volatility
Projection 1	○	◑
Projection 2	◑	◑
Projection 3	●	●

● = high ◑ = moderate ○ = low

Figure 8.9: Projections for the Driver Resource Costs for Energy Production and Storage

Due to the uncertain cost prognoses the German government and industry will try to get more independent from resources with increasing price development and high volatility and will focus on alternative resources with stable prices. Because of today's lack of knowledge how the political, economical and technical situation will develop, future resource prices are unknown parameters.

8.3 Scenarios

The three scenarios of the topic smart storage are influenced by the certain and uncertain drivers. The three drivers with the highest impact and the highest uncertainty are the key drivers, shown in figure 8.10. Each scenario is built up on one projection of each key driver. The key drivers are consumer mindset, technology development and resource costs. Beside the consumer attitude, the costs and the technological advancement of storage and alternative technologies are factors which particularly influence the future development of storage.

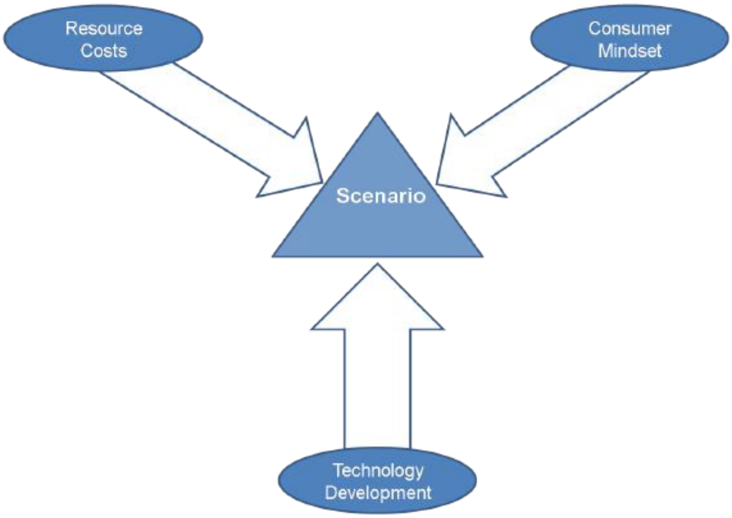

Figure 8.10: Key Drivers for the Scenarios

Each of the three scenarios is built up on the combination of respectively one projection of each key driver. The projections of the other uncertain drivers, governmental push and development of electrical mobility, influence each scenario in a different way as well. The stable drivers are the basis principle and stay the same in all scenarios. However, they influence the scenarios in different ways. Besides, the weak signals are factors that adumbrate future scenarios already today.

In the following sections three possible scenarios are described for the year 2025: **European Grid**, **Centralized Storage** and **Integrated Green Future**.

The most likely scenario is the **Integrated Green Future**, as there are already many signs which are going in this direction. The governments announced financial support for research and development in the field of electric cars and advanced batteries. In addition, E-Energy model regions like eTelligence or MeRegion are getting support from the government to develop and proof concepts. As the efficiency for renewables increased in the past quite fast, the profitability of renewables without subsidies will take place in a near point in the future. Considering this, the people should not underestimate the future and rather be a part in the development.

8.3.1 Scenario 1: European Grid

The **European Grid** scenario is characterized by insufficient central storage and battery technology, moderate resource prices for fossil fuels with low volatility and a consumer mindset that solely focuses on individual benefits like costs, shown in figure 8.11.

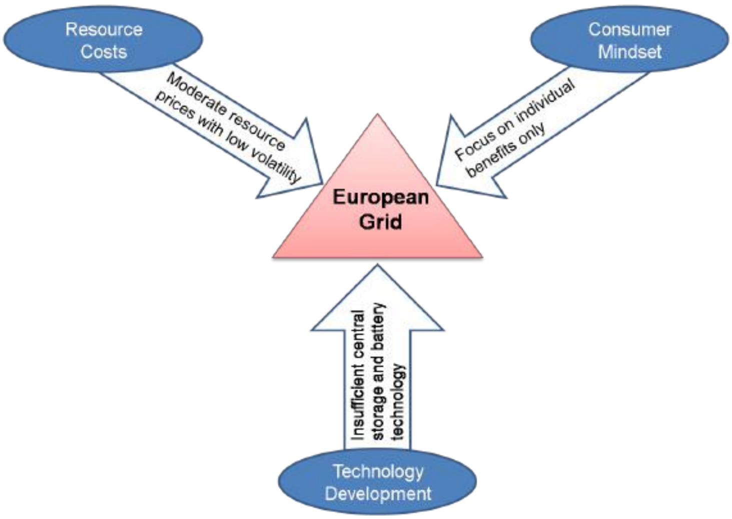

Figure 8.11: Projections of the Key Drivers for the Scenario "European Grid"

Renewable energy technology for wind, solar, biomass and geothermal energy is advanced and competitive to nuclear energy in terms of efficiency. In comparison storage technology has made slow progress. Producing storage solutions that are capable of supporting renewable energy production is too expensive. The prices for fossil fuels are moderate at about the level of 2009 with moderate volatility. In contrast the prices for battery materials increased due to the additional demand for lithium and other ingredients used in portable batteries as well as for cars. The environmental impact of the consumer behavior is of minor relevance. The primary concern of the consumer is to get cheap energy at high security of supply with highest possible convenience.

The consumers push towards production of cheap energy leads to a combination of renewable sources and fossil fuels. Consumers and utilities oppose the use of storage because of high costs as well as insufficient technology.

8.3.1.1 Scenario Description

The key element in this scenario is energy transmission technology. Instead of using storage, fluctuating energy supply from renewable sources is distributed throughout Europe immediately. Meteorological differences in Europe account for the fact that at some time energy can be produced at certain parts of the continent while in others production levels are very low. If it is cloudy in Germany for example, the sun in Spain is shining and excessive solar power is used to support Germany. As these environmental factors change frequently the European grid and transmission technology are used to lever cheap renewable energy and balance the supply internationally. The introduction of high voltage DC transmission enables long term transportation of energy with little losses. Moreover, first applications for supra-conduction show the potential of distribution in AC networks over short distances at large efficiency. As a result grid infrastructure was expanded to overcome bottlenecks in international transmission.

The German national grid is operated by one single company which is affiliated to the Bundesnetzagentur. Therefore the government invests in building up and maintaining the grid. Moreover, the government played an important role in creating European regulations and standards to establish seamless integration of national grids. These regulations are a base of international exchange as they secure fair competition and allocation of energy.

Energy Production and Storage

The energy mix consists of mainly coal and other fossil fuels as well as renewable sources but no nuclear energy. A significant share of renewable energy is produced in large energy parks where wind, solar and geothermal energy are the dominant sources. These parks are primarily owned by utilities and co-investors. Energy production capacity is used very efficiently as wind turbines are located in the North of Europe whereas solar power is produced in Southern parts and North Africa, like shown in figure 8.12.

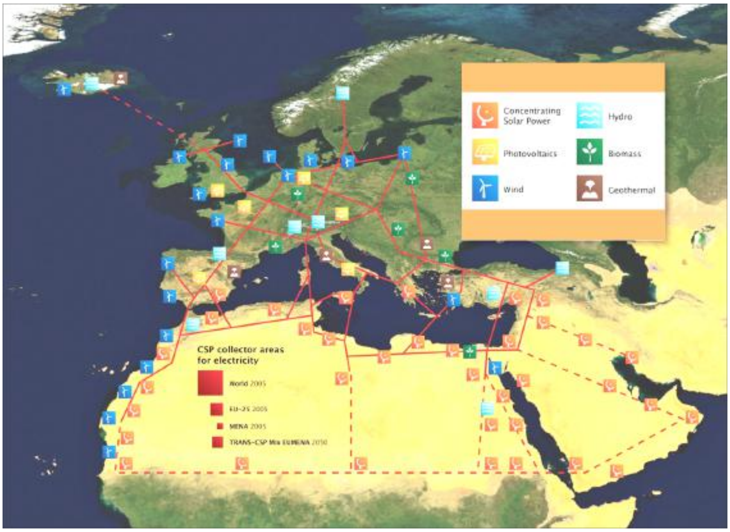

Figure 8.12: European Grid
Source: Siemens AG [327]

As a consequence of the European grid, supply and demand of energy is determined on an European level and German customers get their energy also from other countries or even continents. In case renewable energy production throughout Europe exceeds the demand, they are adjusted down in favor of power plants running on fossil fuels because their shutdown is more expensive. If in contrast renewable sources cannot provide the necessary amount of energy the share of fossil fuels is expanded to ensure security of supply. Fossil fuels at moderate prices and low volatility are a good fit for utilities to optimize their energy mix. Even though renewable sources are in terms of production costs competitive to fossil fuels, utilities want to keep their share as low as possible. The intermittency requires complex control and distribution with the grid as storage is no real option. However, utilities are forced by governmental regulations to make use of renewable to some degree. In the future they will have to increase the share anyway. Sooner or later infrastructure for coal transportation will reach its limits because of the increasing worldwide demand.

Storage technology is not relevant. On the one hand batteries still lack of enhanced performance to store large amounts of energy. As energy density has only doubled since 2009 batteries do not play an important role as storage. On the other hand large compressed hydrogen energy storage (CHES) technologies could not make their proof of concept. Compared with the cheap way of producing energy through fossil fuels, utilities are not willing to invest into capital intensive storage solutions. First of all this increases their costs, second of all they have to focus on grid investments and obviously consumers have security issues.

Consumers

They are generally satisfied with their low energy prices and the overall feeling that a noteworthy amount of energy is produced by renewable sources. Their main concerns are not with the actual reduction of energy consumption or higher efficiency. An updated form of the EEG is in place, as the initial version was not scalable enough to deal with the increase of renewables. Still consumers get fixed feed-in rates above the market price. Some private households as well as businesses own solar panels and small windmills to produce energy and profitably sell it to energy brokers. Private households invest in renewable energy because of good return on investments. Considering the demographic changes and overall decrease of per-capita income however consumers want to have cheap energy and invest their money in other things than in energy.

E-Mobility

Electric vehicles have not reached a critical mass in the **European Grid** scenario. Battery technology is not capable of delivering power for adequate distances at low prices. Most Consumers are not willing to pay extra for electric vehicles and rely on highly sophisticated internal combustion engine (ICE) vehicles that have a low TCO and a very high efficiency. In particular moderate resource prices for fossil fuels compared to high resource prices for battery material favor ICEs. Obviously there is no sophisticated infrastructure for electric cars and consequently they are not used as decentralized storage by utilities.

To solve the problem of increasing traffic and pollution in cities caused by urbanization, regulations for banning cars from certain areas as well as contingents for driving in cites are active. Moreover, public transportation and taxi services increased in popularity.

Utilities

The number of energy suppliers increased dramatically compared to 2009. The importance of market places and pricing mechanisms is very high as there is an international adjustment throughout Europe. Market players that trade energy and use arbitrage deals are active. Consumers focus on their goal to get cheap energy and several competitors compete on that by having new opportunities on international markets.

E.ON as a producer of energy is the most important electricity company in Europe with other German players like RWE following. These large utilities own most of the large renewable energy facilities in Germany or are strong investors. Furthermore, they have strong local positions in Spain, Italy, Portugal and North Africa where they acquired other utilities. E.ON started various takeovers all over Europe to strengthen its position, now having a large share of overall renewable production capacity which makes them very strong in end consumer sales.

Economy

The German economy benefits from low resource prices and low energy prices in the end. The energy sector shows a moderate market growth especially with further advancement of renewables. Besides that large industrial companies like Siemens benefit of heavy grid investments and infrastructure products. Nevertheless, the German energy sector is not very innovative and is not competitive to countries like the USA and China accounting for about 70 percent of worldwide production of renewable sources.

Environment

As the government wanted to comply with climate goals, they were a strong force for the expansion of renewable sources. They contribute to a cleaner energy production in Germany and throughout Europe. The European grid still requires using coal and burning other fossil fuels to balance volatility in green energy supply as well as wasting excessive renewable energy by regulating it down. Energy production could be cleaner and more environmentally friendly. In public discussions however India and China get the blame for environmental destruction. Europe does not push environmental regulations by limiting their economy to take global responsibility like they did in the past.

8.3.1.2 Weak Signals

The Desertec project launched in July 2009 aims at building renewable sources for solar power in an area of 17000 square kilometers in the Sahara Desert in Africa. German companies like E.ON, RWE, Siemens and many others are involved in that project. The goal is to transmit produced energy to Europe and to cover about 15 percent of total energy consumption. For that purpose Siemens develops high voltage DC transmission technology that works at efficiency levels of about 3 percent loss per 1000 kilometers. [305] [320] [331] If the Bundesnetzagentur succeeds in operating the grid in the future, it would be possible that the grid is renewed through the efficient high voltage DC transmission technology. This would enable a profitable transportation of electricity over long distances which are needed for this scenario. In addition, it is important that the European Union give out subsidies for the advancement of the grid in entire Europe. Another signal for this scenario are increasing mergers and acquisitions between the utilities.

8.3.2 Scenario 2: Centralized Storage

The **Centralized Storage** scenario is characterized by advanced central storage technology, high resource prices with high volatility and consumers that mainly focus on individual benefits when it comes to energy topics, shown in figure 8.13.

Renewable energy technology for wind, solar, biomass and geothermal energy is advanced and competitive to nuclear energy in terms of efficiency. Besides that technology for large storage systems made the proof of concept and is already in place. The prices for fossil fuels and their volatility increased since 2009. In addition high demand for materials necessary for battery production let prices increase to a moderate level. In that context consumers are concerned with individual benefits namely price-performance ratio and convenience which are the decisive factors. If they additionally have the chance to help the environment but they are willing to do so.

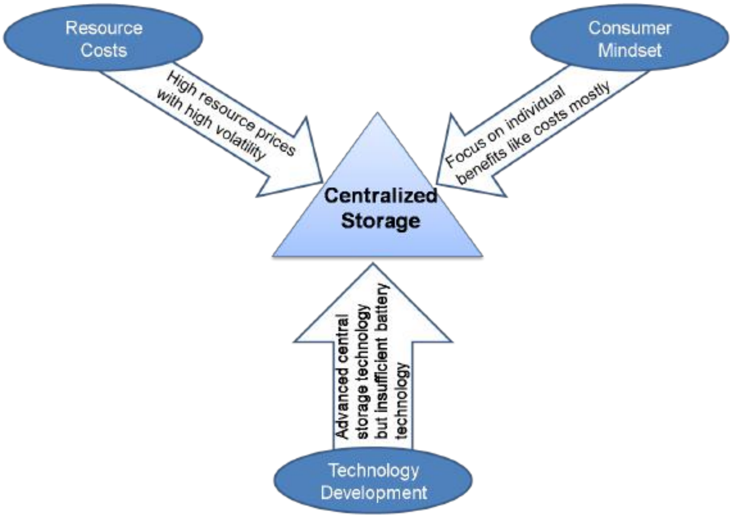

Figure 8.13: Projections of the Key Drivers for the Scenario “Centralized Storage”

8.3.2.1 Scenario Description

Consumers, businesses and the government push for the use of renewable sources instead of fossil fuels to reduce dependency on fossil fuels and swap to cleaner energy production. In order to overcome the intermittency of renewable sources central storage solutions became important for the energy system. However, decentralized battery solutions are not accepted because they are too expensive and do not provide enough benefits. Renewable energy becomes very important for the energy market. Solar panels and wind mills are good investments with good return on investment compared to the capital market for businesses and private households.

Energy Production and Storage

The energy mix is a combination of fossil fuels and renewable sources. The nuclear phase out that was completed by 2022 needed to be compensated which was to large extend done with renewable sources. Meanwhile production capacity of fossil fuels was not replaced by renewables. However, the energy production becomes increasingly decentralized. Not only do consumers accept renewable sources and their reliability attached with storage but they actually invest in it. Decentralized energy producers either consume the energy directly themselves or feed it back to the grid. As decentralized storage like batteries is not used by most customers they do not store energy. However, central storage solutions are necessary to overcome the intermittency of renewable sources that are broadly used. Nearly all of this storage capacity is owned by utilities. Compressed hydrogen energy storage (CHES) reached efficiency levels above 95 percent and is used by utilities to ensure independent security of supply for Germany up to several days. CHES need high investments and consumers get charged for these. In an overall calculation with prices for fossil fuels, this way of producing and storing energy is profitable.

Although battery technology made significant improvements compared to 2009, the development had a slower pace than central storage solutions. Battery technology is capable of providing short term central storage to the grid but high production costs prevent them from broad use. In the end limitations in production mechanisms but also increasing resource prices for battery related materials prevent batteries from being applicable for the mass market. Lithium is a limited resource and most battery technology is more or less dependent on it. As a consequence the supply from South American countries and Tibet is an important factor of battery prices. Unfortunately, China uses Tibet's resources mainly for self supply and the South American countries try to create an alliance similar to the OPEC. Their attempt is to control supply rates and consequently to dictate the price for lithium.

Consumers

They favor individual benefits such as low energy prices, convenience and security of supply over global environmental considerations. Nevertheless, many consumers understand that investments in renewable energies and supporting technology does not result in financial disadvantages and additionally has positive global impact. Moreover, consumers are aware of the fact that global climate issues will probably affect their individual benefits and certainly the ones of their children. As they consider car traffic and businesses as the most important leverage for environmental impact, they are switching their cars and use public transportation as well as they demand environmental awareness from businesses.

E-Mobility

Electric vehicles currently are not capable of replacing ICEs or hybrid cars. Battery technology is not advanced enough to provide all necessary factors for consumers to accept it as a replacement. However, for specific usage like in inner cities technology is sufficient and through several incentives the TCO for consumers is lower than with gasoline driven cars. Because of governmental initiatives to reduce pollution, utilities provide electricity for cars at very low prices. Companies and public transportation use this to switch to battery powered cars and buses. In addition many people use a second car just in the city that has to be very small and only needs to cover distances of less than 50 kilometers before recharge. There is no sophisticated infrastructure for electric cars. Utilities provide several charging stations but do not want to include cars in any storage concept. There is no communication infrastructure or controlling system established. Moreover, car manufacturers and battery providers could not agree upon a standard for car batteries. Consequently their development costs along with maintenance and infrastructure investments are on a high level. Storing energy in electric cars is not in place.

Utilities

In the current market situation utilities face hard challenges. First of all consumers invest in their own renewable production capacity and the sales of utilities goes down. As consumers are demanding cheap energy prices the situation gets even worse for the utilities with renewables. Secondly utilities do not have additional markets in order to compensate the development with it. Of course charging electric vehicles is an opportunity but their success rate is not yet sufficient. As a consequence it was inevitable for utilities to invest in renewable sources and to use economies of scale to reduce energy prices for end consumers.

Economy

Reducing the dependency on fossil fuels was a challenging but also very important step for the German economy. Governmental initiatives through the EEG paid off. Production capacity of renewables installed in Germany is capable of providing a significant share of the energy mix. Currently money goes to research institutes focusing on storage technology. While Germany failed with batteries and other decentralized storage, scientists and industry contribute to the development of hydrogen based storages. In fact Germany has a strong position in engineering and consulting on these large scale projects. Furthermore, the German car industry, that is very important for the whole economic system, split up. While some manufacturers focus on making ICEs more efficient as well as hybrid cars only, others try to differentiate themselves with electric vehicles. As these cars are primarily used in inner cities, the consequence is a diverse production portfolio.

Environment
The governmental push towards renewable sources through incentives and regulations paid off. Obviously renewable sources owned by utilities were mainly used to compensate the nuclear phase out. As nuclear energy is not producing much CO_2 emissions, renewable sources cannot optimize that issue significantly. Nevertheless, Germany complies with climate goals and is one of the driving forces in climate protection. This is due to several regulatory initiatives and the overall increase in energy efficiency as well as green decentralized energy production. One of many examples for such initiatives is the ban of cars with gasoline engine from parts of the inner cities to ensure acceptable pollution levels.

8.3.2.2 Weak Signals

Currently only few compressed air energy storage solutions are in place and utilities are very careful because of high investments. However, large projects are planned and the technology made significant progress in the past. In addition, high investments in R&D for hydrogen storage are made. Hydrogen is a very common material for industrial companies and their storage as well as transportation is optimized and could be implemented in compressed storage solutions. [324] [323] As signals for this scenario, the grid parity of renewables and conventional power plants as well as improvements in the usability and efficiency of central storage systems can be seen.

8.3.3 Scenario 3: Integrated Green Future

The **Integrated Green Future** scenario is characterized by advanced technology for central storage and batteries, high prices and volatility for fossil fuels and a consumer mindset that is not limited to individual benefits, shown in figure 8.14.

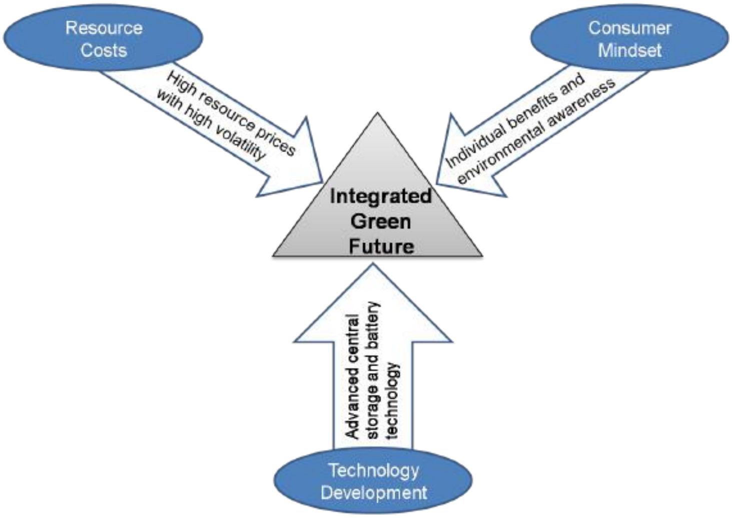

Figure 8.14: Projections of the Key Drivers for the Scenario "Integrated Green Future"

Advanced storage technology makes it possible to compensate the dependency on external environmental factors of renewable energy sources. Energy can be stored central in compressed hydrogen energy storage as well as decentralized in batteries and small hydrogen storages. Fossil fuels have increased in price and volatility beyond peaks measured in 2008. This price trend was active for the past ten years resulting in high prices and insecurity for German private and industrial customers. In contrast, the prices for lithium and other metallic battery ingredients have only slightly increased. The demand for lithium is on a moderate level with overall slight increase compared to 2009. Looking at the consumer mindset, both individual benefits and environmental impact play a similarly important role. Consumers focus on costs and reliability of energy supply. Besides that they are concerned about the environment and their behavior reflects an understanding of environmental issues. Consumers put effort into influencing the environment in a positive way. As a consequence they are actively involved into the energy market and also adjust their behavior to factors other than just costs.

8.3.3.1 Scenario Description

High resource prices for fossil fuels along with technology improvements in the energy sector push towards the use of renewable sources. Storage technology plays an important role as it is the dominant and cheapest way to balance the intermittency of renewables. Furthermore, consumers actively decide whether they only want to use renewable energy or also produce it by themselves. Some of them even invest in own storage capacities. Their goal is to be able to control energy usage behavior themselves. With that in mind consumers individually optimize energy usage and have financial benefits in the end. Maturity of Technology and consumer acceptance made the success of electric vehicles in inner cities possible. They play an important role in the national storage concept as well as they are of significant importance to the German economy.

Energy Production

In 2025 energy production through fossil fuels especially coal is the predominant energy source. However, decentralized energy production with renewable energy sources plays a significant role in the energy mix.

Solar panels have reached grid parity for some time and perform at efficiency levels far beyond nuclear energy. At the same time production processes for solar applications perform at low costs. Thin layer panels and hydrogen-based silicium materials along with nanotech optimizers replaced traditional silicium wafers. As a result solar energy is a competitive and clean way of producing energy. Photovoltaic devices are in broad use with diverse areas of application. Besides the traditional solar panels on roof tops, they are implemented in mobiles, cars, on streets and to generate energy where it is needed. Catalysts enable renewables to generate hydrogen out of sunlight and water to store produced energy locally. In particular wind energy is the most important source of renewable energy in Germany. It is both used centralized in large applications onshore and offshore mostly in the north as well as decentralized. Turbines are quiet and work with low pressure allowing wind energy to operate closely to people.

Utilities could lock their strong position in energy production by investing in large energy facilities and virtual power plants from renewable sources. Nevertheless, private households and businesses to large extend have their own renewable sources installed making them so called prosumers. They are able to produce parts of their energy themselves at much lower costs then the grid provides, some of them even produce more energy than they actually need. Of course their problem is the volatility of renewable sources and the fact that production time and consumption time do not match to large extends.

Compared to 2009 consumers do not have fixed electricity price tariffs anymore.

Via a smart grid it is possible to have two way communications between energy suppliers and consumers. As a result, flexible tariffs that reflect the prices through demand and supply market mechanisms are in place. ICT makes it possible for consumers to have insight into prices and to decide whether to consume or not. Price differences during the day are used by some customers to amortize their batteries as they buy cheap electricity during nights, store it and sell it back to the grid to higher prices during the day.

Consumers prefer not to sell their energy back to the grid in general but use it themselves. Fixed feed-in prices are not guaranteed and therefore consumers face variable prices. As these prices are determined by supply and demand on a national base, consumers that feed in energy would compete with generally high supply as most solar panels produce energy at the same time during the day. As a result prices would be very low which is why consumers prefer to use as much of their produced energy themselves as possible. The EEG that historically provided the framework for feeding in is not active. First of all it was not scalable enough to handle the large expansion of renewables that took place. Secondly, it was harmful for German industry as manufacturers used promised feed-in tariffs to sell renewables overpriced and stop innovating. Meanwhile US and Chinese made up for leading positions in the market being strong competitors to German companies.

Storage

The storage system is interconnected. Utilities need extensive storage capacity to lever cheap and clean energy of renewable sources. Therefore, they use large central storage as well as decentralized storage.

First of all they use large central storages. Pumped hydro and compressed air energy storage solutions are used for short term balancing of several hours whereas compressed hydrogen energy storage solutions are used to balance long term intermittency of renewables. New units for that purpose are already in construction. CHES is working at efficiency levels above 95 percent and providing high energy and power density by using hydrogen to put it under pressure and store it in caverns under the surface. The availability of hydrogen is close to 100 percent and guarantees short term supply readiness in less than 15 minutes. The high energy density ensures supply for German energy need for several days while the high power density guarantees the smooth supply for all energy demand even without parallel production. Security issues with hydrogen are minimized by efficient storage mechanisms as well as safety standards.

Because central storage needs high capital investments, utilities also focus on expanding decentralized storage capacity in form of batteries in particular with electric vehicles. However, only few private households invest in own battery capacity because it still is expensive, they have little experience and are not sure what development the future of storage will bring. From a technology perspective batteries match necessary requirements for broad application like fast charging time, high power density and availability. Nevertheless, smart infrastructure that can be used with storage is in place. Through smart meter appliances two way communication between consumers and utilities is possible. Energy and additional data can be transferred from any smart meter or energy access to another, e.g. consumer to provider. The system works very similar to the Internet addressing system with an IP based protocol.

When it comes to batteries, nowadays not only their technology but also recycling them is of major importance. Batteries from a chemical perspective only have limited lifetime in form of charging cycles. Afterwards their energy and power density decreases dramatically. However by recycling them, material can be used again with only little losses. This helps to deal with the limited resource supply. Moreover, recycling battery material and chemicals is the only way to protect the environment from toxic material and waste.

Consumers

Private consumers care about their energy consumption and consider environmental impact when making decisions. Moreover, they see renewable sources as a good investment that not only provides good return on investment to them but also makes them independent to produce own energy. Consumers are aware of the fact that most appliances in their life are dependent on energy. Sophisticated storage solutions make it possible for consumers do not have to care about security of supply even with intermittency of renewable sources.

Another aspect that is of crucial importance for consumers is to have real time insights into their energy consumption and behavior. This is possible by using ICT enabled devices like smart meters. Considering the fact that several households own or rent electric vehicles and some of them replaced all their gasoline driven ones, consumption of energy replaced consumption of gasoline somehow. This development plays into consumer behavior and mindset to keep track over energy consumption not only aggregated and once a year but to be aware of what appliance takes how much energy at what time.

The billing for energy is adjusted to consumer needs. First of all cars have different energy plugs than other energy appliances. Secondly all consumers are have insight into their bills as tariffs reflect variable prices and they are generally adjusted to usage behavior. Furthermore, the fact that environmental branding became important as social attribute shows the importance of the topic in society. Private households as well as businesses use for example their electric vehicles to demonstrate environmental awareness and lifestyle. In fact this is an enormous factor for consumer mindset to accept and further push green energy.

Nevertheless, consumers feel that their leverage on environmental change is relatively low compared to what businesses can do. Consequently businesses use their environmental behavior as strong branding and marketing towards customers. In addition governmental regulations and benefits as well as cheap energy make renewable sources and storage profitable for them.

E-Mobility

In this scenario E-Mobility is successful as consumers swapped their fuel-powered cars for rechargeable models. The total cost of ownership for electric cars is lower than the one for fuel-powered cars with internal combustion engine. Energy providers benefit as they can use decentralized car batteries as storage to balance their production curve. Electric cars pay off because of advanced battery technology, scale effects in production and high prices for gasoline. Lower costs along with the positive environmental impact makes consumers favor electric cars over ICEs. As a result, electric vehicles developed an ecosystem that involves several different players as figure 8.15 shows.

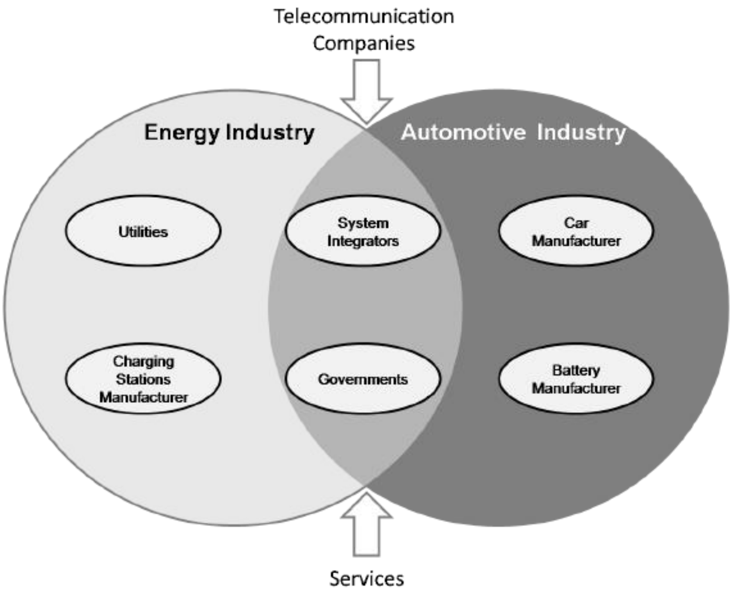

Figure 8.15: Overview of the E-Mobility Player

Initially, the adoption rate for electric cars was pushed through governmental support in form of tax benefits and subsidies as well as free charging spaces in cities provided by utilities. Moreover, customers got accustomed to electric cars through the broad testing phases in model regions. Now that electric cars are a mass market, governmental support is reduced and electricity for charging is not free anymore.

Battery technology makes it possible to build electric cars with a performance similar to ICEs. Traveling more than 500 kilometers is possible because the capacity is more than ten times better compared to 2009. In addition batteries can be recharged in less than 15 minutes which convinced the customers to switch. At the same time prices for batteries dropped significantly. The standardization of car batteries was a major factor to reduce costs besides technological development. In the end this resulted in a mass application of electric cars and it was certainly required for consumer acceptance. Car manufacturers and battery providers benefit from this standard because of easier maintenance, higher compatibility and shared development costs. Consequently car owners can charge their car at any standardized plug-in spot all over Germany and in most European countries. The next step would be a European standard which is currently developed together with the EU. Adequate infrastructure for electric cars is provided in cities and on the countryside. This infrastructure relies on three factors that are necessary to run cars, power supply, billing for it and efficient load management for car batteries.

Power supply is provided by large utilities like E.ON and former oil companies like Shell. They used their market power to build up an infrastructure for charging. Oil companies have extended their market to energy production from renewable sources and established large production capacity. To easily sell this power they are active in the car electricity market. As charging stations can vary in their size to meet the specific requirements they are available in much higher quantities than gas stations are nowadays. All charging appliances are based on a common standard created by power suppliers and car manufacturers. Although charging stations are owned and power is provided by specific utilities, cars can be charged at any station that shares the standard. If consumers have a contract with a provider of the E-Car Alliance (ECA), they can use any station within that large network without any additional costs. The model is similar to the cash group alliance in the banking system.

For charging the cars there are basically two different types of contracts available: a subscription model for miles and an energy usage model. This different types are demonstrated in table 8.16. The subscription model allows consumers to freely charge their cars at any ECA station within the predefined contract limit (e.g. 20000 kilometers per year) which makes it a limited flat rate. If customers exceed that limit extra usage is charged according to contract terms. Subscriptions and charges vary in battery model, contract lifetime, car usage and some other factors. Charges depending on the battery are measured by energy density. Small vehicles with small batteries have lower costs per mile than large cars with large batteries. Contracts are signed with the purchase of a new car at the car dealer making them resellers for energy subscriptions. Typically a subscription is made for three years providing not only terms of energy supply but also a leasing model for batteries. As the battery contributes a large share to the overall costs, the leasing model reduces initial investments by rising subscription fees. During that period car manufacturers guarantee high battery quality with more than 80 percent DOD (depth of discharge = left overall capacity). Often contracts are upgraded by maintenance and insurance services.

The second contract model is based on a pay-as-you-go service similar to how gas-stations operated in 2009. Consumers do have a basic contract with a minimum monthly fee with energy providers but they do not have any subscription for miles. Accordingly they can charge their battery at any ECA station while they only get charged for the amount of energy that was necessary for that. These customers do not have leasing models for batteries. Consequently they are more independent but also responsible for their battery and energy consumption. Overall it depends on how consumers use their car to determine the best contract fit.

	Subscription contract	Pay as you go contract
Cover	Electricity Battery Leasing	Electricity
Charging	Flat, e.g. 20000 km/year	Energy (kWh) necessary for charging, Prepay possible
Subsidy	Battery amount depends on subscription, up to free car	NA
Contract time	>12 months	Short, enables flexible provider switch
Possible additional services	Insurance, maintenance, traffic services etc.	

Figure 8.16: Types of Contract for Charging Electrical Cars

Along with the high convenience for customers, the system has one big disadvantage. Cars can only be charged by licensed supplies. Utilities have these licenses and provide infrastructure with for consumers to charge their cars at home need. If consumers want to charge their cars with their own renewable sources, they need to get a license for that from the state. As these licenses are very expensive it is only profitable for private households with many cars or businesses. Consequently average consumers cannot use their own car as storage for their renewables but would have to invest in separate storage capacity.

To handle billing every electric car is equipped with a unique identification device that communicates over mobile phone networks. First of all this allows customers to easy connect their cars to the supply infrastructure and automatically get billed. Second of all telecommunication providers benefit from the application of their competencies and billing system within the car industry as well as the increased traffic on their networks. Moreover, this enables customers to get detailed information on their car usage, subscription data and current situation on the Internet as well as on a usage statement. Another major aspect that reflects the similarities of telecommunication systems and electric cars is the use roaming models with the contracts. By using mobile authentication, German consumers are able to use charging stations outside the ECA network for example in other countries and be sure of adequate billing.

Having an increasing share of electric cars that are used as storage solutions, utilities have load management appliances in place to ensure sufficient supply for car owners as well as dynamic load levels to flatten production curves.

Although battery and car technology is advanced, cost issues make it necessary to adjust the performance of electric cars to its use case. The market does not provide cars that combine all positive aspects of battery powered solution but rather focuses on value for specific usage. The first major application is city electric vehicles (CEV). Most CEVs are either used by commuters as an additional car for inner cities only or by car rentals. The market for car rentals increased dramatically since 2009 supported by low inhibition threshold of customers to impulsively use a third party car for one way travels. With rental cars consumers expect easy access to cars all over the city and to be able to leave them at any destination. Both, rentals and CEV owners expect cars that enable safe and fast city travel at low cost. Therefore CEVs typically are small vehicles optimized for shorter distances of less than 100 kilometers and with quick battery charging. Because of increasing traffic and resulting pollution in cities, local authorities banned ICEs from certain areas of cities in most German cities which also supported the acceptance of electric vehicles and the usage of rentals. To overcome traffic issues CEVs have navigation systems that are able to communicate with real time traffic channels to ensure best routes in cities. Moreover, cars are able to communicate with each other to optimize driving like they for example have synchronized starts at traffic lights. Consumers are willing to pay extra for these services as traffic is one of their major concerns. Electric vehicles produce significantly lower noise than ICEs and therefore the car noise in the cities is nearly gone. Meanwhile some manufacturers equip their cars with sound systems as certain consumers want to hear an engine in their cars.

In contrast cars for outer cities are designed to cover larger distances. Usually these cars are larger than city cars and their batteries have a higher energy density. Fully electric cars are gaining increasing market share in this domain. Nevertheless, plug-in electric vehicles with gasoline and biogas powered engines are common and can also be used for load management to some degree by utilities. Sports car manufacturers position their cars with sportive design and high power batteries at high costs. These cars are particularly useful for load management and customers often use subscription models making them raw models for electric vehicles. However, these cars are only sold in low quantities.

Overall electric vehicles benefit from acceptance by private households as well as electricity providers. Accordingly the car industry puts effort into further development of cars, battery technology and infrastructure. One promising development is for example photoelectrical car paint that charges car batteries while driving and will reduce dependency on subscriptions and charging slots. Furthermore, infrastructure enhancements like large scale induction charging is currently tested in pilot projects. With this technology it would be possible to equip highways with inductors that constantly charge cars while driving. This provides security for drivers and business opportunities for electricity providers.

Governmental Behavior

Governmental initiatives and regulations currently aim in two directions, ensuring long term industrial competitiveness for Germany and securing sufficient state income. Environmental protection and climate goals do not have significant impact on Germany itself as Germany is one of the leading countries when it comes to a green energy mix. To reach the first objective a combination of subsidies, taxes, and investments is currently pursued in the field of battery-powered vehicles. The government's strategy is to create prosperity for Germany through long term economical growth. Historically they pursued that through initiatives for renewable sources like the EEG, which is canceled now and through reduction of dependency on fossil fuels to strengthen the domestic market.

Meanwhile the financial situation of the government, characterized by high dept and high expenses for subsidies, requires keeping track of sufficient state income. A major regulation concerns taxes for cars. As historically the government had significant earnings through petroleum tax, this is decreasing due to the switch to electric vehicles. Accordingly tax regulations are adjusted to power tax for cars. Meanwhile utilities face a similar problem affected by E-Mobility. CO_2 certificates that originally were assigned to the transportation sector with gasoline vehicles are now necessary with utilities as they contribute an increasing amount of power for transportation. Currently there is heavy discussion about adjusting the assignment of CO_2 certificates and eventually a solution will be found in near time.

Utilities

Per-unit generation costs of utilities have increased since 2009, mainly because of the adoption of renewable forms of energy, like solar and wind. Firstly, they had to invest in infrastructure for transmission and management. Furthermore, any carbon tax or cap-and-trade scheme will affect energy prices. Additionally the adoption of renewable sources by private households and businesses that partly produce their energy themselves decreased the sales of utility companies.

Considering that electric vehicles are a pillar for utility business by creating new revenues. However, electric vehicles create new revenues for utilities. Only charging electric cars would not have been a base for long term revenues. By using subscription models to sell electricity, infrastructure and additional services utilities have a save and growing market to cover. Moreover, vehicle charging is mainly done at night and therefore utilities can satisfy electricity demand without installing any significant additional generation capacity. In addition they position themselves in the minds of their customers not only as electricity companies but also as forces of environmental sustainability.

Economy

The energy sector especially through the combination with ICT is a major pillar for the German economy. Renewable energy sources, electric vehicles and storage are focus areas for many companies and provide jobs for the German workforce.

Obviously the US and China play a more important role at the global market for renewable sources and battery technology. While the US companies focus on innovation and cutting edge technology, Chinese companies is leader in economies of scale and efficient production processes. Both types have successful market strategies and are ahead of Germany. By having a closer look, Germany shows its competencies in diversification. Companies and research institution have high reputation when it comes to special appliances and focused solutions in the areas of renewable and battery technology. Moreover, Germany has a strong position in engineering of large central storage solutions like compressed hydrogen energy storages or also with carbon dioxide capture and storage.

Historically car manufacturing was always very important for the German economy. The revolution of electric cars was a major challenge for the German car industry and they had to reinvent their businesses. In the end this was successful because they used their competencies and strengths in the right way. Attackers faced significant entry barriers like manufacturing scale, brand equity, channel relationships and to some degree capital.

Changes in the car sector affect both manufactures and companies along the whole value chain. First of all system integrators who combine energy industry with automotive industry (utilities, Original Equipment Manufacturers, government) are active in the market as cars and electricity grows together. Secondly, electric cars changed structures and jobs in supply and maintenance for cars. Battery powered vehicles do need other parts than ICE, for example they do not need any transmission. An integrated system of electric engine, control systems and the battery interface is is the important part in an electric car. As a result they not only need different maintenance but more important less maintenance is required as service intensive parts like catalytic converter, transmission and others are not in place anymore. Although restructuring the sector was necessary and job cuts were inevitable, overall the market showed growth and the intersection of energy and cars employs more people than 2009.

Environment

Looking at Europe, several similarities to Germany can be found. However, in some parts of Europe the situation looks different. Energy production capacity of renewable was extended in almost all countries. Some of them wanted to comply with their climate goals, others just wanted to get independent of high and volatile resource prices. In the first case renewable sources play a more important role and efforts to optimize climate impact of energy production from fossil fuels is made. Currently first carbon dioxide capture and storage solutions are installed to store CO_2 emissions from burning for example coal. As a result emissions of carbon power stations can be reduced making them less harmful to global warming.

Energy consumption worldwide increased since 2009. Although the importance of green sources in the energy mix increased, the overall amount of environmental harmful energy production did not decrease significantly. As a consequence the world still faces challenges mainly pointing to emerging countries as well as India and China. However, India and China participates in international climate regulations and they pursue initiatives to expand the share of renewable sources like solar panels or wind energy as they are not more expensive in producing energy in particular because prices for fossil fuels are very high.

Nevertheless, these countries do neither have sufficient infrastructure nor do their citizens have enough disposable income to invest in such sources. As a consequence international regulations must be set and financial support must be given to these countries in order to lever the highly sophisticated energy solutions worldwide.

8.3.3.2 Weak Signals

The energy production in 2009 shows increasing share of renewable sources especially wind energy. Solar panels are about to reach net parity in the next few years and to further increase their efficiency. Moreover, storage units are tested with several wind farms to reduce the given intermittency. Governments and research facilities invest large amounts of money into research on battery technology. Universities see a significant demand for battery specialists from industry companies, especially in the US. In addition signals of electric vehicles can be identified. Car manufacturers show prototype cars at international trade shows and compete against each other in terms of environmental branding. First vehicles that show technology potential like the Teslamotors Roadstar are already built. E.On installed several charging stations in different German cities, for example one at the main building of the Technical University in Munich. RWE even started a road tour alongside with TV commercials to show technology potential of electric vehicles and generate consumer awareness [318] [306] [326] [325, p. 77-83, 87]. Major advancements within battery technology as well as in charging possibilities are signals for this scenario. In addition, a changing product portfolio towards electric vehicles of the existing major automotive companies is a strong signal.

8.4 Product Idea: Storage Cloud

Referring to the scenario **Integrated Green Future**, three basic assumptions are made. Firstly, the market price of energy is variable and depends on the time of the day. Secondly, compensation for feeding energy into the grid is below the market price at all times because on the one hand renewables are cheap and efficient, on the other hand electricity from providers is attached with taxes and tributes. Thirdly, renewable energy technologies are lucrative investments for households.

8.4.1 Executive Summary

A large number of private and industrial customers have renewables they cannot use efficiently because they do not own storage capacity. Feeding their excess energy back to the grid is less rewarding than using it on themselves later on. The **Storage Cloud** solution solves that problem by providing an outsourced storage service that customers can access on demand for a monthly fee. With stored energy from customers, revenues are generated through trading on energy markets.

8.4.2 Customer

The service approaches customers that generate excess energy but cannot store it for later use. The target groups are private households and industrial customers. Their renewable energy technologies are capable of providing a significant share of the total energy demand independent from providers. However, generation and consumption time differ especially for private households and without storage capacities energy has to be fed back to the grid.

8.4.3 Problem

Customers want to store cheap excessive energy from renewables instead of feeding it to the grid as the price they receive for a feed-in is below the price for consumption from providers, mainly due to taxes and tributes. Storing renewable energy is therefore preferred but most of them do not own storage capacity. Investing in own storage capacity for most of them is not an considerable option because of a high initial investment and uncertain running costs some of which are uncertain with regard to the probability and time of occurrence. Other than that they are uncertain about technological development and the lifetime of storage. Finally, own storage lacks of overall convenience, mainly because of the need for space in the basement and maintenance issues. Although some customers own electric vehicles, they cannot use them as a storage solution. Most of them are not willing to acquire the license to charge their cars and are therefore bound to utilities that have the right to do so.

8.4.4 Solution

The solution is to provide customers a service for outsourced storage capacity that they can use on demand for a fee. Consumers can save their energy to the **Storage Cloud** and get it back when they need it. Using virtual mass storage service provides all advantages of having own storage but overcomes its main disadvantages.

Consumers therefore get a personalized account and an appliance at home that automatically arranges energy in- and outflow. No personal oversight and engagement is needed but consumers have all necessary flexibility with their energy. The service determines the energy amount to be stored in case of over generation or to be consumed in case of over demand as well as the timing of the energy flow automatically. To further convenience, it includes taking care of the storage, meaning that the customer has no personal risk involved regarding storage lifetime, capacity reduction and necessity of maintenance. Consequently, the solution allows for long term planning compared to the case of decentrally owned storage as it assumes responsibility for unexpectedly occurring costs. In addition, space for the storage does not have to be at customers' disposal and neither installation costs nor high initial investments are necessary.

Customers are provided with access to software that is designed for monitoring and prognoses purposes. It also displays monthly savings, which result from the use of the service as opposed to a feed-in to the grid.

8.4.5 Technology Behind the Service

The company operates a **Storage Cloud** by connecting decentralized smaller storage capacity to one large virtual mass storage that customers can access. This concept refers to a trend in information technology that software is not installed on personal computers but saved rather centrally at the provider; personal computers access the software using the Internet. The storage cloud consists of two sorts of storage capacity where the first one is owned and maintained by the company itself and the second one is used from external providers.

The company maintained storage serves as base load. This part of the storage park is built of small batteries that are connected with each other, enabling the company to expand the farm gradually over time according to the development of the customer base's size. It also helps to avoid high initial costs of investment and further difficulties that arise when compressed air energy storage or a pumped hydro system is constructed. Besides scalability this concept also accounts for higher flexibility and reliability as the system is depended on numerous small and easily interchangeable units instead of one big central unit.

The second part of the storage park is a co-operation between the company and diverse entities that operate an emergency or standby power supply system. These systems use electricity from their own large-scale storage in the case that their usual power source is not delivering. Employing such systems is either autonomous or explicitly regulated by law. The company stores electricity on these systems and can use it on demand. The company guarantees power delivery to the entity when an emergency occurs. Stadiums represent an example where such standby power supply systems are used. In this case, the exact time of a possible system power-up is predictable because the date and time of an event is known.

The composition of the cloud is shown in figure 8.17.

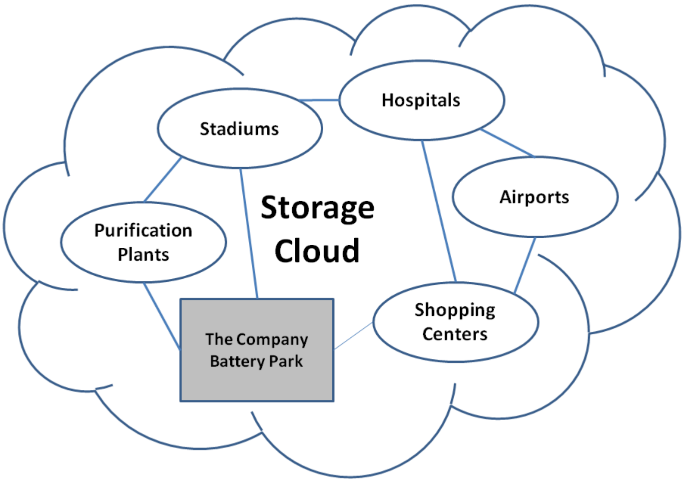

Figure 8.17: Composition of the Storage Cloud

In the cloud, both sorts of storage are connected not only with each other but also with the customer. Using the smart grid, this connection allows for a bi-directional flow of energy, an application of getaways and for assigning energy flows to the proper customer. The concept works with IP based protocol of the energy system that allows to connect each specific customer to the **Storage Cloud** and to transfer energy. The company offers a storage service that requires no personal involvement in the sense that choosing an energy source for the household's consumption is done by the system automatically. If generation from renewable sources creates surpluses, the excess is automatically stored on the corresponding account. In case renewable generation cannot supply the demand, energy of the cloud is used.

Customers receive software which is able to monitor the status of their storage account. In addition, this software shows monthly saving by calculating how much the customer would pay to utilities in the case of excess demand and subtracting the amount it would receive from the market for feeding in as well as the monthly payment for the storage service. Finally, a graphical user interface is built in to inform customers about weather conditions and forecasting. The company is able to guarantee unlimited storage period and capacity due to the scalable system.

Software that works with data from weather forecasting services is applied in the company to allow for making prognoses about the development of energy supply and demand over time and support better planning.

8.4.6 Business Model

The company's revenue is created through two streams, storage as a service and energy trading. This is shown in figure 8.18.

Figure 8.18: Revenue streams

Customers who sign up for the storage service are offered two options to choose from, both of which involve a monthly fee. The first one is a subscription flat rate charged monthly. Purchasing this package allows customers to use the service without limits regarding both the period of storing and the amount stored. They have unlimited flexibility in storage use. The second option is a monthly subscription fee for a limited storage contingent in different sized packages. Each package is designed to satisfy different sizes of renewable generation plants and puts a corresponding limit on the permitted monthly energy flow to the **Storage Cloud**.

Whereas, this channel of the business model is based solely on the function of a virtual mass storage provider and is used only within Germany, the second business model is targeting non-transparent global markets with meteorological and time differences between regions. With the aggregation of stored energy from customers revenues are generated through trading on energy markets. One of these markets is the spot market among others like futures market and energy auctions. Storage capacity is used for keeping energy on stock and selling it at high prices, in other words, during peak demand hours. One possible concept is to use different time zones along the energy grid to lever varying peak hours across the continent or beyond. For example the highest time difference is three hours between Moscow and London.

8.4.7 Business Partners

Various entities are involved in addition to households and industrial customers. Externally procured storage capacity lies in the hands of entities that use an emergency power supply system. The company works with stadiums, hospitals, private clinics, airports, cold stores, shopping centers, banks, datacenters and purification plants.

Contracts are signed with insurance companies to insure against breakdown of the **Storage Cloud**. In addition further insurance is required for trading and the possibility of shortfall on supply for consumer demand on stored energy. In order to mitigate the probability of such an occurrence, the company utilizes ad-hoc energy production from utilities and geothermal power generation plants which generate energy in a non-intermittent manner.

To enable the desired flow of energy, the company co-operates with grid providers and uses their technology for the transmission of energy from the storage to the customer and vice versa. These companies also provide the technology necessary for a communication that builds on IP gateways and allows for an identification of energy in- and outflows.

A storage maintenance company is employed for handling the company's storage park. Information about the weather permits prognoses of energy generation and consumption. This information is provided to the company by weather forecasting stations. In order to receive access to spot markets, trading is done on energy exchanges. Such exchanges in Europe are for instance the European Energy Exchange, the Italian Power Exchange and NordPool.

The company co-operates with solar power plant and wind turbine developers that establish relationships with households and the industry and promotes its storage service using this channel. The co-operation is designed to present an opportunity for signing up for the service of the company right on the spot when renewable energy generation equipment is purchased.

Figure 8.19 illustrates the relationships of the company and the corresponding flow of money.

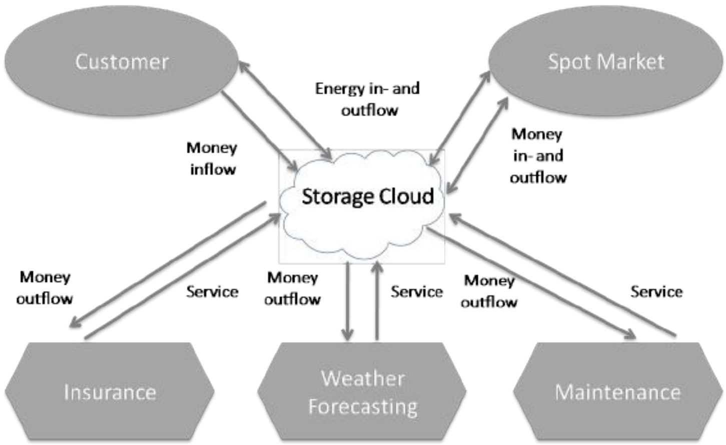

Figure 8.19: Business Relationships

8.4.8 Competitors

Two classes of competition are distinguished. The first class represents competition in the storage service and the second in energy trading.

Energy providers are competitors as they have an influence on energy delivery and feed-in prices which determine how lucrative the idea of joining the **Storage Cloud** is. Such providers are for instance the utilities. Furthermore, utilities have a thorough technology knowledge and a solid customer base on which they can build if they decide to create a virtual storage. Storage manufacturer and developers also aim to compete by offering lower costs and higher convenience when they design individual storage systems for households and industrial customers.

The energy trading business is non-transparent on a global basis and has numerous participants that include utilities, industrial companies with own generation plants, banks and hedge funds.

8.4.9 Value Chain

Operations cover two parts of the evolved value chain, illustrated in figure 8.20. The company offers storage solutions and engages in electricity retail. However, it needs to use the externally operated smart grid as a means for transmitting energy with proper identification of the customer involved in the transmission.

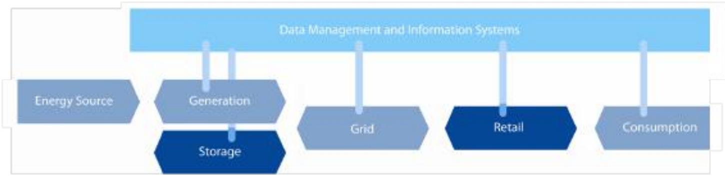

Figure 8.20: Evolved Value Chain

8.5 Conclusion

The **Integrated Green Future** scenario shows one way storage could shape the future as a Missing Link. Storage can be a powerful enabler for the renewable energy and automotive industry. However, this development depends on several key factors as discussed and certainly requires initiative, commitment and compromises by governments, industry and private households. In the upcoming years the development of storage technology will become a major topic. Large investments by governments and venture capitalists let companies have the vision of being the next Google in energy. Without a doubt, technological breakthrough in battery technology can be the holy grail for a company to equip a future fleet of electric cars and also to have an optional sales opportunity for renewable sources. History in energy and technology showed that disruptive innovation can happen, however especially in this case the depth and pace of change is uncertain. Up until 2025 consumers are in either scenario not likely to have their own advanced storage capacity to make optimal use of renewable sources. Service and subscription models will gain importance in the future as they help customers to spread initial investments and companies to stay close to their client base. The product idea **Storage Cloud** shows how customer needs can be addressed by such models in the future. Changes in the energy sector will be challenging for most existing companies but also will provide opportunity for emerging businesses. In the upcoming years we will see innovation in technology, business models and governmental regulations.

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Chapter 9

9 New Market Places

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Adrian Sennewald

Companies have to adapt their strategies to the new market situations in order to stay competitive. E-Energy creates electricity market possibilities that can be found by looking at the new participants and functions. Three factors determine the future development of electricity market places. Firstly the impact of ICT and the flow of information shapes how market places function. Secondly the power supply infrastructure enables market places to emerge. Thirdly the consumer electricity market participation influences the market structure.

These key factors were identified by using a scenario planning methodology and used to develop three possible scenarios. The first scenario is called Giants Amongst Each Other. In this possible future projection market places are characterized by a few major utilities that trade electricity bilaterally on the basis of long term contracts. In contrast thereto, second scenario is characterized by a large number of market participants. This scenario is referred to as Beehive. Here electricity trading is organized through a big international electricity exchange market. Consequentially the market has a polypolistic structure. The third scenario which served as the foundation for the business idea is called Interconnected Swarms. The name stands allegorical for the micro-markets that emerge on a regional basis and are linked through an exchange market the so called New European Electricity Exchange (NEEX). Although, ICT is highly sophisticated in this scenario it is not capable of collaboratively controlling all devices along the complete electricity value chain on a nationwide scale. In addition to that there are a lot of prosumers i.e. people that play the role of a consumer and producer at the same time. These prosumers need an electricity trade market in which they can participate as an individual. These two facts form the basis for the above mentioned micro-markets. This new market structure leads to drastically new retail services.

Building on the framework given by the Interconnected Swarm scenario the business model is a special retail service that addresses the needs of prosumers and offers consumers incentives to play a more active role in the electricity market. This service clusters con- and prosumers in the same distribution grid into Virtual Prosumers (VPs) and offers them an electricity exchange market on multiple levels. On level one customers benefit from real-time prices that their automated gateways use to adjust the behavior of in-house storage, generation and consumption devices. On level two participants within the same distribution grid are grouped into a VP allowing for trading within itself. On the third level the individual VPs can trade with anything beyond the transmission grid from other VPs to the NEEX. Trading within and between levels is determined by a real-time pricing system. The service provider's revenue is created by the spread between the price consumers have to pay for electricity and the price producers get paid for electricity.

9.1 Introduction

Major changes are going on in the German energy sector. The share of renewable energy sources are increasing, fossil fuels are becoming scarce, a phase out of nuclear energy has been put forward and unbundling along the value chain is required by law. The focus of interest in this chapter lays on how mentioned changes influence electricity market places until the year 2025. This concerns where and how electricity is traded, who participates in markets and which market form is dominant. It is very important to keep in mind that the focus lies exclusively on electricity market places. The scope of this report is not to provide forecasting models but rather to answer the question about what the future might look like by using scenario planning.

The following process was used to make this report: In a first step the ten most influencing drivers for new market places were determined partly based on the foregoing basic reports. Next those drives were ranked to determine the key drivers which are the most important and uncertain drivers. The projections of the three key drivers build the foundation on which the scenarios were built - each having a unique constellation of the particular projections. These scenarios can now give us a picture on how electricity market places in 2025 may look like. A business model was developed to demonstrate how the Interconnected Swarm scenario may look like in detail.

This report is structured according to this process. The driver analysis describes the drivers, their possible projections and implications followed by the three possible scenarios. Finally the business idea proceeds the third scenario on which it is based.

9.2 Driver Analysis

In the following section the ten most relevant drivers for new market places in electricity trading by 2025 are described. These drivers are divided into certain and uncertain drivers. The certainty of a driver depends on how reliable a projection for 2025 can be made. Furthermore, three key drivers are identified among the uncertain drivers. These are the ones who are highly uncertain and have a big impact on market places. Figure 9.1 shows the ten drivers mapped according to their impact and uncertainty.

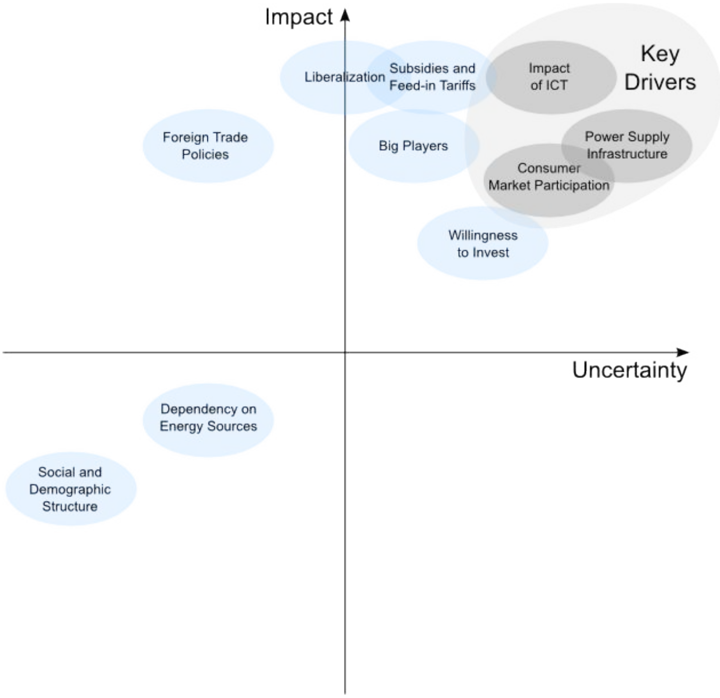

Figure 9.1: Drivers according to their uncertainty and impact

9.2.1 Certain Drivers

Concerning electricity market places in 2025 four certain drivers can be identified. In the following these four drivers are listed with respect to their impact, beginning with the driver that has the highest impact. Figure 9.1 shows how the drivers are ranked according to their impact and extent of certainty. After a short description a projection is made for each driver showing the development that is to be expected until the year of 2025. In addition the main implication for market places is given for the respective projection.

9.2.1.1 Liberalization of the Electricity Sector

Similar to other markets in the electricity sector there have been political efforts to break the monopoly of formerly state-owned companies and encourage competition. In Germany energy providers had to split up along the value chain into separate companies as enforced by the Energy Industry Act (EnWG) [336]. Liberalization of the electricity sector has a direct and high impact on markets where electric power is traded. If only a few companies control the whole value chain the structure of the energy market will be completely different as if there is a polypolistic structure.

Liberalization can be taken as a certain driver as it is dominated by EU-guidelines and regulation. On a EU-level the biggest fractions in the parliament agree that they want to ensure a competitive market and avoid monopolies be enforcing unbundling of electricity companies along the value chain [348, 345].

It can thus be expected that in the future companies that are active on the market are unbundled and will remain unbundled along the value chain. It is not completely certain to what extent companies are given enough freedom to cooperate with each other by law.

For the market the legal structure that implements liberalization and namely unbundling and third-party-access will create a need for trading of electricity along the value chain. Independent from legislation market places could be structured in two ways. Either companies make direct long-term contracts with each other or trading of energy takes place in shorter timeframes.

9.2.1.2 Foreign Trade Policies

Trade policies for electricity play an important role for the structure of the European power grid. National governments can either decide to protect their local market by building up high tax barriers or they can decide to open this market for international and intercontinental trading. The importance of this driver is highly correlated with the possibility of transmitting energy over long distances with little losses. Within the European Union it is likely that the latter option will emerge as the European Commission has agreed on working on a joint Trans-European Network that connects all European countries. They have agreed on cooperation in research and the promotion of industrial investments in this sector [342]. This implies that market places on a European level might emerge or at least barriers to such a market will be reduced.

9.2.1.3 Dependency on Energy Sources

Most trends concerning dependency on energy sources are quite foreseeable in their impact for 2025. Therefore, the dependency on energy sources is treated as a certain driver.

Figure 9.2 shows that according to [335, p. 13] coal reserves will last for another 200 years at least, natural gas and oil reserves will last for another 60-70 years. Consequently, by 2025 bottlenecks for fossil fuels cannot be expected whereas dependency on import from foreign countries is will increase along with prices [335, p. 13].

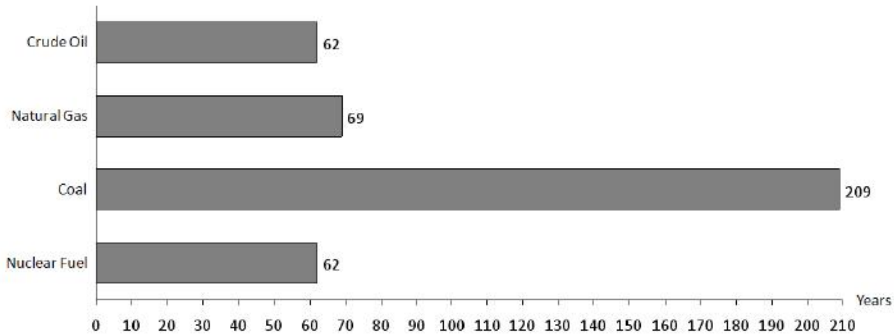

Figure 9.2: Fossil fuel reserves
Source: adapted from Bundesministeriums für Wirtschaft und Arbeit [335, p. 13]

Above all oil and natural gas prices will climb as they are the skimpiest of resources. Still the extent is fairly uncertain for most fossil fuels other than coal, where prices can be expected to be on a similar level as today or just slightly above [338, pp. 11 - 13]. The nuclear plant phase-out on the other hand with uranium as a energy source represents a huge impact as it has to be replaced. However, some uncertainty remains whether lifetimes of nuclear plants will be prolonged or not. As renewables will have a much bigger share of generated energy they will compensate some of the nuclear sources. Figure 9.3 shows what the composition of electricity generation will be like in 2025 in relation to energy sources.

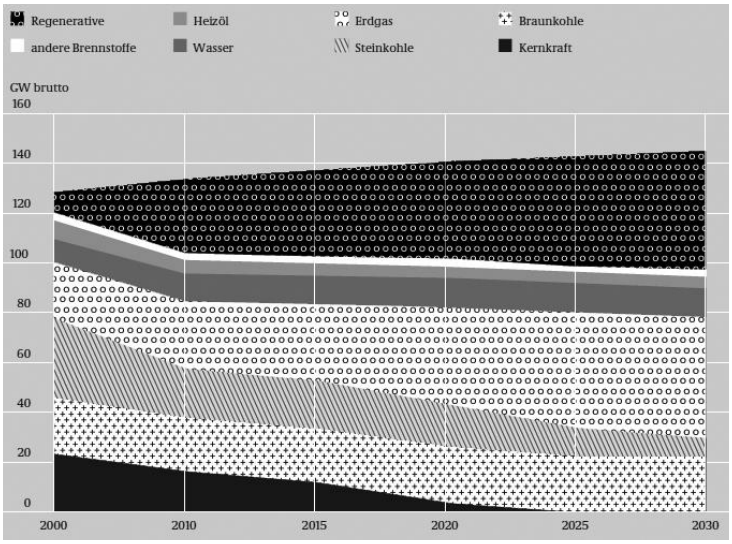

Figure 9.3: Development of power plant farms 2005 to 2030
Source: adapted from Bundesministeriums für Wirtschaft und Arbeit [335, p. 33]

Overall, dependency on fossil fuels will to decrease and dependency on renewable sources will rise. This implies that dependency of energy has a slightly different character in 2025 as renewable sources are on the one hand much more volatile but on the other hand decrease dependency on import of fuels from foreign countries. However, it is not yet certain to which extent this new character will develop. Market places will have to cope with this and therefore need new mechanisms to enable a stable supply.

9.2.1.4 Social and Demographic Structure

Demographics play an important role for market places, because the regional distribution of people determines where markets emerge. In addition the development of population in terms of age groups, ancestry and education level has a big impact on who is market participant. These factors are quite foreseeable and therefore a certain driver for market places. In 2025 Germanys' birthrate is going to be still fairly stable at about 1.4 children per woman. The population will have decreased to about 79 million people, with a share of about 34 percent being older than 60 years old (compared to 82 million people and 26 percent older than 60 in 2009) [347]. It becomes clear that elderly people are going to play a more important role in society.
Urbanization also progresses and by 2025 about 77 percent of the population is going to live in cities (2009 about 73 percent) [350, p. 79]. The change

of population in different regions can be seen in figure 9.4. A trend toward urbanization is clearly visible. The net migration to Germany will be about two to three million people until 2025. Thus, about 17 to 18 million people with immigration background will live in Germany [333, p. 3].

The level of education is expected to rise due to a greater share of people with a higher education although overall graduation numbers will decrease due to a shrinking number of children [343, p. 87]. For the rest of Western Europe similar demographic developments are expected to take place. Urbanization will increase and older people will become a bigger share of total population. However, Europe's total population is going to increase until 2025 [340].

For markets social and demographic structure of 2025 implies that elderly people and people in congested areas have to be taken into account.

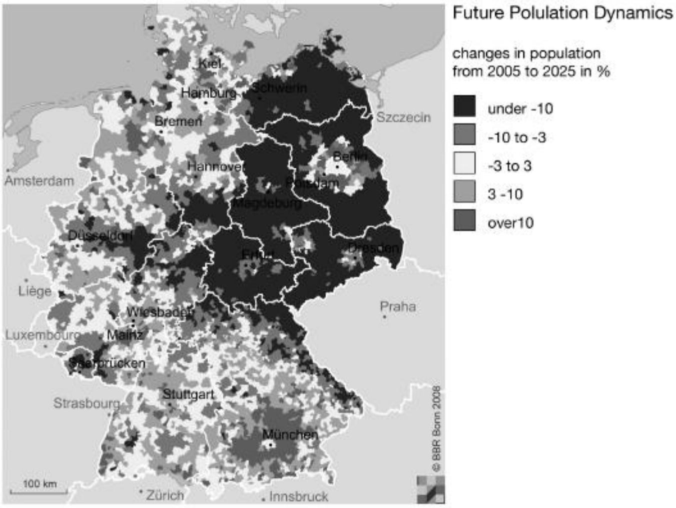

Figure 9.4: Dynamic of German population until 2025
Source: adapted from Bundesamt für Bauwesen und Raumordnung [333, p. 2]

9.2.2 Uncertain Drivers

Six uncertain drivers for market places in 2025 are identified. In the following the six drivers are listed. Figure 9.1 shows how the drivers are ranked according to their impact and extent of uncertainty. Again, a short description of each driver will be given followed by plausible prjections for its development until 2025. To sum it up the main implication for market places is drawn from each respective projection.

9.2.2.1 Impact of ICT on Energy Supply

The first key driver concerns the extent of information and communication technology (ICT) used along the value chain. This mainly determines the way of communication as well as the amount of information that can be provided to each entity along the energy value chain. Market places are strongly influenced by these two factors because they allow for new and differently shaped market places. It is not yet foreseeable to which extent ICT will be used along the electricity value chain and it is therefore an uncertain driver. An exception to this are smart meters. There is a law requiring that all buildings that are newly constructed or renovated have to install a smart meters from 2010 onwards according to §21b of the Energy Industry Act [336]. Consequently, most buildings are going to have a smart meter in 2025. Three probable forms how further ICT usage could look like in 2025 are described below.

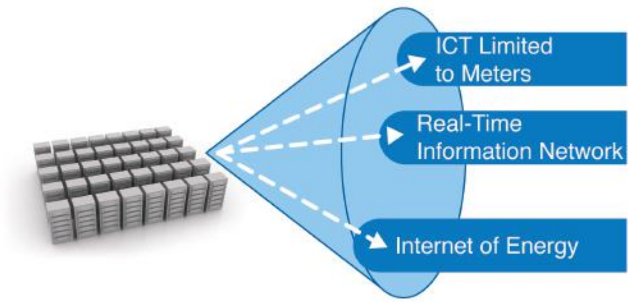

Figure 9.5: Projections for impact of ICT on the energy supply

1. ICT Limited to Smart Meters

   Although, most consumers own smart meters there is no information exchange between retailer and consumer except for the amount of electricity the consumer has consumed. The reasons for such small extent of ICT usage are privacy issues as well as lack of information processing capabilities. Thus, there is not much information that is provided by the consumer which can be used to smooth the load curve. However, consumers can see from their smart meter how much and for what price they consume electricity. This implies for market places that there is only little exchange of information in addtion to electricity prices.

2. Real Time Information Network

   ICT is embedded along the value chain in a way that real time prices for electricity are available to every entity. ICT also enables consumers to buy and sell electricity at real time prices. Either an evolved smart meter or a second device provides this possibility. However there is no information from smart devices provided to other entities of the value chain. A central control of devices is therefore not possible. However, electricity market places have a coordination function as the real-time-price they provide may be used to coordinate other markets.

3. Internet of Energy

   Almost all devices are able to communicate along the whole value chain. Information exchange by smart devices allows for automation of electricity consumption, production and storage. The system controls itself possibly by using the price of electricity as a coordination mean. However, this is limited to certain number of devices, as the complexity otherwise would be to big. Hence, there is for each region an own ICT system, but the systems can communicate with each other some specific informations. It can therefore be conceivable that on market places not only human beings but also electronic devices participate. As a result electricity trading might partly be automated by ICT. This implies that there can be a move toward more virtual market places.

9.2.2.2 Power Supply Infrastructure

The third key driver for market places in 2025 is the infrastrucuture of power supply. The infrastructure considered here consists of three dimensions: energy storage including e-mobility, electricity generation and electricity transmission. How storage is going to look like in 2025 is very uncertain, because from today's perspective no dominant storage concept exists. Concerning electricity generation it seems to be quite certain that renewables will play a bigger role. However it is not totally clear whether generation takes place on a central or decentral basis and to what extent. This is directly linked to the transmission of electricity. In case of decentral generation electricity mainly has to be transported over short distances. If electricity is mainly produced in a few big plants on the other hand it has to be transported over longer distances. In the following the three most likely forms how infrastructure can look like in 2025 are described.

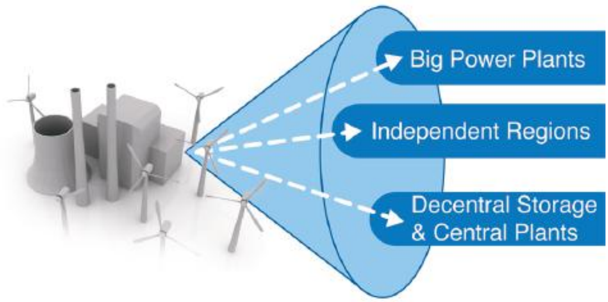

Figure 9.6: Projections for power supply infrastructure

1. Big Power Plants

   There are no new solutions to store big amounts of electricity. Decentral storage (e.g. e-cars) is very rare and negligible. Consequently volatility in electricity generation cannot be smoothed by storage technologies. Power supply is done by a few very big plants, because fusion technology and projects like desertec and offshore windfarms are able to supply a nearly unlimited amount of electricity. Transportation of electricity is done over very long distances. Therefore the transmission network is fully developed across Europe and even across some continents. This means that the efficiency of transportation is very high even over long distances. The power supply infrastructure creates an environment which implies that there exists only one big exchange market place as generation is dominated by a few big players. Much of the trading might not take place at a market place but rather in the form of direct over-the-counter contracts.

2. Independent Regions

   Electricity can be stored central or decentral in form of hydrogen or other new storage technologies. Private people as well as industries run their own combined heat and power generators (CHPs), photovoltaics (PVs), fuel cells or wind mills. Thus, generation of electricity is very decentralized. In addition electricity is generated where it is needed and thus leads to short distances in electricity transmission. The transmission network is capable of bi-directional electricity flow. The infrastructure consequently enables that concerning power supply different regions are almost independent from each other. The consequent implication for market places is that micro market places can emerge.

3. Decentral Storage and Central Plants

Electric vehicles and other decentralized storage possibilities are available. Power generation is a mixture of mostly big central power plants. Storage is mainly used to smooth the load curve and the volatility of renewable energy sources. However, storage serves only as an intraday buffer and is not capable to provide electricity over longer periods of time. Transportation of electricity takes mainly place within Germany or Europe. The consequence for market places might be a shift toward an European market.

9.2.2.3 Consumer Electricity Market Participation

Consumers can be split up into private people and industry. Nevertheless, both are part of the same environment and society and therefore act in a similar way. Consumer market participation is the first one out of three key drivers as it has a big impact on market places. Market places reflect the charakteristics of consumer behavior as consumers are one important part of the market. Furthermore, the market form is directly affected by the extent of consumer participation. It is very uncertain how the average consumer is going to participate in the market by 2025, because this is influenced by many factors. However, four probable projections of consumer behavior can be identified.

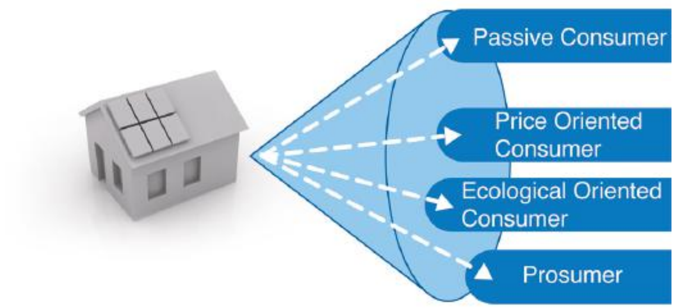

Figure 9.7: Projections for consumer electicity market participation

1. Passive Consumer Market Participation

   Consumers are only passive participants of the electricity market. This means that they do not care much from which retailer they buy and to whom they sell their electricity. Consumers are also not very interested in other services of retailers than power supply. They prefer fixed electricity prices as well as fixed feed-in tariffs in order to have planning reliability for their budget. For electricity market places this implies that active participants are limited to companies which are especially active in the energy sector.

2. Active and Price Oriented Consumer Market Participation

   Consumers adjust their behavior according to the price of electricity. Thus, they do not only change their retailer in order to save money but see the price of electricity as an incentive to adjust their consumption behavior. Consumers only produce electricity if there are subsidies or other monetary incentives. Therefore, they are primarily active market participants when they buy electricity. The main consequence for the market is that the demand side responds very sensitively to price changes. Demand is very resilient.

3. Active and Ecologically Motivated Consumer Market Participation

   Consumers are very environmentally aware and as a result care more about the source of electricity than about its price. This mindset also means that they are aware of dissipation of energy. Hence, energy efficient and environmental friendly products are much better adopted by consumers. In this sense they are active market participants in order to shape which sources of energy are offered and consumed.

4. Prosumer Market Participation

   The consumer is not only an active participant of the market as customer but also as an energy producer. Most of the prosumers produce energy through gas turbines with combined heat and power, photovoltaics or even run their own wind mills. They actively adjust their production according to electricity prices and are aware of their dual role in the market as consumer and producer at the same time. Additionally, high environmental awareness is another incentive to use mainly renewable energy sources to generate electricity. This also means that there is a high readiness to invest in the requisite technology. For market places it can be derived that due to the high number of people who want to participate it is likely that several markets will coexist in order to decrease complexity.

9.2.2.4 Subsidies and Feed-in Tariffs

Subsidies promote specific technologies, energy sources or companies. They are mainly used as politcal instruments and are therefore changing over time. This implicates that they are an uncertain driver. Markets in which subsidized products are traded grow more rapidly due to an increase of profitability. Thus, subsidies have an impact on where and how fast markets emerge. At the moment there is a law which fixes the feed-in tariffs on a annualy decreasing basis. These subsidies are at the moment above the average market price for electricity. However, these fixed feed-in tariffs are only granted for a certain period of time (e.g. 20 years for photovoltaics [337]). At the moment it is very uncertain how much people will be paid for their electricity in 2025 when their granted time of feed-in tariff has expired.

A possible projection is that renewable energies especially photovoltaics and wind energy might be subsidiezed until 2025. There might be new feed-in tariffs granted after the old ones expired. Politics may try to push technology as hard as possible toward renewable sources. This might also mean that storage thechnologies are subsizided in order to allow for renewables to be a bigger share of the energy mix. As a result market places might have to cope with fixed feed-in tariffs. Furthermore, prices for electricity coming from storage might also traded at market places.

On the other side it might also be a possible that the mindset of politics shifts toward supporting new technologies like fusion. Therefore, the focus of subsidies might lie on research and development projects which work on new solutions to generate big amounts of electricity in an efficient and environmentally reasonable way. Subsidies for renewables might decrease and feed-in tariffs might not be prolonged. The implication for market places would then be that they are dominated in terms of location and coordination by few very big market players i.e. the companies which receive most of the subsidies as they are able to do research in the fields mentioned above.

9.2.2.5 Big Players in the Electricity Market

At the moment the German energy market is dominated by the four major utilitis (EnBW, E.ON, RWE and Vattenfall). These companies have a very high market power. As new business and service ideas emerge, e.g. in the area of electricity-related ICT, it is not yet certain if the big players of today will incorporate those services into their portfolios or if new market entrants will control these new services. Due to the fact that companies with market power are able to influence market conditions, this driver is important for market places. Projections in different directions are conceiveble.

The four big players might still dominate the electricity energy market in 2025 as they might have found a possibility to circumvent liberalization efforts of the government. Therefore, market places are mainly controled by a few companies.

Another possibility is that there might be some big companies from other European countries which participate in the market in addition to the four traditional players. This implies that market places in Europe might be more interlinked.

The third plausible projection is that due to unbundling there might not be any big companies anymore. Instead a lot of medium sized players participate in the market. Consumers might be represented through mergers and be in this way medium sized players, too. Accordingly market places are not dominated by special companies.

9.2.2.6 Public and Private Investments

Private and public investments have a big impact on projects or technologies. These investments are an indicator for business opportunities. For example investments made by major utilities have a big impact on several other drivers like infrastructure, ICT usage along the value chain and dependency of energy sources. Thus, market places are at least indirectly affected. But it can also be directly invested in new market places, i.e. the market place is the business opportunity itself. At the moment big investments in the energy sector are needed for the extension of transmission networks, new power plants and research and development of renewable energy sources. The major utilities report that they are actually investing big sums of money in these areas. Future investment desicions mainly depend on business opportunities these companies identify. Public investments are up to the political parties which control the German government and may therefore focus on different areas over time. Also demand-side investments are an important part of this driver. These are outlays that consumer make for example in more energy efficient equipment and are dependent on the consumer behavior. Two main directions can be identified in which investments might go until 2025.

Renewables deliver high potential business opportunities. Thus, private investments in the energy sector focus more on the development of renewable electricity generation. To enable a high share of renewable sources in the energy mix, there is also a need for investments in the grid [339, pp. 23 - 24]. Due to regulation these are not very attractive investment opportunities, so public investments might be concentrated more on this area. Investments in the creation of market places which specifiy on trading of renewable energy might be the result.

It might also be plausible that private investments are more focused on research and development to run existing technologies more efficient. For example big investments might be made to reduce CO2 emissions of coal power plants possibly funding research or testing facilities in the area of carbon capture and storage (CCS). Public investments might also try to push new technologies like fusion. As investments are mainly made in non volatile electricity generation technologies market places have to cope more with consumption load curves.

9.3 Scenarios

In the following scenario planning methodology is used to describe three possible futures for the German electricity market of 2025. They are based upon different coherent projections of the three key drivers that have been identified above. These drivers have been choosen as a basis for the scenarios as they have a very high impact on electricity market places. The impact of ICT on the energy supply mainly determines how market places function in terms of information flow. Power supply infrastructure enables where market places can emerge. Finally, the market structure is strongly influenced by the consumer electricity market participation. As it is quite unclear how these key drivers evolve until 2025, it is possible to create the three scenarios heading into different directions.

9.3.1 Scenario 1: Giants Amongst Each Other

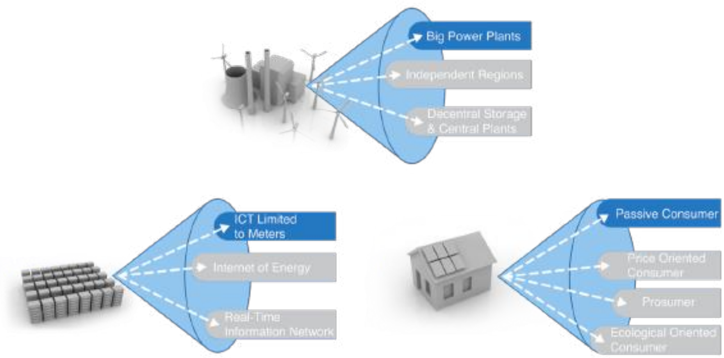

Figure 9.8: GAEO key drivers and projections

Within the Giants Amongst Each Other (GAEO) scenario a long-distance transmission grid enables retailers and producers to trade energy over huge distances on a daily basis. Electric energy is generated by centralized power plants some of which are equipped with new technologies that are more environmental friendly than in previous times. The internationally accessible market as well as large scale power plants keep energy at a constant low price. Through a market place power producers are connected with retailers on an intercontinental level. Power is produced in big plants all over Europe. Storage technologies do not play a big role. With a constant supply of cheap energy from central production plants storage never turned out to be economically reasonable for private and industrial, centralized and decentralized concepts. ICT does not play an important role for the energy exchange market either. Most consumers have a smart meter in their home that can communicate the actual household consumption to their supplier in real-time. But there is no communication between household appliances and the power grid. Smart meters are the endpoints of the power grid in every household. There are few islanded intelligent gateways to enable home automation devices, but there is no data exchange with the power supplier as it is not necessary. The majority of consumers demand cheap energy. These passive users do not care much about their consumption as energy prices are so low that their consumption does not have a significant impact on their available budget. The electricity market situation can be described as bilateral oligopoly as of only a few big companies are existing on the market and trading energy to a few retailing companies.

9.3.1.1 Scenario Description

An important driver for this scenario is the European transmission network's regulatory structure. The big transmission system operators (TSO) have created a network that makes it easy to transmit energy from one point to any other point in Europe with very little losses. The endpoints in the transmission network are connected to the local distribution grids. A second important driver in this scenario is the existence of a political framework for foreign trading created by the EU to promote selling energy across borders within the EU as well as to secure agreements for intercontinental trading (e.g. with Africa or Russia).
Even though the German government tried to push distributed power generation the concept of Virtual Power Plants and Virtual Power Systems that balance themselves never worked out. Cheap electricity and the consumers' lack of interest led to its failure. Other reasons were the overestimated capabilities of ICT and storage as well as wrong estimations concerning the feasibility of the distributed generation concept. Renewable energy sources being highly volatile and unpredictable have proven not to be able to account for base load. Storage hardly exists and there is a lack of technologies that would allow conceOnly big power plants are economically reasonable. pts like Vehicle to Grid to flourish. Storage solutions are expensive whilst their ecological impact is questionable. Furthermore, the already mentioned constantly low energy prices make energy trading using storage economically unreasonable.
By 2025 Germany's social structure has changed. More people live in urban areas making central energy production more reasonable. The phenomenon of so called prosumers - people that both consume and produce electric energy is quite rare in respect to urbanization.

Only big power plants are economically reasonable
Production capacities of renewable energy sources from the consumer-side are of no relevance compared to the capacities of nuclear plants and can not replace their missing load after the nuclear phase-out. As a reaction to this

Germany has built more fossil fuel plants running on either coal or gas. To avoid a violation of Germany's commitment to maximum CO2 emissions carbon capture and storage plants are implemented. These storage plants get filled with CO2 emitted by central power plants. They are mostly located under ground or in the North or Baltic Sea. Emerging costs and the phase out of the subsidization for renewable energies raises fear of raising energy costs in Germany [334]. Centralized power plants combined with a high voltage, long distance transmission grid prove to offer the most cost-efficient supply of electricity. Therefore drawing in investments from the major utilities in Europe. These new power generation concepts consist of more efficient and environment friendly fossil fuels plants. Other than that major renewable energy farms are bundled to produce a consistent amount of energy that can be transported to where it is needed.

The availability of cheap energy on the European energy market leads to more imports to Germany and to more investments in neighboring countries by German utilities [332]. These cheap electricity imports give retailers the chance to pass low prices on down to their customers who maintain their passive behavior. Energy is taken as granted. People do worry about their energy consumption as there is no incentive to do so. Nevertheless, total energy consumption will stay on a consistent level. The replacement of old appliances with more energy efficient ones compensates for increasing energy consumption.

ICT that controls the energy value chain is too expensive

The new appliances do not have any standardized capabilities to communicate with the power grid. They do not need any smartness to save energy. The smart meter is the endpoint of the ICT-controlled power grid in every household. These meters transfer the actual household consumption in real-time to their retailer. With this data retailers are able to balance their activities on the spot market and use them to better forecast their activities. The end-user does not benefit from ICT consciously with the meter doing little other that making billing more comfortable.

Unbundling the companies along the energy value chain is and has been a legal requirement for quite some time now. Nevertheless it has not lead to more competition or a more diverse market. Once more low energy prices can partly be blamed for this. This fact along with high entrance barriers set by existing market players that have a tremendous market knowledge, technological advantages and superior financial assets have kept new competitors from entering the market. New players have simply lacked the resources needed to reach scale effects. In the European electricity market a relatively small amount of big companies still own all big central power plants. The number of retailers that distribute the energy to the end customer has not risen significantly either. Next to generators and retailers the third kind of player in the energy market are transmission system operators responsible for transmitting electricity from the producer to the retailer.

No market place exists

Theses developments have created a bilateral oligopoly market situation meaning that only a small amount of providers exist to face the retailers. The three types of players mostly have long term contracts amongst each other. There are few producers that run renewable energy plants feeding in their irregularly produced energy, but due to the lack of storage technologies they play only a little role on the energy market. The market players invest in different technologies instead. The big TSO's upgrade their transmission lines with technologies for long distance transmission and connect their grids with each others internationally. The companies in the production domain concentrate their actions on big central plants. This includes production farms for renewable energy sources like wind farms or photovoltaics as well as new plants for fossil fuels. A European Energy Exchange like the European Electricity Exchange (EEX) exists but most trading is done in the form of over-the-counter contracts (OTC).

9.3.1.2 Weak Signals

This scenario is shaped by the existence of central power plants, long distance transmission lines and resulting cheap prices for energy. If already existing power generating concepts for big plants turn out to work on a commercial basis, this would persuade the big companies to invest in centralized power plants. Studies concerning the Traveling Wave Concept investigate designs for plants that are in the gigawatt dimension and can supply complete cities. The patent holding company Intellectual Ventures claims that such reactors can run for 50 to 100 years without refueling or removing any used fuel from the reactor [341][351]. The Desertec project is a signal that leads to centralized generation plants of renewable energies. The members of the foundation agreed to establish a network of renewable production plants using windmills, photovoltaics, water power and geothermal farms all over Europe and in the desert of Africa. The produced power is transmitted over High Voltage Direct Current to any European country [349, p. 11]. Fusion power is still a concept that would if it becomes ready for commercial use only be useful in big centralized dimensions. If these projects of central energy production are carried out it can be taken as a hint to development in the direction of this scenario.

Another weak signal for this scenario is the failing of the Vehicle to Grid concept. In this case, the whole idea of balancing the volatility of distributed energy sources could fail and all efforts taken in this direction might turn out to be useless [346, p.13].

9.3.2 Scenario 2: Beehive

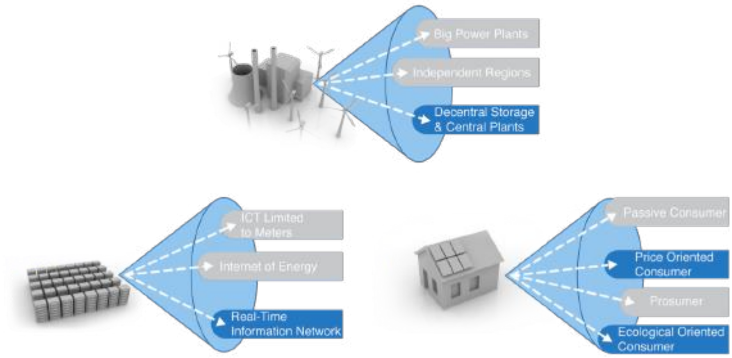

Figure 9.9: Beehive key drivers and projections

This scenario is characterized by two kinds of active consumers that demand either green or cheap energy. Different means of storage and generation options are available and in use. All parts of the value chain are dominated by an ample variety of providers some of them highly specialized in niches.
In this scenario the market is mainly characterized by the availability of different means of storage and centralized power plants. ICT technology allows for two-way communication but is not standardized. The Consumer actively monitors and adapts his consumption motivated either by the price or ecological factors. Since this is the case electricity has different qualities that can be used to distinguish offers from the utilities.

The market is dominated a wide variety of different providers that are active in different areas of the value chain. This scenario differs from the others by existence of one big international energy exchange market where all of electricity trading takes place.

9.3.2.1 Scenario Description

In this scenario the EU's goal to produce 5 percent of consumer-side electricity from renewables has been more than met, with Germany producing a big part of its electric energy from renewable sources. The most important such source in Germany is wind energy. The high investments required to erect efficient turbines in suitable areas keeps the most of the generation in the hands of the major utilities. In the north of Germany offshore windparks use efficient new turbines and rotors to maximize the productivity of each set up generator. Bundled into virtual power plants energy from these plants can be sold as green energy.

As the percentage of renewable energy rises, so does the intermittency of production. In order to adjust to the load curve storage is needed in a decentral or central fashion. Even though storage takes place on both the generation and the consumption side of the grid, a majority is implemented close to generation, for the virtual power plants. This is mostly due to the fact that the vehicle to grid concept never really caught on. Neither the consumer nor the car manufacturers had any major benefit, which led to other strategies. Even though there are other business models for consumer side storage it is not widespread enough to relieve the major utilities.

Technological developments make markets larger and more accessible
High and ultra high voltage transmission lines not only connect new offshore power plants but also improve transmission on a national and international level. Being efficient in transmission is crucial in order to make best use of the energy which at times can be quite scarce. To be more efficient in transmitting electricity ICT is used.

The use of information technology has been widely accepted. Its major success was to allow intermittent energy sources to be used more efficiently. Advanced metering which has been implemented on all stages of the grid allows the utilities to have better control over their virtual power plants. Yet to be able to forecast more efficiently the utilities try to sell energy and offer tariffs in ways that will influence the consumption behavior to their advantage. These new business models can require the usage of metering all the way down to the device level. The information layer will offer them ways to distribute the load and to sell electricity in new ways, other than just billing for Kilowatt hours.

ICT has made the market more accessible. Large scale contracts are still popular among major market players while the role of online energy trading becomes more popular among all types of utilities. Consumers prefer more flexible tariffs that give them good control over the price. It is now easier for smaller players to act in this field. Still since trade has to be linked with consumption most trading is motivated by actual needs preventing trading from getting out of hand. ICT also enables consumers to become active market participants as they are able to adjust their consumption according to price signals provided by smart meters.

User preferences influence storage
In most cases consumers choose to consciously control their energy consumption behavior in their everyday life. They can either manually control their consumption or at least set preferences for automated systems to act for them. In this sense they are active participants in the electricity market.

Energy prices are still minimal yet for businesses with very high energy consumption it will be worthwhile to have an energy department controlling prices and tariffs and their consumption. These new departments will control CO2 emission issues, Electricity and other types of energy as well as the efficiency of new developments. Corporate social responsibility (CSR) and new developments will be the main benefits gained from this activity with live energy cost reduction playing a less important role. To ensure profitability the investments in this sector are still very limited.

Depending on the prices distributed storage linked with smart devices and machinery can be of value for the consumer. In this case individuals could flatten their load curve making them suitable for more attractive pricing models that utilities have to offer. There could be for instance different levels of kilowatt caps set by utilities. Each of them having cheaper pricing than regular unpredictable consumption. If attractive enough these pricing models will act as an incentive to invest in storage - mainly by making it more cost effective on the long run.

Private and industrial consumers become active for two reasons. One group has realized that they can save money by adjusting their behavior or trying to find more suitable tariffs for their preferences. Another group of customers base their behavior on moral considerations. They want to use green power that comes from renewables. But other qualities of electricity play a role as well. Consumers tend to prefer to consume power that has been produced in their home country and creates jobs.

Suppliers have adjusted to these preferences of active consumers and have even pushed the development by advertising green tariffs and discount tariffs.

Legal policies foster green energy

Especially subsidies provided by the German government promote the development of storage technologies and the use of renewable energy sources that are free of CO2 emissions. Research is also funded heavily, making efficient storage to become more widespread among consumers.

Due to the monetary incentives given by subsidies big private investments are made in the fields of green technology and efficiency. Individual Consumers invest in storage possibilities such as electric cars with batteries. In addition investments in ICT systems made by network operators and the public will allow the grid to access distributed storage more easily and therefore use them as a buffer. Feed-in tariffs create a new market for electricity trading, even though it is most likely to have only a small effect on savings for the consumer side. Due to these tariffs the market for the production of power plants that use renewable sources has grown.

Foreign trade possibilities enable electricity to flow across European borders more easily allowing energy to be traded in a more flexible manner. Generators are put up in areas where they make most sense in order to compete in an international market. Market players in this field are active across borders. A big power provider for instance may want to generate energy for south Germany in Italy instead of in northern Germany. This may be more efficient but for the most part it allows the power provider to not have to enter a German competitor's region. Ultra High Voltage transmission lines make it possible to transfer energy over long distances without much of a loss.

However, the European regulation forces companies to be more unbundled, this means that companies can only own parts of the value chain. Therefore, the major utilities concentrate on generation and transmission over long distances. These policies make it easier for smaller companies to enter the market in all areas of the value chain. Especially the market for retailers - companies that do not own any electricity facilities but only buy and sell electric energy - will grow.

In an aging society with the biggest part of the population living in urban areas many customers are concerned about their energy consumption. Nevertheless they are not willing to make big investments in technology. They are happy with clear and understandable tariffs.

Generation partially consists of decentral power plants that are mainly run by major utilities in a cluster. The biggest part of them produces electricity from a variety of renewable energy sources. As many of these sources are highly volatile, small storage facilities are used to ensure security of supply. Major coal plants will most likely be able to compete with renewables as nuclear energy production gets phased out. CO2 prices make this type of production less cost efficient than they are currently.

Market places have to cope with an ample variety of participants
While new market players focus on the providing of new equipment for the ICT-infrastructure or niche services like green energy or certain forms of discount prices (i.e. by offering tariffs with kilowatt caps), existing market players have adapted their offerings to the new possibilities. Markets can more easily be monitored and prices are more dynamic. Energy prices could fluctuate at a high degree allowing utilities to maintain high profits. Incentives allow for consumers to adapt their consumption in order to flatten the load curve. Some discount prices offer cheap electricity prices to customers if they let their supplier access their hardware and devices. Suppliers could thus for example turn refrigerating devices of when power is expensive. Major utilities will try to access distributed storage at low prices.

In this scenario energy trading takes place at a European energy exchange market very much like the EEX. As there are many companies active in the electricity sector there is a need for an exchange market that takes this market structure into account. At the exchange market electricity with different attributes like environmental friendliness can be traded. Various forms of trading exist. There are OTC contracts along with a highly resilient spot market. The exchange market is a global one, regional markets don't exist.

9.3.2.2 Weak Signals

As this scenario is dominated by customers that become active a weak signal hinting that the future might be developing in this direction would be a high number of consumers who start changing their power providers. This development would go along with an increasing number of power suppliers and service providers in the area of electricity. Such providers can also be companies that do not see their traditional competencies within the area of electricity supply. The involvement of the Deutsche Telekom Laboratories for example is a development that makes a future similar the one described in this scenario seem more likely.

If storage develops and businesses come into existence that install electric storage facilities and make revenue by buying and selling electric power this hints in the same direction.

9.3.3 Scenario 3: Interconnected Swarms

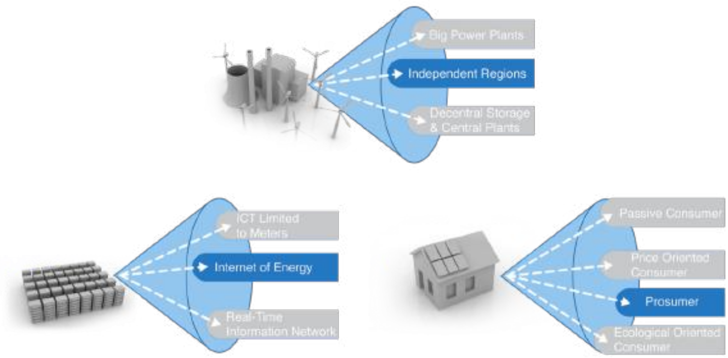

Figure 9.10: Interconnected Swarms key drivers and projections

This scenario describes a technologically advanced world in which consumers have become prosumers. Energy generation takes place on a decentral basis. Under the influence of political regulations the energy market has become a higly diverse one.

The main characteristic of this scenario lies in the existence sophisticated ICT along with decentral prosumption behaviour. Prosumption can well be coordinated by ICT but the complexity of the system is nevertheless too complex to allow for nationwide direct coordination of all paritcipants in the electricity value chain. This leads to the evolution of local markets within seperate distribution grids. A connection to the national grid exists though most of energy trading takes place within local power networks.

Other than in the first two scenarios the micro-market structure in this scenario leads to the possibility that consumers and prosumers directly participate in the market. To many prosumers the traditional relation between supplier and customer does not apply any more.

9.3.3.1 Scenario Description

In this scenario the market is dominated by prosumers that are able to produce electric energy themselves and feed it into the power-grid on both the private as well as the industrial sector of the energy market. Decentral generators such as photovoltaics, gas turbines and windmills are widely installed. Storage facilities using batteries, hydrogen and such are available and have been installed in many houses.

Highly sophisticated ICT controls power generation, distribution and consumption. All transactions are undertaken in real-time as all parts of the value chain can be controlled by ICT. Buildings are equipped with smart meters and also with gateway devices (usually included into the meters).

In an aged society technological breakthroughs garantee for convenience and efficiency

In this future ICT technologies has developed a lot further. Electric devices make daily life convenient. Many households are equipped with home area networks (HANs) that allow their household devices to interact with each other. These devices are built on open standards and interfaces. Where different standards exist for different producers they are open and devices from third producers can be adjusted as they are supplied with adequate firmware. An aged society will not be as technically inclined as younger generations, requiring new ICT services to be more tangible and understandable. Trends towards urbanization slightly effect certain fields of energy consumption such as heating and individual mobility resulting in a lower consumption or necessity in specific areas. Whereas the overall energy consumption is expected to slightly incline by 2025.

The change in energy production to mainly renewables has only been possible due to significant improvements in efficiency of electric devices and a decline in overall energy consumption. Production costs of renewables have decreased as significant technological improvements have been made. Mainstream production of renewable electricity sources has decreased prices for these sources. In addition to that increased prices for fossil fuels also pushed the competitiveness of renewable sources.

For technical reasons voltages in grids have not changed. There are still high and extra high voltage grids for long range transmission and low voltage grids that connect to the end-consumer. Extra high voltage grids are not built any more because none of the newly developing power plants need such high voltage. For prosumers who can produce much electricity it has become possible to connect to medium voltage grids like some industrial consumers in order to avoid transformation losses and problems.

EU and National Regulations have changed the energy mix

Politics have had much influence on the development of technology and the energy market. Subsidies provided by the German government allowed for businesses and private households to equip themselves with generators that run on renewable energy sources. Prosumers and Producers that have invested in renewable energy sources or combined heat and power generation twenty or more years earlier are faced with the situation that they are not granted certain prices for feeding electricity into the grid. Most of them have invested into private storage facilities or participate in small local storage systems offered by third providers. Some of them produce more electricity on average than they consume. At least during times when specific renewable sources are plentiful available e.g. during a storm or sunshine some people produce an electricity surplus.

Energy generation is strongly dependent on prices for CO2 emissions. A strict European framework for emission trading has been put into place supporting the trend set by feed-in tariffs and reduced taxes for the generation of electricity from renewable sources and the usage of e-cars.

Germany has seen a phase out of nuclear energy. Coal as a source of energy has lost popularity amongst generators. This is due to a rise in price for fossil energy sources as well as political support of renewable energies. Power generation is mainly decentral and the main sources are photovoltaics, wind energy and gas turbines used in combine heat and power facilities. Whilst bigger power plants still exist they only satisfy a small part of total power demand. They are mostly directly connected to local communities who own them or have a direct contract with the energy producers. These energy generators mainly use geothermal, hydro- and wind energy.

On a European level well-defined standards exist in the area of electricity and electricity-related ICT. Two way communication can take place over Internet connection.

In the area of electric devices legislation has been introduced that limits energy consumption of household devices. Top-runner regulation sets limits to maximal power consumption of electric devices. These limits are determined by the consumption of the most efficient device of the same kind a certain number of years earlier.

Liberalization of the electricity market has been further pushed by politics leading to complete unbundling of companies in the electricity sector. Companies can only own one part of the value chain. Grid operators are allowed to demand fees for the usage of their grids but their are caps as to the maximum revenue from grid usage fees. Suppliers directly pay grid operators fees for the usage of their grids.

In order to promote use of renewable energies the European Union has made an effort to introduce strict regulations in its member states. Much of German legislation regulating the electric energy market are in fact implementations of

European regulations. These regulations have raised energy throughout all of Europe. Even though some countries still rely on nuclear energy and this can be imported to Germany local renewables are compatible as prices on energy from other European countries have risen with the introduction of feed-in tariffs and high CO2 prices. A big advantage of local production is also that losses in transformation and transmission can be minimized.

E-mobility is promoted by reduced taxes on electric cars. They have become an available form of transport that is used by many con-/prosumers. But even though these e-cars have evolved and the necessary infrastructure has been set up in Germany electric vehicles exist alongside traditional vehicles with combustion engines.

The design of interregional electricity market places faces the demand of consumers with electric vehicles who want to use and possibly feed in electric energy outside their home region. This demand for the possibility of roaming with electric vehicles is met by companies that naturally have control over electricity distribution in different parts of a country such as railway operators who have gained importance on the market as non-polluting means of transport face strong political support.

Storage facilities are widely available

As power sources are decentrally installed and mostly highly volatile, storage technology plays an important role. Private consumers can use their electric vehicles to store electric energy and use it when needed or feed it into the local grid. Industrial consumers have widely invested in different means of storage facilities. These investments have become profitable as batteries have become cheaper. Other means of storage that are installed locally include fly wheels that use mechanical energy, compressed gases, potential energy of fluids (i.e. small pump storage hydro power plants) and chemical storage, i.e. in hydrogen.

Privacy plays an important role as strong privacy regulations are put in place by the national government following EU-legislation and consumers are well aware and informed of privacy issues. Privacy can nevertheless easily be handled as communities share joint electricity markets and thus no information about individual consumption needs is accessible from the outside. Within community networks as well as between them sophisticated encryption methods are employed in ICT. As all power trading is done by computers, protocols have been developed that ensure that information about energy consumption cannot be read out from computers by companies, governments or private people. Companies exist that offer the installation of such ICT-equipment that enables smooth transaction of electricity whilst keeping crucial private information within the encrypted ICT-system.

Local market places evolve in a diverse market

Concerning the market structure there has been a shift from big power providers to small companies that offer rather specialized services such as leasing of storage facilities or ICT-services. This market structure is supported by legislation that strictly controls companies and forces them to be unbundled along the value chain. The big market players in the areas of electricity production and technology focus on selling technical equipment and providing services for maintenance and the ICT-infrastructure. These changes make markets much easier accessible to smaller companies.

Markets can more easily be monitored and prices are more dynamic. For the reason that not all consumers produce their own electricity especially in urban areas a business model has evolved where companies lease generating and storage facilities to those people.

Market places can in this scenario be expected to evolve on a local level for direct exchange of locally produced power. As there are many actors involved direct trading between prosumers is possible. Local communities will share their own power networks in cities different suburbs will trade energy amongst themselves. Nevertheless there will also be a need for interregional and international market places that allow for electricity trading in case of local shortages and thus ensure security of supply. These markets cannot accept consumers themselves as traders because even very sophisticated information technology can not deal with millions of participants at energy exchange markets. The global energy exchange takes place on European level even though consumption and generation matching is mostly achieved on local levels to avoid transformation and transmission losses. This global electricity exchange market can be seen as a successor to the EEX with the difference that trading periods will be much shorter and it will cover the whole European continent and neighboring regions but offer separate trading platforms for different regions. Electricity trade will be focused on a spot market and this New European Energy Exchange (NEEX) will always be online and accessible for trading.

As very many local markets evolve naturally different suppliers some of them former municipal suppliers take up the possibility of using local distribution networks to form local markets offering tariffs to consumers and producers. This offers the possibility to design a virtual standard platform for these local markets. Although, from a technological point of view generators would be able to control the consumption of their customers' electric devices, privacy regulations hamper these technologies and are therefore only deployed by few suppliers.

All market places in this scenario are virtual ones. ICT will allow for computers to handle the trading of electricity. Electricity prices on national and international level do not play an important role. Whilst electricity prices mainly cover the cost of investments in local storage and generation facilities there are additional fees for companies that offer services such as the ICT-market platforms and for hardware solutions. These can in many cases be fees that are only paid once in order to obtain the necessary equipment.

In addition, as the electricity infrastructure is highly decentral the problem of computing cannot only be solved by installing big server capacities. There need to be computers and ICT-connections with all market participants including private prosumers, industrial energy consumers, service providers and institutions that allow for Europe-wide security of supply. It is thus clear that the area of ICT that relates to electricity exchange has become a big and fast-evolving market that offers possibilities for many companies that are specialized on hardware and software enabling cloud-computing solutions for power supply.

9.3.3.2 Weak Signals

This scenario will be pushed by the existence of decentral storage facilities at competitive prices. If the price of storage and availability for installation in private homes and business hits a critical level it will be likely that the German electricity market is moving in a direction as this scenario predicts.

Micro-markets will especially come into existence if there are many consumers who become prosumers. This happens if decentral electricity generation is cheap enough to be profitable. Consequently, this development is influenced by production costs for decentral power generation devices but also by subsidies and incentives from politics for the set up of those energy sources and feed-in tariffs. If subsidies should be cut in Germany this scenario would become less likely. If on the other hand production costs for decentral energy generation devices namely for fuel cells, photovoltaics, windmills, gas turbines decrease or subsidies rise these would be signs that make this scenario more probable. Significant increases in price for fossil fuels would also hint to a development into a future like the one described in this scenario.

Furthermore, a rise in environmental awareness will spur development toward a future as described. If natural disasters occur that can be linked to climate change or pollution by electricity generation politics that support renewable energies will be more likely to be favored by the people.

On a legal scale developments are visible that indicate that this scenario is a probable one. E-mobility is promoted by the German government. Unbundling of electricity companies has already been enforced [336]. Renewable Energies are fostered by the Erneuerbare-Energien-Gesetz [337].

Market signals hint in the same direction. In a joint-venture Volkswagen and electricity-supplier Lichtblick have agreed to produce to produce CHP-units for private homes [344].

Due to these developments this scenario is taken to be the most likely one out of the three. Even if it has not become complete reality in all of Germany by 2025 it is very likely that a market place like the NEEX will have created and that micro-markets will have evolved in some parts of Germany. The scenario is thus a good basis for a service idea that doesn't require all of Germany to be split up into micro-markets and can deal with the partial coexistence of traditional markets.

9.4 Service Idea: Virtual Prosumer

In the Interconnected-Swarms-scenario the grid has become too complex for all individual market participants to be controlled on a national level and the evolution of micro-markets is anticipated.The end of the EEG makes distributed power plants owned by prosumers of very little value since they often lack the ability to sell their excess energy. Building on this framework given by the scenario an electricity retailer can address these problems by providing a micro-market in the form of a virtual electricity exchange platform. This service clusters con- and prosumers in the same distribution grid into Virtual Prosumers (VPs) and offers them an electricity exchange market on multiple levels. Customers benefit from real-time prices that their automated gateways use to adjust the behavior of storage, generation and consumption devices. As a Virtual Prosumer the service provider can connect them to the NEEX which will allow for electricity trading on a European scale in the Interconnected-Swarms-scenario.
The service works on three levels offering:

- price adjustments to the outside by trading with other prosumer clouds and/or at the NEEX
- low real-time prices inside the prosumer clouds promoting matching
- in-house matching through automated gateways in control of relevant smart devices in a building

9.4.1 Service

The service offered is a virtual energy exchange market that communicates real-time prices to customers. Prices remain valid for a certain short period of time. Automated devices stream the pricing information and base their energy trading activity on it. Individuals subscribed to this service are provided with a gateway linked with a smart meter capable of matching consumption and production within the building and trading the excess or lack of electricity. This gateway also allows for a cooperative control system to manage smart devices based on the users preset preferences.

To make these small scale systems work trading has to be performed in the most efficient way. Clusters of consumers and prosumers within the same distribution grid form so-called Virtual Prosumers. These groups are at a size that can be managed most efficiently. They are very similar to virtual power plants (hence the name) except for the fact that they can either have an electricity in- or output or equilibrium. Within the VP a match is made between generation and consumption by automated electricity trading regulated by price. To the outside these platforms act similar to minor utilities, large consumers or generators.

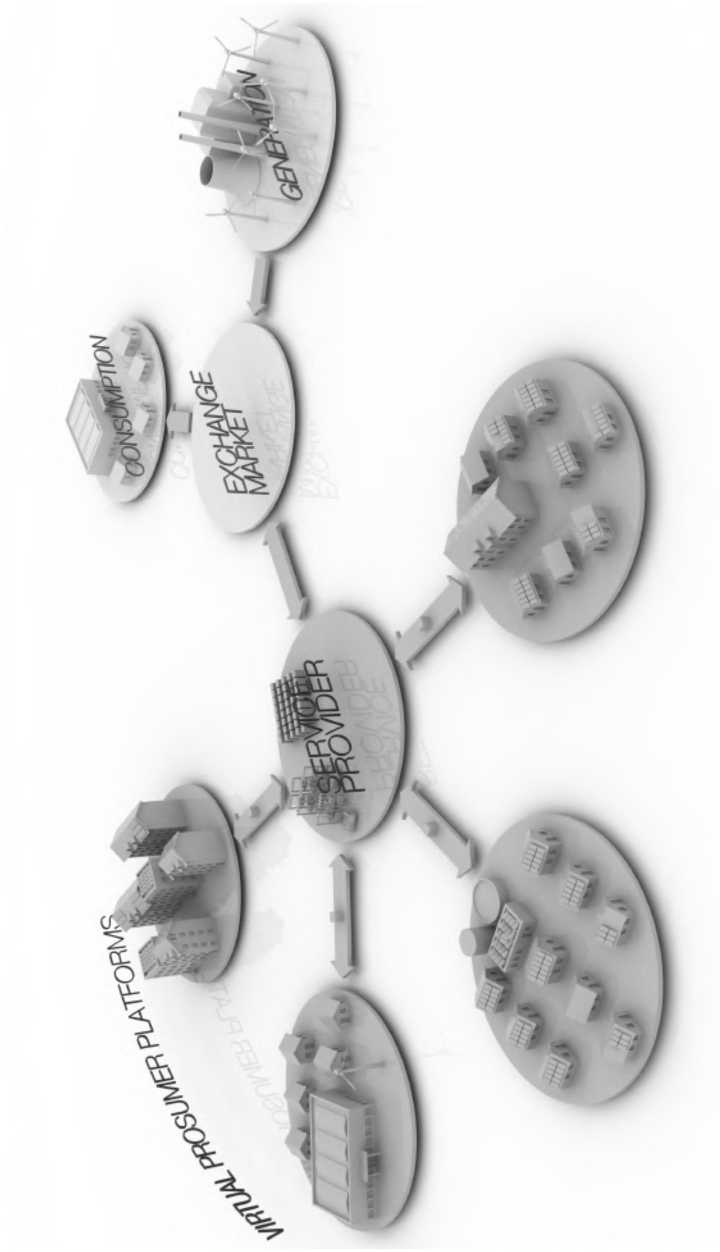

Figure 9.11: Illustration of the Virtual Prosumer Service Provider Platform

9.4.2 Customer Needs

There are mainly two kinds of consumers addressed by this business model. The first group consists of consumers that want to benefit from electricity that they produce with their own facility (see Producers). The second group either has a big and/or flexible enough power consumption so that real-time-pricing helps them to save money or are motivated by their ecological awareness. Especially price aware consumers benefit from owning small storage facilities (see Consumers). Both groups do not only include private but also business or industrial consumers and prosumers. The first kind of customers, mostly having volatile production facilities like windmills, photovoltaics or biomass can at times show similar behavior patterns to the second kind of costumers, the consumers.

The VP service provider concept has especially proven to be profitable as in the micro-markets-scenario as there is quite a large number of prosumers that want to feed power into the grid. In post EEG times this is not always an option. To conventional consumers as the ones that exist today joining a VP might not be all that appealing as most benefits from this service come from energy trading within the local platform itself. Joining this platform lets the traditional consumer enter an environment in which there are incentives to invest in storage or generation. Active consumers may find this to be an attractive way to take even more action.

For the consumer of the future the automated home devices and pricing systems are not enough to adjust their consumption behavior and fulfill their need for to be an active market participant. Instead of monthly billing the customer will get live information about electricity consumption and pricing inserted into their everyday customized media or newspaper alternative.

Producers

These customers are very valuable for the service, as they are are responsible for electricity generation, the component that enables this service to offer an energy price cheaper than the one traded at the global energy market. The accumulated demand or supply of electricity a VP has to offer makes it a big enough player to trade at the NEEX.

This business model targets customers with renewable energy sources, that are not granted fixed feed-in tariffs anymore. This means, that these customers mostly have no buyer with an attractive offer as they used to have with fixed feed-in tariffs. As it can be expected that in the chosen scenario subsidies will adjust to the market price for energy. In this case forecasting gives over-capacities a slightly lesser value than the going electricity rate at the NEEX. This makes the service attractive for these prosumers as we can generally offer higher prices than a competitor's fixed price models.

Consumers
These customers have the biggest advantage from the VP as they can consume energy to a lower price than they would otherwise have to pay. Consumers can also benefit from devices reacting to the real-time pricing and forecasting models provided by the energy gateway's pricing system. The concept of the VP would not work with passive consumers alone though. Most competitors offer energy prices based on the global market. Interestingly as a side effect the ecology or price aware consumer can benefit from real-time pricing by investing in production and/or storage. As many consumers with storage facilities can benefit from forecasting models letting them either buy and sell energy at a profit or buy it cheaply and have devices consume without certain time constraints. Furthermore with a large number of companies offering a variety of hardware solutions it will be easy to make incremental investments depending on ones budget.

9.4.3 Layers of Electricity Exchange

Figure 9.12: Three levels of clustering

The Virtual Prosumer service provider performs its services on multiple levels. In order to ensure data privacy information is stored and processed in the layer in which it is generated sending the average values of a cluster to the next level. Level one represents the individual prosumers which can be a household, business building or free-standing generator. Electricity consumption and generation matching is performed by sending out the excess and importing the lack of electricity from the next level. Level two performs matching inside the Virtual Prosumer platform sending out the excess and importing the lack of electricity from the next level. Level three is the final level that reaches everything beyond the distribution grid: Electricity is either traded among Virtual Prosumers or bought on a national or international level by using exchange markets such as the NEEX.

9.4.4 Functioning of Electricity Exchange

The electricity exchange system calculates prices for buying and selling electrical power on all of the three levels mentioned above. In order for price information to be reliable for a longer time customers have different pulsing options. They could buy electricity at a price that remains valid for either an hour or on a minute-to-minute basis depending on their preferences. The energy exchange system will offer a few different pulsing options to consumers. Resulting from that prices are transmitted to smart meters installed on the consumer side. Adequate devices in households and businesses can use this price-information in order to shape consumption to their advantage.

The Virtual Prosumer is a platform that connects customers to a local network within the same distribution grid. By bundling prosumers on a regional level the otherwise uncontrollable complexity of the grid can be controlled efficiently.

Complex software systems running on servers and gateways maximize efficiency by running matching and forecasting models.

9.4.5 Implementation of Gateways for Buildings and Building Blocks

For the first level there are companies that provide technologies geared towards using data on the consumption patterns from buildings or building blocks. These are collected by gateways linked to the smart meter that are capable of balancing in-house production and consumption automatically. Private prosumer houses can for instance balance the consumption of their appliances like the washing machine and refrigerator with the energy production of their generation facilities like photovoltaics, small windmills and gas turbines using produced energy at times of little value. At the same time gateways are capable of taking the storage capacities of individual prosumers into the calculation for balancing. Pricing information makes the best use of energy whether consumption occurs in-house or not.

In some cases gateways do not need to be provided as suitable hardware may already be available. Firmware updates allow for such devices to adapt its functionality and become VP compatible. In other cases customers may already have an installed HAN that relies on well-defined ICT-standards. These gateways do not need to be separate pieces of hardware instead they have integrated smart meters. Such a device has the benefit of being able to be installed during the ongoing process of replacing conventional meters by smart ones. As smart meters, gateways and smart devices in HANs rely on open

standards barriers between different platforms are eliminated. The integration of outfitted customers of all types into the Virtual Prosumer cloud is made possible by such.
Most of all the electric device market booms as ICT systems can finally be used in an effective way. Actors in this sector include computer, electronics as well as white ware companies. Even producers of individual transportation solutions can offer storage that can be controlled remotely. Their activities in this field are very limited as neither the vehicle producers nor the consumers truly benefit from this concept. By letting car batteries be controlled by the grid the consumer looses what makes individual transportation attractive: Being able to go wherever he wants and whenever he wants. Car manufacturers see themselves as a byproduct of the electricity market which doesn't match with their otherwise superior image.
Although the consumers of energy have possibilities to adjust their consumption behavior it is important that they do not need to participate in the trading process themselves. Their hardware will do the trading for them. Outfitted with pre-programmed settings they can act autonomously. Nevertheless customers can if they want modify the configuration of their hardware by either choosing certain profiles or even completely programing it manually. Again their attitude towards energy consumption will shape their settings.

In a fully automated home devices and pricing systems are not enough to adjust the prosumers' behavior and fulfill their need for to be an active market participant. To make the process more transparent the customer will get live information about electricity consumption and pricing inserted into their everyday customized digital media or news source.

9.4.6 Processes

Forecasting models calculate prices which are then feed to the consumers in VPs. As a secondary process matching of load curves is achieved as automated consumption behavior adjusts to the offered real-time prices.

9.4.6.1 Forecasting

Forecasting allows the Virtual Prosumer service provider to evaluate its possible future trade volume and value of energy with the goal of setting prices for the consumers. Historic data on consumer behavior and weather are used to create a model of the future.

- Consumer Behavior Forecasting

  As an example of level one the consumer behavior can be monitored in detail if smart devices are available. Otherwise only data coming from the smart meter can be used, which includes only the time and amount of energy that was either consumed or produced. The gateway stores and processes the information looking for patterns to base its forecasting models on. This improves trading and the control over smart devices. The forecasting includes probable consumer reactions to price changes.

- Weather Forecasting

  To have an idea on how reliable the renewable plant could be weather forecasts have to be evaluated. Alongside these general weather reports using the locally generated weather information can create very reliable data for the Virtual Prosumer. If for instance every PV outfitted roof has a program checking the size of the PV along with the amount of energy consumed one could find out how cloudy it is. This information linked to the location, wind direction and storm force can provide an exact forecast for other PVs in the area that are also sharing their information.

9.4.6.2 Price Calculation

The price calculation is set up in a very flexible way. Once a price has been calculated the service provider pushes it to the consumer and commits to it for a certain period of time (e.g. 1 minute or 30 minute intervals). Within this time the consumers, producers and smart devices can decide to take action. Figure 9.13 shows the process chain for calculating prices. Each step is automatically processed by either the central computer or the Virtual Prosumer Gateways.

1. In the first step of the price calculation process, the central computer requests the actual consumption data of all the connected Virtual Prosumer Gateways. The consumption of a Virtual Prosumer can be negative as they might be producing more energy than they consume or positive as they may be consuming more than they produce. The Virtual Prosumer Gateways are only communicating the total consumption, due to efficiency and privacy reason.

2. All the gathered production and consumption data is aggregated. In the case of more energy demand than production, electricity needs to be bought at the NEEX or other VPs. Otherwise, electricity can be sold at the NEEX or other VPs.

3. The price for the purchased energy at the NEEX is communicated to each Virtual Prosumer Gateway along with information about the distribution of produced over-capacities from other VP Grids. The retailer adds his margin to this price.

4. The Virtual Prosumer Gateway uses the resulting data as a basis for the calculation of their energy trading possibilities relative to the grid.

5. Here the current data is send to the first level customers: the household gateways, smart meters, industrial gateways and independent, distributed power plants.

6. The devices, provided with new production and consumption data now decide how to react accordingly. Their reaction will change the electricity load curve, which will be taken into consideration in the next price gathering cycle.

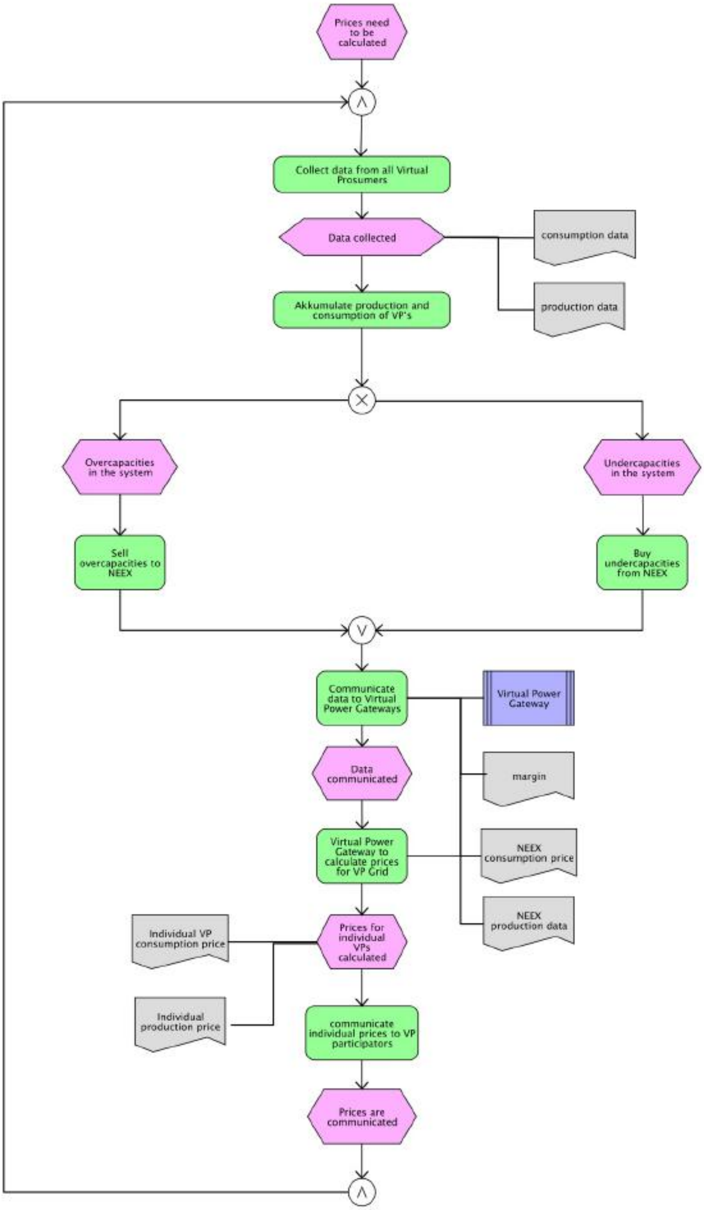

Figure 9.13: Process of price calculation

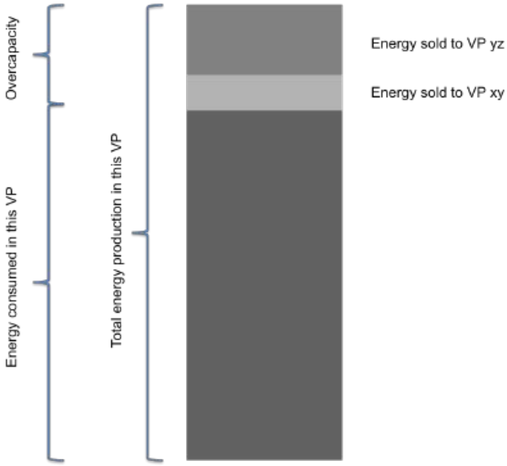

Figure 9.14: Example composition of the consumption price for one Virtual Prosumer

Figure 9.14 shows an example for the composition of the VP's consumption price. It is calculated by the VP Gateway after the fixed prices at the NEEX and the distribution ratios have been transmitted from the central computer. The total current consumption needed by this Virtual Prosumer to the time of the calculation process is represented the complete bar. The Virtual Prosumer Gateway receives this data permanently from the participants' smart meters. The bottom part of the bar represents the demand that can be covered by the production from within the Virtual Prosumer Grid. The next parts of the bar represent over-capacities supplied by other Virtual Prosumers. The top part of the bar is the energy bought from the NEEX in order to fill up the gap. The NEEX price is fixed to the specific moment in which the calculation is performed from information retrieved from the central computer by VP Gateway. Electricity provided by producers within the Virtual Prosumer Grid as well as other nearby VPs will always be priced slightly lower than the price from the NEEX. Data on all VP energy capacities can be retrieved from the central computer for the gateway to evaluate its value. The new calculated consumption price of all VPs combined will now be made up of the ratio of produced energy from the whole system times the calculated price for this energy plus the ratio of the energy from the NEEX times these prices.

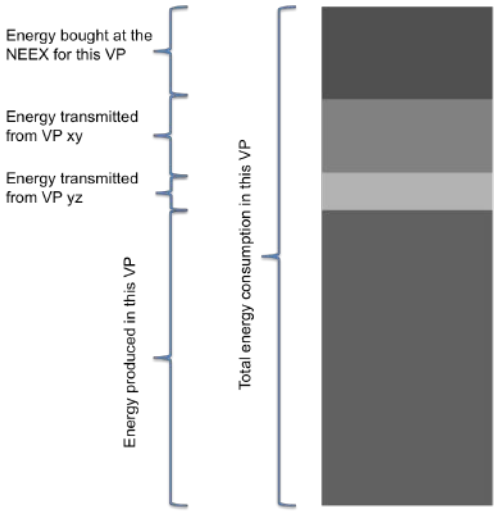

Figure 9.15: Example composition for the production price of one Virtual Prosumer

Figure 9.15 shows the production price composition depending on the place the produced energy is consumed. In most cases, the produced energy is consumed within the Virtual Prosumer Grid which leads to a feed-in tariff that is a certain percentage lower than the NEEX price. However if the demand in this grid is saturated the energy has to be sold to another VP or even at the NEEX. Feed-in tariffs adapt to transmission losses while sending electricity to other VPs or the NEEX. The Virtual Prosumer Gateways take all these costs into consideration as they can calculate the losses in transmission on the basis of tables with the distances between VPs as well as the knowledge about the NEEX price at the time being. This price is send to the distributed production facilities connected to the system.

9.4.6.3 Matching

Matching generation and consumption plays a central role in a grid with a high percentage of intermittent energy sources. It will especially be key activity of the VP service provider. Matching happens automatically and without active control as a response to price developments at the energy exchange market. By clustering customers level by level the task of matching becomes possible on a large scale. The first layer for instance matches the combined data from the clustered individuals in the same building. Information is less complex to handle efficiently which is challenging due to the fact that energy trading implies not only the money flow but also the energy flow and consumption. Using different levels for matching minimizes energy losses by having the shortest possible distance and no transformers to flow through. The improved efficiency leads to a benefit in pricing making it worthwhile inside the respective level.

9.4.7 Revenue

The Revenue of this business model is generated through the margin the Virtual Prosumer Service Provider adds to each energy transfer. An energy transfer is either buying energy from the NEEX for one Virtual Prosumer, transmitting energy from one Virtual Prosumer to another or distributing energy within one Virtual Prosumer. This especially means that the Virtual Prosumer Service Provider pays less money to the producers for feeding electricity into the grid, than the consumers pay to consume it. If one Virtual Prosumer is generating over-capacities, these capacities are transmitted to other Virtual Providers. Mostly the electricity has to be transformed for this process, which leads to losses. These losses are taken into the price calculation process of the feed-in prices so that long distance distributions do not affect the margin of the service provider.

To be competitive the margin added to NEEX transfers will be leveled up with branch standards. The margin added to Virtual Prosumer transfers can be on a percentage basis higher because the total consumption price is lower than market standards. This is the competitive advantage for the service provider of this business model.

In cases of exceptionally high fluctuations in the power supply matching will play an important role. Price caps set by individual consumers that are willing to take on the risk of experiencing blackouts will have them cut off from the grid. These blackouts don't have to be experienced by individuals for a long period of time as they could run on a minute-to-minute pulsing.

9.4.8 Partners

Virtual Prosumer service providers have partnerships and similar contracts with hardware-suppliers. These suppliers can - provided with well-defined communication standards - produce smart meters which are able to read out up-to-date-prices from the energy exchange. If not yet widespread technologies and devices will have to be promoted.

In large cities where apartments buildings are common some landlords can have large PVs installed that will make the Virtual Prosumer platform attractive for them. They could partner with the Virtual Prosumer service provider and have all tenants in the building participate. By doing this their energy can be managed most efficiently serving the needs in the building first and then sending excess energy into the distribution grid.

Figure 9.16: Illustration of a possible future household

9.4.9 Competition

The Virtual Prosumer business model will have to compete with a large variety of competitors. Most of the offers can be seen as indirect competition that is not aimed at the same customer group.

Competitors are mainly traditional electricity providers that offer a model for more passive consumers. Prices per kilowatt-hour are fixed for certain times of the day. By not using real-time pricing they must add a higher margin in order to reduce their risk. The Virtual Prosumer platform on the other hand uses real-time prices and can afford to have lower prices with more realistic forecast models.

Some of them offer flat rate prices for different kilowatt amounts. They for instance give their customers a certain price for energy as long as they stay below a predefined amount of kilowatts. This is very similar to current DSL or mobile phone pricing models. In such a case the smart meters can be set to not exceed this limit letting the utility perform forecasts at lower risks. For this offer the customer will be able to have an active consumption behavior. They will also be able to use similar smart devices as in the Virtual Prosumer case making the market for such hardware larger.

Consumers who move frequently look for ways to support their mobile lifestyle. For them the price of energy doesn't matter as much as a provider that can offer them a hassle-free service that can follow them when they move from one home to another. This market will be large enough to draw the attention of a few niche retailers. They keep their customers loyal by providing a service that lets them easily check in an out of their home's smart meter while maintaining the same account. Prices per kilowatt-hour don't play a big role for the passive consumers in this segment neither do smart devices.

9.4.10 SWOT Analysis

In the following a short SWOT analysis demonstrates the situation of the VP business model in its current stage. Strengths and weaknesses are related to the business model itself whereas opportunities and threats are given by external factors.

The biggest strength of this business model lies in the new approach of satisfying customer needs by obtaining a market that allows flexible pricing bi-directional electricity trading. Moreover providing an infrastructure that allows intermediates participating in the electricity market to be skipped also demonstrates a strength of this model. In other words by cutting off the middle men surcharges could be reduced to a minimum. This is one of the reasons why this model is able the offer low prices to customers while still having a sufficient margin.

A weakness this business model may have is that it only has a competitive advantage when a critical mass reached. For an internal exchange of electricity to take place enough prosumers have to belong to the VP. Thus, network effects have to be taken into consideration.

Opportunities for this business model emerge through the change of the generation infrastructure. The more decentralized small scale power plants exist the greater the need is for a feed-in solution like the one this model offers. This is especially important in post-EEG times.

Threats come from regulations as there might be restrictions to protect end consumers. On the other hand an oversupply and consequently a sharp drop in electricity price might also endanger this model.

9.4.11 Roadmap

Different stages are required to implement this business model. In the first phase software and hardware for exchange market and customers are developed and tested.

The second stage starts with the evolved New European Energy Exchange. Especially the feature that allows for continuous spot market trading (including weekends and holidays) is crucial. Now suppliers can start building Virtual Prosumer networks focusing on niche clients with special needs like storage facilities or renewable sources and no more feed-in tariffs. The actual breakthrough of the business model happens with the government starting to drop feed-in tariffs for prosumers. At this point prices within VP-clouds are lower than elsewhere due to avoided transmission and transformation losses.

9.4.12 Complimentary Offerings

With the implementation of Virtual Prosumer Networks several secondary business models and further services arise.

- Price-Forecasting as Ancillary Service

  The Virtual Prosumer platform is supported by a forecasting service that takes anticipated consumption, weather forecasting and anticipated prices at the international exchange markets into account. This data can just as well be offered to customers as an ancillary service. Hardware will be provided by business partners that can use price forecasts to determine the optimal behavior of a customer's device and control them accordingly. Price forecasting does not have additional costs as it will be done for the basic business anyways. It can easily be made available to customers over the Internet. As a service it can be offered for free to attract customers or for a small monthly fee.

- Non-Volatile Sources With High Variable Cost

  The real-time pricing offered by the Virtual Prosumer gives customers the opportunity to make money by buying a power generator that has high variable generating costs such as a gas turbine. This device can then be run when electricity prices are high with higher margins as would be possible with different pricing options.

- Storage

  Customers can install storage facilities such as a flywheel or batteries to profit from differences in price at the electricity exchange by buying electricity and storing it when prices are low and selling it again when prices are high.

- Flexible Appliances

  A group of customers that will profit much from the pricing system offered by the Virtual Prosumer are customers that own devices with a high energy consumption and don't need to run at any specific time. In such a case the device can wait until electricity prices are low. Private customers with laundry machines and driers can benefit from this idea as much as industrial consumers that use cold storage rooms which can preserve cold temperature for a while.

9.5 Conclusion

This report has outlined three different scenarios for market places based on different projections of the key drivers ICT, power supply infrastructure and consumer behavior. Ten drivers have been taken into consideration to develop these possible futures of the German electricity supply structure. One scenario pictures a bilateral oligopoly in which few retailer have long term contracts with few producers. In another scenario the electricity market is dominated by a vast variety of producers, service providers and suppliers. And in the last scenarios local micromarkets exist where many prosumers trade among each other. For the last scenario a potential business idea has been developed, that uses the new potentials of the micro market structure. It proposes setting up local electricity exchange markets called Virtual Prosumers. These markets offer a solution thats is similar to load curve matching and avoiding of transmission and transformation losses by offering a price for electricity to the inside of these clouds and trading to the outside. If this business model is implemented within the next years it might very well become reality by 2025.

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Chapter 10

Bundling and Integrated Solutions

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The energy market of the future will be a lot more complex for consumers and more competitive for energy suppliers. Consumer demand for simple integration or bundling solutions could increase and open up new possibilities for innovative business models to gain market share. Those offers are of a great value for the customer, which finds an appropriate solution to an overwhelming complexity, as well for the utility, which offers strategic product with high margin. Based on the identification of the main drivers behind future developments, three possible scenarios of the energy market in 2025 are described. Each scenario features a specific and coherent combination of drivers which distinguishes the scenarios from each other. Additionally, weak signals illustrate why the future can possibly match each of the scenarios. The "Usual Suspects" scenario is an extrapolation of today's situation which only contains slight modification in the electricity industry. The "Fabulous World of E-Energy" scenario depicts a situation where common action of governments and markets dramatically change the industry. Finally, the "Magnificent Many" scenario features few but relevant evolutions which create a need for bundling and integrated solution. Because this moderate evolution appears to be the more likely one, "Tariff Sheriff" is developed for the "Magnificent Many" scenario, where the context is particularly suitable for bundling and integrated solution. Targeting complex energy markets, "Tariff Sheriff" is introduced as a web-based integration service which helps consumers to find the best energy supply for their needs. It exemplifies how new integrated services could look like, which are based on the fundamentally changed market situation.

10.1 Introduction

The energy markets of the future will be a challenge for consumers. E-Energy will add a dimension to the energy sector. Therefore, a wide variety of services and products around the efficient and intelligent use of the scarce energy in the future will occur. At the same time many new companies will enter the market and offer these new products and services. The energy market will be very complex both on the consumers' site as well as on the producers' site. It will be difficult to keep track of the market development. The demand for transparency in the energy market will be high. Bundling and integrated solutions are one relevant approach to meet the demand. These solutions offer related products or services at a single price and turn them into a unified whole. Thus, they help to reduce the newly added dimension of E-Energy.

This report covers different aspects of bundling and integrated solutions for E-Energy. The scope of the report is a scenario analysis for the energy market of 2025 and the development of one specific bundling and integrated solution. The report follows the structure: At first the executive summary presents the key findings of this report. Then the ten most relevant certain and uncertain drivers are discussed in detail. Based on these drivers three distinct scenarios are developed. Then on the basis of the most likely scenario the specific bundling and integrated solution is presented and explained. The conclusion is the final part of the report.

10.2 Driver Analysis

This section defines the certain and uncertain drivers that influence the future of the E-Energy market with relevance towards bundled offers and integrated solutions as well as the projections of these drivers. They are ordered by impact on the market, beginning with the one with the biggest impact. Therefore, the key drivers, which characterize the three scenarios presented later, are the complexity of markets, the willingness of customers to participate in this market and the degree and kind of standardization of technology. Figure 10.1 gives an overview of the categorization of the drivers concerning impact on bundling and integrated solutions as well as their certainty.

10.2.1 Certain Drivers

Several certain drivers have considerable influence on the energy sector of the future and can be expected to develop in a certain way. They are described in detail in the following.

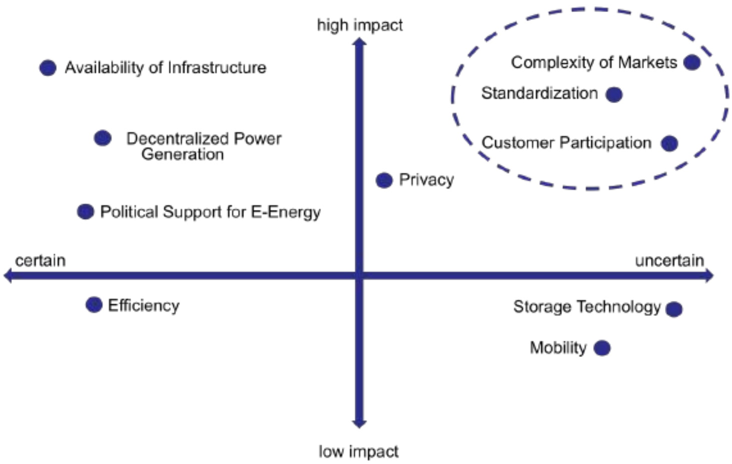

Figure 10.1: Categorization of drivers

10.2.1.1 Availability of E-Energy Infrastructure

The driver evaluating the availability of E-Energy infrastructure measures the amount of smart devices which are installed on the grid or at home to monitor electricity consumption. Since generation and storage facilities are the topics of the accordingly named drivers, this driver deals with smart meters and components of smart homes. Smart metering, with two way communication capability and more accurate user information is essential to the implementation of E-Energy. Furthermore, this additional information is of great value for those offering integrated solutions where different services are coordinated. In addition, in order to function efficiently, smart homes need to exchange aggregated information with the outside world, opening opportunities for bundling with other services. These communications could be managed by telecommunication operators for instance.

Due to the clear will of stakeholders (EU, national authorities and utilities) these driver perspectives appear certain. Smart metering will become a reality and deployment is already taking place in some European countries. Many pilots are currently examined in Germany [358]. Moreover, EU legislation to promote smart metering already exists, others are expected to follow [362]. Smart home devices already exist especially in the USA and are part of the house of the active customer [357].

Most probably, E-Energy infrastructure will be widely available in the future. Nonetheless, the implementation is more uncertain. However, depending on what objectives of the roll-out are of priority, the allocation could be either ruled by governments or be driven by competition [382].

As a result new services are necessary to manage this infrastructure and those services can be part of integrated solutions. For instance, the management of the Smart Home gateway by the utility could part of a specific offer. Consequently, this development opens a wide range of opportunity for bundling.

10.2.1.2 Political Support for E-Energy

Political support for E-Energy is a driver which is defined by the strength of the political will to actively start and support research on the topic as well as to introduce a comprehensive E-Energy network in the whole country. This support directly influences the level of E-Energy development and distribution and thus the need for bundling and integrated solutions. The strength of political support is defined by existing or planned laws, political statements and manifested goals, and funding of E-Energy projects. It also includes general political objectives which affect the energy market. Without political support, there is a lack of E-Energy infrastructure, which in turn prevents the creation of integrated solutions.

On the European level, several goals have been set by the EU commission for the future to achieve sustainable, competitive and secure energy [359]. Furthermore, the 20-20-20 plan aims to increase energy efficiency by 20% and the amount of renewable energies to 20% by 2020 [354]. In Germany, the government started an integrated energy and climate program. It supports E-Energy by funding of research (e.g., six model regions in Germany, E-Mobility and storage), passing of several relevant laws, including the mandatory installation of smart meters and granting tax benefits for the usage of energy management systems [364]. Furthermore, the government set the goal of one million electric plug-in electric vehicles on the road by 2020 [363].

Considering the strong political support at the moment and that E-Energy is an integral part of using renewable energy in an efficient way, it can be concluded that it is a certain driver. In 2025, both on the EU and national level, E-Energy is actively supported and continually introduced as a key feature on the way to a sustainable and secure energy supply involving a more and more increasing share of renewable energies.

In this actively supported E-Energy system, integrated solutions can be established in an easy way without the risk of losing political support for the encapsulating framework. As political support encourages the development of a more complex energy market, there is a continuously increasing need for integrated and bundling solutions.

10.2.1.3 Energy Efficiency of Devices and Processes

In order to further optimize the energy consumption by using more efficient devices and improving processes that consume energy, there will be a high demand for integrated solutions that make the new opportunities comprehensible.

These services could help creating new processes or install new, more efficient devices in buildings [367, p. 79]. Finally, such services could be bundled together energy tariff offerings. Efficiency refers to both the technical efficiency of technologies for generation, storage, transmission and distribution as well as to optimizing the consumption of energy by enhancing business processes and employing intelligent IT-based control systems [367, p.80]. To support that, governments can create incentives through tax deductibility or regulate how efficient devices have to be [366, pp. 14 - 16]. As the number of options to improve the efficiency of energy consumption increases, it is becoming more difficult for energy consumers to select the right options. This opens up the opportunity of offering integrated solutions that help consumers in this process. There is an undoubtable need to use energy more efficiently as resources are scarce and also because it is an opportunity to save money. Therefore, the following development is to be expected:

The technical efficiency and manufacturing process of most devices will increase. For example, new materials in solar panels will make them less expensive [379, p. 14]. Also, the efficiency of buildings will be improved by storing energy with less loss [371, p. 2] or using lost heat [365, p. 14]. Furthermore, the industry will harness their significant potential for energy savings. Specific plans on how to implement the savings in Germany exist and will be enforced by the government [365, p. 4]. While traditional advances in technical efficiency are possible, information and communication technology in devices that consume a lot of energy, like household appliances or industrial machines, will lead to the the strongest improvements [379, p. 3].

10.2.1.4 Decentralized Power Generation

For assessing how widely decentralized generation sources are spread, the driver of decentralized power generation is introduced which is closely related to the structure of the energy sector. The more complex this structure, the higher is the demand for bundling and integrated solutions. Thus, the driver includes the amount of energy supplied from distributed sources and the number and type of suppliers.

The amount of renewable energies, and thus the number of decentralized power generation sites, has increased substantially over the last years [369]. To reach the political goal of at least 20% renewable energies in 2020 [354, 364] and to set off the effects of the nuclear phase-out in Germany, a further increase in this number can be expected. Currently, decentralized power generation is boosted by the large-scale introduction of home-installed gas turbines by Lichtblick and VW [377]. Based on this knowledge, it can be concluded that decentralized power generation forms a certain driver.

In 2025, there is widespread distribution of decentralized energy generation from various types of suppliers. Due to the politically enforced introduction of renewable energies, more and more decentralized generation sites emerge on the private and commercial scale. Households are increasingly equipped with wind mills, solar panels or small gas combustion engines either on their own or by companies based on business models around rental. On the larger-scale commercial side, the number of windmill parks, solar panel parks and biomass plants has increased by a substantial level.

This development leads to a growing number of market players, products and services. As customers become more and more overwhelmed by the number of options, a higher demand for integrated and bundling solutions arises. This demand can be matched by interesting services and products which make use of the chances offered by the rising complexity and again provide convenient offerings for the consumer.

10.2.2 Uncertain Drivers

Besides the certain drivers, other decisive factors exist which influence the future state of the energy sector. However, several developments could occur for each of them, which are described as projections for each uncertain driver in the following.

10.2.2.1 Complexity of Markets

Complexity of markets describes the political will to increase competition within the energy market and the actual market structure. The driver is relevant because the more complex markets are (e.g. high number of market players, low vertical and horizontal integration) the higher the demand for and the benefit of bundling and integrated solutions will be.

The driver is uncertain because it is impossible to predict how the political majority situation will develop and affect the political will concerning E-Energy. However, the European Union stated three major goals: secure energy supply, sustainability of energy supply and competitiveness within the European energy market [354]. In order to achieve the last goal one standardized European grid is intended to be established to facilitate cross border energy exchange. In addition, both on the EU and the national level governments try to increase competition by liberalizing energy markets and unbundling predominant market players. However, the Energiewirtschaftsgesetz from 1998 tried to increase competition and failed to prove that political will does not necessarily lead to a more competitive market. Instead interaction between political sector and market forces is necessary. Each of the following projections is a combination of the political will and the market structure and presents a distinct way of how the driver could develop. They are chosen because they are the most likely projections.

1. The government enacts laws to liberalize the market and unbundle the big market players. Within a short period of time prices would no longer be regulated by authorities but follow supply and demand, consumers would be able to choose between many different suppliers and tariffs. Additionally ownership of generation companies and network operators would be unbundled. Vertical and horizontal integration would be very low and many new companies could enter into the market. Thereby the market would be extremely complex and intransparent. This projection implies a huge need for bundling and integrated solutions to keep track of the market development. Thus both consumers and producers have an interest in new products and services.

2. The government also enacts laws to liberalize the market and unbundle the big market players. The four predominant market players would legally be unbundled. However, in practice the separated divisions would still work closely together and control the market. New market entrants would not have the chance to gain significant market shares because the big market players would be put them out of business would simply purchase all relevant entrants. Vertical and horizontal integration would be very high and the market would not be complex. The projection implies that bundling and integrated services are not important for the market because a few companies dominate the market and control the entire value chain. Therefore, neither energy consumers nor energy producers have a need for bundling and integrated solutions.

3. The government enacts laws due to other major societal problems. Thus there would not be any political pressure on market players to change their behavior. However, big market players from other industrial segments would consider E-Energy to be an interesting topic that is worthwhile investing money. Since these companies would not have the necessary know-how they would try to cooperate with companies in the energy sector. Especially new market entrants would be good partners. Thus many new companies would have a chance to establish themselves on the market and gain significant market shares. Vertical integration would be high whereas horizontal integration would be low. The projection shows that many new participants enter the market and succeed because of cooperations with existing market players. Therefore, market complexity increases and bundling and integrated solutions are interesting for entrants as well as for incumbents to know-how.

10.2.2.2 Customer Participation

Customer Participation describes the degree of customers' willingness to take an active part in the energy market. Customers may have different motivations for participation such as environmental awareness, price changes or the desire for more control over their energy consumption [381, p. 4]. Customer participation is important because it defines the scope for new bundling and integrated solutions customers are willing to consider and accept.

The driver is considered to be uncertain since human behavior can hardly be predicted. External factors such as climate change or technological catastrophes (e.g. Tschernobyl) as well as internal factors such as environmental awareness or disposable personal income can direct individual behavior in various directions. However, three projections are chosen because they present distinct levels of participation.

1. The large majority of customers are passive and do not change their energy consumption behavior. They would stick to today's supplier-user relationship and remain unconcerned ratepayers in the energy market. There would be no personal initiative for participation. This projection implies that customers do not care about new energy products or services. Therefore, the implementation of innovative bundling and integrated solutions is likely to fail.

2. Customers are active due to - for example - higher price sensitivity or environmental awareness. They have an interest in different tariff systems and, therefore, demand more transparency from the energy supplier. However, customers would lack the necessary money to become energy producers themselves but would be willing to host decentralized energy generation capacities. They would also be characterized by a high willingness to provide private data for new energy saving services for the benefit of reduced energy costs. This projection opens up a wide range of opportunities for bundling and integrated solutions since customers care about their energy consumption. As a consequence customers are willing to try new products and services related to E-Energy as long as the usability is simple.

3. All customers are be active and a large proportion is also participatory and proactive. Customers would have the necessary disposable income to buy and install new energy technologies in their households. In addition, they would generate electricity and feed it into the grid and become prosumers. Thus they would act on the supply as well as on the demand side. Therefore, the energy market would become more complex. This projection extends the range of opportunities for bundling and integrated solutions even further. Customers who act as prosumers can offer decentralized energy generation as well as new bundling and integrated solutions for the E-Energy market.

10.2.2.3 Standardization of E-Energy Technology

The driver of E-Energy technology standardization describes the emergence and acceptance of technical standards concerning all aspects of E-Energy, including the physical layer, information and communication layer and other protocols regarding additional services, e.g. for business transactions. Only if standards are established, an integration or bundling of existing products and services can be reasonably realized. Therefore, standardization is an integral requirement to offer such services.

European-wide or worldwide standards already exist for isolated parts of the communication layer. However, no standards for end-to-end communication in an Internet of energy have been defined yet [380, p. 28]. Currently, several groups work in parallel on standardization within the EU which might lead to the existence of competing standards. In order to avoid such developments, the EU commission looks into setting up a standardization consortium to bundle these efforts [380, p. 29].

Moreover, standardization is strongly dependent on the interests of involved parties from the energy and other sectors with competing technologies [356], adding another degree of freedom to future developments. Hence, this driver is considered to be uncertain. Several projections could possibly emerge within the time frame of this report:

1. Emergence and acceptance of European standards concerning all relevant E-Energy components. This development is strongly driven by political will and results in a well-specified E-Energy networks with high compatibility and interchangeability, where all players can rely on compliance with the standards. Some less important standards are not as well-specified and depend on regional developments or market players. Integrated solutions can be created with little effort by keeping to the standards. Hence, the comparatively simple implementation results in a multitude of integrated and bundling solutions the consumer can choose from.

2. Europe-wide emergence of standards for the most important interfaces of E-Energy only. This development is partially driven by the legal and political framework, which ensures connectivity between all parts of the grid. However, many other standards with lower importance are specific to the influence of market players or historical reasons. In this situation, integrated solutions may be designed with reasonable effort when dealing with elementary aspects. More elaborate services must care about incompatibilities and solve evolving problems on their own. Consequently, the introduction of integrated solutions is partially hampered, but nevertheless successful for many applications.

3. Company-based emergence of standards as result of the influence of market players or historically caused growth of E-Energy networks (i.e.,

limited to few countries, one country or even parts of a country due to dominance of a company). While standardization consortiums tried to introduce well-defined standards, no agreements could be found. The employed technology solely is the result of more locally restricted attempts of standardization or of the market power of the dominant player in that region. At interfaces between such subnetworks, special adaptors ensure the functionality of the whole grid. Establishing integrated solutions becomes difficult, since significant work has to be spent on developing adaptors to different systems. These problems significantly slow down the introduction of integrated solutions.

In all projections, standardization predominantly happens for infrastructure, i.e. with regard to smart meters, transmission and distribution, whereas a lack of standardization is more pronounced on the consumer side.

10.2.2.4 Storage Technology

Storage technology is the technology used to store energy for a certain amount of time and therefore also influences both the possibilities for integrated solutions as well as the complexity of markets in the future. Advanced technologies in that field could for example allow energy to be drawn from the grid when it is inexpensive. This energy could then be used later when taking energy out of the grid would be more expensive. An additional feature of future storage devices is controlling them over the Internet [372, p. 69]. There are three levels of storing energy: in large, fixed storages like Compressed Air Energy Storage [372, p. 69], in small, fixed storages at the consumer's site or near decentralized power generators that produce energy intermittently. Additionally, the trend towards electric vehicles requires appropriate means of storage. In any case, storage systems will be an integral part of an energy system that contains a lot of renewable energy sources [360].

At the moment, it is still uncertain whether the requirements to small-scale storage technologies for decentralized fixed storage and mobile storage will be met in the future. Nevertheless, technological breakthroughs are possible due to the higher attention that this field now receives [372, p. 68]. That and the fact that the requirements of large-scale fixed storage technologies on energy density, weight and robustness are lower makes significant advances in this field likely. These advances are therefore the basis of the following projections on how storage technology could evolve:

1. Large-scale storage: Fixed storage technologies for large-scale use evolve further and more facilities are built. However, storage technology for applications at a smaller scale like at the consumer's site do not become economic enough to reach a significant deployment or their operation is too complicated and therefore disliked by most consumers. Instead, large-scale

storages are operated by fewer, bigger companies. Also, mobile storages do not evolve enough to fully replace combustion engines in vehicles. These facts lead to less opportunities for offering integrated solutions, as the storage eco system is rather manageable without additional offerings.

2. Extensive fixed storage: Fixed storage technologies both for large and small-scale use are improved and become sufficiently economic to be widely used. Storages with smaller capacity are deployed to a lot of small power plants that use renewable energies. These power plants can both be at consumers' sites or be part of bigger energy parks like wind parks. There is a number of alternative technologies on which these storages could rely like improved batteries or compressed gas storage [353]. In spite of that, mobile storages do not evolve enough to fully replace combustion engines in vehicles. The large number of distributed storages creates the opportunity for new market entrants to bundle dynamic tariffs that for example give consumers with their own storages financial advantages. In addition, energy tariffs could be bundled with subsidized storage devices to make them more attractive to consumers. Furthermore, the increased number of alternatives makes consulting services attractive to consumers and producers.

3. Efficient storage for every scale: In addition to very mature fixed storage solutions, mobile storage solutions like batteries meet the requirements towards cost, robustness, charging time, number of cycles and energy density. Such batteries could be the result of significant improvements with NiMH, lithium-ion or lithium-polymer batteries [353]. Therefore, they spur the development of electric vehicles. These vehicles mostly replace the ones based on traditional combustion engines. This outcome is accompanied by the mentioned opportunities of integrated solutions with fixed storages and a whole new eco system of electric vehicles on top of that. Accordingly, a wide variety of bundling dynamic tariffs with offerings for distributed storages and batteries in cars becomes viable. These offerings could for example combine the rental of car batteries and distributed storages with an energy tariff both for homes and charging cars. Again, the large number of possible alternatives to choose from makes consumers and producers inclined towards consulting services.

10.2.2.5 Availability of Customer Data

This driver measures the possibility for market players to access data of customers. This issue becomes crucial for the reason that smart metering provides accurate data valuable for the different market players of the evolved value chain. This data is of utmost importance for service providers and companies proposing integrated solutions.

Two factors influence the availability of customer data, rendering this driver uncertain: the reluctance of customers to give away their data and the circulation thereof. Customers are shown to value costs and transparency higher than data security [373]. Secondly, a liberalized electricity market would foster the exchange of data since many operators would have to cooperate and customer could expect more benefit from giving their data.

1. Both market players and customers do not hesitate to share data. This could arise in highly liberalized and complex electricity market where a specific legal framework would secure data exchange. An increased efficiency would then be expected. Aggregated information could circulate, allowing small players to access data easily as well. Thanks to this increase accessibility, the market would be more attractive for small and medium markets players. This imply that a wider offer of integrated solution could be proposed to the customer, leading to an increased benefit for te customer.

2. Customers accept to give their data but certain market players are reluctant to share with their competitors. This would be expected if the market complexity doe not significantly evolve. Big and historic players maintain a decisive advantage by forcing smaller players and new entrants to aggregate data themselves if they wish to offer bundled services. This relative lack of transparency would deter operators from proposing offers bundling services which differ from their core competencies. Furthermore, the limited number of offers of integrated solution will make them less beneficial to the customer since competition would be lower. As a result the customer would be more hesitant to give his data.

10.2.2.6 E-Mobility

The driver of E-Mobility expresses the tendency to use electrical energy for person mobility. The main impact of this tendency is the emergence of substantial storage capacities via vehicle to grid (V2G) systems. For example, routing system and battery loading are sophisticated services which will be proposed to customers. Consequently, the management of this storage capacity offers bundling opportunities and could be integrated into services such as electricity retailing.

Two different business models are possible for V2G systems [374]. The first one is built around ancillary services. In this case, utilities are the beneficiaries. This model is all the more attractive that the electricity market is liberalized and competitive. The second one is a model for customers who are willing to reduce their electricity bill by using the energy stored in their car. The future of E-Mobility depends on these two models and is thus very uncertain. Based on the current situation analysis and given that the goal of the German government is to have one million electrical cars in the street by 2020 [380], three projections are possible:

1. The first projection consists in a marginal share of electrical cars, inferior to the objectives, due to the low attractiveness of both models. Services bundling E-Mobility would therefore be very rare. The needed infrastructure for loading cars would be lacking as well.

2. The second projection is based on a share of electrical close to the objectives. The model for customers will then be driven by the utility market. Utilities or third party could offer bundling offers containing the management of stored energy. A routing system would allow utilities to efficiently use the storage capacity of E-Cars. Utilities would propose appropriate services in wider offers such as electricity retailing or Smart Home management.

3. The third projection is a higher share than expected. Both models would then have been attractive enough to motivate this fast evolution. Mature V2G technologies as well as appropriate tariffs would be required, for example. In such configuration, E-Mobility would be a major asset for both utilities and customers and would appear in numerous integrated services. In addition to the bundling possibilities offered by the second projection, customer would have the opportunity to manage freely their E-Cars. For instance, the customer would be able to use the electricity stored in the E-Car for home devices or to load the E-Car with a specific energy. Integrated solutions would be very similar to the second projection except they would be more complete and more complex.

10.3 Scenarios

In the following part, this report presents three alternative scenarios of the E-Energy market with regard to integrated solutions. Each chapter presents a possible perspective of the future and provides present and future indicators that support the scenario. The third scenario is considered to be the most likely one.

10.3.1 Scenario 1: The Usual Suspects

This scenario presents an extrapolation of today's world. Thus, the following projections are chosen. In 2025 the four major utilities dominate the market. Only regional standards exist in the E-Energy sector and prevent many new companies from entering the market. Therefore, complexity and competition within the market are very little. Consequently, customers do not have an incentive to change suppliers and remain passive. With new technologies and increased efficiency the world develops technologically towards E-Energy but society remains the same. From the perspective of 2025, customers and market structures are historical whereas the technological world has arrived in the future. Figure 10.2 provides an overview of the described key driver projections that lay the foundation for scenario 1.

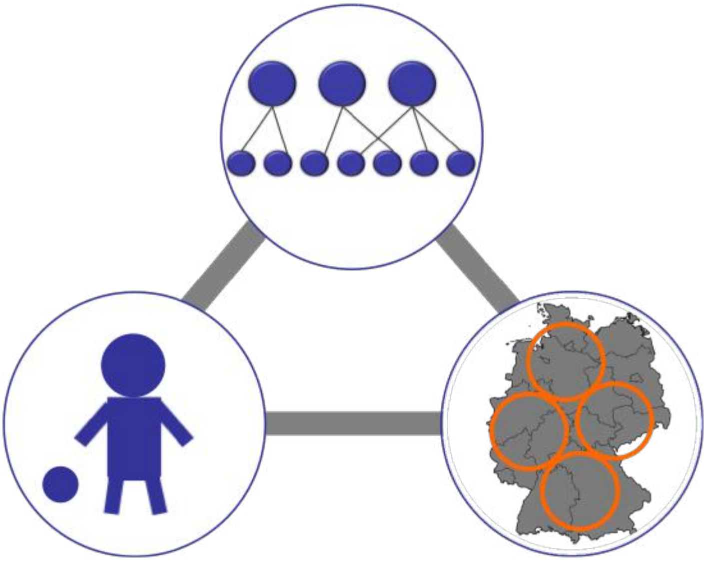

Figure 10.2: Key driver overview for scenario 1

10.3.1.1 Technological Evolution

Energy efficiency plays an important role. Major improvements in the fields of energy generation from renewable sources have been made and the share of electricity generation from renewable energies has increased considerably. New offshore wind parks with larger and more advanced wind turbines as well as advanced photovoltaic systems (e.g. organic cells) are the most important renewable energy sources. With increasing efficiency, electricity from renewables becomes continuously cheaper and begins to compete with fossil fuels and nuclear energy even though efficiency has also increased in this sector. Coal and gas plants are more efficient and use carbon capture and storage technologies to reduce carbon dioxide emissions. Due to technological progress small generation facilities such as CHPs and renewable energy systems are available on a large scale and contribute a significant amount of electricity to the overall consumption.

As the share of renewable energy sources in electricity generation increases, the transmission grid is exposed to a highly volatile input. To cope with this problem and ensure a secure energy supply a European grid is established to facilitate cross-border energy exchange. The European legislative framework has led to the necessary standardization of the grid. While the standardization of the grid is politically motivated and installed Europe-wide, standardization of communication protocols is achieved by the major utilities in Germany. Within their sphere of influence the existing standards are sufficient and special adaptors at the interfaces ensure the necessary exchange between the regions.

Large fixed storage technologies such as compressed air storage and molten salt are mature and used by the energy providers. In contrast there is almost no improvement with small storage. Neither batteries nor hydrogen or any other technology are advanced enough to be used on a large scale. Due to excellent weather forecasting large fixed storage facilities as stated above are sufficient to protect the grid. Thus, from a technological point of view small storage facilities are not crucial for the security of the grid. Because of weak mobile storage technologies the number of exclusively electricity driven cars is negligible whereas hybrid cars are state-of-the-art. Consequently the concept of storing electricity in e-cars does not work. E-Mobility fails in Germany also because the major utilities are afraid of investing in the necessary infrastructure.

Physical infrastructure for E-Energy is in place on a nationwide basis. The vast majority of households are equipped with smart meters, that can provide detailed information about consumption. Many households also use smart devices that can be controlled by a central unit in the building. As communication protocols are regionally standardized these central units (gateways) can exchange information between the household and the energy supplier. Therefore, a more energy efficient operation of all household devices is possible and decreases energy costs.

10.3.1.2 Consumer Behavior

Due to more efficient electricity consumption and increased efficiency of energy generation scarcity of fossil fuels does not impact energy prices as much as expected and prices increase slowly but gradually over time. Since the major four utilities dominate the market the relationship between provider and customer can be described as one-to-many. Because of the low number of energy suppliers and the lack of distinguishing features between them customers remain passive energy recipients and accept the historical supplier-user relationship. Consequently, the willingness to switch suppliers is weak because energy prices do not vary between the suppliers. From an ecological point of view the major utilities in Germanys do not differ either. Their generation portfolios contain similar shares of renewable energies and fossil fuels. Thus it does not matter which company supplies the customer regarding ecological aspects. As a consequence the personal initiative of customers to care about energy based on different goals is negligible. The most important concern is convenience. Since most households possess at least smart meters this concern is addressed by more comfortable tariffs and services offered by the energy suppliers. For smart homes even more convenient services are available.

In order to guarantee smooth and simple services, exchanging information is crucial and suppliers must gather information from consumers related to their electricity consumption in order to predict future peaks. As German customers are traditionally concerned about data privacy they are reluctant to share this information. However, most consumers take a pragmatic approach to the issue. Especially younger people are more willing to accept a compromise between data privacy and convenience for the benefit of a more efficient consumption and lower energy costs. They are not as anxious about data privacy as the elderly because they have grown up in a digitalized society and, therefore, their privacy concerns are not as distinct. Nonetheless, new data privacy technologies and legal regulations ensure data security and protect personal rights.

10.3.1.3 Legal and Political Situation

As stated above data privacy is an important topic for the political sector. Hence, the government has enacted laws to protect critical customer data. This initiative results in a general acceptance of new E-Energy infrastructure among customers. Since prices increase only slowly and customers do not have the chance to switch providers the overall interest of the population remains low. Climate change is important and urging but not of public awareness as everyday life of most customers is not affected by the environmental changes. Thus, political campaigns try to raise environmental awareness to stimulate a more conservation-conscious consumption of energy. In order to use energy even more efficiently smart meters are mandatory for all households and additional smart devices (e.g. for smart homes) are state-aided. The government also provides research institutions and universities with money to maintain the leading position of Germany in certain technology segments related to E-Energy.

Both on the EU level as well as on the German level many laws have been passed to liberalize the energy market, unbundle the major utilities and facilitate the market entry. From a legal perspective liberalization is successful. The divisions of bigger companies are legally separated. However, in practice the divisions still work closely together and the four major utilities dominate the market. Thus from an economical point of view liberalization is not a success and the market structure of the energy sector is an obstacle to young companies, technological innovations and to the societal progress in general. Therefore, the German government strives for more influence in the energy sector in order to stimulate economic growth. Overall the political will to increase competition for the benefit of society is immense but difficult to accomplish.

10.3.1.4 Value Chain and Market Players

The E-Energy market is dominated by the four major utilities because the liberalization of the Germany energy market has not been successful. Vertical and horizontal integration is high. Consequently, overall complexity of the energy market is low. The four incumbent utilities control all parts of the value chain including power generation, transmission and distribution, storage and retail. To bridge the existing technology gap concerning ICT they cooperate with large companies from other relevant industrial sectors. With exclusive cooperation contracts they ensure that the entrance barrier for new companies is high. If new companies enter the market the incumbents either put them out of business or simply acquire them. Thus, there are very few small and independent companies on the market.

Energy generation takes place in different ways. Large new coal and gas power plants produce the base load. Large offshore and onshore wind parks in the northern part of Germany generate parts of the base load as well. In addition to these centralized plants decentralized power generation facilities such as small windmills, photovoltaics and geothermal plants are widely used in Germany to produce energy. Small Combined Heat and Power plants are also installed in many households. They are centrally controlled and can be used to react quickly to unexpected peaks in the load curve. Due to the volatile character of energy from renewable sources large fixed storage facilities are installed to cope with high peaks in the generation curve. The four major utilities own all generation and storage facilities. For decentralized generation they pay a monthly fee to the household where CHPs are placed. The transmission and distribution grid has been modified and adapted to the challenges arising from the increased share of electricity generated from renewable sources. Since the European grid is established, shortages in energy supply in Germany can be balanced with energy from neighboring countries.

10.3.1.5 Weak Signals

The recent Bundestag elections have changed Germany's political landscape and increased the likelihood of this scenario. The new business-friendly government plans to prolong the lifespan of existing nuclear power plants. Thus the major utilities will gain additional profit that must be invested partially in a sustainability fund. Nevertheless the suppliers will keep a lot of money allowing them to increase their dominating market position. At the same time the government plans to reduce subsidies for the renewable energy sector. Therefore, the upcoming legislation period will be decisive for the market structure in the E-Energy sector.

At the moment customers do not care about their energy consumption [381, p. 8]. It is very unlikely that customers will change their behavior radically within 15 years. Therefore, their overall interest for the E-Energy sector will be very low and they remain passive in the energy market.

European and German politics will continue to liberalize the energy market and unbundle the major market players. The degree of consequent enforcement of the new legislation will determine the likeliness of this scenario. If liberalization and unbundling are not properly enforced, this scenario will very likely become a reality.

The number and type of cooperation in the energy market will also be an interesting indicator. The cooperation between Lichtblick and Volkswagen is an example for future joint ventures in the E-Energy sector [377]. The lower the success rate of these new joint ventures is, the more likely scenario 1 will occur.

10.3.2 Scenario 2: The Fabulous World of E-Energy

A fast, but needed evolution is described in this scenario. The perspective of natural resources exhaustion poses a threat to the future of a thriving and stable European continent. The only solution appears to be a fast and thorough evolution of the electricity industry. Therefore, voluntary commitment to promote liberalization and standardization combined with relevant technologic breakthroughs shape a market where advanced integrated solutions are possible. Figure 10.3 provides an overview of the key driver projections that build the foundation of scenario 2.

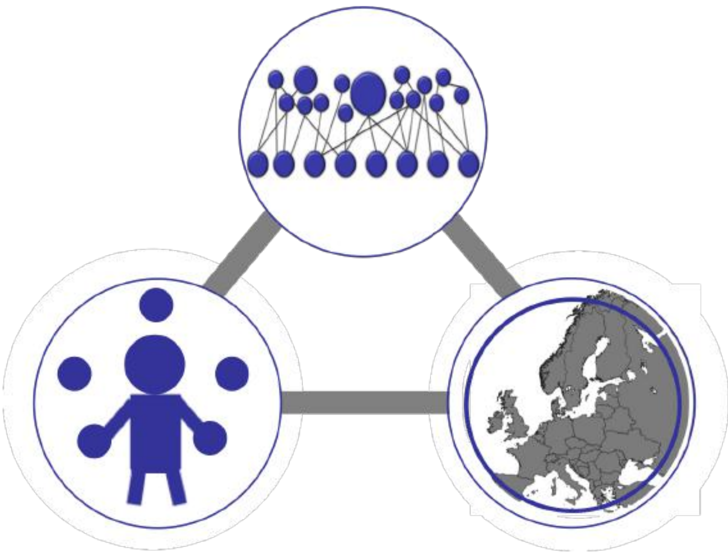

Figure 10.3: Key driver overview for scenario 2

This scenario is the combination of high standardization, high consumer participation and high market complexity. This key driver configuration materialize the fact that this scenario describes a world were significant progress occurred. The government and the EU are determined to liberalize the all electricity industry and standardization, which brings down technical barriers, is a crucial tool to do so. Facing this liberalized market, which is much more complex, the customer has a clear incentive to choose actively offers and even to become a prosumer. Given the current unanimity about the necessity to tackle climate change, governments' intervention is likely to trigger such a scenario.

10.3.2.1 Technological Evolution

First of all, electricity generation has undergone important changes towards strong decentralization, emerging prosumers, and high shares of renewable energy. These changes rely partially on the following matured generation technologies. Wind turbines have, thanks to improvements in the automatic transmission, reached an advanced level of efficiency and now take benefit from the high potential of the North Sea region. Photovoltaic also proves to be efficient enough to provide electricity at reasonable prices. New technological breakthroughs ensure a long term visibility into the development cycle of panels. Longevity has been extended. Raw materials such as selenium are available for a long time. Recycling costs have been reduced. Most importantly, the carbon footprint of photovoltaic is sufficiently lower than any fossil fuel technology to compensate for its relatively higher cost. Photovoltaic enables the consumer to become a producer as well. Solar thermal has become mature as well and numerous large scale plants are run in the south of Germany. Technological evolution allows them to efficiently convert solar radiation into energy as well as to store this energy. The need to deal with intermittency, which is inherent to renewable energies, is therefore partially addressed. Thanks to efficiency improvements, biomass technologies industry evolves into its current form: A widely decentralized system consisting mainly of combined heat and power devices (CHPs). Overall, the concept of virtual power plants has been widely implemented along with a significant move towards decentralization.

Storage technologies have proven to be advanced and matured. Concerning fixed storage, efficient storage exists at every scale in accordance with the third projection of the storage technology drivers. Furthermore, storage technologies also meets specific requirement allowing electrical cars to become competitive.

Transmission and distribution technologies evolve in order to cope with new requirements. Distributed generation and virtual power plant are possible because transmission and distribution connects them efficiently to the grid. Therefore, technologies have improved significantly, especially in the field of long distance transmission. An advanced metering infrastructure also contributes to improving the control of the grid operator over the network, thus enabling a substantial efficiency gain. Moreover, the need to feed energy back into the grid also has to be addressed through technological solutions.

Consumption of electricity has been widely rationalized thanks to the smart metering infrastructure. In addition, a growing number of household or business facilities are equipped with optimization devices and even a small share of energy independent buildings appear. Moreover, E-Mobility has brought a new kind of electricity consumption. Information and communication standardization has reached a high level allowing the smart devices from different brands to communicate. The aggregation of data is typically done by a gateway which is either integrated in the smart meter or not. Therefore, in an important share of household and business facilities local area energy management systems are implemented and continuously exchange information with utilities over the Internet.

10.3.2.2 Consumer Behavior and Electricity Market

Customer participation has raised thanks to increasing environmental awareness, wider technology friendliness, higher financial stakes and more diverse electricity procurement possibilities. This participation happens through the energy management system set in some buildings, the active choice of retail offers, and the generation of electricity at the customer's place. Thanks to relatively high prices, these efforts are fruitful and the customer usually expects to save money on a middle term perspective.

In that stable world, environmental conservation appears as a priority for an increasing number of customers. Those customers concerned about environmental matters are definitely willing to contribute to conserving the environment.

Therefore, customers are willing to have a close look at their electricity consumption. However, they lack time and technical capabilities to do so properly: Some customer have to deal with their smart home, their photovoltaic panels in the backyard and their electric vehicle. In addition, the majority of customers are, to a certain extent, willing to trade private data against more efficiency. This behavior makes consumers very open for integrated solution offers. The criteria they value the most are convenience and efficiency.

10.3.2.3 Legal and Political Situation

Policy makers are widely responsible for making the electricity industry what it is in 2025. The European Union has been striving for liberalization in many industries for a long time, including the electricity industry. However, countries such as Germany or France used to be reluctant to implement the liberalization. In this scenario, national governments have found a compromise allowing liberalization to take place in Germany in 2025. Driven by the conviction that liberalization of the entire industry is necessary to meet the objectives, German government has forced the historic operators to be fragmented in different and completely independent companies. Some of them have been has been taken over by new operators, others remains independent and are thriving.

Besides liberalization-related regulation, other legal frameworks express the strong political support for E-Energy. This involvement proves to be extremely fruitful, especially in term of standardization and technological innovation.

Public awareness remains high concerning both nuclear energy and global warming. Therefore, electricity generation is still in the spotlight and public opinion influence appears to be crucial. The nuclear phase out has taken place as planned and is presented as a decisive move toward renewables. Taking over from electricity imports, low carbon dioxide emission power plants gradually compensate the missing generation capacities. Small scale generation facilities are promoted through incentives and important research credits. On the European and global scale, measures effectively deter power plant operators to opt for fossil fuels. Besides environmental concerns, European energetic independence and the unavoidable trend to increasing fossil fuels prices have been advocating these measures.

Increased competition over transmission and distribution has been made possible thanks to lower control on profits of grid operators. The potential profit of this activity has become high enough to attract new grid operators. Consequently, new entrants have successfully entered the market and markets players are able to make the required investments.

Support for E-Energy is especially strong on the consumption side. First a legal framework to liberalization is provided and therefore controls the significant increase in services and offers available to the customers. Standardization has also reached a high level thanks to the combined effort of European and national relevant authorities. Due to this standardization, the customer can combine products from different brands without fearing incompatibilities. Public authorities are involved in the data management as well, they have established and continuously improved a legal framework fostering data exchange and addressing privacy concerns at the same time. Companies holding that data are carefully examined according to the relevant legislation. In addition, operators cannot hide data, legislation and authorities make sure that transparency is preserved. Finally, incentives have been created to accelerate the E-Energy infrastructure installation and relevant measures have been taken concerning low budget households.

10.3.2.4 Value Chain and Market Players

The evolution of electricity markets is characterized by an international competition and, as a consequence, higher complexity of this market. Prices are volatile, especially on the European Energy Exchange (EEX) which has gained in importance. The polypoly of the big four has come to its end and many other companies have entered the market. Given that the new entrants mainly originated from other European countries, the international trading has grown. The market is also impacted by the decentralization of the industry. This decentralization has triggered the creation of local market places where electricity is traded on a local area.

Within this new market configuration, the value chain has changed and now includes numerous activities originated from the ICT industry. In particular, generators and storage devices have evolved and been upgraded with the ability to communicate with other devices.

The thorough decentralization of generation opens a wide range of opportunities for improved and customized services. Generation capacity can be installed at home, while consumers receive money or a bonus on their monthly bill for providing the space. This compensates for both the relatively high initial capital needed to purchase a generation facility and the relatively long time to make this investment profitable. Smart home management can also be included in the offer.

Storage has quickly emerged in the past 15 years. Storage capacity relies both on fixed storage such as compressed air and mobile storage. The first one had been technologically feasible for a long time and became necessary to utilities to manage the intermittency of renewable sources. However, the cost of storage remains high and its management is a complex task for the storage operator. On the other hand, E-Mobility is thriving and provides benefits to both customers and utilities. High fossil fuel prices make electricity comparatively cheap, which compensates its convenience drawbacks. Utilities have installed an infrastructure allowing customers to feed electricity back to the grid and therefore use electrical cars as storage. E-Mobility offers extremely interesting bundling options: Car batteries are useful to both the utility and the customer, but are provided by car manufacturers. Those batteries can either be owned by the consumer, by the utility or even by a third party who leases it. But if a consumer can easily use the electricity stored into its car battery, it is significantly harder to sell it to another market player. Cooperation between car manufacturers, utilities, smart home providers and storage operator is then necessary to come up with a convenient service for the customer. Thus storage capacity management is frequently proposed as part of an integrated solution.

Because of the high complexity of the market, data management has become an activity of utmost importance for two reasons: First, with the vertical integration coming to its end, the market players of different phases need to be coordinated. The data management layer allows the whole industry to function harmoniously. Moreover, its efficiency in conveying data is a critical success factor to the liberalization which aims at providing better prices and services to the end users. The degree of efficiency of activities such as load management, demand management and storage management relies on the accuracy of data provided to the utilities. The task is all the more complicated in a decentralized industry. To control such coordination, utilities often require services from big companies such as Cisco or IBM.

Second, data management is also crucial in order to provide valuable services to the end customers. The need for convenience pushes the customer to deal with a very limited number of suppliers. Thanks to the advanced standardization, many services such as storage and generation management can be bundled. Gathering data about customers themselves and their environment are of strategic matter in so far as market players who are given the data by the customers can come up with better integrated solutions. These solutions contain for example relevant new smart home or building devices, storage or generation capacity or even contract management with utilities. This market is totally new and companies from the Internet and telecommunication industries gain a high market share.

10.3.2.5 Weak Signals

Numerous current signals point out such a scenario as likely. Firstly, there is an observable political will to implement E-Energy. President Obama has repeatedly mentioned that the smart grid is the answer to essential topics in the energy field [356]. Chancellor Merkel also supports E-Energy in such a way [364]. The objective of one million cars by 2020 supports this direction as well. Therefore, the political support for E-Energy may remain strong and even increase in the future. Concerning the liberalization process, the EU seems committed to liberalize various network industries. Important steps will be carried out in the near future for train and postal services [361]. This support could trigger the needed evolution to reach the situation that this scenario describes. High investments in research, new infrastructure, progressive mindsets and thorough government intervention characterize this scenario and require a clear political support.

Numerous further developments could also indicate that the future of E-Energy is developing toward this scenario. A thriving European economy and a relatively stable political situation could highlight the necessity to tackle environmental matters. Pessimistic predictions in terms of fossil fuels could trigger a strategic move towards E-mobility and renewable energies. An increased legitimacy of EU authorities, by successful liberalization in other sectors, could also ease the decisive processes of standardization and liberalization.

10.3.3 Scenario 3: The Magnificent Many

This scenario is the one that appears to be the most likely one based on the present weak signals, which are presented later. It includes a more complex energy market than the one of today, which is mostly driven by new market players, while governmental efforts have been largely unsuccessful. The entrance of new small companies and existing companies from other industries like ICT has led to a market situation with a lot of competition and weakened the dominance of the traditional major suppliers. Small companies have in particular changed the generation and energy retail market and often partner with other companies to combine their efforts. However, as building and maintaining the infrastructure for transmission and distribution and big power plants is hardly attractive to new companies, the grid and those power plants are still in control of few major companies. As some of their profits in this area are limited by governmental regulation, these offer simple, integrated solutions for rather conservative customers to increase their profits and make choices easier for customers in this more complicated market. In addition, power resellers offer more flexible energy tariffs and upgrade them with services like consultancy services for optimizing the customers' consumption. Consumers now are willing to change their consumption behavior to a certain degree and care more about the sources of their energy, but only few of them generate power of their own. Finally, a lack of full standardization of household devices still requires consumers to keep a certain degree of attention to their energy consumption and tariffs. Figure 10.4 provides an overview of the key driver projections that make up scenario 3. In this setting, many opportunities arise to offer bundling and integrated solutions.

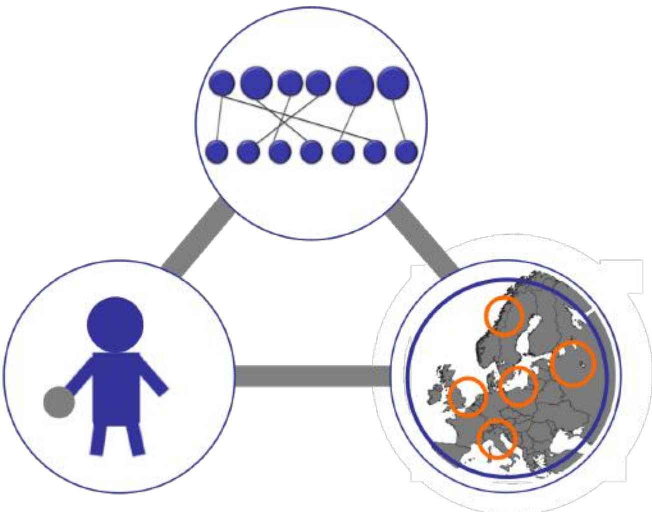

Figure 10.4: Key driver overview for scenario 3

10.3.3.1 Technological Evolution

Communication protocols between E-Energy devices are built on top of the usual widespread Internet protocols as Internet technology has proven to be the most robust way to connect various devices. Following the tradition of the development of Internet protocols, these standards have not developed out of a political movement, but rather by companies that have formed consortia and specified open standards that can be implemented by all market players. Their main intention is to develop a common set of technologies together to minimize the risk of wasting resources on technologies that will not be established on the market. On the other hand, they aim to still be able to differentiate their products from their competitors. Therefore, basic protocols for exchanging pricing and consumption information as well as fundamental remote control features like switching devices on or off are standardized and allow interoperability among the devices. There are also standards that allow generators and storage devices to be both remote controlled by service providers as well as standardized protocols that enable these devices to change their behavior independently. Finally, the communication between nodes of the transmission and distribution grid are standardized as well. Therefore, exchange of energy between different grid operators is possible. However, more advanced features in consumer devices are not part of open standards as device manufacturers wish to retain them as their unique selling propositions. Considering consumer devices, there are islands of products or companies whose products integrate very well with each other and only work together with devices of other islands on a very basic level. This fragmentation is especially apparent with smart household appliances and home automation systems. Nevertheless, the level of standardization is sufficient to provide services and products which are based on the personal consumption behavior and household equipment of individuals.

Furthermore, the efficiency of generators and the one of the transmission and distribution grid has improved. As a consequence, transmitting power over a longer distance like from the north of Germany to the south has become more feasible than in the past. This makes decentralized, intermittent power generators more attractive. Therefore, there is a high number of decentralized generator devices, which are mostly operated by small companies. Due to these improvements, energy from decentralized generation sources can not only be sold regionally, but also in more distant regions. Consequently, smaller energy providers need a means to sell their energy to customers all over the country.

Storage technology has evolved with two different speeds: Stationary storage systems have advanced sufficiently in terms of robustness, capacity, longevity and have become inexpensive. However, smaller, mobile storages have only made linear progress and are not suitable for a wide use in electric vehicles. Their energy density and charging time still are not sufficient to replace combustion engines. Stationary storages like battery packs are very common in many households and allow both storing surplus energy generated by generators at the consumer's site as well taking electricity out of the grid to store it for later use or sale, when prices would be higher. In addition, bigger storages for large scale application to store energy from nuclear power plants in times of less consumption are technologically advanced enough for an extensive use. Additionally, the progress in storage technology contributes to decrease the amplitude of the aggregated load curve of countries like Germany.

Smart meters are widely spread and installed in most private and business buildings. They allow measuring the consumption in realtime and can upload this information to other devices through a standardized protocol. Some smart meters also bear gateway capabilities and are able to not only measure the consumption of a whole building, but also for individual household devices that are compatible with the according standard. Also, household devices that have been upgraded with the ability to respond to different energy prices are used by a significant number of consumers, but most homes contain only a few number of these devices. As a consequence, most of these devices remain rather independent and are not controlled from a central device. Instead, they are configured separately and directly fetch price information from the Internet. Accordingly, analyzing their consumption behavior or remote controlling them is basically possible for Internet-based service providers, but only with the homes of few customers. The installed technology allows to provide consultancy services based on individual consumption profiles. Further optimization potential around smart devices still exists and could lead to solutions based on this observation.

10.3.3.2 Consumer Behavior

Consumers are actively interested in energy and their supply thereof. This has not been the case forever due to the abundance of energy supplied from various sources of cheap generation. However, the growing realization of the climate change and its dangers as well as rising energy prices bring the issue to public attention. Therefore, a large share of customers is environmentally aware and prefers energy from renewable and climate-friendly sources, leading to the desire for intentional decisions on one's sources of energy. Some consumers go one step further and participate in the energy markets as "prosumers" by generating electricity in their own decentralized facilities. This includes solar panels, wind mills or CHPs. Nevertheless, the amount of consumers becoming prosumers will remain at a comparatively low level due to the majority's convience-oriented attitude.

Although environmental awareness and the wish to take an active role have risen, convenience is an important factor. People have to care about many different things in their daily lives and do not want to spend too much time and effort on making decisions. This collides with the increasing complexity of markets. The multitude of suppliers, contracts and tariffs overwhelms the average customer who is not able to get an overview of all offerings within the amount of time and effort he is willing to spend. Due to this conflict, consumers are interested in convenient facilitating services which help them to grasp the complexity of markets. Otherwise, they are in danger of becoming frustrated and loosing interest in the topic, using easy bulk tariffs as in the past. Solutions serving this particular need are therefore likely to be introduced.

In the age of digital technology and communication, data privacy is not negligible. However, most consumers are characterized by a pragmatic approach to the issue due to the ever-increasing share of "digital natives". They are not overly careful about sharing data which is not too private, but still appalled by unauthorized or illegal misuse, because they expect responsible treatment of their personal information. However, consumers are willing to give away data in a controlled way to allow for custom-tailored services offering transparency or cheap prices, which could not be realized otherwise. Hence, the chance exists to provide services which are built around analysis of personal data.

Similarly, the consumers attitude towards E-Energy devices is of a positive nature. People value the information they can get from smart meters and the savings that result from smart appliances. Consequently, they have no objections towards these devices and buy them, continuously replacing non-smart devices in average households. On the other hand, the concept of E-Mobility has not taken off for multiple reasons that also involve customers. Apart from cities, acceptance of purely electrical vehicles that are charged from the grid is limited, since the small range and long recharge times of batteries conflict with the independence and convenience a car should offer. Furthermore, doubts about discharging batteries to the grid prevented large-scale establishment of the concept, although it has been actively promoted by politics.

10.3.3.3 Legal and Political Situation

In general, the framework customers and suppliers interact within is given by the legal and political situation. As in the past, liberalization of markets is still an actively supported goal of European economy policies. Nevertheless, unbundling of the big energy suppliers was only partially successful and has not been corrected until recently. But the the new capabilities of technology as well as the changed requirements of consumers towards using energy more efficiently make it easy for new companies to enter the energy market, resulting in an unbundling of the energy market for economical instead of political reasons.

The influence of politics on the energy sector is not limited to this aspect. Other important factors are determined by legal regulations and political initiatives as well. Privacy legislation is stricter in comparison to the past and gives citizens more rights to control their data, whereas companies have to obey stronger rules which limit the usability. Still, as mentioned above, customers are aware of the issue, but make active use of the restrictions only to a certain extent for convenience reasons. Furthermore, contracts and documents are also considered valid in a digital form without being explicitly signed on paper in a secure technical framework. This follows from the considerable number of commercial and public services that are offered digitally. Signing into services and buying products is therefore easy, fast and flexible.

Besides, the EU commission actively engages in standardization processes through the establishment of consortia. Through the agreement of the commercial and public side, standards covering the most important aspects of E-Energy have been reached this way. Caused by the complexity of the task and the number of involved interests, initiatives are lagging behind technical developments, which creates incompatibilities by means of new devices or proprietary solutions.

Altogether, the legal and political situation is advantageous for the establishment of bundling and integrated solutions, as standardization and the number of market players are influental factors for the demand towards such services and products.

10.3.3.4 Value Chain and Market Players

The generation of electricity takes place in two ways: Large power plants like nuclear or coal power plants still produce a significant share of the electricity. As their construction and operation requires vast investments, they are operated by the traditional big suppliers. The remaining part of the electricity is supplied by a decentralized array of plants that use renewable energy sources like wind power or solar energy. These smaller plants are mostly owned by a large number of small companies and in some cases by consumers that use them to partly power their own homes and feed unused energy back in to the grid. However, most consumers prefer not to operate generators themselves. Instead, some providers place their generators at the consumers' site and offer them a monthly rent or other benefits like allowing them to use a part of the generated energy for themselves. For the consumers, this has certain benefits: Although they do not operate these generators and therefore do not become producers themselves, they gain financial advantages on energy supply without having to invest a lot or having the burden of high maintenance cost. Providers of such generator distributed networks reward consumers because energy used at the same location does not suffer transmission loss and installing them at consumers' houses is inexpensive compared to other locations. These smaller suppliers often form joint ventures with established companies that manufacture the necessary devices or operate the grid and its intelligence that is required to adjust the generation to energy prices.

The allocation of storages is similar to the one of generators: On the one hand, the few major companies and also some smaller companies that specialized on the generation of energy from renewable sources operate large-scale facilities based on technologies like Compressed Air Energy Storage. On the other hand, there is also a significant number of smaller storages near individual smaller power plants like wind mills and in the houses of consumers. Again, there are multiple models to which party finances storage devices. One option consists of small, specialized companies renting the space for storages from consumers and small plant operators. The alternative is that the users of these storages buy or lease them. While the former option has been more attractive to most people in the beginning, the latter will become the dominant model when storages will have proven to be sufficiently robust and inexpensive. In contrast to stationary storages, mobile storage solutions required for electric vehicles are still limited in their use due to their lack of capacity. As most consumers favor cars for flexibility, electric vehicles, which can only be used for short distances, have not reached the mainstream.

The transmission and distribution of electricity in this scenario remains to be controlled by a few big companies similar to the present state. This is mainly because building and maintaining the necessary infrastructure is very expensive and hardly attractive to new entrants of the market as there are limited technological advances in the relevant technology and profits are limited by regulatory laws. Nevertheless, as the future transmission and distribution grids are upgraded with information technology, the existing grid operators have formed joint ventures with new market entrants that provide this upgrade. As profits are limited to a certain amount, the grid owners also offer integrated solutions. Such value-added services will enable them to still make more profits than with only selling their traditional services to other companies that resell them to the consumer.

Retailing energy is the most promising part of the value chain for integrated solutions and bundled offers and thus the most competitive one. Both the traditional energy suppliers and new resellers contribute to the significant complexity of this market. The few big companies mainly focus on offering simple, comprehensive and reliable solutions to more conservative customers, which do not want to tackle the complexity of this market. Therefore, they provide customers with variable tariffs, smart devices that seamlessly work together and help them with technical issues like installation and operation of these devices.

New resellers on the other hand differentiate themselves from the traditional suppliers by offering more complex, but also more innovative tariffs and integrated solutions. Such tariffs include giving customers a bonus on their bill, if they adapt their consumption behavior in a certain way. These reseller do not take part in the generation, storage or transmission and distribution of electricity, but buy it from energy exchange markets. Companies acting as providers of bundled solutions will both be completely new companies that offer tariffs together with consulting services as well as existing companies from other industries like banks and insurance companies. This leads to a very active environment with a wide range of different offers. While most of the companies contribute to the new complexity of this market, some specialize on consulting bigger customers like businesses in choosing providers and energy strategies. Generally, the complexity of the retail market is a chance to provide solutions which provide a clear overview of the multitude of options which are offered to the consumer.

10.3.3.5 Weak Signals

There is a number of current developments that support the configuration of the key drivers in this scenario.

Firstly, there has been a movement in European politics towards liberalizing markets that were dominated by governmentally owned companies in the past. Until now, this endeavors have only led to a limited success in the energy market due to the high cost for entering these markets [355, p. 27]. On the other hand, new companies like Google [352] have started already to introduce products that augment the efficiency of energy consumption by using information technology. As the costs of operating a grid will not fundamentally change, it will be these new market entrants offering new products and services that will have a chance of succeeding in this market and eventually increase its complexity.

Secondly, the number of people familiar with IT and that are also interested in optimizing their power consumption and energy sources is growing in Germany. Using the web for comparing prices or online shopping in particular is quite common in Germany. Furthermore, environment friendly electricity tariffs are offered by a wide number of energy of utilities in Germany, which proves that there is an interest in such tariffs.

Thirdly, there currently is a clear movement towards technical standards for certain parts of the energy value chain. For example, due to the high infrastructure cost, there are already a number of standards for transmission and distribution like IEC 61850 [378, pp. 102f]. Also, standards like OpenADR in the United States for exchanging pricing information [376] will encourage the EU and European companies to agree on similar standards. However, home automation systems at present are hardly standardized. Although they use standards like TCP/IP as a basis, the protocols that build on top of that and control the actual automation are mostly proprietary [380, p. 15]. This leads to the conclusion that in this scenario, technologies that build the energy infrastructure will be standardized at a high degree, while technologies on the consumer side will be standardized only to a rather basic degree. The appearance of walled gardens, closed sets of information services, in combination with household devices would further support this scenario.

In addition to the key drivers, there are also indicators for the expected outcomes of the other aspects in this scenario: The significant number of solar panels and wind mills in Germany are part of this trend. However, very small generators and storages in private houses are rather rare. Instead, renewable energy generators are mostly operated by small companies. Thus, a growing number of such small energy producing companies and a comparatively low participation of private households in energy generation is future indicator of this scenario.

As integrated solutions that incorporate the consumer's behavior pose a challenge in retaining the privacy of customers, a more open attitude of consumers would be an indicator if this scenario. Currently, about 70% of consumers would already be willing to provide certain companies with electricity usage information to gain financial benefits [373, p. 32]. Consumers actually using services where they have to provide such an amount of personal data is a further indicator towards this scenario.

10.4 Service Idea: Tariff Sheriff

Tariff Sheriff is based on the third scenario, described above. It is a web-based service that gives personalized suggestions on which energy tariffs to use. It therefore analyzes the energy consumption behavior and presents the user the best alternatives. The web service addresses convenient consumers that want to spend little time on analyzing tariffs, but still want to save money.

10.4.1 Description of Service

Tariff Sheriff is a web-based service that provides a convenient way for customers to find an energy supplier, contract and tariff which suits his needs the best. For this purpose, the user's energy consumption data of the past is transferred to Tariff Sheriff which uses this information to build an energy consumption model of the customer. Together with energy production forecasts and customer-defined preferences, all available contracts and tariffs are matched with the prediction model to find the optimal solution for the customer. Additional value added services such as convenient suggestions to improve energy consumption are offered to the customer in case this might fit an even better tariff. The results are presented in an easy-to-use web interface, where the user can change his supplier or contract with little effort. Tariff Sheriff then performs the change on the user's behalf by means of a standardized interface to suppliers.

Figure 10.5 gives an overview of the process of finding the right tariff for the user and changing to a new tariff. In the following, each step of the Tariff Sheriff service is described in detail.

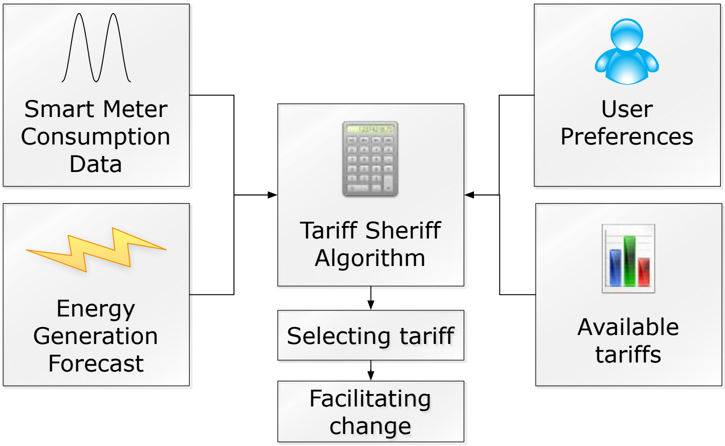

Figure 10.5: Recommendation and selection process

10.4.1.1 Transfer of Consumption Data

At the heart of Tariff Sheriff lies the analysis of customer electricity usage data to build a consumption prediction model. Therefore, to use the service, the consumer has to give an insight into his consumption patterns by allowing Tariff Sheriff to access his smart meter over the default smart metering communications channel. Owing to privacy concerns and the different degrees of advancement of smart meters installed in buildings, the retrieved data ranges from simple load curves to separate usage profiles for each smart appliance.

The customer has a variety of choices how much and which information he wants to supply to the service. Generally, the larger the amount and the more detailed the data, the better is the prediction model. That means a higher number of usage profiles, which is ideally broken down into single devices, allows the service to find a better solution to one's preferences in the end. In the ideal case, the customer allows Tariff Sheriff to continuously track all electricity usage directly from the smart meter over a longer time. On the minimum side, some aggregated consumption curves can still be used to build a less detailed model.

The decision which data to supply is strongly correlated with the issue of data privacy which should not be underestimated. Therefore, customers of Tariff Sheriff actively decide on data usage: If there are no concerns, they can allow the service to directly access the smart meter and log information. It is possible to restrict this access to aggregated load curves instead of device-specific load curves. Tariff Sheriff encourages transparency and informs the user about the data that is transferred to the service and stored for analysis. More cautious customers can also upload aggregated load curves manually to the website instead of having them uploaded automatically.

Figure 10.6 gives an example of the user interface presented when users give Tariff Sheriff the permission to use their smart meter data.

10.4.1.2 Specification of Customer Preferences

Energy consumption patterns are the core aspect in determining a suitable contract. In addition, active customers also have specific preferences about their energy supply like. Hence, after supplying information about energy consumption, users can enter further preferences in a simple and easily understandable web-based questionnaire. In the end, this leads to a preference profile which includes factors such as importance of renewable energies and environmental friendliness (i.e. energy mix), cost, risks, customer support, comprehensibility of the tariff as well as the contract duration. As shown in figures 10.7 and 10.8 the user may weight each of the factors according to his own criteria.

Additionally, the customer can optionally provide further information such as personal calendar data from applications like Google Calendar. This way, possible times of absence or increased energy usage can be considered when matching tariffs with the preferences and consumption model. The resulting consumption model is based on state of the art machine learning techniques like Support Vector Regression. The model is trained with all data supplied by the customer and general consumption trends as input features and can predict energy consumption for certain time slots with high confidence.

10.4.1.3 Search for Optimal Solutions

All collected information about the customer is integrated into a preference profile and a consumption model. Besides, models are created for each different contract or tariff. They include descriptions of the properties of generation and the pricing scheme of the contract. By adding knowledge about price developments in the past and forecasts about developments in the future, Tariff Sheriff aims to predict prices for each tariff. Several information sources contribute to the model, like weather forecasts or seasonal trends. All information sources are again used as input features for a Support Vector Regression.

In the next step, Tariff Sheriff matches the consumer profile with all tariff profiles. The consumption model is compared with the production model of the energy supplier by summing over the demand and the predicted price per time slot, thus yielding variables such as the expected price and the probability of price fluctuations. All information about the tariff properties and price developments is finally evaluated according to a distance function, which is calculated using weight factors based on the criteria specified by the user. In the end, the best tariffs are those which minimize the distance function.

This process yields a list of solutions ranked according to the criteria and their weights specified by the customers. For instance, if a customer is only interested in a minimum price, the service identifies the tariff which most probably yields the lowest costs. More complex combinations of preferences are treated accordingly. The model also detects opportunities for value added services by integrating them into the detection process. The process of searching for optimal solutions is solely done by Tariff Sheriff and not visible to the customer.

10.4.1.4 Choice Between Alternatives

After the identification of contracts and tariffs that fit best, the results are presented to the customer on the website and are ranked according to the previously specified criteria. Figures 10.9 and 10.10 demonstrate how the according user interface could look like. Furthermore, the new offerings are compared to the old contract. The most important facts about the contract, e.g. duration of the contract or type of pricing scheme, are summarized uniformly. Additional information about the contract and on how the ranking was created can also be displayed for interested customers.

At this point, Tariff Sheriff also presents value added services or offerings that are related to switching the tariff or might result in an even better tariff. More details about value added services are given later on.

10.4.1.5 Contract Formation

Having found a good contract that fits his need, the customer can close the contract with a few mouse clicks on the Tariff Sheriff website. The first time, he has to enter all relevant data which can then be stored for further contract changes. On the user's behalf, Tariff Sheriff automatically terminates the old contract either by contacting the old supplier over a web-based system or in a conventional way. Afterwards, Tariff Sheriff signs up the customer with the new energy provider according to the chosen tariff by means of interfaces to the databases of the involved suppliers.

10.4.1.6 Keeping Customers Updated

Once a customer decides for a tariff and a certain supplier, this does not have to be the best solution for all the time. Changes in the customer's consumption behavior or the emergence of new tariffs and suppliers might lead to a better solution. Therefore, Tariff Sheriff offers the possibility to continuously match the old or progressively updated consumption prediction models with the database of tariff models. The identification of a better solution than the one chosen by the customer results in a previously specified way of notification, e.g. via e-mail. Analogously, the new contract ranking is presented to the customer, who can change to the new supplier with a few mouse clicks.

10.4.1.7 Mockups of the User Interface

- The smart meter asks the user for permission to transfer data to Tariff Sheriff

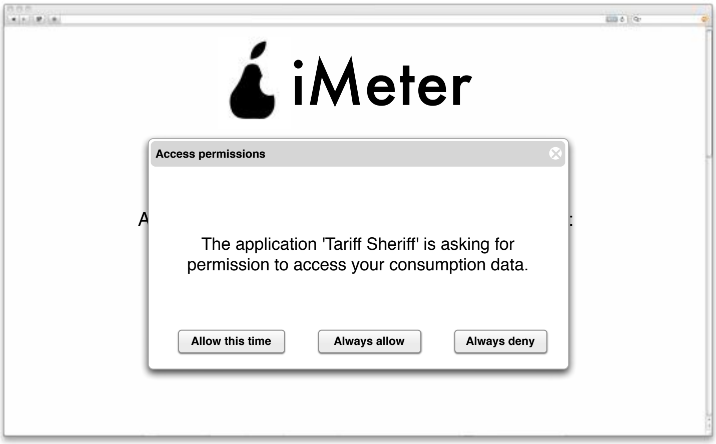

Figure 10.6: Tariff Sheriff Mockup - Permissions

- Users give Tariff Sheriff their personal preferences for their energy tariffs

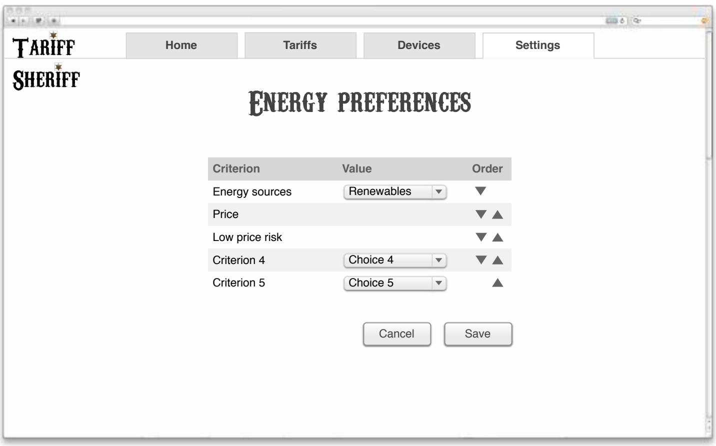

Figure 10.7: Tariff Sheriff Mockup - Preferences

- Users give Tariff Sheriff their personal preferences for their energy tariffs (close-up)

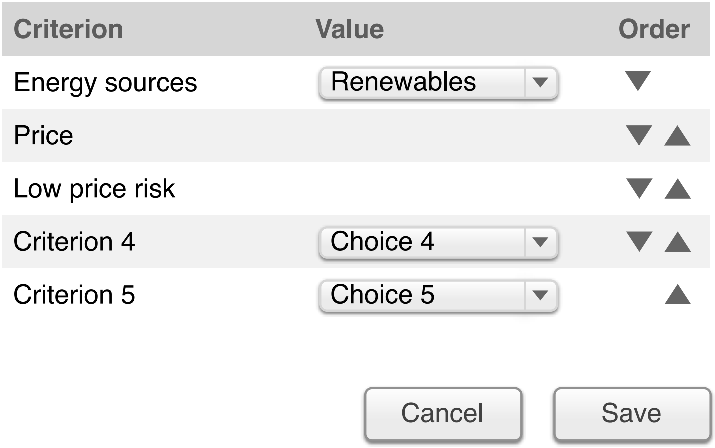

Figure 10.8: Tariff Sheriff Mockup - Preferences (Close-Up)

- Users are presented with three options to choose from

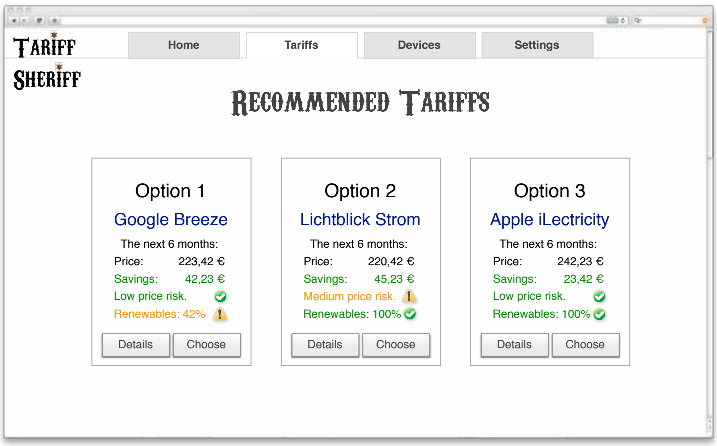

Figure 10.9: Tariff Sheriff Mockup - Choice

- Users are presented with three options to choose from (close-up)

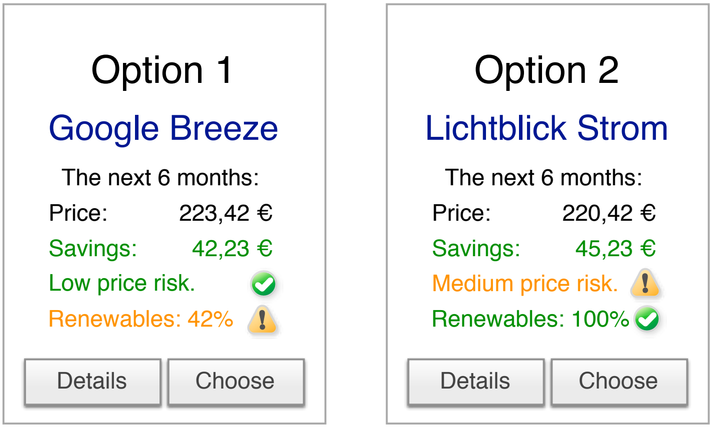

Figure 10.10: Tariff Sheriff Mockup - Choice (Close-Up)

10.4.2 Required Infrastructure and Knowledge

In order to provide the Tariff Sheriff service, infrastructure and extensive knowledge in machine learning is required. In the following, all necessary factors are described.

10.4.2.1 Customer Service

The first aspect of Tariff Sheriff is dealing with customers. This involves two major areas: retrieval of smart metering data and offering a website to perform all transactions involving the consumer. Hence, ITC infrastructure to connect to smart meters securely and to load data is needed. Depending on how well-standardized protocols for this task are, data retrieval involves more or less effort. Moreover, a convenient, user-friendly and dynamic website has to be designed, maintained and provided.

10.4.2.2 Model Building and Machine Learning

The most difficult part is building machine learning models for consumption and tariffs. Importantly, experts on machine learning and data processing are required for this step of the Tariff Sheriff service to develop and run the central system functions. As machine learning and data mining are computationally intensive, appropriate IT infrastructure is crucial.

10.4.2.3 Contract Formation

Since consumers should be able to change contracts in an automated way with a few mouse clicks, special attention has to be given to this aspect of the service. A secure IT interface must be established with suppliers to terminate and set up contracts. Furthermore, up-to-date tariff and contract information has to be collected from suppliers and entered into the Tariff Sheriff knowledge base.

10.4.3 Benefits and Customer Needs

Since Tariff Sheriff plays the role of an interface between end customers and utilities, Tariff Sheriff has two kinds of customers. The first type of customer is the end user. Obviously, the product is dedicated to individuals who consume electricity and who have the possibility to choose their energy provider as well as their offer. However the typical customer of Tariff Sheriff has much more precise characteristics. Firstly, the typical customer is active or even participatory, as described in the customer participation driver. Using Tariff Sheriff requires a bit of effort and a small amount of time. Therefore, the customer should have an active or even participatory mindset. In addition, the typical customer will be quite familiar with online shopping. He must be either especially price sensitive or particularly environmentally aware, ideally both.

Tariff Sheriff can answer several potential needs of such a customer. Firstly, the need for saving money can be addressed by providing the customer with the cheapest offer for his personal consumption. Similar to that concern, the need of customers to have an outlook on his future electricity bill can be addressed as well. Thanks to price and risk prediction of Tariff Sheriff, the customer can choose a tariff where the end price is rather certain. The customer also has the possibility to choose offers which are certified as environmentally friendly by Tariff Sheriff. This addresses further needs of the customer: the need for transparency and the desire for environmental commitment. Another aspect of the concept of Tariff Sheriff is the need for understanding. It is addressed in so far as Tariff Sheriff allows the customer to visualize the concrete impact of the abstract terms of a contract or the technical details of a product. This leads to a group of early adopter composed of both young educated professional and students.

Utilities are also costumers of Tariff Sheriff. Of course, all offers from every utility would be taken into account but some of these utilities would be customer in so far as they will pay us a fee regarding the model of affiliate marketing. Such a utility will be a company which lacks customer awareness. Typically, this company will be young and based on a differentiation business model. This difference will be highlighted through Tariff Sheriff if it complies with the preferences the customer stated in the beginning.

As for the needs of these utilities, they are straightforward. A higher transparency of the market helps those companies to gain new customers, answering their need to increase their market share. Furthermore, they hope to gain visibility.

Unique Selling Proposition

The unique selling proposition of Tariff Sheriff can be characterized by three words: Smart, simple and unbiased which could be a marketing slogan. These features are critical success factors for the product.

Essentially, Tariff Sheriff comes up with predictions. These predictions have the great advantage to be easy to check a posteriori. The customer can merely compare the price Tariff Sheriff came up with and the actual price. Therefore, if Tariff Sheriff predictions are smart, they will appear as such to the customer.

Tariff Sheriff is simple for two reasons. First, Tariff Sheriff is easy to use. Uploading or providing data is technically easy and questionnaires are understandable for a non-expert. Additionally, thanks to the advanced customization possibilities, the results that Tariff Sheriff comes up with are very concrete. On the other hand, by using Tariff Sheriff the consumer avoids consulting the websites of many different utilities which might offer similar services restricted to the company.

Finally, Tariff Sheriff is and appears unbiased. Advice provided by Tariff Sheriff is legitimate and does not seem like advertising in disguise. This point is crucial in so far as the credibility of our prediction is the only thing driving the customer onto the website. Such positioning is a comparable advantage toward utilities websites.

10.4.4 Business Model

The business of Tariff Sheriff is based on affiliate marketing. The fundamental principle of affiliate marketing works as shown in figure 10.11. An energy consumer who wants to change either his tariff or the supplier searches for an online platform that provides a service to compare different tariffs and retailers (see figure 10.11 (step 1)). The consumer finds the website of Tariff Sheriff, provides the personal data necessary for the service and receives a list of tariffs which fit the customer's preferences best. The comparison of tariffs includes prices and a standardized presentation of the contract. Then the consumer can easily change his contract by (automatically) filling out the contract on Tariff Sheriff and signing it (see figure 10.11 (step 2)). In this model Tariff Sheriff is the independent affiliate of many energy retailers. The suppliers pay Tariff Sheriff a certain amount of money (range between 5 and 15 Euro) for every customer that signs one of its contracts (see figure 10.11 (step 3)). That means that Tariff Sheriff uses the 'cost per action' approach where the supplier only pays when the desired action has occurred. In addition suppliers have to pay a fixed fee every month since Tariff Sheriff is a platform that facilitates switching suppliers. In a market with many participants suppliers have a significant interest in being listed on Tariff Sheriff because the service creates transparency in a complex market environment. That is especially important for new companies that just entered the market because they cannot afford to invest much money into marketing and advertising.

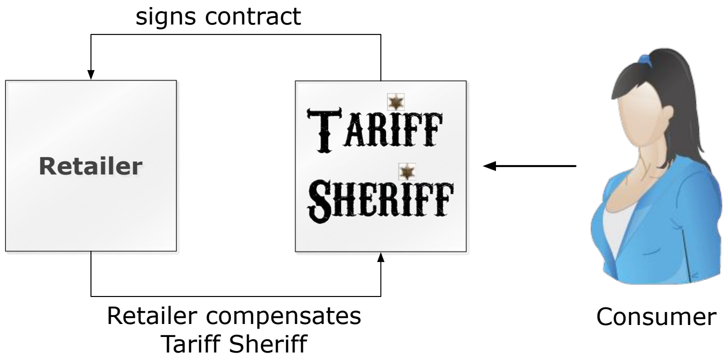

Figure 10.11: Affiliate marketing

Since the concept of Tariff Sheriff is based on simplicity and an all-out-of-one-hand approach customers will be more willing to switch providers. At the moment only 14% of the customers have switched their supplier and only 10% are considering to change within the next two years [375, p. 7]. Convenience, a lack of obvious distinguishing features and the impression that a change will not save a significant amount of money are the main reasons why customers are reluctant to change [375, p. 7]. The underlying scenario describes that customers will be more active in the energy market, care about their energy consumption and different tariffs. Therefore, many customers will be interested in changing tariffs. Assuming that there will be as many energy consuming household in 15 years as there are today (roughly 39 million), assuming that the percentage of customers actually changing contracts will increase and assuming that a certain percentage of customers will change contracts on a regular basis the potential net sales of Tariff Sheriff will be large enough to securely run the business. As soon as a critical mass of loyal customers will be reached the initial investment will quickly be amortized and the costs per customer will be extremely low.

10.4.5 Market, Players and Value Chain

Tariff Sheriff is integrated into the value chain of the E-Energy sector as an intermediary step between retail and consumption. In scenario 3 retailing is described as the most competitive part of the value chain since both the traditional energy suppliers and new resellers contribute to the significant complexity of the market. As retail companies are the actual contractual partners of the consumption party and complexity increases on the retail level there is demand for an integrated solution on the consumption level such as Tariff Sheriff to keep track of the different retail companies and their tariffs.

Tariff Sheriff compares different tariffs based on the customers' preferences, facilitates switching contracts and is paid on a 'cost per action' approach by retail companies. Therefore, it must cooperate with these companies. At first especially small companies such as new entrants have an interest to work closely with Tariff Sheriff. As soon as Tariff Sheriff gains a significant market share and reaches broad brand awareness also major utilities will cooperate. Besides, Tariff Sheriff needs customers who are willing to switch their provider and who want to use an innovative service to improve the changing process.

Large utilities are the most relevant competitors because they are afraid of losing existing customers via Tariff Sheriff. Therefore, they try to interfere with the service by providing exclusive contracts to their customers. However, new entrants' contracts are better because they must increase their market share. Consequently, customers use Tariff Sheriff. Other new participants within the new part of the value chain are also competitors. They use different approaches to create transparency in the complex market. Thus it is very important to monitor the market for competitors.

10.4.6 Value Added Services

One option to keep competitors away are value added services. A value added service aims at making the product more attractive and more profitable. The following ideas are two examples of such value added services.

First, one value added service could be that Tariff Sheriff features a social network. Obviously, the topic of this social network would be energy. Members would be exchanging information, tips and advice about their electricity consumption. They could for example compare their load curve. Moreover, this community could be a precious asset for Tariff Sheriff. These loyal and highly motivated members could attract others customers and provide new users with an effective support.

Tariff Sheriff could also be used not only as a practical way to choose an appropriate contract but also as tool to rethink consumption. Since Tariff Sheriff has precise information about the electricity consumption of the household at its disposal, it can easily come up with proposals. These proposals could be extremely diverse: buying new home devices, changing some energy consuming habits slightly or adjusting some existing smart devices.

The basic solution would be to ask the customer what he wishes. In order to make it concrete and easy to understand, the website could feature an interactive consumption curve. Therefore the customer who wants to smoothen a peak drags the curve with the cursor and then Tariff Sheriff comes up with appropriate measures aiming at smoothing the peak. Of course the impact of this change would be explicated according to the priority stated by the customer.

The evolved solution would be to actively propose home devices or better settings of existing home devices. Then the customer would ask for an optimization of his electricity consumption in general. Tariff Sheriff will then not only submit an offer and possibly give some consumption advice. Tariff Sheriff will rather propose a bundle of solutions including the utility offer, adapted home devices and relevant home settings. The benefits according to customer's criteria would be provided in a manner similar to the basic model. This solution would go one step further in term of customization since Tariff Sheriff customizes not only the tariffs but also the home devices and their settings.

Therefore the information provided to the customer would have a higher value. Moreover, affiliate marketing could be extended to home devices resellers, increasing the potential revenue for Tariff Sheriff.

10.5 Conclusion

Developing scenarios is a way to get a glimpse of the future. It is impossible to predict if any of the presented scenarios will be reality in 2025, or if the actual situation lies somewhere in between. Nevertheless, they give a good impression on how the energy sector could look like in the future.

Unless a presently unimaginable solution for making energy more abundant is found, gradual change will occur with regard to the mindset of people and the offerings of energy suppliers. It is uncertain how strong this transformation will be, but chances are that consumers want to take an active role in a market which is considerably more complex than today. Due to the shift of premises through climate goals and the introduction of E-Energy, the opportunity to enter the market with new and innovative business models emerges and increases the number of offerings.

Tariff Jungle is one possible idea on how to navigate through this maze of options, which might overwhelm customers. It is one of many options to provide a service of bundling and integration in an environment of a changing infrastructure and customer roles. However, many other business models could be conceived and realized with the same or increasing levels of available E-Energy infrastructure. For instance, the machine learning models of Tariff Jungle might also be used in a more complex setup for energy trading by buying cheap energy and selling it to consumers in a custom-tailored manner.

Besides these services, it is possible to think of a seemingly endless multitude of other business ideas. Specialized models offering incentives when limiting energy usage, insurances against fluctuating prices or roaming models for E-Mobility are just a few options.

Obviously, numerous possibilities of running integrated services in the framework of E-Energy exist. It remains to be seen when and how they are adapted in the future. Under any circumstance, they offer the unique opportunity to run a business which benefits both the consumer and the environment.

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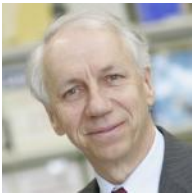

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