# Contract No. IST 2005-034891

# Hydra

**Networked Embedded System middleware for
Heterogeneous physical devices in a distributed architecture**

# D10.6 Business Models in Building Automation

**Integrated Project**
**SO 2.5.3 Embedded systems**

**Project start date: 1st July 2006** **Duration: 52 months**

**Published by the Hydra Consortium**
**Coordinating Partner: Fraunhofer, FIT.**

**22 December 2009 - version 2.0**

**Project co-funded by the European Commission**
**within the Sixth Framework Programme (2002 -2006)**

**Dissemination Level: Public**

**Document file:** D10.6 – Business Models in Building Automation

**Work package:** WP10 – Validation and Business Modelling

**Task**: [T10.2 – Business Modelling]

**Document owner:** Siemens AG SIS

**Document history:**

| Version | Author(s) | Date | Changes made |
|---|---|---|---|
| 0.1 | Florian Roehr, Siemens AG SIS | 23-06-2009 | Set up of initial structure and first content added. |
| 0.2 | Walter Schneider, University of Paderborn | 08-12-2009 | More Chapters added and some rework. |
| 0.3 | Florian Roehr, SAG SIS | 14-12-2009 | Description of business ideas and cases |
| 1.0 | Walter Schneider, UPB | 15-12-2009 | Last rework before internal review |
| 1.1 | Walter Schneider, UPB<br>Florian Röhr, Siemens AG SIS | 17-12-2009 | Incorporation of first review comments and corrections |
| 1.2 | Gernot Gräfe,<br>Siemens AG, SIS | 18.12.2009 | Some comments and minor corrections |
| 1.3 | Florian Roehr SAG SIS, Walter Schneider UPB | 22.12.2009 | Final incorporation of review comments and corrections |
| 2.0 | Florian Roehr SAG SIS, Walter Schneider UPB | 22.12.2009 | Document ready for submission. |

**Internal review history:**

| Reviewed by | Date | Comments |
|---|---|---|
| Trine Fuglkjær Sørensen, In-JeT | 17-12-2009 | Minor remarks with respect to language and content |
| Andrea Guarise, Mauro De Bona, Innova | 18-12-2009 | Minor comments, reported throughout the document |
| Adedayo Adetoye, University of Reading | 18-12-2009 | Minor remarks with respect to language and content |

# Table of Contents


**1. Introduction ........ 6**
1.1 Background ........ 6
1.2 Purpose and context of this deliverable ........ 6
1.3 Methodology ........ 7
1.4 Content of this deliverable ........ 7
**2. Executive Summary ........ 9**
2.1 The products........ 9
2.2 Smart Metering/ Smart Grids ........ 9
2.3 Market conditions ........10
2.4 Stakeholders........10
2.5 Business models and cases ........11
**3. Hydra products ........ 14**
3.1 Middleware ........14
3.2 Development tools........16
3.3 Typical home automation applications ........16
3.3.1 The home automation sphere ........17
3.3.2 The smart metering device........17
3.3.3 The service provider sphere ........17
**4. Smart Metering and Smart Grids........ 18**
4.1 Smart Metering ........19
4.2 Market overview........22
4.2.1 Description of the market........22
4.2.2 Smart Metering projects around the world ........23
4.2.3 Stakeholders in the smart metering market ........25
4.3 Outlook: Smart Grids ........27
4.4 EU Legislation and initiatives on Smart Metering ........28
**5. Business models and cases ........ 30**
5.1 Outcome of the exploitation and business modelling workshop ........30
5.2 Business idea: Energy controlling for peak shaving ........31
5.2.1 Description of the business idea ........31
5.2.2 Stakeholders........32
5.2.3 Business models ........34
5.2.4 Business Case for flexible prices........35
5.3 The business idea of Lichtblick and VW ........41
5.3.1 Introduction ........41
5.3.2 Business idea ........41
5.3.3 Business model ........42
5.4 Comparison of the business ideas ........42
**6. References ........ 44**
**7. Appendix ........ 45**
7.1 Workshop........45
7.2 Workshop Agenda........45
7.3 Workshop Participants........46

# Figures

Figure 1: Price growth for Electricity in EU ........................................................ 6
Figure 2: Middleware Layers ........................................................................ 14
Figure 3: Software Architecture Layers ............................................................ 15
Figure 4: Smart Meters as enabling technology for smart energy efficiency solutions ........... 19
Figure 5: Typical Smart Meter ...................................................................... 20
Figure 6: Market Growth EU for Smart Metering ................................................... 22
Figure 7: The basic structure of a liberalized energy market ..................................... 27
Figure 8: National Smart Metering Initiatives in EU .............................................. 29
Figure 9: Overview of the business idea ........................................................... 32
Figure 10: Interrelations between the involved stakeholders .................................... 33
Figure 11: Development of the average energy price in Germany since 1998 to 2009 .......... 36
Figure 12: Distribution of the domestic energy consumption ..................................... 37
Figure 13: Price development for one MWh on the energy stock market in 2008 ................ 38
Figure 14: Example business case for a fix energy price ......................................... 39
Figure 15: Example business case for a flexible energy price .................................. 40

# 1. Introduction

## 1.1 Background

The Hydra project develops a middleware for networked embedded systems that allows developers to create ambient intelligent applications. System developers are thus provided with tools for easily and securely integrate heterogeneous physical devices into interoperable distributed systems. The Hydra middleware is based on a Service Oriented Architecture (SOA), to which the underlying communication layer is transparent. The middleware includes support for distributed as well as centralised architectures, cognition and context awareness, security and trust and is deployable on both new and existing networks of distributed wireless and wired devices that typically are resource constrained in terms of computing power, energy and memory. The middleware is being validated in three application domains: building automation, healthcare and agriculture.

In this deliverable we will highlight the impact of Hydra technology on the building automation domain. We will in detail introduce the idea of installing the Hydra middleware into a home automation device infrastructure. Through various discussions and workshops with external experts the focus within the building automation domain was adjusted to the topic of intelligent energy management in a home automation setting. The integration of so called smart meters into home automation infrastructures interconnected and enabled by the Hydra middleware is seen as a big opportunity to optimize energy consumption on device level and to gain more energy efficiency in buildings.

The prices for energy on the energy markets are increasing constantly and therefore the realization of energy savings as well as the improvement of energy efficiency is important for energy consumers like common households and also for industry. Besides the rising demand of energy consumers, governmental organization throughout Europe plan to forcefully introduce smart meters to the energy markets. A lot of countries throughout the EU already have a roadmap for releasing laws forcing people and utility companies to install smart meters in the households. Countries like Sweden and Italy have been using smart meters for energy metering for years now, whereas countries like Germany and UK are still far behind.

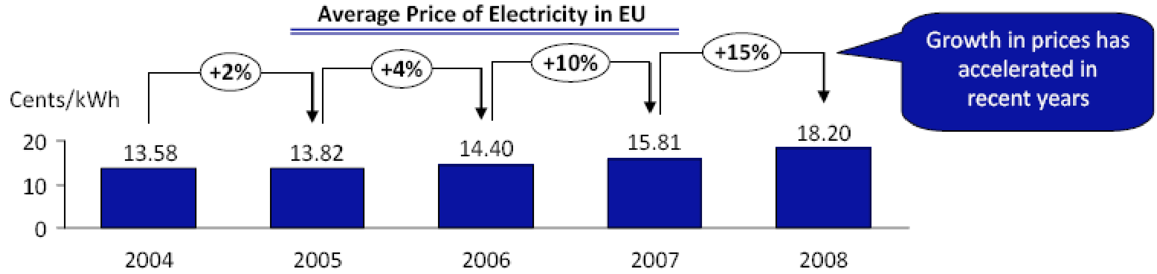



**Figure 1: Price growth for Electricity in EU[1]**

## 1.2 Purpose and context of this deliverable

An integral part of the Hydra project is the analysis and development of realistic business models for developer users and respectively service providers. New research into defining and measuring value creation in dynamic constellations based on the Hydra middleware was needed. This work has led to innovative business structures involving content providers, service providers, device manufacturers, and system integrators in collaborative efforts. The goal of the work is thus to provide the business and market models, which can be used for customers and users of the Hydra middleware, and to

[1] Cp. Capgemini, 2008: Smart Metering: The holy grail of demand side energy management?

instantiate them in realistic, sustainable business cases in the selected domain. The present deliverable provides internal and external documentation of the work undertaken in WP10 of the Hydra project. Moreover, it acts as an internal communication vehicle to the Hydra consortium partners, in order to make our business modelling work transparent among all partners and to arrive at a mutual understanding of the proposed process.

## 1.3 Methodology

In order to secure a wide foundation for the business cases, the Hydra project has conducted one-day high-level workshops in each domain with a group of experts in the field. The workshop was anticipated by several round tables and conference calls among the Hydra business deployment working group for brainstorming the on the most suitable use cases to be investigated in WP10. To discover possible business models in the building automation domain, a specific workshop on European level was organised in Berlin, Germany, on October 16th 2009. Experts from a range of different stakeholders in Germany, Denmark, Italy and the UK were invited to participate in the workshop. The participants represented diverse viewpoints such as energy producers, IT solution providers, IT consulting companies and experts in the field of renewable energy sources. The agenda has been attached in the Appendix

The workshop was initiated with a lecture on Networking systems and devices – visions and possibilities in the Internet of Things and Services. The lecture described how the Hydra middleware could facilitate advanced, networked services for monitoring and proactively controlling of devices in smart homes. An introduction to the status quo of smart metering was also presented as lead-in to the discussions that followed. Besides the presentations, the rest of the day was devoted to expert discussions on three topics:

Firstly, the experts introduced themselves and explained their motivation and interest for smart metering and related services. During this first introduction some limitations and opportunities of smart metering were already identified resulting in an initial discussion about how the new technology could best be used.

The discussion then turned to identification of the business framework, actors and stakeholders in the smart metering market environment. The experts identified early adopters of smart metering and discussed the potential of subsequent services bringing added value to the stakeholders. These early adopters will later be used for the development of business models for Hydra enabled applications.

Finally, the experts attempted to estimate the potential value and revenue streams, pricing models and cooperation strategies in the smart metering service market. Obviously, this area is very complex and depends on certain circumstances and preferences. Thus, no ideal answer could be found. However, the Hydra business modelling tool will be able to perform various simulations for future services under different conditions allowing us to estimate potential revenue streams of the stakeholders in focus.

The meeting minutes of the discussion can be found in The Appendix, too. The discussion yielded important input to the business cases presented in this deliverable.

## 1.4 Content of this deliverable

The focus of this deliverable will be on intelligent energy management because this is what the experts and the workshop emphasised as most important. The Hydra middleware has the potential to meet the upcoming demands in this area. In particular the Hydra middleware offers the chance to overcome the hurdles of missing standards for communication and network integration of smart meters. Accordingly we shifted the focus of the building automation domain in this direction.

In a first step the deliverable will provide a rough overview about the Hydra products followed by an overview of the market conditions and a comparison of smart meter initiatives in representative EU countries as well as a summary of the legal framework. Afterwards, a chapter on various energy market models will follow. This includes a consideration of the main stakeholders, their requirements and benefits with respect to smart metering. In addition two energy market models will be introduced - one summarizing the current status of the energy market in Germany without smart meters and another one describing the future developments and changes on the market. The last chapter will provide an initial business case with respect to the application of the Hydra middleware in the smart metering context.

# 2. Executive Summary

## 2.1 The products

The Hydra products are not intended to be deployed directly by consumers or private end customers. Rather, the Hydra project offers a toolbox that supports developers to build smart building automation applications more easily. By using the Hydra development tools in the development of new devices and applications, producers can provide value-added intelligent solutions for their customers, where the complexity is hidden behind user-friendly interfaces. The goal for the producers is to be able to build cost-efficient Ambient Intelligence (AmI) systems with high performance, high reliability, reduced time to market and a faster deployment and even integrate the assets of the installed base. The Hydra project develops the middleware itself (in the form of software libraries) and also accompanying development tools like a Software Development Kit (SDK), a Device Development Kit (DDK) and an IDE (Integrated Development Environment). The middleware itself consists of three layers - the network, service and semantic layer. Each layer holds elements according to their functionality and purpose. The device and application elements are described in detail in D3.9 Updated System Architecture Report. The SDK and DDK are two different views on the middleware. The SDK will allow developers to develop innovative software applications with embedded ambient intelligence - using the middleware, while the DDK will allow device developers to enable their devices to participate in a Hydra network. The IDE will provide solution developers with a high-level interface for developing networked embedded AmI applications. The IDE is integrated with common IDE's such as Eclipse and Visual Studio.

A typical building automation platform consists of several devices and embedded systems that are all interconnected by the Hydra middleware and can thus interact among each other. Developers can now utilize the Hydra network to build up ambient and intelligent home automation applications, e.g. by writing intelligent web services for automation of devices based on the context engine, that is able to process external or internal information coming from the distinctive devices of the Hydra network. All devices interoperate on the basis of web services. The Hydra network is thus completely platform agnostic and scalable.

In our view, the future of Hydra in the building automation context is in the active control of home appliances and devices that can remotely be controlled by the grid operator. In the context of a typical smart home automation network than is connected with the Hydra middleware this means that Hydra helps to integrate a smart meter as a bi-directional gateway connected to a smart electricity grid and to the home automation network. The smart meter can then be used for submitting for instance price signals from the grid in order to impact the energy demand of households and minimize their energy consumption and spending.

## 2.2 Smart Metering/ Smart Grids

Smart Metering consists of Smart Meter devices and a comprehensive information and communications infrastructure. Smart Metering, often also referred to as Advanced Metering Infrastructure (AMI), allows utility companies and consumers to measure and analyze energy consumption remotely. The first step of AMI deployment is the rollout of smart meters, which basically provide a digital two-way communication between utility companies and individual households. This communication feature can be seen as a door opener for future related offerings and services around smart metering.

A typical AMI network needs a two-way communication between the meters in the field and the central database located at a utility company's computing centre. A neighbourhood area network (NAN) provides a permanent communication link by aggregating all household meters in the area to a concentrator for backhaul to the utility company's data centre. There are different NAN communication solutions on the market such as broadband over powerline (BPL), Wi-Fi, WiMAX (802.16) satellite, radio frequency (RF) and GSM/GPRS or 3G networks. But there is no universal standard for metering communication as there are varying requirements depending on the location of the metering device and the connectivity options (e.g. city centre vs. rural location).

AMI includes in basic configuration the following components:

- Meters — Electromechanical, solid-state electronics and microprocessor-based.
- Communication –such as PLC, BPL, Wi-Fi, WiMAX (802.16), satellite, radio frequency (RF) and Global System for Mobile Communications (GPRS/GSM)
- Software — Meter Data Management software for central meter data processing, repository and dissemination.

AMI provides the communication between the smart meter and the operators' back office systems which enables in a basic mode automated reading and accurate data collection on consumption.

But Smart Metering is not simply electronically collecting information from a meter. As the communication is not limited to meter data alone, it can also provide information about consumption, tariffs, alerts and complementary services. Thus, it facilitates advanced energy services provided to the households that will additionally be able to improve energy efficiency. AMI will even allow for dynamic pricing models in the future. Current power pricing models are usually fixed rate systems with no real dynamic components. Dynamic pricing models are seen as a major method to rise user awareness for energy efficiency and saving.

## 2.3 Market conditions

The European Union set itself ambitious targets by the year 2020: to reduce the output of greenhouse gases by 20%, to improve energy efficiency by 20% and to increase the percentage of renewable energy by 20%. Thus, the current European transmission grid is exposed to several challenges, such as the

- integration of decentralized energy sources like off-shore wind power parks or solar cells on roofs of houses spread all over the country,
- the massive trading flows a liberalized energy market entails,
- and an active demand-side management measure.

To achieve these targets the deployment of Smart Metering systems across Europe is seen as essential as they are the foundation for the smart grid of the future.[2] Smart grid technologies are believed to be the largest opportunity to meet the EU targets and could globally reduce 2.03 GtCO2e (gigatonnes of carbon dioxide equivalent per year), worth €79 billion. Thus, Smart Metering industry in Europe is expected to boost with people's increasing interest in more energy efficiency. Policies across the EU are encouraging the use of smart meters with it becoming mandatory in some countries. There is a full compulsory policy for Smart Metering roll out in Italy, Spain and Sweden. Subsequently 80% of European consumers are expected to have smart energy meters installed in their homes by 2020.

## 2.4 Stakeholders

In the context of our business case we have identified following relevant stakeholders:

**Consumers**

Consumers are getting more active in managing energy efficiency and buying renewable-energy resources as a result of high energy prices and concerns about climate change. AMI has the potential to support requirements such as demand response, net metering, dual metering and feed-in tariffs, where homeowners can sell the electricity they generate through own renewable energy

[2] SMART 2020: PATHWAYS TO SCALE, The Climate Group, 2009

sources (e.g. solar panels) and distributed storage (including plug-in hybrid electric vehicles) back to utility companies.

Gartner believes that in the near future, consumers will be able to use personal communication devices such as cell phones to remotely control the power consumption of smart appliances in their homes. This is a paradigm shift from utility-company-centric demand side management systems to consumer energy management systems.

In recent years, it is not unusual that private households produce their own electricity too, running e.g. own solar panels. These so called "Prosumers" are consumers and producers at the same time, as they are feeding excessive energy into the grid network. With rising prices for energy and a growing awareness for energy efficiency and global warming it will become more and more popular for households to generate renewable energy on their own.

**Utility Companies**

Before deregulation of the energy markets throughout the EU the utility companies were dominating the whole value chain, from the production of energy to the delivery to customers. But due to deregulation of the markets most of the utilities split up into retail companies, network operators, electricity producers, and metering providers. These stakeholders are introduced subsequently.

**Retail Companies**

A retail company earns money by contracting the customers and selling units of energy to them. The retail company is managing the whole process of supplying customers with the contracted amount and type of electricity or energy. The company is also even responsible for buying the appropriate kind of energy at the stock market, e.g. wind, solar, nuclear or coal as ordered by their end customers. Thus, the retailer has to book transportation capacity from network operators and buy loads of electricity from the energy stock market or directly from the power producers.

**Transmission and Distribution System Operators**

There are two types of system operators: the transmission system operator (TSO) and the distribution system operator (DSO). The TSO takes the electricity from the generators to the different localities and distribution networks. The DSO provides his local grid network to carry the energy the last mile to the customers. The retail companies pay for the transportation service over the grid network and will be refunded by their end customers, as the transportation fee will be incorporated in the price for a unit of electricity.

**Metering service providers**

Metering service providers will basically offer the metering of consumption, but they will probably offer also innovative added value services based on new smart metering technologies. For example, they could proactively control distinctive household appliances remotely, depending on the current price or other context factors. A precondition for that kind of service is the integration of smart meters into the house automation infrastructure. The metering service provider as the owner of the metering service could then offer these advanced control services on device level to the retailers who will then offer an extension to the consumer contracts providing certain Service Level Agreements (SLA). Thus, they could gain access and control over the household appliances that do not need to be operated all the time, such as implementing a buffer capacity into the grid network. By this means they will be able to prevent or at least reduce critical peak situations and balance the electricity load demand.

## 2.5 Business models and cases

There currently exist two alternative ways to construct a service enabling load balancing/ peak shaving. Flexible prices for instance will become very probable. For instance utility companies in Germany are forced by authorities to offer flexible prices by the beginning of 2011. This means in detail that in peak times, where more energy is expected to be consumed than available, the prices can increase to sort out price sensitive consumers. Whereas in low consumption periods, when more energy is available than can be consumed the price can be decreased in order to attract more people to consume energy. Especially charging e-cars should either be broad forward or postponed to situations where the energy supply exceeds the expected energy demand. This strategy for example is already implemented in some countries, where smart meters are adopted.

On the other hand load balancing could be gained via a direct controlling of home facilities. This means that a direct controlling signal will be sent to households, thus some devices will be reduced in their performance or even switched off in the case of peak situations. The direct controlling is only possible with respect to the customer preferences. In this case consumers and the energy providers are required to agree upon Service Level Agreements (SLAs). Customers are expected to receive a discount for granting access to their devices.

Depending on the description of the business idea and the individual stakeholders various business models seem to be realistic:

- Private households could benefit from flexible prices if they change their consumption pattern and postpone the energy consumption of certain devices in the case of a peak situation to times where the energy is cheaper. In the case of a direct access to their devices they could receive a discount for granting the metering service provider access to them.
- Smart metering service provider could benefit by offering new service. Thus he could offer smart meters where the Hydra middleware is implemented. This implementation could be charged once. Furthermore they could offer energy consultancy services based on the real-time information they are receiving for each device within a household.
- Energy retail company have energy supply contracts with the private households. They have to pay the metering service provider for executing the billing. When they are offering flexible pricing contracts to the private households, they can forward the rising costs for buying in energy units at the energy stock market. Thus they can improve they profit. Due to the fact they benefit most from offering flexible prices they have to pay the service charge to the metering service provider for offering flexible prices to the private households.
- Grid operator also benefits from the peak shaving, because each saved peak improves the lifetime of the power grid. Instead of offering flexible prices, the grid operator could also achieve peak shaving by sending a request for saving energy to the metering service provider. The grid operator has to pay a certain percentage for each saved energy unit to the metering service provider for offering this service. Furthermore the grid company also has to pay compensation to the private households for granting access to their home devices.

On the basis of assumptions an example business case for offering flexible has been calculated for the private households, retail companies and metering service providers. By offering flexible prices, retail companies are able to forward rising as well as falling costs for energy and to increase their amount of coverage, thus they do not have to take the risk of rising prices alone. The business case for the private households is also positive because they have to pay less per year than before by shifting their consumption to low situations. The metering service provider can increase its revenue and amount of coverage by offering a service for enabling the flexible prices. But anyway this depends on the flexible pricing scheme. When playing around with the price or other input data, you can see that the business case for the private households can turn from being negative to positive.

In contrast to this idea, Lichtblick and VW have introduced a new idea, where they would like to make energy production more flexible. Instead of reducing the energy consumption in times where not so much energy is available because of wind calm, Lichtblick wants to compensate this gap by feeding power into the grid from flexible small home power plants that are combined to one big virtual power plant.

This idea is completely different to our idea, because we would like to shift energy consumption and Lichtblick and VW would like to produce more energy when it is needed. Their business model behind is kept very simple. For a fixed amount of 5000 €, older heating systems will be removed as well as recycled and the home power plant of Lichtblick will be installed. The installation and further service and maintenance are offered against a monthly fee of 20 €. Furthermore customers have to pay a usage-based fee for heating based on the price of 5.79 €/ Cent for one kilowatt-hour. As compensation the customer gets a monthly basement rent of 5 € as well as 0.5 €/ Cent for each energy unit feed back into the grid. Nevertheless the home power plants remain the property of Lichtblick.

# 3. Hydra products

Hydra products are not intended to be deployed directly by consumers or private end customers. Rather, the Hydra project offers a toolbox that supports developers to build smart building automation applications more easily. By using the Hydra development tools in the development of new devices and applications, producers can provide value-added intelligent solutions for their customers, where the complexity is hidden behind user-friendly interfaces. The goal for the producers is to be able to build cost-efficient Ambient Intelligence (AmI) systems with high performance, high reliability, reduced time to market and a faster deployment and even integrate the assets of the installed base.

The Hydra project develops the middleware itself (in the form of software libraries) and also accompanying development tools in the form of a Software Development Kit (SDK), a Device Development Kit (DDK), and an Integrated Development Environment (IDE).

The middleware is based on a service-oriented architecture, to which the underlying communication layer is transparent, and which includes support for security and trust, distributed as well as centralised architectures, reflective properties and a model-driven development of applications.

This chapter will briefly introduce the Hydra products to the reader in order to backup the various business models that can be derived from Hydra's unique benefits. The business models will be developed in the following chapters, including an explanation of the business rationale related to the creation of value through new services, value transactions and market relations among the stakeholders.

## 3.1 Middleware

The Hydra middleware is providing interoperability of networked embedded systems, supporting distributed as well as centralised intelligent architectures.

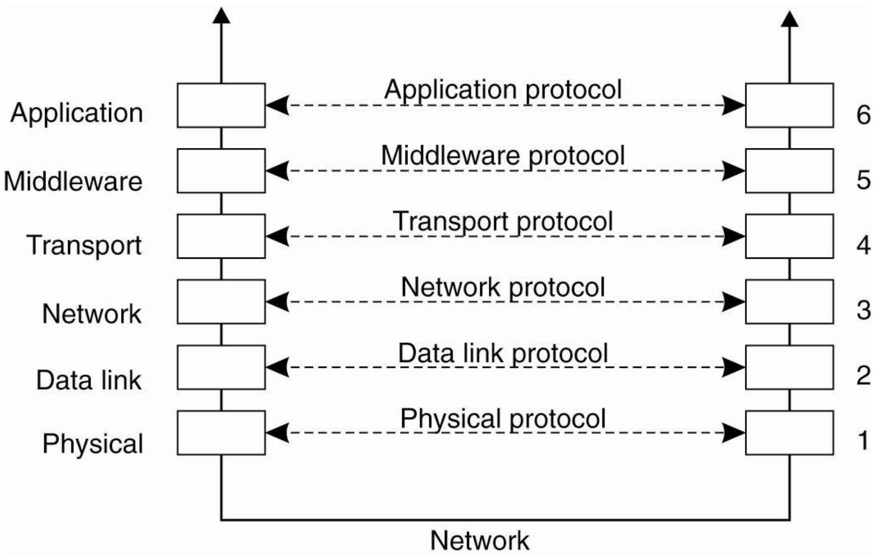



**Figure 2: Middleware Layers**

The concept of middleware in distributed systems is often taken to mean "the software layer that lies between the operating system and the applications on each site of the system"[3]. Another characteristic in terms of the ISO OSI stack[4] is that middleware provides protocols that run on top of the transport layer and that provides services to the application layer[5] as shown in Figure 2, Middleware Layers. Thus, application services such as graphical user interface support or domain-specific application functionality and transport-level services such as sockets are most often thought not to be part of middleware.

The desired functionality is implemented through various layers and components in the Hydra middleware as visualised in the following architecture:

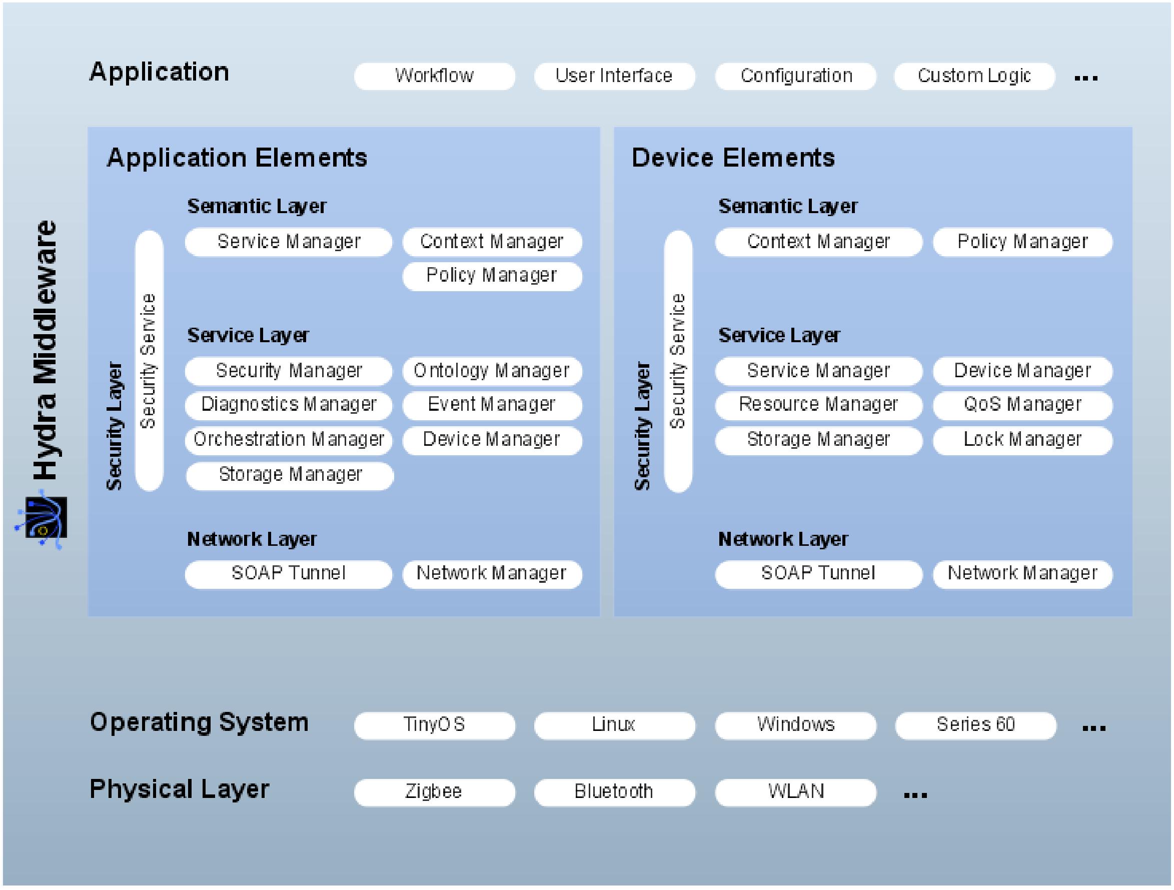



**Figure 3: Software Architecture Layers**

The Hydra middleware elements are enclosed by the physical, operating system and the application layer shown at the bottom and at the top of the diagram respectively. These three layers are not part of the Hydra middleware.

The physical layer realizes several network connections like ZigBee, Bluetooth or WLAN. The operating system layer provides functionality to access the physical layer and manages many other hardware and software resources and provides methods to access these resources. The application layer contains user applications.

The middleware itself consists of three layers - the network, service and semantic layer. Each layer holds elements according to their functionality and purpose. Note that some device elements have similar counterparts among the application elements, and are thus similarly named. Both device and

[3] Cp. Krakowiak, 2003
[4] Cp. Day and Zimmerman, 1983
[5] Cp. Tanenbaum and Van Steen, 2007

application elements have a Security Manager. To express that the security manager is an orthogonal service, it is depicted in a vertical format and covers all three middleware layers. The device and application elements are described in detail in D3.9 Updated System Architecture Report.

By incorporating semantic web services at the device level, the Hydra middleware opens up for interoperability of networked embedded systems and provides provision for creating AmI services and systems through a model-driven, semantic approach. Every device, sensor, and actuator enabled with the Hydra middleware will be able to be considered as a unique service, and support for dynamic reconfiguration of devices will allow for self-configuration of applications. The middleware thus has provision for monitoring systems, discovering failures, reasoning about failures, and reacting to failures within the Hydra middleware environment.

The Hydra Middleware is strongly focused on wireless objects and aims to hide the complexity of the underlying infrastructure while providing open interfaces to third parties for application development and ease of use for end-users. The communication layer is thus not part of the middleware.

In order to solve the rapidly growing challenges of privacy, identity theft and trust, the Hydra middleware addresses security goals such as confidentiality, authenticity, and non-repudiation by a particularly trustworthy design and implementation of personalised agents.

## 3.2 Development tools

To facilitate application development based on the Hydra middleware a series of development tools are available: A Software Development Kit (SDK), a Device Development Kit (DDK) and an Integrated Development Environment (IDE).

The SDK and DDK are two different views on the middleware. The SDK will allow developers to develop innovative software applications with embedded ambient intelligence - using the middleware, while the DDK will allow device developers to enable their devices to participate in a Hydra network.

The SDK consists of the managers and associated tools (compilers, archivers, debuggers, documentation, etc.), which are used to develop an application, together with the associated programming interface. In contrast, the DDK consists of the managers needed to Hydra-enable a specific device. Both the SDK and the DDK offer Hydra functionality but at a low programming level.

The IDE will provide solution developers with a high-level interface for developing networked embedded AmI applications. The IDE is integrated with common IDE's such as Eclipse and Visual Studio.

## 3.3 Typical home automation applications

Hydra specific implementations will be determined by actual customer requirements at the time of deployment. However, due to its generic nature, an attempt has been made to identify typical building and home automation applications using the Hydra middleware.

A typical smart home automation application is based on several devices and embedded systems that are all interconnected by the Hydra middleware and can thus interact among each other. Developers can now utilize the Hydra network to build up ambient and intelligent home automation applications, e.g. by writing intelligent web services for automation of devices based on the context engine, that is able to process external or internal information coming from the distinctive devices of the Hydra network. All devices interoperate on the basis of web services. The Hydra network is thus completely platform agnostic and scalable. A Hydra SDK toolkit allows for rapid development of the home automation applications.

### 3.3.1 The home automation sphere

The household's devices are interconnected in a Hydra Home Automation Network (HAN). The HAN interconnects with other sensors, embedded systems, and devices in the environment that can eventually record contextual information, e.g. sensor data from certain devices of the HAN. Data can be stored and pre-formatted on active nodes/ gateways, which operate personalised software bundles in an OSGi (Open Service Gateway initiative) framework. The gateway can also buffer simple services, which is needed during periods of non-connectivity.

The gateway also manages incoming connections from the WAN or Internet adapting them to the available user terminals, as well as autonomously regulating the connected devices in the HAN. For devices not capable to operate web services (due to resource constraints or proprietary concerns), the gateway also operates as a platform for virtualisation of such devices. Data to or from external sources are transmitted securely to and from the platform through fixed or mobile public or proprietary networks.

### 3.3.2 The smart metering device

The smart meter is the central device for metering the household's energy or power consumption. It consists in its basic function of a power meter and a network connector. The network connector is commonly a Powerline Communication Module sending and receiving data directly over the power grid network to/from the metering service provider or utility company. Alternatively the connector could either be a fixed network card or a wireless module like WLAN, Bluetooth or ZigBee sending and receiving data to/from an Internet gateway. Even built in GSM/GPRS and 3G cellular modules can be used for outdoor communication to a WAN.

### 3.3.3 The service provider sphere

The metering service provider installs the smart meter in a private household in order to meter the household's consumption of power or energy and to remotely poll the collected data regularly for invoicing. Alternatively the consumption data can be monitored in shorter frequency, even nearly in real time, if wished. Thus, the smart meter is the central device to deliver automatically the consumption data of the household into the energy retailer's accounting and invoicing systems and databases. This is the basic service the smart metering service provider offers to the energy retail companies.

# 4. Smart Metering and Smart Grids

The European Union has set itself ambitious targets by the year 2020: to reduce the output of greenhouse gases by 20%, to improve energy efficiency by 20% and to increase the percentage of renewable energy by 20%. Thus, the current European transmission grid will have to meet several challenges, such as

- the integration of decentralized energy sources like off-shore wind power parks or solar cells on roofs of houses spread all over the area,
- the massive trading flows a liberalized energy market entails,
- and an active demand-side management measure.

If the grid network is to be transformed to meet all these requirements then the metering infrastructure must be transformed likewise. The application of smart meters EU wide can provide the data transparency needed to make the grid network of the future function which may, at the same time, effectively change consumers' behaviour.

To achieve these targets the deployment of Smart Metering systems across Europe is seen as essential as they are the foundation for the smart grid of the future.[6] Smart grid technologies are believed to be the largest opportunity to meet the EU targets and could globally reduce 2.03 GtCO2e (gigatonnes of carbon dioxide equivalent per year), worth €79 billion. "In total, ICTs could deliver approximately 7.8 GtCO2e of emissions savings in 2020. This represents 15% of emissions in 2020 based on a BAU estimation. In economic terms, the ICT-enabled energy efficiency translates into approximately €600 billion ($946.5 billion) of cost savings: €553 billion ($872.3 billion) in energy and fuel saved and an additional €91 billion ($143.5 billion) in carbon saved assuming a cost of carbon of €20/tonne."[7] (BAU: Business as usual.).

| | € bn | $GtCO_2e$ | % 2020 BAU |
|---|---|---|---|
| Smart Grid | 79 | 2.03 | 3.9 |
| Smart Logistics | 280 | 1.52 | 2.9 |
| Smart Buildings | 216 | 1.68 | 3.2 |
| Smart Motors | 68 | 0.97 | 1.8 |

**Table 1: Estimated savings in representative fields of ICT applications compared to 2020 Business as Usual[8]**

One course of action in order to meet these objectives will be a wider use of smart metering technology; this will enable utility companies to collect data about consumers' energy consumption behaviour. Smart meters can thus be used to gain more transparency for utilities and consumers

[6] Cp. SMART 2020: PATHWAYS TO SCALE, The Climate Group, 2009
[7] Cp .The Climate Group Smart 2020 Report, The Climate Group, 2008
[8] Cp. The Climate Group Smart 2020 Report, The Climate Group, 2008

and can help to identify reasonable cornerstones for energy efficiency measures. Additionally smart metering can provide information about demand changes, nearly in real time, so that utilities can better forecast their peak loads. Additionally they can provide further added value services including e.g. demand management, and outage detection and prevention. Smart meters are seen as the gateway to intelligent devices in the home automation network and can be the enabler for new pricing models on the market. In summary, the availability of a smart meter with a built in two-way communication at the consumer's site can act as a door opener to a wide range of new and innovative services. It represents a prerequisite for the next generation smart grids of the future incorporating and integrating even single intelligent devices in the household's home automation network. This can be the foundation for next generation smart services bringing added value to the market stakeholders in the context of intelligent home automation and energy efficiency controlling on device level. In this sense smart meter bridge smart grids and smart buildings to allow integrated energy efficient systems (see figure 4).

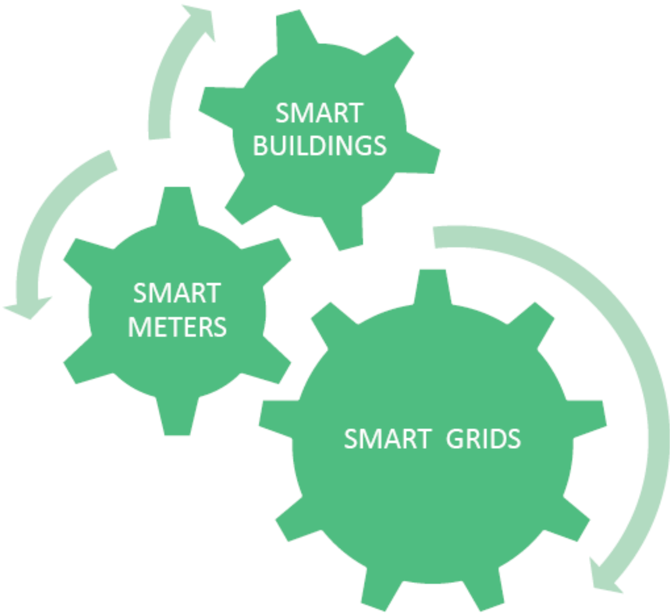



**Figure 4: Smart Meters as enabling technology for smart energy efficiency solutions**

## 4.1 Smart Metering

Smart Metering, often also referred to as Advanced Metering Infrastructure (AMI), allows utility companies and consumers to measure and analyze energy consumption remotely. The first step of AMI deployment is the rollout of smart meters, which basically provide a digital two-way communication between utility companies and individual households. This communication feature can be seen as a door opener for future related offerings and services around smart metering. Several utility companies such as Enel in Italy have already pioneered efforts to replace traditional electric and natural gas meters with new, digital smart meters such as the one shown in Figure 5.


**Figure 5: Typical Smart Meter[9]**

A typical AMI network needs a two-way communication between the meters in the field and the central database located at a utility company's computing centre. A neighbourhood area network (NAN) provides a permanent communication link by aggregating all household meters in the area to a concentrator for backhaul to the utility company's data centre. There are different NAN communication solutions on the market such as powerline communication (PLC), broadband over powerline (BPL), Wi-Fi, WiMAX (802.16) satellite, radio frequency (RF) meshed wireless networks and GSM/GPRS or 3G networks. But there is no universal standard for metering communication as there are varying requirements depending on the location of the metering device and the connectivity options (e.g. city centre vs. rural location).

Even in the home networking space there is a wide variety of communication protocols and media and no single standard for device communication.

AMI includes in basic configuration the following components:

- Meters — Electromechanical, solid-state electronics and microprocessor-based.
- Communication –such as BPL, Wi-Fi, WiMAX (802.16), satellite, radio frequency (RF) and Global System for Mobile Communications (GSM)
- Meter Data Management software for central meter data processing, repository and dissemination.

  AMI provides the communication between the smart meter and relevant parties and their back office systems which enables automated reading and accurate data collection on consumption.
- Consumers receive more accurate information on their energy consumption and billing, thus allowing them to modify their behaviour and reduce the amount of energy they consume.

[9] Cp. Echelon's NES Chosen for First Advanced Metering Project in Switzerland, Echelon 2009

Advanced metering has even been described as "a technology that offers revolutionary change in the relationship between supplier and customer".[10]

- Suppliers do not only save on the costs of meter reading, but can now offer a range of tariffs. Consumers can choose the most economical tariff according to their consumption patterns. These can include time of use tariffs and critical peak pricing. Currently, the Distribution System Operators (DSOs) have only rudimentary information at best on electricity flows in their grid. The data provided by Advanced Metering Systems can improve the utilization of grid and generation assets. The deployment of Smart Metering would allow the DSO to accurately pinpoint outages, reduce nontechnical losses and thus optimise the functioning of the distribution grid.
- Advanced Metering also provides benefits to electricity generation. Increased demand-side management and changes in consumers' energy use patterns could slow the trend to energy demand growth and thereby reduce the need for additional generation capacity (balancing energy). Advanced Metering could "round off the peaks" thereby reducing generation costs and making more efficient use of existing generation capacity. Furthermore AMI can help to detect failures and power cuts or even electricity loss and theft in any location.
- Further benefits of Smart Metering would be the ability to facilitate the adoption and feed-in of micro-generation, as well as the societal benefits of increased energy efficiency and reduced greenhouse gas emissions.

But Smart Metering is not simply electronically collecting information from a meter. As the communication is not limited to meter data alone, it can also provide information about consumption, tariffs, alerts and complementary services. Thus, it facilitates advanced energy services provided to the households that will additionally be able to automatically improve energy efficiency.

AMI will even allow for dynamic pricing models in the future. Current power pricing models are usually fixed rate systems with no real ICT involvement or dynamic components. Dynamic price models will rise user awareness for energy saving.

Gartner positions AMI at the peak of its "Hype Cycle for Intelligent Grid Technologies, 2008." Its position on the Hype Cycle indicates a discrepancy between high user expectations and the immaturity of provider offerings.[11]

Thus, there are also some hurdles for AMI left to overcome in the near future. For instance there is a huge investment required to exchange all of the old hardware in the field with new smart metering devices. The question will be who carries the burden of this investment? Another challenge is the lack of technical standardization of AMI devices and communication protocols as well as a variety of national directives and legislation which even prevents large scale investments e.g. roll out of smart meters across national borders. On the consumer site there has to be a certain level of consumption that justifies the investment in a technology that saves energy. From a household's investment perspective, the smart metering devices have to pay off fast, i.e. there has to be a recognizable savings effect on their energy bill. Besides there are concerns about security and privacy. These are twofold. On the one hand consumers fear to provide too much private data about their way of living to the metering operators. On the other hand there is a threat for the whole grid, as hackers can possibly cause a major blackout after breaking into a smart-grid system. They could possibly gain control of thousands of meters and can shut them off simultaneously or they could dramatically increase or decrease the demand for power, disrupting the load balance on the local power grid causing a blackout.

[10] Cp. McCracken, R.: Smart Meters: Gizmo or Revolution?, Energy Economist, Issue 317, 2008

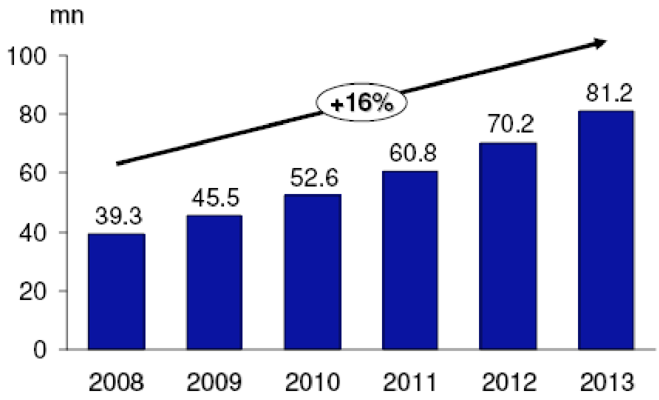
[11] Leong, A., Sumic, Z.: Dataquest Insight: Smart Meters for Intelligent Grids to Drive Semiconductor Growth, Gartner 2008

## 4.2 Market overview

Smart Metering industry in Europe is expected to boost with people's increasing interest in more efficient energy consumption. Policies across the EU are encouraging the use of smart meters with it becoming mandatory in some countries.

There is a full compulsory policy for Smart Metering roll out in Italy, Spain and Sweden. However, installed base of smart electricity meters in Europe is expected to reach 81.2 million units by 2013 (see Figure 6). Subsequently 80% of European consumers are expected to have smart energy meters installed in their homes by 2020.

Market Size:




*Mn= million units*

**Figure 6: Market Growth EU for Smart Metering[12]**

### 4.2.1 Description of the market

The energy market in Germany, for instance, is exposed to social and political forces since its deregulation in 1998. Due to people's growing ecological awareness and rising commodity and energy prices customers change their behaviour. The demand for renewable energy is rising and at the same time consumers are becoming more price sensitive. Thus, consumers are more often willing to change their energy provider and the market is in rapid change. Accompanying this development, utility companies and governmental organisations have strengthened their activities to fund more and more alternative types for energy-generation like solar energy, wind energy, water energy as well as biomass. The rising demand for alternative and renewable energy types force utility companies now to change their way of thinking about their way of producing and distributing electricity, because these new emerging types are mainly produced offshore and decentralized. This is a fundamental change to the energy production and distribution paradigm of the past, as electricity from fossil and nuclear sources, for instance, was always produced at a central location and was then distributed for instant consumption to households and industry in the field.

Utility companies must be able to deliver and provide a sufficient amount of energy in every possible moment, in order to cover the local energy demand. Otherwise it would come to a collapse of the power grid in the case of a strong and not covered demand, a so called critical peak. The task of balancing energy supply and energy demand becomes even more challenging due to the fact that the amount of disposable renewable energy is hardly controllable and predictable. If renewable

[12] Cp. The Smart Metering – Europe report, Netscribes 2009

energy is available it must be used. However, if due to the weather conditions no renewable energy is available the utility companies must cover the energy demand anyway by back up production facilities.

Intelligent embedded systems like smart meters can make adequate contributions in order to be able to handle the in-time provision of energy with respect to the current energy demand. At the same time they can also contribute to an efficient handling of resources.

Smart meters are able to gather the customers' energy demand in real-time. This information as well as the forecast of the available primary energy can be matched in order to gain more energy efficiency. Smart meters are a door opener for companies to deliver new services into the customer households but current main issues are the actual value of the benefits provided by the integration of smart meters into the energy supply chain and into the house automation infrastructure, the cost involved and the distribution of cost and benefits of smart metering between market parties involved.

Currently there are several smart metering projects running. Smart metering promises many benefits and projects in Europe, the USA and other countries show that smart metering is technically feasible.

### 4.2.2 Smart Metering projects around the world

In order to provide a rough overview about the current status of smart metering this section contains some representative smart meter projects in Italy, Sweden, the United Kingdom and USA.[13]
The Italian utility company ENEL introduced smart meters already in 2001.[14] Before deregulation of the energy market ENEL made the decision to introduce smart meters as first utility company worldwide. Important reasons for ENEL were the expected savings or revenues in the areas purchasing and logistics, field operations, customer services and revenue protection. The regulator or government or other market parties had no or only marginal influence on requirements ENEL had to fulfil. By the end of 2005, ENEL had 27 million smart meters installed, of which 24 million meters are being remotely managed and bimonthly read.
In Sweden the first studies into smart metering were carried out in 2001.[15] Some companies had pilot projects then, but the government foresaw opportunities for energy savings and wanted to exploit the potential benefits. By obliging the grid companies to a monthly meter reading for all electricity users by 2009, the government stimulated the introduction of smart metering. This bill was passed in 2003. Since the decision, investments in smart metering have developed in a faster rate than required by law.

In the UK, regulator Ofgem recently explored the potential of smart meters.[16] Drivers are among others the potential contribution to meeting requirements from the Kyoto protocol, requirements by the EU Energy Services directive, rising energy prices and international developments in smart meters. Ofgem is still open to all options; the consultation process will take some more time.

The main driver for introducing smart metering in the USA is to increase the reliability of electricity supply through the reduction of consumer peak demand. California has a summer peak demand for power during approximately 50 to 100 hours per year. This permanent peak is mainly due to the increasing use of air conditioners. The main energy agencies of California saw demand response as an important mechanism to decrease the peak situations. All three major California utility companies[17] developed their own plans to implement AMI systems to all residential customers.

[13] Cp. http://www.leonardo-energy.org/webfm_send/435
[14] Cp. "Evaluating The Leading-Edge Italian Telegestore Project", presentation by Fabio Borghese, ENEL, Business Development Executive, Infrastructure and Networks Division
[15] Cp. Maandelijks uitlezen van elektriciteitsmeters, Eindverslag van regeringsopdracht 2002, Statens Energimyndighet (Sweden)
[16] Cp. Domestic Metering Innovation, Consultation Document, Ofgem (UK), 2006.
[17] Cp. Pacific Gas & Electric, Southern California Edison, and San Diego Gas & Electric.
(Together, these utilities are automating approximately 16 million meters.)

Deployment plans call for installing all advanced meters and communications infrastructure by 2012 or 2013, and represent some of the largest AMI deployments in the world. In response, a number of significant changes are occurring in AMI technology innovation and price reductions, as vendors seek to capture their share of this market.
One of the best examples of a successful smart metering project is the Florida Power and Light (FPL) company. FPL's major drivers in the business case for adopting smart metering are to minimize outage and restoration, combined with demand management. Over the last 20 years FPL has seen more than $1 billion dollars savings in the distribution grid alone. Furthermore the company has avoided the construction of additional power plants. This has saved an additional $3 billion dollars. And there is still potential for a lot of more savings in the future, as the utility has only installed smart demand management with 500,000 of its 4.4 million customers up to now. Additionally by smart metering FPL is now able to control peak load preventing the need for peaking plants that burn fossil fuels. Thus smart metering has reduced the amount of carbon emission. The company can reduce emissions by up to 750 tons of carbon at peak for every hour it uses load control (at 2,000 MW of load control compared to coal based energy production). FPL has managed to integrate load control seamlessly by smart metering; so that most customers do not even know if and when their load is being reduced. The utility has still over a 99% customer retention rate.

| **Country** | **Smart meters** | **Companies involved** | **Actions undertaken** |
|---|---|---|---|
| Italy | 27m+ | Enel SpA, Cap Gemini, Echelon | World's largest smart meter deployment whereby Enel deployed smart meters for its entire customer base from 2000-2005. The system provides a wide range of advanced features, including the ability to remotely turn power on or off to a customer, read usage information from a meter, detect a service outage, detect the unauthorized use of electricity, change the maximum amount of electricity that a customer can demand at any time; and remotely change the meters billing plan from credit to prepay as well as from flat-rate to multi-tariff. Enel has estimated the cost of the project at approximately €2.1 billion and the savings they are receiving in operation of €500 million/yr _ 4-year payback |
| Canada | <1m | NA | Ontario government set a target of deploying smart meters to 800,000 homes and small businesses throughout the province by the end of 2010 |
| Turkey | >1.5m | Elektromed | Prepayment smart gas/water/electric meters implemented including 1m gas meters. Prepayment water meters approached 500.000 units at end 2008, close to a world record. |
| Netherlands | NA | Oxxio | In September 2007, the Dutch government proposed that all 7 million households should have a smart meter by 2013, as part of a national energy reduction plan. |
| Ireland | NA | NA | In 2007, the Minister for Communications, Energy and Natural Resources, pledged to introduce smart meters for every home in the |

| | | | |
|---|---|---|---|
| | | | country within a five year period |
| Nordic countries | 8m | Vattenfall, Fortum, E.ON | As of 2008, almost all of the DSOs in Sweden had signed contracts for AMM solutions. In Finland and Denmark, the share of metering points under contract was 23% and 15% respectively with Norway at 6% (Source: Berg Insight) |
| Australia | 1m | NA | Essential Service Commission of Victoria, Australia (ESC): planned rollout timetable requiring interval meters to be installed by 2013 for all small businesses and residences with new and replacement installation commencing in 2006. The ESC forecasts that within 7 years of the start of the rollout up to 1 million large customers and other customers will have existing meters upgraded to interval meters. |
| USA | 9m | PG&E | Jurisdictions such as California are actively pursuing the same technology. On July 20, 2006, California's energy regulators approved a program to roll out of communications co-processor electronics to 9m gas & electric household customers in the Northern California territory of PG&E. These meters report electricity consumption on an hourly basis. This enables PG&E to set pricing that varies by season and time of the day, rewarding customers who shift energy use to off-peak periods. The peak pricing program will start out on a voluntary basis, and the full rollout is expected to take five years. The smart grid also allows PG&E to give customers timing and pricing options for upload to the grid (see vehicle-to-grid). The largest municipal utility in the U.S., the Los Angeles Department of Water and Power (LADWP), has chosen to expand its advanced metering infrastructure (AMI). |

**Table 2 : Overview of smart meter roll-out and planned roll-out (to date)[18]**

### 4.2.3 Stakeholders in the smart metering market

**Consumers**

Consumers are getting more active in managing energy efficiency and buying renewable-energy resources as a result of high energy prices and concerns about climate change. AMI has the potential to support requirements such as demand response, net metering, dual metering and feed-in tariffs, where homeowners can sell the electricity they generate through own renewable energy

[18] Cp. "Green IT", Global Sector Review, SG Equity Research, 2009

sources (e.g. solar panels) and distributed storage (including plug-in hybrid electric vehicles) back to utility companies.

In recent years, it is not unusual that private households produce their own electricity too, running e.g. their own solar panels. These so called "Prosumers" feed their own produced energy into the grid network. This brings two advantages: the first is that the households reduce their energy bill and the second is that they are even able to earn money by selling the energy they don't need. In the future it will become more and more popular for households to generate renewable energy on their own.

In addition there are new entrepreneurs and small firms on the market who run wind driven generators or renewable energy sources.

**Utility Companies**

Before deregulation of the energy markets throughout the EU the utility companies were dominating the whole value chain, from the production of energy to the delivery to customers. But due to deregulation of the markets most of the utilities split up into retail companies, network operators, electricity producers, and metering providers. These stakeholders are introduced subsequently.

**Retail Companies**

A retail company earns money by contracting the customers and selling units of energy to them. The retail company is managing the whole process of supplying customers with the contracted amount and type of electricity or energy. The company is also even responsible for buying the appropriate kind of energy at the stock market, e.g. wind, solar, nuclear or coal as ordered by their end customers. Thus, the retailer has to book transportation capacity from network operators and buy loads of electricity from the energy stock market or directly from the power producers.

**Transmission and Distribution System Operators**

There are two types of system operators: the transmission system operator (TSO) and the distribution system operator (DSO). The TSO takes the electricity from the generators to the different localities and distribution networks. The DSO provides his local grid network to carry the energy the last mile to the customers. The retail companies pay for the transportation service over the grid network and will be refunded by their end customers, as the transportation fee will be incorporated in the price for a unit of electricity.

**Metering service providers**

Metering service providers will basically offer the metering of consumption, but they will probably offer also innovative added value services based on new smart metering technologies. For example, they could proactively control distinctive household appliances remotely, depending on the current price or other context factors. A precondition for that kind of service is the integration of smart meters into the house automation infrastructure. The metering service provider as the owner of the metering service could then offer these added control services to the retailers who can make an extension to the consumer contracts providing certain Service Level Agreements (SLA). Thus, they could gain access and control over the household appliances that do not need to be operated all the time, such as implementing a buffer capacity into the grid network.

**New technology and services providers**

With the introduction of smart meters, new stakeholders will join the market. At the moment a lot of companies are already doing research on the information and communication technologies (ICT) related to smart grid networks in order to find out, how the production, distribution and consumption of electricity can be optimized. Smart meters are only one item in the future smart grid. New companies will join the market and offer new technologies and services to optimize the management of electricity grids.

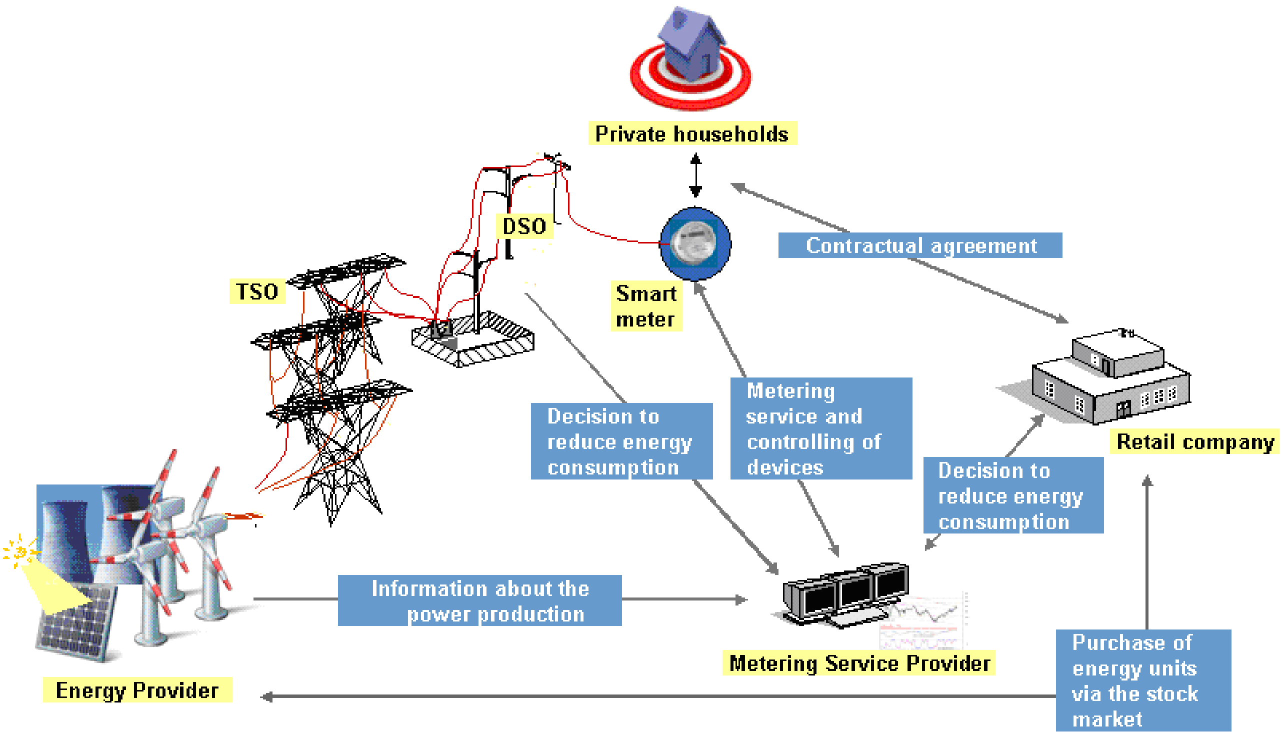



**Figure 7: The basic structure of a liberalized energy market[19]**

As a consequence, the energy market is getting more and more fragmented, as one can see for instance in figure 7. New stakeholders are entering the market and innovative services around smart grid and smart metering technologies will shortly be launched. Governments´ guidelines and a targeted research funding have additionally accelerated the market's transformation process.

### 4.3 Outlook: Smart Grids

An intelligent grid or smart grid is the vision of a future electricity delivery infrastructure that will be realized through advancements in IT, communications and operational technologies. Intelligent grids can improve the responsiveness and resilience of power delivery systems and give consumers a more active role in managing their energy consumption.

Smart grids, which are defined by the Smart Grids Technology Platform as "an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers, and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies."[3]

Smart grids save energy and reduce carbon emissions by developing an interactive network that links multiple energy providers with numerous energy users using advanced technologies such as advanced metering infrastructure and services (smart metering services). Unlike traditional systems in which energy flows from utility to consumer, smart grid systems allow both information and energy to flow in either direction. Data on energy production, energy costs, energy sources, and energy consumption is made available to producers and consumers. These data can then be used as inputs into automated or managed decision-making processes to manage energy demand, choose energy providers, or schedule energy use for off-peak periods.

Supply and demand management (SDM) is the core challenge for future electricity grids. A growing share of distributed energy resources– based on the growing proportion of renewable energy, control energy capacities – have to be expended so that an optimized grid can communicate with demand side loads that offer a number of options to make the grid load predictable via shiftable

[19] Source: own figure

loads, interruptible loads, and loads that can be scheduled. This will require important changes in technical functions of energy grids. Furthermore AMI needs intelligent end user devices.

### 4.4 EU Legislation and initiatives on Smart Metering

There are two existing EU Directives directly related to smart metering:

Firstly, the Metering Directive[20] (adopted in 2004) has streamlined regulations so that electric, gas and water meters approved in one Member State are automatically approved for use in all other Member States. The objective of this Directive is to make it easier for EU meter manufacturers to market their products throughout Europe, thus increasing competition in the metering market.

Secondly, the Energy Services Directive[21] (adopted in 2006) requires Member States to develop plans for achieving targets for saving energy from end users and recognize the importance of electronic metering: In defining energy efficiency improvement measures, account should be taken of efficiency gains obtained through the widespread use of cost-effective technological innovations, for instance electronic metering.

There is a further statement from the "Communication from the Commission to the Council and the European Parliament on a first assessment of National Energy Efficiency Action Plans as required by Directive 2006/32/EC on Energy End-Use Efficiency And Energy Services.":

"Member States can encourage energy savings in all sectors by raising awareness of the need for taking action and the practical possibilities available. The Directive requires Member States to ensure that information on energy efficiency mechanisms and financial and legal frameworks is transparent and widely disseminated to relevant market actors, and to promote energy end-use efficiency. They should ensure that information on best energy savings practices is widely available. Such information measures, coupled with clear price signals, tariffs encouraging energy efficiency and better feedback on actual consumption, through improved billing and smart meters, should put end-users in a position to make better-informed decisions on their energy use and on taking up energy efficiency incentives."

Although the second Internal Market for Electricity Directive (2003/54/EC[22]) laid out measures on customer protection in its annex, which included the right to receive "transparent information on applicable prices and tariffs", it was the Security of Electricity Supply Directive (2005/89/EC[23]) which addressed Smart Metering for the first time. Article 3 says that Member States shall take appropriate measures to safeguard the balance between the demand for electricity and availability of generation capacity, which may include, "encouragement of the adoption of real-time demand management technologies such as advanced metering systems." The Directive on Energy End-use Efficiency and Energy Services (2006/32/EC) addressed the subject more specifically, but at the same time placed so many conditions on the meter and billing requirements as to make the mandate very weak. Article 13 of the Directive stipulates that:

"Member States shall ensure that, in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers are provided with

[20] Cp. Directive 2004/22/EC of the European Parliament and of the Council of 31st March 2004 on measuring instruments.

[21] Cp. Directive 2006/32/EC of the European Parliament and of the Council of 5th April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.OJL114, 27.4.2006

[22] Cp. Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC - Statements made with regard to decommissioning and waste management activities

[23] Cp. Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment Text with EEA relevance.

competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use." Moreover, "Billing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption."

In conclusion Smart Metering has been identified as an important factor for the implementation of European Union policies related to energy efficiency, renewable energy and security of supply.

Since the deregulation of the energy market the German government and the European parliament have released new market rules in form of laws, guidelines and ordinances in order to guarantee the cooperation of the established market players and to raise more ecological awareness. To push the establishment of new meter technologies the German government has released a new guideline in 2005 which describes the deregulation of the metering business. In addition they released an enhancement of the Energiewirtschaftsgesetz (EnWG, Legislation related to the energy economy) which results in the opening of the metering business for competitors. Beyond these laws new buildings as well as renovated buildings have to integrate a smart meter into their house in order to be able to meter the current energy demand in real-time. This law becomes obligatory on 1st January 2010. In addition, existing metering devices must be exchangeable on customer preference. Customers also have the right to ask for a monthly or half-yearly energy bill to gain more transparency of their consumption behaviour. Until 30th December 2010, utility companies must be able to offer tariffs which provide a stimulus to save energy and which enable the controlling of the energy demand.

The following figure shows various national initiatives within the EU:

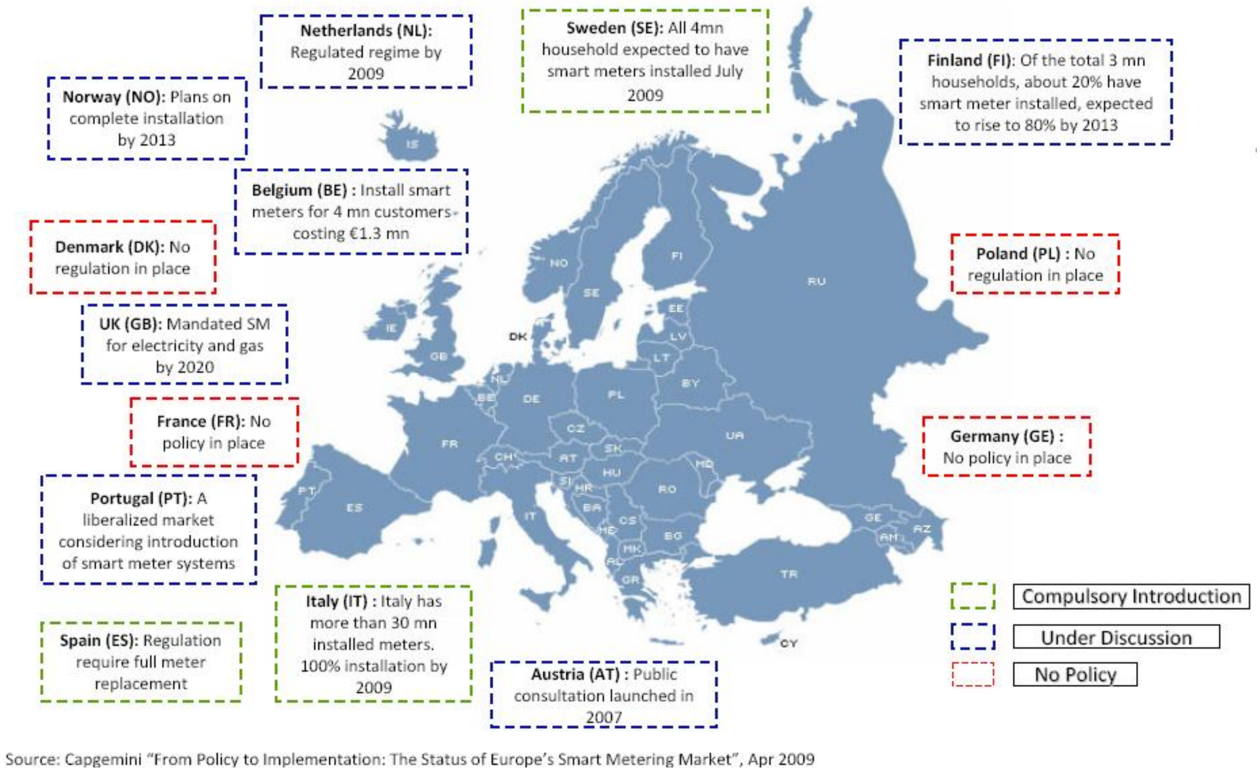



**Figure 8: National Smart Metering Initiatives in EU[24]**

[24] Cp. "From Policy to Implementation: The Status of Europe's Smart Metering Market", Capgemini, 2009

# 5. Business models and cases

## 5.1 Outcome of the exploitation and business modelling workshop

As preparation for the deliverable we have conducted an international workshop with experts along the energy value chain. Energy experts from EON, Vattenfall Europe, Dong Energy as well as Siemens and other research and consultancy organisations dealing with energy-related stakeholders provided us their perspective on the market. Thus we got a lot of information during the workshop about the energy market itself and its main challenges.

The energy market is being broken up into different smaller parts since its de-regulation, which results in rising challenges for the utility companies, because they are forced to sell their grid as well as to outsource the metering business. Furthermore they are facing expensive power peaks as well as negative prices due to the highly volatile amount of renewable energy sources (solar and wind power).[25] Especially the balancing of energy is very expensive compared to the basic load. This prepares the stage for new stakeholders that are currently entering the market as well as new services and solutions. Therefore new business models have to be discussed in this respect.

Metering service providers for instance are entering the market as a new service providers who are offering metering services based on the information gained from the smart meter. Due to their information basis they are gaining from the smart meter, they will probably offer services to private consumers, like the provision of the information of their real time consumption via a web portal, as well as energy retail companies. These retailers can then for instance derive supplementary services of higher value from those basic services and tailor a more targeted offer to their end customers, e.g. targeted or individual tariffs. Due to special contractual agreements between the metering service provider, the private households and the retailer, the retailer could possibly trigger the smart metering service providers to lower the households' energy consumption possibly over price signals that they send out at peak time or in a low demand situation.

The access point for metering service providers to enter the private households will be the smart meter. There are different approaches to access the smart metering services market. Some companies offer only a device integrated in their own secure network and they will only grant a loop back access to the metering information over a web portal. Others offer a device that can be integrated in an open network.

At the moment the most important marketing tool for utility companies seems to be the price, but legal changes and a forced de-regulation as well as people's rising consciousness about the climate change has initiated a change in thinking. Sustainability has now become an objective for the companies, too. A rising amount of customers is asking for tariffs which include renewable energy sources.

As conclusion of the exploitation workshop we see that there will be no future in just selling pure energy. Utility companies cannot maintain their profit margins with producing only "black energy". Price sensitive people will always change their energy provider when they see a chance for a cheaper offer by another provider. Therefore new supplementary services need to be offered delivering extra value to the customers in order to bind them to the energy provider.

Furthermore we have learned from the experts, that load balancing is one of the most promising services within the energy domain:

- A decrease of peak situations of 10 % in its height within the power grid reduces costs around 100 million $ per year only in California.[26]

[25] Cp. http://www.faz.net/s/Rub0E9EEF84AC1E4A389A8DC6C23161FE44/Doc~E1A6A559028CF41F8AD3F57D0E13E3F4E~ATpl~Ecommon~Scontent.html (German Source)

[26] Cp. http://www.economist.com/displaystory.cfm?story_id=14586006

- A decrease of peaks of 5 % in its height would already balance the investments into smart metering.
- Furthermore the peaks cause a significant wear out of the grid infrastructure. The grid infrastructure will run a hundred years without peaks compared to only 20 years with only four peaks a day.

Therefore services and solutions are needed that are able to address the above mentioned problems.

## 5.2 Business idea: Energy controlling for peak shaving

### 5.2.1 Description of the business idea

With respect to the discussion during the exploitation and business modelling workshop as well as the market development, a business idea for controlling the energy consumption has been developed. As we know, peak situations are very costly for the utility companies as well as threaten the lifetime of the power grid. Therefore the following idea was developed based on Hydra technology.

In order to be able to control the energy demand with respect to the energy available, utility companies require an infrastructure in order to be able to access the households. Therefore the centrepiece for realizing this business idea will be the smart meter as access point and the Hydra middleware for networking home facilities.

In a first step all home devices like the geothermal heat pump, the heater, the air conditioning as well as the e-car at home have to be networked via a middleware with the smart meter. Thus the utility companies get the information about the overall energy consumption in real-time as well as anonymous information about the number of geothermal heat pumps, air conditionings and e-cars within the region they are providing energy to. Furthermore the utility companies know the overall load status of the e-car batteries of their customers and thus can use this information for an improved forecast of the upcoming energy demand. Customers can check their energy consumption online via a mobile phone or PDA.

Secondly, the middleware handles all relevant customer preferences, like the price sensitivity, preferences with respect to room temperature, e-car usage and so on. Customers can maintain their preferences online. Via incoming price information or direct controlling signals that are send depending on the energy supply the middleware decides if the e-car will be charged or if the heater can be switched off. The following picture gives an overview about the business idea.

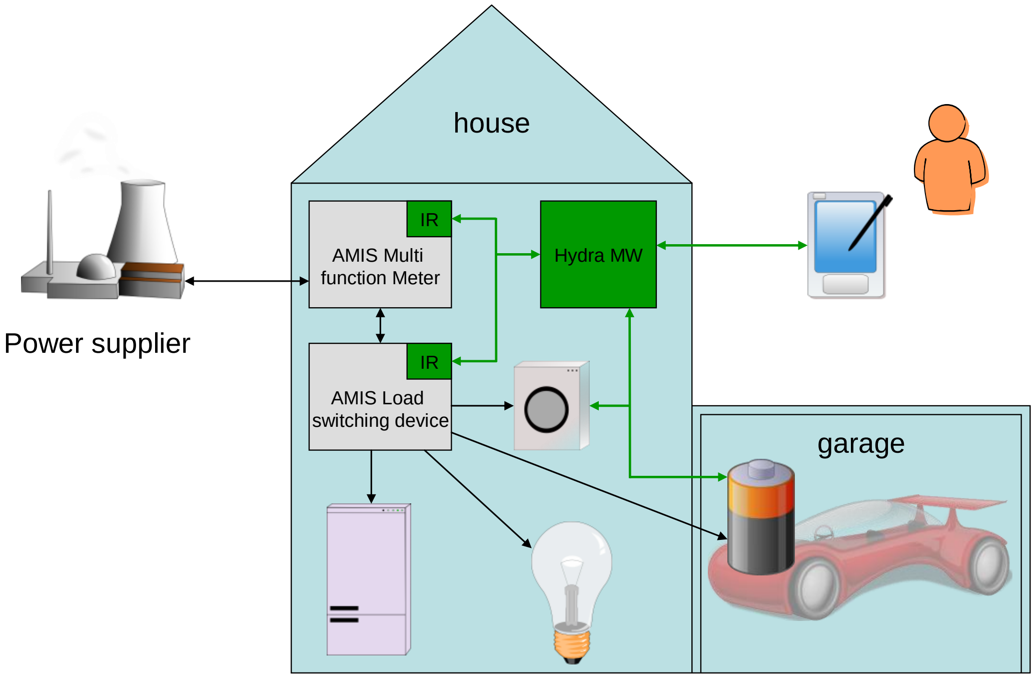



**Figure 9: Overview of the business idea**[27]

As mentioned there exist two alternative ways to construct a service enabling load balancing/ peak shaving. Flexible prices for instance will become very probable. For instance utility companies in Germany are forced by authorities to offer flexible prices by the beginning of 2011. This means in detail that in peak times, where more energy is expected to be consumed than available, the prices can increase to sort out price sensitive consumers. Whereas in low consumption periods, when more energy is available than it will be consumed the price can be decreased in order to attract more people to consume energy. Especially charging e-cars should either be broad forward or postponed to situations where the energy supply exceeds the expected energy demand. This strategy for example is already implemented in some countries, where smart meters are adopted.

On the other hand load balancing could be gained via a direct controlling of home facilities. This means that a direct controlling signal will be sent to households, thus some devices will be reduced in their performance or even switched off in the case of peak situations. The direct controlling is only possible with respect to the customer preferences. In this case consumers and the energy providers are required to agree upon Service Level Agreements (SLAs). Customers are expected to receive a discount for granting access to their devices.

### 5.2.2 Stakeholders

Before the business model for the business idea can be analysed and its business potential can be assessed, it is important to have a complete overview of all involved stakeholders that are interacting with each other. Furthermore each stakeholder has a different motivation in mind which needs to be analysed before a business model can be developed.

[27] Source: own figure

During the discussion with energy experts four major actors and stakeholders have been identified with respect to the provision of a service "energy controlling for peak shaving". The following four stakeholders have to be discussed:

- Private households
- Metering service providers
- Energy retail companies
- Grid operators

The following figure summarizes the main interrelations between them.

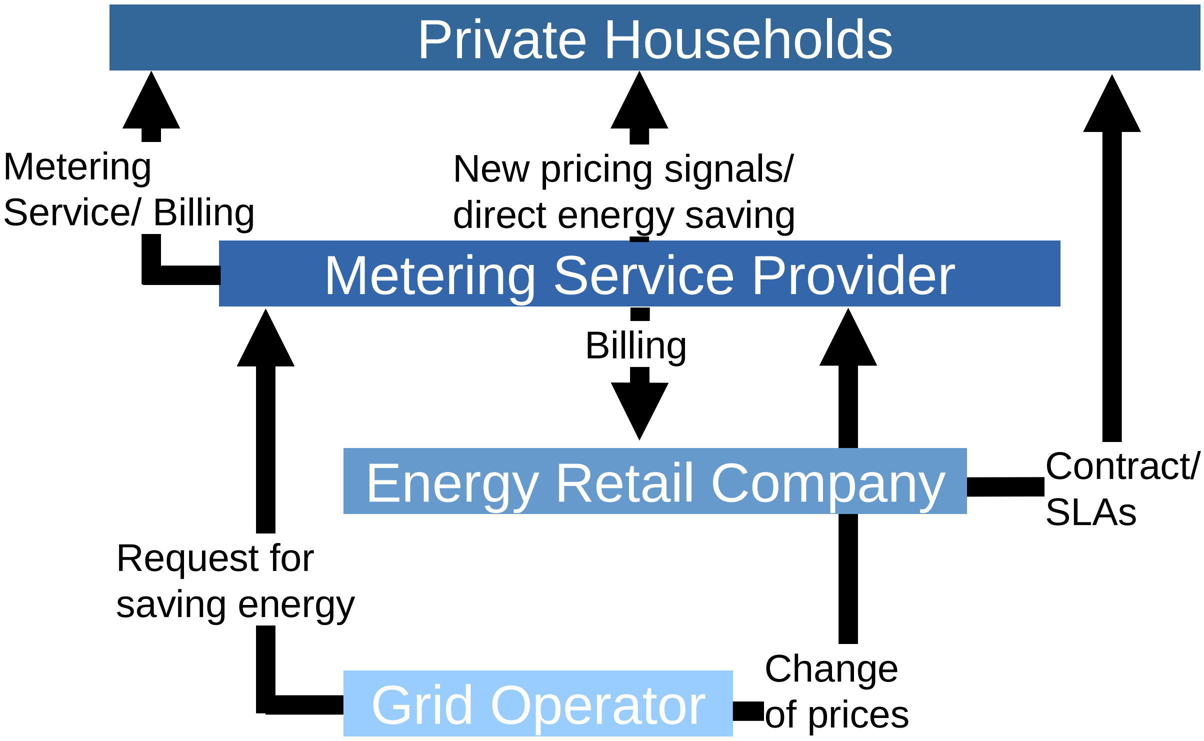



**Figure 10: Interrelations between the involved stakeholders**[28]

- **Private households:** The private households engaged in energy supply contracts are the target customers of this business idea. They are supposed to have an interest in energy efficient solutions, but their main interest is to save money. Thus each solution that costs the households more than it brings in as monetary benefit will not be applicable. In a first step, in order to be able to use this kind of service, they have to implement the middleware to network all relevant home facilities as well as the smart meter. Via networking them, the customers do always know how much energy they are consuming for each device in their households. For example the customers receive the information that even a small sized digital picture frame consumes power worth 15 € if it runs the whole year. Probably information like this already changes the customers' behaviour.

  In a second step, they have to choose between two different energy supply contracts.

  - One contract could be a flexible pricing contract. In case of peak situations private households have to pay more money than in low peak situations.

[28] Source: own figure

- The other contract type consists of the service level agreements. Within this contract private households grant smart metering service providers access to dedicated home devices. Depending on the agreed service level agreements the private households get a discount on the monthly power bill.

- **Smart metering service provider:** The smart metering service provider is the interface between the retail company and the private households. He is interested in selling value-added services to the customer and to the retail companies. Therefore the metering service provider provides metering services to the private households. As compensation for this service he receives a monthly metering fee. He knows how many fridges, washing machines, geothermal heat pumps, air conditionings and heaters are currently running in a certain region. Furthermore he knows the current battery status of the future e-cars that are connected to the home infrastructure. Based on the information he always knows the current demand of energy and the potential for saving energy. Thus the metering service provider is able to execute the controlling of the households' home devices with respect to their individual service level agreements. He is also doing the monthly billing for the retail company against a fee.

  Beyond these tasks the metering service provider receives a request from the grid operator to balance the load in peak situations. This request is matched with the private households' preferences. Thus the metering services provider directly influences the energy consumption of a device by switching it off for example.

- **Energy retail company:** The energy retail company has an energy supply contract with the private households. Two types of contracts are supposed to be offered. One contract could be a flexible pricing contract, the other based on service level agreements. The energy retail company is interested in offering new and innovative business models in order to make it more attractive for the private households to buy energy from them and to bind them on a long term perspective. Furthermore the retail company is cooperating with dedicated metering service companies. The energy retail company has to carry the burden of rising short-term prices at the energy stock market but is not able to forward these prices to the end customer due to fix pricing contracts. These rising costs are decreasing the retail companies' profits. In the case of flexible prices that help to shave peaks they need to buy only less energy at high short-term prices. Furthermore they are able to forward the rising are falling costs to a certain extend to the private households.

- **Grid operator (DSO/TSO):** The grid operator is interested in the balancing of the load because peaks outwear the grid. Each peak reduces the lifetime of its grid. Therefore the grid operator is interested in reducing peaks and leveling the load profile. Therefore he could send out impulses via the metering services provider in order to achieve a balancing of the load.

### 5.2.3 Business models

Depending on the description of the business idea and the individual stakeholders the following business models seem to be realistic:

- Private households: With respect to the implementation of flexible prices the private households could benefit from them if they change their consumption pattern. These means in detail that they postpone the energy consumption of certain devices in the case of a peak situation to times where the energy is cheaper. In the case of a direct access to their devices they could receive a discount for granting the metering service provider access to their devices.

- **Smart metering service provider:** As mentioned, the smart metering service provider is offering metering services against a service fee. The implementation of a Yellow Strom smart meter costs for instance 79 € plus an additional monthly metering fee of 8.13 €[29]. In order to be able to provide controlling services these smart metering service providers could offer smart meters where the Hydra middleware is implemented. This implementation could be charged once. Furthermore they could offer energy consultancy services based on the real-time information they are receiving for each device within a household. With respect to the energy controlling in peak situations, the smart metering service provider could not charge the private households for this service, but rather the grid operators who are benefiting more because of load shedding of the grid. They could pay a certain amount of money for each unit the smart metering service provider has saved at the customer side as a kind of service fee. When realizing the peak shaving via flexible prices, the metering service provider can claim a certain percentage of the price for his service.

- **Energy retail company:** The energy retail companies have energy supply contracts with the private households. They have to pay the metering service provider for executing the billing. When they are offering flexible pricing contracts to the private households, they can forward the rising costs for buying in energy units at the energy stock market. Thus they can improve they profit. They benefit most from offering flexible prices because they are able to forward the rising are falling costs to a certain extend to the private households which increase their amount of coverage in the future. Due to the fact they benefit most from offering flexible prices they have to pay the service charge to the metering service provider for offering flexible prices to the private households.

- **Grid operator:** The grid operator also benefits from the peak shaving as we learned from the experts' discussion, because each saved peak improves the lifetime of the power grid. Instead of offering flexible prices, the grid operator could also achieve peak shaving by sending a request for saving energy to the metering service provider. The grid operator has to pay a certain percentage for each saved energy unit to the metering service provider for offering this service. Furthermore the grid company also has to pay a compensation to the private households for granting access to their home devices. This compensation will be paid through the retail company.

### 5.2.4 Business Case for flexible prices

On the basis of the following assumptions an example business case for the idea for enabling peak shaving has been calculated:

- 20.000 private households with an average yearly power consumption of 4.000 KWh (This means a daily energy consumption of 11 KWh)
- They have to pay an average price for one KWh of 23,21 Cent[30]

[29] Cp. http://www.eex.com/en/Market%20Data/Trading%20Data/Power/Intraday%20%7C%20Spot/Intraday%20Chart%20%7C%20Spot/spot-intra-chart/2008-12-22/a

[30] Cp. http://www.energie-verstehen.de/Energieportal/Navigation/Energiepreise/strom,did=309424.html?view=renderPrint (German Source)

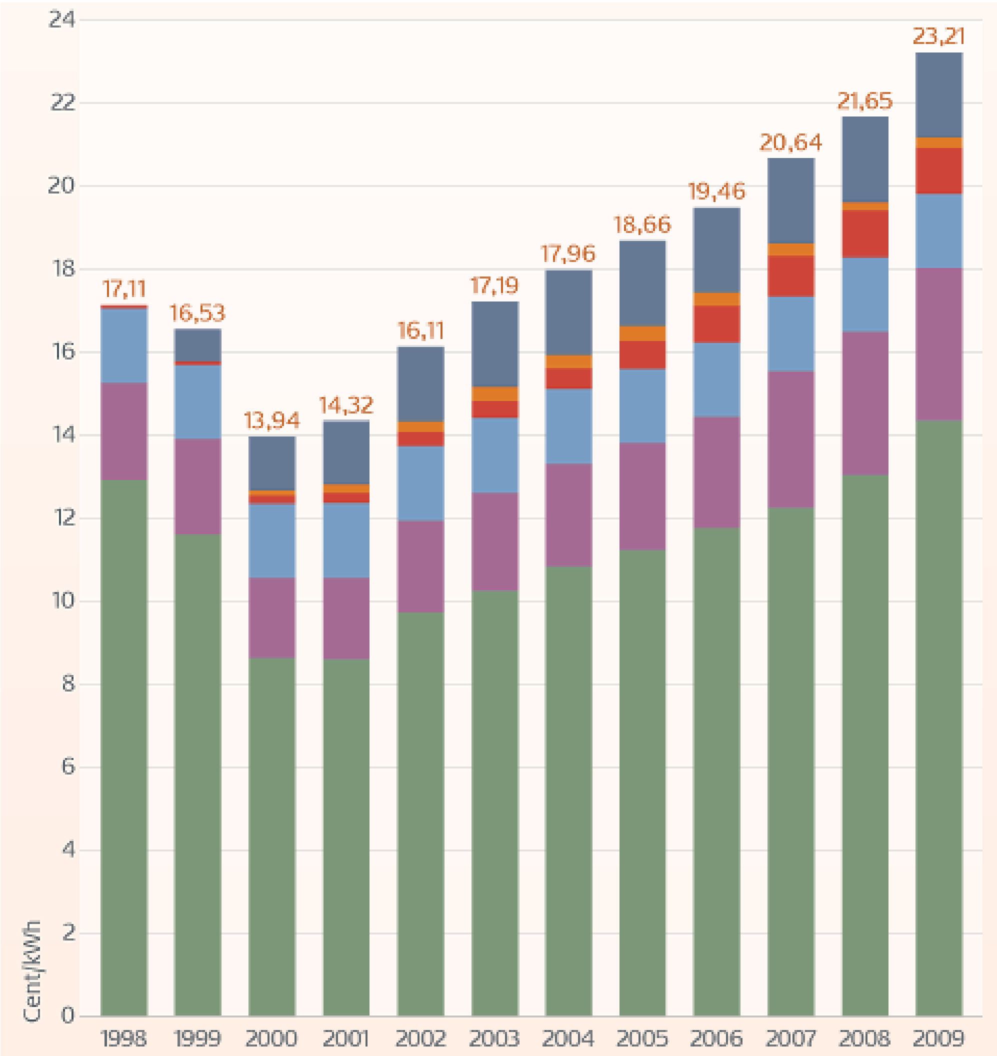



**Figure 11: Development of the average energy price in Germany since 1998 to 2009**[31]

- Around 56% of the private energy consumption within the household seems to be flexible and can be shifted, because not all home devices are appropriate for shifting them from low to peak situations. The following figure gives an overview about the distribution of the private energy consumption.

[31] Cp. http://www.energie-verstehen.de/Energieportal/Navigation/Energiepreise/strom,did=309424.html?view

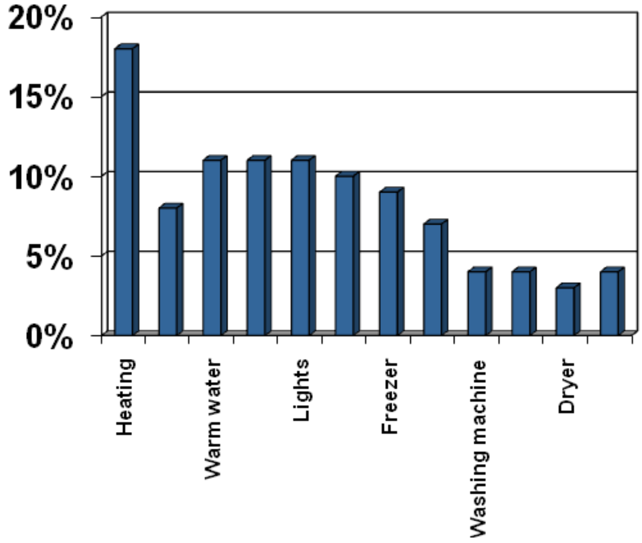



**Figure 12: Distribution of the domestic energy consumption[32]**

With respect to our assumptions the power demand of the heating, heat pump, fridge, freezer, washing machine, dish washer and dryer is flexible. For comfort reasons and due to the people's individual behaviour a flexibility rate of 56% will not be realistic. Therefore we assume a rate of 40% for the following business cases.

- One retail company will be considered that has to pay the costs deriving from peak and low situations
- Depending on the development of the energy stock market in 2008 there have been 18 days with low situations where one MWh cost around 30 €, 18 days with peak situations where one MWh cost around 100 € and 329 days where the average price for one MWh cost 50 €. To simplify the business case we assume that these peak and low pricing situations last one complete day instead of one hour. The following figure gives an overview about the price development for one Mwh in 2008.

[32] Own figure, data from http://www.gruene-muenchen-stadtrat.de/Klimaschutz/hengstenberg.pdf

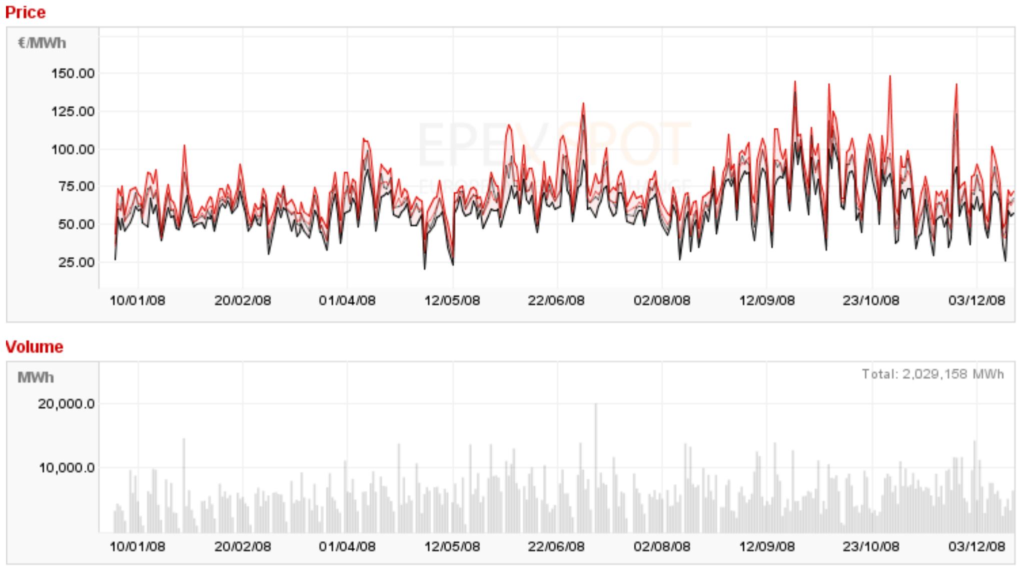



**Figure 13: Price development for one MWh on the energy stock market in 2008**[33]
(The red lines marks the high prices and the black line the low prices.)

- The flexible prices, that the private households have to pay, depend on the relation of the price for one MWh to the average price of one MWh.
- The metering service provider will also be considered. The metering service provider bills the customers (1) by taking a one time fee of 70 € for the meter installation and (2) by taking a yearly metering fee of 60 € (5 € per month).
- When offering flexible prices the metering service provider can increase the installation fee. The price of 0,10 € for offering the flexible prices has to be paid by the retail company for each price adaption per household.
- The metering service provider has also to pay for the Hydra technology.
- The grid operator will be taken out of consideration at this point of the business case consideration, because we will only discuss flexible prices.

To be able to compare the present situation with the future where flexible prices become realistic, it is necessary to make the calculations with a fixed price in a first step and compare the profits of the retail company without flexible prices and after the implementation of Hydra to realize flexible prices.

[33] Cp. Source: European energy exchange market [www.eex.com]: http://www.eex.com/en/Market%20Data/Trading%20Data/Power/Intraday%20%7C%20Spot/Intraday%20Chart%20%7C%20Spot/spot-intra-chart/2008-12-22/a

| Business Case without flexible prices | | | | | | |
|---|---|---|---|---|---|---|
| **Private households** | Data | Units | **Retail companies** | Number of days | Average price for one MWh | Total costs for all households |
| Number of private households | 20000 | | normal pricing niveau | 329 | 50 € | 3.605.479 € |
| Average consumption per year | 4000 | kwh | peak situations | 20 | 100 € | 438.356 € |
| Average consumption per day | 10,95890411 | kwh | low situations | 16 | 30 € | 105.205 € |
| Total consumption for all households | 80000000 | kwh | Total costs | | | 4.149.041 € |
| Price for one energy unit | 0,23 € | | Revenues | | | 18.568.000,00 € |
| Averge cost for one household including the fees for metering services | **988,40 €** | | Amount of coverage | | | **14.418.958,90 €** |
| One time costs for the installation of the meter | **70,00 €** | | **Metering service provider** | Data | In total for all households | |
| Total costs in the first year | **1.058,40 €** | | Meter installation fee | **70,00 €** | 1.400.000,00 € | |
| Total yearly costs after the first year | **988,40 €** | | Yearly metering fee | **60,00 €** | 1.200.000,00 € | |
| | | | Revenues | | 2.600.000,00 € | |
| | | | Costs for buying meters | **65,00 €** | 1.300.000,00 € | |
| | | | Amount of coverage in the first year | | **1.300.000,00 €** | |
| | | | Amount of coverage after the first year | | **1.200.000,00 €** | |

**Figure 14: Example business case for a fix energy price** [34]

[34] Source: own calculation

| Business Case with flexible prices and cost for Hydra | | | | | | |
|---|---|---|---|---|---|---|
| **Private households** | Data | Units | **Retail companies** | Number of days | Average price for one MWh | Total costs for all households |
| Number of private households | 20000 | | normal pricing niveau | 329 | 50 € | 3.605.479 € |
| Average consumption per year | 4000 | kwh | peak situations | 20 | 100 € | 263.014 € |
| Flexible energy consumption | 0,4 | | low situations | 16 | 30 € | 147.288 € |
| Average consumption per day | 10,95890411 | kwh | Yearly costs for flexible prices | | | 72.000 € |
| Average consumption in peak situations | 6,575342466 | kwh | Total costs | | | 4.087.781 € |
| Average consumption in low situations | 15,34246575 | kwh | Revenues | | | 18.536.093,56 € |
| Total consumption for all households | 80000000 | kwh | Amount of coverage | | | **14.448.312,74 €** |
| Average price for one energy unit | **0,23 €** | | **Metering service provider** | Data | In total for all households | |
| Price for one energy unit in peak situations | **0,31 €** | | Meter installation fee including Hydra upgrade | **80,00 €** | 1.600.000,00 € | |
| Price for one energy unit in low situations | **0,20 €** | | Yearly metering fee | **60,00 €** | 1.200.000,00 € | |
| Averge cost for one household | **986,80 €** | | Flexible pricing fee (for retailers | **0,10 €** | | |
| One time costs for the installation of the meter | **80,00 €** | | Revenues from metering | | 1.200.000,00 € | |
| Total costs in the first year | **1.066,80 €** | | Revenues for pricing service | | 72.000,00 € | |
| Total yearly costs after the first year | **986,80 €** | | Costs | **65,00 €** | 260.000,00 € | |
| | | | Investments for Hydra | | 200.000,00 € | |
| | | | Amount of coverage in the first year | | **1.112.000,00 €** | |
| | | | Amount of coverage after the first year | | **1.272.000,00 €** | |

**Figure 15: Example business case for a flexible energy price** [35]

On the basis of the previous mentioned assumptions the business case is positive for the retail company. His amount of coverage would increase by 30.000 €. The business case for the private households is also positive because they have to pay 1.6 € less per year than before. But anyway this depends on the flexible pricing scheme. When playing around with the price or other input data,

[35] Source: own calculation

you can see that the business case for the private households can turn from being negative to positive. The metering service provider can increase its revenue and profit by offering a service for enabling the flexible prices by around 70.000 € per year.

Furthermore the calculations took only a very limited number of peak and low situations into account. It was also a very limited price range assumed. At the stock exchange energy prices turn even negative i.e. in certain situations organisations even get money in addition to the energy they use because there is a huge excess capacity[36]. We also assumed that the peak and low situations will be valid for one complete day, whereas under realistic assumptions prices can change on a hourly or even minutely basis. This would also change the business case.

## 5.3 The business idea of Lichtblick and VW

The purpose of the previous described business idea is to reduce peaks, by shifting energy consumption to times where the consumption level is low and a lot of energy is available. Due to the volatile amount of renewable energy resources there are times when a lot of more energy is available because the wind is blowing strong. Thus more energy is available than demanded. On the other hand less energy could be available, when the wind stops blowing. Via flexible prices or a direct access to the facilities, the energy consumption can be shifted from peak to low situations. In contrast to this idea, Lichtblick and VW have introduced a new idea, where they would like to make energy production more flexible. Instead of reducing the energy consumption in times where not so much energy is available because of wind calm, Lichtblick wants to compensate this gap by feeding power into the grid from flexible small home power plants that are combined to one big virtual power plant.

This idea is completely different to our idea, because we would like to shift energy consumption and Lichtblick and VW would like to produce more energy when it is needed. Therefore the idea of Lichtblick will be introduced at this point, because they have a very interesting business model behind their idea. Later in chapter 5.4 both ideas will be compared in order to highlight there pros and cons as well as to identify the idea with the greatest business potential.

### 5.3.1 Introduction

Recently Europe's largest carmaker Volkswagen is cooperating with the German eco energy supplier Lichtblick. Lichtblick is an independent Electric Power Company and German market leader in green electricity. Specialized in environmentally friendly systems, Lichtblick has been working on a new in-house energy system. Together with VW, they have created a combined heat and power (CHP) generator called "ZuhauseKraftwerk" (HomePowerPlant). These thermal power stations run on the existing natural gas engines that Volkswagen has built for its Caddy and Touran EcoFuel eco-friendly small vans.

### 5.3.2 Business idea

In contrast to the first idea, Lichtblick and VW are not interested in peak shaving. They are more interested to flexibly feed in more energy in case of peaks or to reduce the amount of conventional energy production in order to gain an optimal complement to renewable energy. Due to the volatile amount of renewable energy resources like wind, there exist situations where a lot of energy is available and there exist situations where the wind stops blowing. In order to absorb these fluctuations utility companies are always forced to feed in additional energy from conventional power plants (balancing energy) for each energy unit produced by wind mills, because conventional power plants need hours before they can produce power. A lignite-fired power plant for example needs seven hours before it can produce energy. A nuclear power plant needs even more than one day. This takes too long to balance the short term fluctuations.

[36] Cp. http://www.faz.net/s/Rub0E9EEF84AC1E4A389A8DC6C23161FE44/Doc~E1A6A559028CF41F8AD3F57D0E13E3F4E~ATpl~Ecommon~Scontent.html (German Source)

Therefore Lichtblick and VW have developed an intelligent concept where they aim to implement small home power plants that can be flexibly switched on or off. These decentralised home power plants are running with gas which supply households with warmth and at the same time they can feed in power into the grid. For the production of power Lichtblick is picking up pricing signals and refers to the price for power at the market. If the price is high, supply and demand diverge, more energy is needed which will be fed in by Lichtblick. The power plant will thus only feed electricity into the grid when it is needed, whereas the heat produced at the same time will be stored, allowing reliable supplies of heating energy and warm water to the building at all times. The power plant allows decentralised, flexible power generation and generates 20kW electrical and 34 kW heat with an efficiency of 92%. The idea is to control all small power stations centrally to form a "virtual power plant" which could provide the backup power that is sometimes required when networks rely on renewable energies such as wind parks. The HomePowerPlant units are remotely controlled via a mobile network or DSL; they can ramp up in a minute if needed.

Their purpose is to build up Germanys largest virtual gas power plant by implementing 100.000 of these decentralised home power plants which can be intelligently controlled and managed with respect to efficiency reasons. The performance of these power plants could replace two nuclear power plants at the end.

To achieve these targets they have designed an offering where Volkswagen is producing the high-efficiency "EcoBlue" CHP (combined heat and power) plant and Lichtblick will be marketing the plants as well as using them for a new, intelligent heat and power supply concept. Therefore they will install fridge-sized home power plants in people´s basements.

### 5.3.3 Business model

The business model is kept simple by Lichtblick. For a fixed amount of 5000 €, older heating systems will be removed as well as recycled and the home power plant of Lichtblick will be installed. The installation and further service and maintenance are offered against a monthly fee of 20 €. Furthermore customers have to pay a usage-based fee for heating based on the price of 5.79 €/ Cent for one kilowatt-hour. As compensation the customer gets a monthly basement rent of 5 € as well as 0.5 €/ Cent for each energy unit feed back into the grid. Nevertheless the home power plants remain the property of Lichtblick.[37]
The innovators compare their business model to a shoal of fish, with many small units pooling their resources to form a large, high-performance community that generates power. This "swarm electricity" can absorb grid failures in green energy supply. Conventional base-load power plants cannot be started up or shut down fast enough to compensate for fluctuations in power supply from solar or wind energy units as a result of changing weather conditions.
The concept makes only sense for bigger housing units or other users with a higher need of energy. The lower limit is determined at an annual consumption of 40.000 kWh.

## 5.4 Comparison of the business ideas

These two business ideas are describing two completely different approaches. Lichtblick and VW are not interested in shaving peaks. Their purpose is to make the power production more flexible by integrating de-central home power plants to the grid and to increase the efficiency of green energy supply. As the home power plants remain in possession of the energy supplier, Lichtblick will profit by the grants and the subsidisation for green energy and the grid feed allowance. For the private households the investments into a new heating system are manageable and the costs for one unit is fixed for ten years, but the private households also commit themselves to an energy supplier for a long duration, who is coevally the owner of the heating system. Only in winter and in transition time will the block heating station work on full efficiency. In addition, the solution does not address the main problems of the grid operators which are facing high costs through these peaks.

[37] Cp. http://www.lichtblick.de/h/preis_297.php (German Source)

In contrast to this, the idea to control the energy consumption directly addresses the main problems that are derived from energy peaks. Grid operators can increase the price in peak situations or directly influence the energy consumption. Furthermore utility companies are also able to react to the volatile amount of renewable energy resources. If a lot of wind is available they could decrease the price for one unit of energy in order to stimulate private households to anticipate events of high energy consumption intensity. In the case of less wind energy, utility companies can increase the price level thus price sensitive households stop consuming energy by postponing energy intensive events.

# 6. References


Borghese, F., ENEL: Evaluating The Leading-Edge Italian Telegestore Project, presentation, http://www.ibm.com/cz/events/AMM/download/Borghese.pdf.

Bundesministerium für Wirtschaft und Technologie, 2009: http://www.energie-verstehen.de/Energieportal/Navigation/Energiepreise/strom,did=309424.html?view (German Source)

Bündnis 90/Die Grünen, Stadtratsfraktion München, 2009: http://www.gruene-muenchen-stadtrat.de/Klimaschutz/hengstenberg.pdf

Capgemini: Smart Metering: The holy grail of demand side energy management?, 2008

Capgemini, From Policy to Implementation: The Status of Europe's Smart Metering Market, 2009

Day, J. Zimmerman, H.: The OSI Reference Model. In Proceedings of the IEEE, (71)12:1334-1340, 1983

Directive of the European Parliament and of the Council of 31st March 2004 on measuring instruments: 2004/22/EC.

Directive of the European Parliament and of the Council of 5th April 2006 on energy end-use efficiency and energy services and repealing Council: 2006/32/EC

Echelon: Echelon's NES Chosen for First Advanced Metering Project in Switzerland, 2009

European energy exchange market [www.eex.com], 2009: http://www.eex.com/en/Market%20Data/Trading%20Data/Power/Intraday%20%7C%20Spot/Intraday%20Chart%20%7C%20Spot/spot-intra-chart/2008-12-22/a

Krakowiak, S. (2003): http://middleware.objectweb.org/

Leong, A., Sumic, Z.: Dataquest Insight: Smart Meters for Intelligent Grids to Drive Semiconductor Growth, Gartner Report, 2008

LichtBlick, 2009: http://www.lichtblick.de/h/preis_297.php

Maandelijks uitlezen van elektriciteitsmeters, Eindverslag van regeringsopdracht 2002, Statens Energimyndighet (Sweden)

McCracken, R.: Smart Meters: Gizmo or Revolution?, Energy Economist, Issue 317, 2008

Mihm, A., Verbraucher zahlen für Überangebot an Öko-Strom, Frankfurter Allgemeine Zeitung, 2009: http://www.faz.net/s/Rub0E9EEF84AC1E4A389A8DC6C23161FE44/Doc~E1A6A559028CF41F8AD3F57D0E13E3F4E~ATpl~Ecommon~Scontent.html (German Source)

Ofgem (UK): Domestic Metering Innovation, Consultation Document, 2006.

SG Equity Research: Green IT, Global Sector Review, 2009

Tanenbaum, A.S. and Van Steen, M.: Distributed Systems. Principles and Paradigms. Addison-Wesley, 2007

The Climate Group: SMART 2020: PATHWAYS TO SCALE, 2009

The Climate Group: The Climate Group Smart 2020 Report, 2008

The Economist, 2009: http://www.economist.com/displaystory.cfm?story_id=14586006

Uppal, Gagan: The Smart Metering – Europe report, Netscribes 2009

Van Gerwen, R.; Jaarsma S.;Wilhite R.,2006: http://www.leonardo-energy.org/webfm_send/435

# 7. Appendix

## 7.1 Workshop

| | |
|---|---|
| **Meeting Subject:** | Business ideas for integrating smart meters via Hydra technology into the house/company communication infrastructure |
| **Venue:** | Siemens AG, Nonnendammallee 101, Berlin, Room number E3087 |
| **Date:** | 16 October 2009 |
| **Chair:** | Dr. Gernot Graefe, Siemens AG, Siemens IT Solutions and Services, C-LAB |
| **Distribution:** | Invited participants, Hydra WP10 partners |

## 7.2 Workshop Agenda

| Time | Subject | Topics to be covered | Time (mins) | Lead participant |
|---|---|---|---|---|
| **08:45** | **Welcome** | Arrival and coffee | 15 | SAG |
| | | Welcome and introductions | | |
| **09:00** | **Smart Metering and Energy Efficiency** | Presentation on Smart Grid and Energy Efficiency | 20 | NN |
| | | Discussion | 10 | SAG |
| **09:30** | **Technologies for innovative energy services** | Overview of the Hydra middleware | 20 | In-JeT |
| | | Discussion | 10 | |
| **10:00** | **Development of business ideas and discussion - Session** | Introduction of the business idea including Hydra's technological contribution | 20 | SAG |
| | | Open discussion | 10 | |
| | | Coffee Break | 20 | |
| | | Specification of the business idea and development of business models | 100 | |
| **12:30** | **Lunch** | | | |
| **13:30** | **Business ideas No 2: Energy By-Call** | Introduction of the business idea including Hydra's technological contribution | 20 | SAG |
| | | Open discussion | 10 | |
| | | Specification of the business idea | 70 | |
| | | Coffee Break | 20 | |
| | | Development of business models | 30 | |
| **16:00** | **Summary** | Summary, conclusions, identified business cases, possible actors and revenues, next steps | 30 | SAG |
| **16:30** | **Close of day** | | | |

### 7.3 Workshop Participants

| Name | Organisation |
|---|---|
| **Experts:** | |
| 1. Ulrich Erik Redmann | Siemens AG, Siemens IT Solutions and Services, Management Consulting, Germany |
| 2. Steve Mullins | Siemens AG, Siemens IT Solutions and Services (Meter Data Management), Germany |
| 3. Prof. Dr. Ramin Yahyapour | University of Dortmund, Germany |
| 4. Leyla Güran | Fichtner IT Consulting, Germany |
| 5. Ralf Hopf | Vattenfall, Germany |
| 6. Thilde Nørgaard Kristensen | Dong Energy, Denmark |
| 7. Marco Jahn (Confirmed) | Fraunhofer Institute, Germany |
| **Hydra consortium:** | |
| 8. Andrea Guarise | Innova SpA, Italy |
| 9. Jesper Thestrup | In-JeT ApS, Denmark |
| 10. Dr. Gernot Gräfe | Siemens AG, Siemens IT Solutions and Services, C-LAB, Germany |
| 11. Walter Schneider | University of Paderborn, Germany |
| 12. Florian Röhr | Siemens AG, Siemens IT Solutions and Services, C-LAB, Germany |