KEMA

Smart meters in the Netherlands

Revised financial analysis and policy advice

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Smart meters in the Netherlands; Revised financial analysis and policy advice

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SUMMARY

Smart energy meters

Smart energy meters are getting plenty of attention inside and outside Europe. These meters can do more than just reflect readings for the use of electricity or gas, for instance. The level of 'intelligence' can vary, but in general these meters can:

- ✓ be read remotely
- ✓ record several tariff periods (more than just a day and a night tariff)
- ✓ register electricity being returned to the grid
- ✓ store accurate consumption patterns
- ✓ provide information about the quality of the energy supply
- ✓ restrict or cut off the user's consumption upon command
- ✓ be controlled remotely.

Together, the smart meter, the communication infrastructure and the centralized processing and storage of data form a smart metering infrastructure. Advantages of a smart metering infrastructure are, among others, a reduction in the cost of the service provision (cost-to-serve), energy savings, improved functioning of the market mechanism, increased security of supply and promotion of the implementation of a smart energy infrastructure (smart grid).

Request of the Ministry of Economic Affairs

In 2005 KEMA, by order of the Ministry of Economic Affairs, performed a societal cost-benefit analysis into the national introduction of the smart meter. Since then there have been many changes in the political, economic and technical arenas, which is why the Ministry of Economic Affairs has instructed KEMA to perform a revised cost-benefit analysis in order to gain insight into the consequences of the changed circumstances (among others, increased attention for energy efficiency and smart grids, and the elimination of the obligation to accept a smart meter). The study requested by the Ministry contains three main elements, which are worked out into main questions in figure S.1.

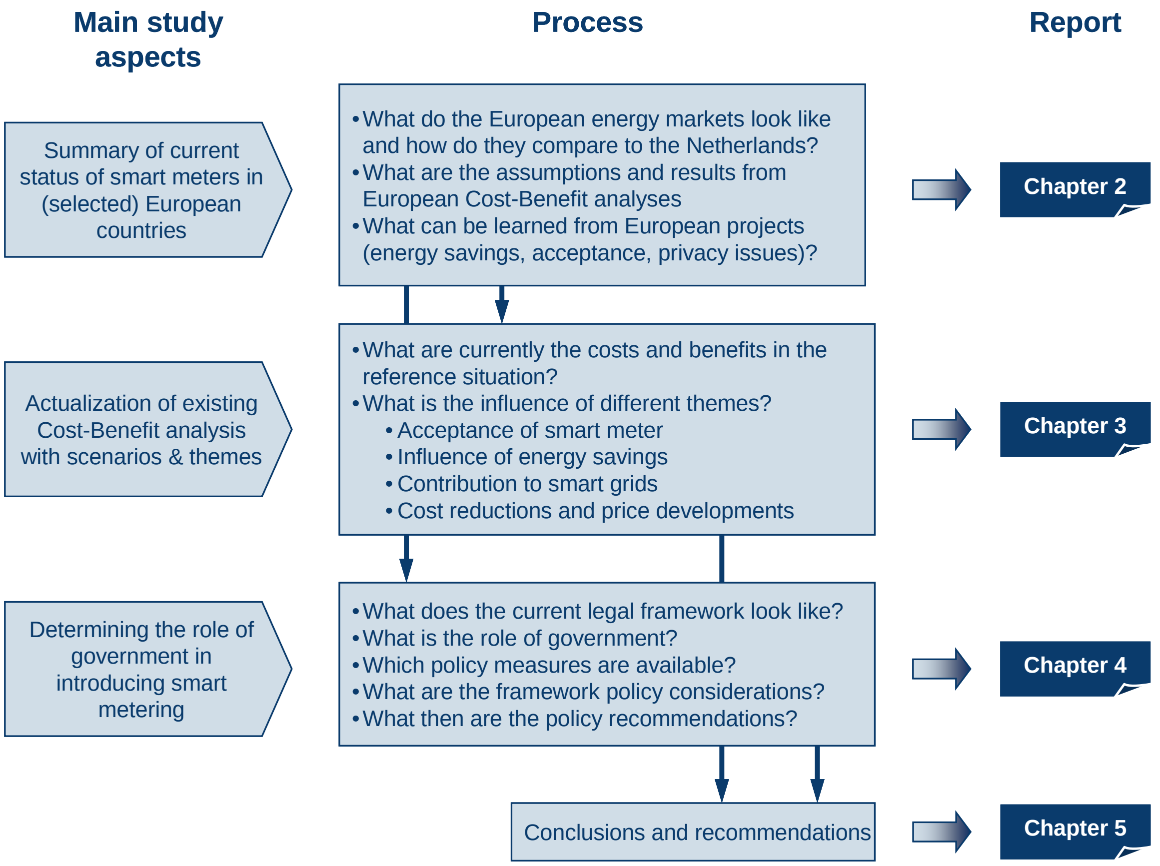

Figure S.1: Defining the questions for this study.

Learning points from Europe

It is apparent from the country inventory that the transition to smart metering systems is in progress in all of (Western) Europe. In Sweden and Italy the penetration level of smart meters is nearly 100%, and in other countries like the United Kingdom and Spain a large-scale roll out has deliberately been chosen.

Important learning points from the country inventory are:

- ✓ in view of the developments in other countries, the current roll out schedule in the Netherlands is realistic
- ✓ there are significant similarities within Europe when it comes to the technology and functionality of the smart meter
- ✓ in-home displays are not provided everywhere, and are handled differently in different countries
- ✓ in a number of countries (societal) cost-benefit analyses were performed prior to the introduction of smart meters. A number of these analyses were positive, a number were negative
- ✓ the estimates for the anticipated energy savings resulting from smart meters are positive and range from a few percent to over 10 percent

- privacy issues with respect to the introduction of smart meters are acknowledged throughout Europe, but these issues have not (yet) played such a prominent role anywhere else in Europe as in the Netherlands
- the most that can be said about the acceptance of the smart meter is that, in view of the nearly 100% roll out, there appear to have been no problems regarding the acceptance of the smart meter in Sweden and Italy.

Updating of the cost-benefit analysis in the Netherlands

The methodology for the cost-benefit analysis has, in the main, been copied from the 2005 study, but important interim changes have been incorporated. Among others, there are the options of refusing a smart meter or having it turned off administratively. The cost level has also been amended in line with current insights (including the costs for privacy and security). The energy saving percentage has been substantiated in more detail and the possible contribution of a smart metering infrastructure to a future smart grid has been taken into consideration.

The reference situation (almost 100% acceptance of the smart meter as well as almost 100% standard readings) refers to a positive business case with a net present value of 770 million euro. The main beneficial items (in order of positive contribution) are energy savings, savings on call centre costs, a lower cost level as a result of increased competition (increased switching) and savings in meter reading costs.

The changes compared to the 2005 situation have been summarized in a number of themes. These have been analyzed and the results are reflected in figure S.2. The themes (in relation to the reference situation) are:

- 20% of consumers have an in-home display and consequently the energy saving benefits of direct feedback
- the electricity prices increase by an additional 20% compared to the reference situation (1.2% instead of 1%) and the costs of the smart meters decrease by 20%
- synergy advantages in the roll out phase result in a savings of 30% on the costs of the roll out (purchase of hardware and software)
- smart grid advantages that are made possible through the smart meter infrastructure are attributed to this business case
- 20% of consumers opt for the ‘administrative off’ situation
- 20% of consumers opt for detailed meter readings
- 20% of consumers refuse to have a smart meter installed.

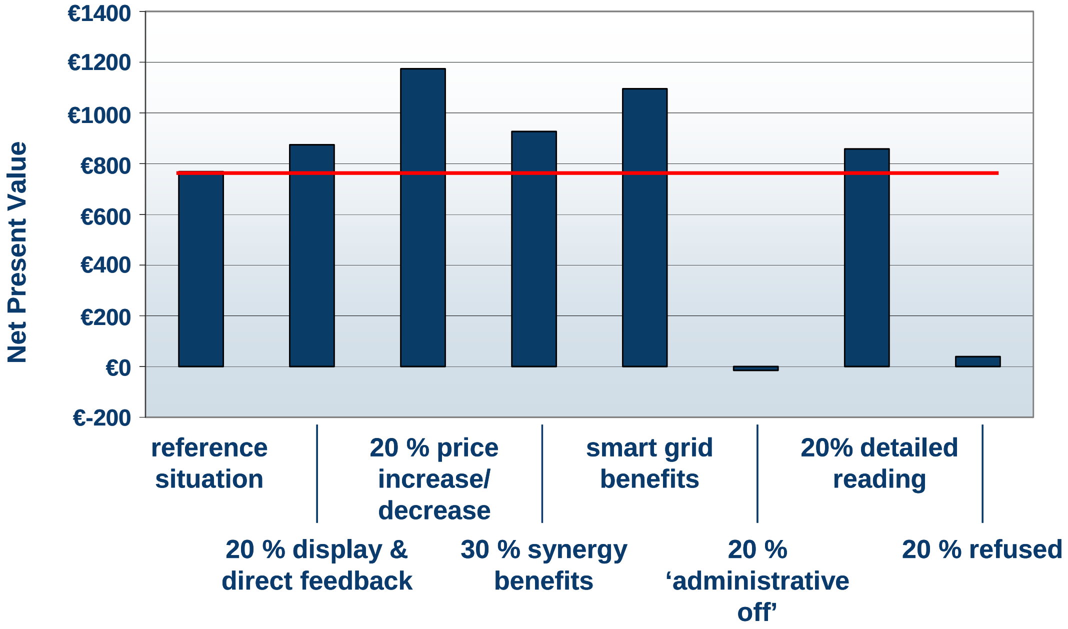

Figure S.2 Net present value of (large-scale) roll out for the seven discussed themes, in comparison to the reference situation.

The role of the government

The legal framework for the introduction of the smart meter is documented in the proposed legislative changes. This legal framework does not allow for enforcement measures for the acceptance of the smart meter. The role of the government will therefore have to focus much more on stimulation, information and persuasion.

Areas for attention with respect to policy targets are the *acceptance* of the smart meter, the *effective use* of the smart meter and an *efficient roll out* of the smart meter. In table S.1 these areas for attention have been broken down further into specific attention points.

Table S.1 Attention points in relation to the three aforementioned areas for attention

attention points	area for attention		
	acceptance	effective use	efficient roll out
information about the benefits of the smart meter	✓		
information about disconnection and privacy	✓		
status information on the meter	✓		
encouraging the use of the display		✓	
position of demand management		✓	
reluctance to switch supplier		✓	
certainty about priority roll out			✓
collaboration between the parties involved			✓
benefits for a smart grid		✓	✓
additional functionalities			✓

Policy advice

It is important that the consumer is approached correctly with a convincing story. This is a matter of marketing and communication and it is advisable to pay sufficient attention to getting the key message about the smart meter, and the communication of this message, perfectly clear. The consumer will require reassurance in a number of areas (he cannot simply be disconnected, he can rely on the fact that 'administrative off' actually means that no metering data is being exchanged, he can have confidence in the security and privacy measures etc.).

To be able to use the smart meter as efficiently as possible it is advisable, among other things, to stimulate the introduction of an in-home display. In addition, increasing the energy awareness among consumers is an attention point.

The realization of synergy advantages in the roll out process is an attention point for an efficient roll out, as is further research into the possible future smart grid benefits of the current smart metering infrastructure.

GLOSSARY

Centralized Access Server (CAS): a central data processing and storage system that provides access to the smart meter and the meter data.

Combined Heat and Power (CHP): whenever fuel is converted into electricity, heat is released. A CHP installation utilizes this heat instead of cooling it. This generates fuel savings when compared to generating power and heat separately.
Combined Heat and Power is already used on a large scale in industrial environments and greenhouse cultivation. However, there is increasing interest in a more decentralized use of CHP, for instance in homes (micro-CHP).

Connected party: a natural person or legal entity who/which has a connection to a grid. In this report the term refers mainly to consumers/households with a connection to the grid. The terms 'connected party', 'low-volume user', 'household' and 'consumer' are used interchangeably in this report, depending on the context.

Consumer port: a connection to the smart meter (comparable to a USB port) that can be used to obtain data from the meter, such as the current energy usage, the actual capacity, various (status) messages and the tariff indicator (for instance whether the day or the night tariff applies). This port is also referred to as P1.

ConsuWijzer: ConsuWijzer (*ConsuGuide*) is the government desk that provides consumers with independent and reliable information about consumer rights (www.consuwijzer.nl). The Netherlands Competition Authority (NMa), among others, is an initiator of this website.

Demand Side Management (DSM): realizing the efficient use of the grid and the power stations by turning equipment in homes (such as washing machines, tumble dryers, dishwashers, heat pumps, chargers for electrical vehicles) on and off centrally and remotely.

Direct feedback: direct feedback to the consumer about the energy usage and energy tariffs where applicable. In this study, direct feedback is linked to an in-home display that is connected to the consumer port.

Display: where this report refers to a display (usually in combination with feedback), this refers to an external display that is installed in a (clearly) visible and accessible location in the home. A smart meter normally also has a display on the meter itself; this is *not* the display being referred to.

Dutch Competition Authority (NMa): the Dutch Competition Authority monitors companies and ensures that they compete fairly and comply with the relevant rules.

Dutch Smart Meter Requirements (DSMR): a document in which specifications for the smart meter are documented based on consultation between the Dutch parties involved. These specifications are built on the basic functionalities in the NTA 8130 (see 'NTA 8130')[1].

General Packet Radio Service (GPRS): this is a technology that is an expansion of the existing mobile telephone network. Using this technology, mobile data can be sent and received more efficiently, quickly and cheaply. There is no longer a need to dial in. The user is always online as it were, but is only required to pay for the data that is actually being sent or received.

Grid operator model: in the grid operator model the low-volume user receives an invoice for the cost of the energy supply (including energy tax) from the supplier and an invoice for the grid management costs from the grid operator.

Home automation: the integration of technology and services within the home, with the objective of promoting a better quality of living for the resident(s) by means of increased security, comfort, communication and technical management.

Indirect feedback: indirect feedback to the consumer on the energy usage and any energy costs. This includes, for instance, making a website available containing historical and recent usage, a (digital) invoice etc. In this study a combination with savings tips and standard usage of energy is also assumed.

Low-volume user: a user who has a grid connection with limited capacity. For electricity this is a maximum of 3x80 Ampere, for natural gas this is less than 40 cubic meters of gas per hour. Normal homes fall well within these limits. The terms 'connected party', 'low-volume user', 'household' and 'consumer' are used interchangeably in this report, depending on the context.

Narrow casting: audiovisual marketing to a specific target group in a specific place at a specific time with a customized message.

Net Present Value (NPV): the total value of a project or a cost or revenue item with the time value of money taken into account (a euro earned in future is worth less today). Important factors in this calculation are the interest rate and the duration. A project is profitable if the net present value is positive.

Norm regulation: a system in which the efficiency of the grid operator is measured against the average efficiency of all the grid operators in the Netherlands.

NTA 8130: a Dutch Technical Agreement[2] documented by NEN containing the basic functionalities of the smart meter in the Netherlands.

Office of Energy Regulation: the Office of Energy Regulation monitors compliance with the Electricity Act 1998 and the Gas Act and is responsible for the most effective possible functioning of the energy market. Within the energy sector this means, among other things, that access to the transport grids must be guaranteed, that there is sufficient transparency and that consumer interests are safeguarded. The Office of Energy Regulation is part of the NMa (see 'NMa').

P1: see Consumer port.

P2: a connector on the smart meter to which other meters (e.g. for natural gas, water or heat supply) can be hooked up.

P3: a connector on the smart meter for linking into the centralized access server (see CTS).

P4: an access port on or behind the centralized access server (see CTS) that allows parties access to the smart meter and the meter data.

Pareto-efficient: an economy is Pareto-efficient if every change in the economy resulting in a prosperity improvement for one party means an equal prosperity loss for another. We call this a social optimum.

Power Line Carrier (PLC): communication technology whereby information is transferred using the wiring of the grid. The speed at which data is transferred and the quantity of data being transferred are relatively limited (for instance when compared to the internet).

Quasi cash flow: annual money streams that have been corrected for their time value (see also net present value). This also refers to avoided costs.

Radio frequency communication (RF): communication technology that uses radio waves. Typically, this is a technology for shorter distances (to 100 m). As an example, an energy meter may be read by driving through the street with a receiver.

Real Time Pricing (RTP): a situation in which the consumer is charged based on a variable, market-dependent electricity tariff that may differ per day or even per hour.

Smart energy infrastructure: also referred to as a smart grid. This is an infrastructure in which electricity is generated and distributed in a more effective, economical, safe and sustainable manner. The smart grid integrates ICT, innovative techniques and technologies, products and services in the entire chain from the generation of electricity, via transport and distribution, to the (domestic) equipment of the end user.

Smart grid: see Smart energy infrastructure.

Smart metering infrastructure: a smart metering infrastructure (also referred to as Advanced Metering Infrastructure, AMI in short) contains the smart meter, a communication infrastructure enabling central data exchange with the meters and a central computer system for sending, processing and saving data.

Smart meter: a smart meter is a meter that is capable of more than just showing the actual meter reading for the energy usage. This type of meter can have various levels of intelligence, for instance a number of readers (more than just a day and night tariff), the possibility of being read remotely, outage consumption patterns, providing information about the quality of the energy supply, remotely limiting usage or disconnecting the user upon command and being managed remotely. As a rule the smart meter can also register the usage of a number of meters (electricity, gas, heat, water). In practice the smart meter is usually integrated with the electricity meter, and other meters are connected to it.

Supplier model: in the supplier model the low-volume user receives a single invoice for energy from the supplier, which incorporates the costs of the grid operator for the transport of energy. The supplier pays the grid operator on behalf of the low-volume user.

Time of Use (ToU): a tariff system in which the consumer is charged based on a rate that depends on the period of usage. The best known is the day-night tariff. The smart metering infrastructure enables the use of more detailed Time of Use tariffs.

Weighted Average Cost of Capital (WACC): this is the weighted average cost of using capital. The more ‘expensive’ the capital (the higher the WACC), the more future benefits are needed to justify an investment today.

CONTENTS

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1 WHY THIS REPORT?

1.1 Smart meters and smart grids

Smart energy meters are currently receiving a lot of attention. The deregulation of the energy markets in Europe and the growing interest in energy savings have mobilized the market for smart meters.

Smart meters are meters that can do more than just reflect readings for the use of electricity or gas, for instance. The level of 'intelligence' can vary, but in general these meters can:

- ✓ be read remotely
- ✓ record several tariff periods (more than just a day and a night tariff)
- ✓ register electricity being returned to the grid
- ✓ store accurate consumption patterns
- ✓ provide information about the quality of the energy supply
- ✓ restrict or cut off the user's consumption upon command
- ✓ be controlled remotely.

To be able to communicate with the smart meter a communication network is needed, such as a mobile telephone network (GPRS) or via the grid (PLC). Through this communication channel the meters are centrally managed and user data is centrally stored and processed. Together, the smart meter, the communication infrastructure and the centralized processing and storage of data form the smart metering infrastructure.

The introduction of smart energy meters, with the accompanying communication infrastructure, can have benefits for the energy suppliers and grid operators and energy users alike. These benefits can generally be divided into five categories:

1. *Reduction of the cost-to-serve:* for instance by reducing the meter reading costs, the ability to quickly generate an accurate final bill, the prevention of fraud and non-payment, etc.
2. *Energy savings:* for instance through direct feedback to the consumer about his energy consumption, or through demand response so that efficient use can be made of the national production park.
3. *Improved functioning of several market mechanisms:* among other things this may mean it becomes easier to switch supplier, customer complaints are handled more quickly, customer retention through improved service provision, real-time pricing, time-based tariff structures, additional services such as security, alarm systems and home automation, etc.
4. *Increase in the security of supply:* having a better understanding of the use of low voltage grids may result in a more reliable grid design and the efficient use of the grids. The detection and analysis of faults will also be faster and better. This may

result in fewer outages, shorter outage times and, consequently, increased security of supply.

5. *Promotion of the implementation of a smart energy infrastructure*: smart meters and the accompanying communication infrastructure can have a significant positive effect on a more intelligent use of the energy infrastructure, the development of new (energy) services, the facilitation of decentralized energy generation and optimum charging of electric vehicles.

As indicated above, one of the advantages of a smart metering infrastructure relates to promoting the implementation of smart grids. Figure 1.1 reflects the relations. A smart metering infrastructure is generally considered an essential part of a smart grid.

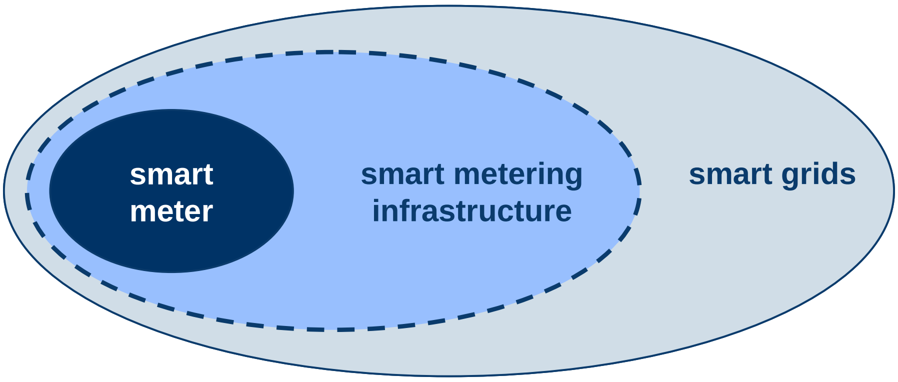

Figure 1.1: The smart meter as part of a smart grid

The term ‘smart grids’ is in fact a collective name for a range of smart solutions that help realize the energy supply of the future. It is an infrastructure in which electricity is generated and distributed in a more effective, economic, safe and sustainable manner. The smart grid integrates ICT, innovative techniques and technologies, products and services in the entire chain from the generation of electricity, via transport and distribution, to the (domestic) equipment of the end user (see figure 1.2).

Smart grids can not be regarded separately from a number of other developments, such as:

- ✓ increasing sustainable energy generation (sun, wind and bio-gas), both on a small and a large scale
- ✓ increasing dependence on electricity as a result of which the security of supply will play an even greater role
- ✓ growing interest in and use of home automation
- ✓ integration of electric vehicles that can serve to store electricity and as variable load.

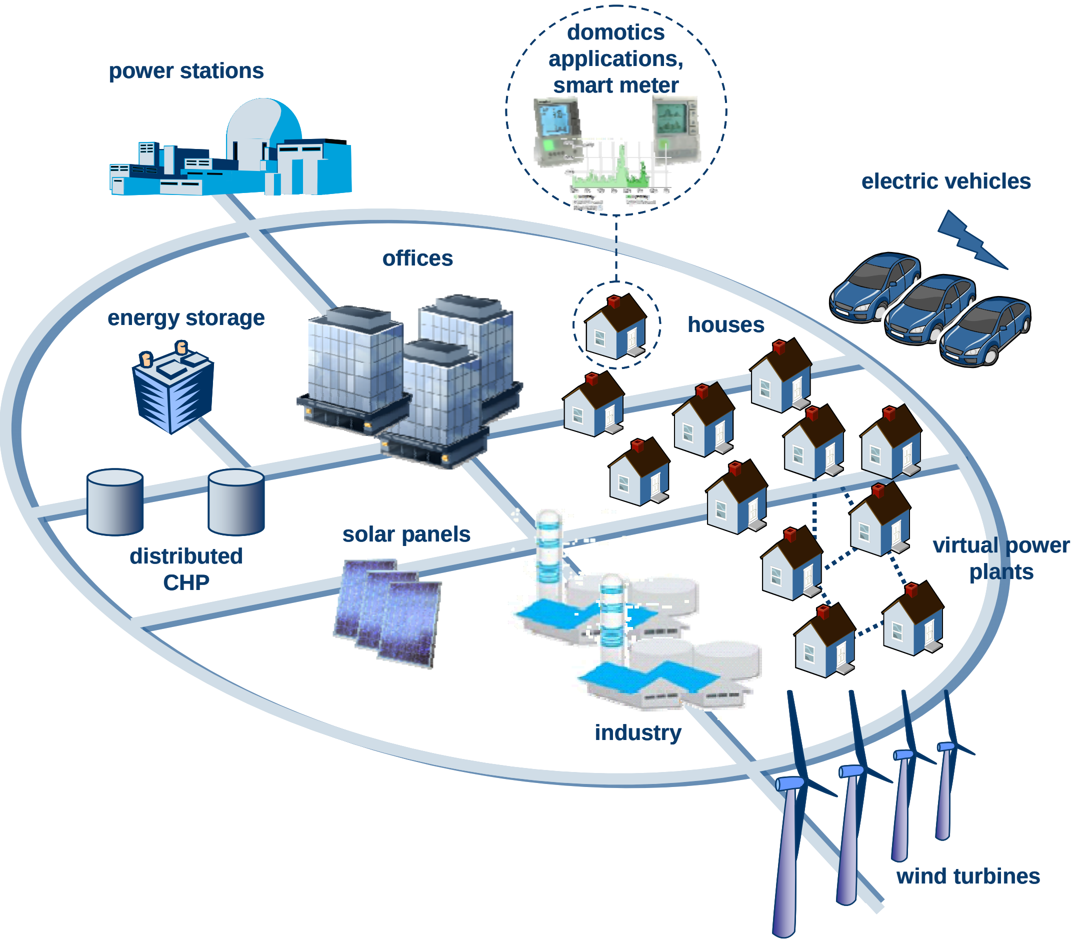

Figure 1.2: 'Smart grids' is a collective name for a range of smart solutions that help realize the energy supply of the future.

The stakeholders involved in the development of smart grids (grid operators, suppliers, the government etc.) currently agree that smart grids are essential to be able to facilitate future developments in the area of decentralized electricity generation and a possible large-scale introduction of electric modes of transport[3]. Smart grids is also one of the three policy themes in the 2008 Energy Report published by the Ministry of Economic Affairs[4].

1.2 Introduction of smart energy meters in Europe and the Netherlands

In Europe, Sweden and Italy are the forerunners when it comes to the introduction of smart meters. At the end of 2006 Italy was the first country in the world where nearly all electricity consumers have access to a smart meter. The reasons that Enel, Italy's largest energy company, transitioned to smart meters were among other things the large number of non-payers *and* the prevention of fraud and energy theft. Sweden followed around July 2009. In Sweden legislation was used to enforce monthly reading of all electricity meters from July 2009. This requirement has resulted in the large-scale use of smart meters in Sweden.

Why this report?

Other countries in Europe are also looking into the large-scale introduction of smart meters, for instance by conducting cost-benefit analyses or by starting up and conducting pilot projects. These developments are partly the result of European legislation which makes the introduction of smart energy meters mandatory in the period leading up to 2020, subject to economic feasibility. The so-called Third Energy Package stipulates that at least 80% of consumers must have these smart metering systems by that date. More about European legislation can be found in chapter 2.

In the Netherlands regulation that stimulates the use of smart meters will also have to be introduced very soon. Some years ago a legislative proposal to this effect was submitted to the House of Representatives[5]. The House of Representatives adopted this proposal on 3 July 2008. Among other things, the proposal included a 2-year ‘trial period’ in which smart meters would only be compulsory in new construction, renovations and large-scale redevelopment projects. After an evaluation the introduction of smart electricity and gas meters in virtually all households would become mandatory in the subsequent period (likely to be a period of six years).

Prior to this ‘roll out’ a thorough cost-benefit analysis was conducted in the Netherlands. This cost-benefit analysis was performed in 2005 by KEMA[6], by order of SenterNovem (now Agentschap NL). In the Netherlands the functionality of a ‘standard smart meter’ was also determined. The latter was done under the supervision of the Dutch Standardization Institute (NEN). These discussions have resulted in a so-called ‘Dutch Technical Agreement’ in this area (NTA 8130), which later was expanded with the so-called Dutch Smart Meter Requirements (DSMR) under the control of the Dutch Independent Grid Management Company.

The aforementioned legislative proposal also suggests that a change be made to the market regulation of the meter market for low-volume users. This concerns the redistribution of responsibilities among the various market parties and bringing the meter itself under the regulated domain. Based on this proposal the grid operator will be responsible for the availability of a suitable meter at the connection address; the supplier will be responsible for the administrative processing of meter data and also becomes the primary point of contact for the low-volume user. The latter also applies particularly to the invoicing (the so-called *supplier model*).

The legislative proposal was debated in the 2008/2009 session year of the Senate. However, a number of problems arose. As a result of a report on a study into the privacy aspects of the use of the smart meter, conducted by the University of Tilburg[7] by order of the Consumer’s Association, a number of senators questioned the potential for infringements of the personal privacy of individuals. There were also questions[8] about a number of *cost-benefit analyses* performed by different parties (see paragraph 2.3) and about the differences between these analyses.

A number of different parties also indicated that the smart meter, the specifications of which had by now been documented in the NTA 8130 and DSMR, was perhaps not smart enough. This suggestion was initially made by Representative Diederik Samsom (people were referring to the *Samsom Six*[9], because roughly six new *functional requirements* were being imposed on the meter), and worked out further by TNO[10], among others, at a later stage. New themes relating to *smart grids*, *home automation* and *electric cars* play an additional role. As a result of these objections (among others), and especially the penal sanctions associated with refusing a smart meter (it was classed as an economic offense), the Senate struggled with the *compulsory nature* of the introduction of the smart meter in the Netherlands.

The aforementioned legislation surrounding the smart meter is soon to be amended by means of a bill amendment proposal[11]. The original legal obligation to accept the meter will be revoked. The consumer will have the option to refuse the meter or accept the meter but block the remote reading facility ('*administrative off*'). With these measures the Minister provides the freedom of choice for the consumer that is requested by most of the political parties in the Senate. Paragraphs 3.1 and 3.2 will deal with this further.

1.3 Requirements of the Ministry of Economic Affairs

Since the cost-benefit analysis performed by KEMA in 2005 by order of the Dutch Ministry of Economic Affairs there have been considerable changes in the political, economical and technical fields. During the Senate debate on the legislative proposal for the large-scale introduction of smart meters in the Netherlands a number of aspects were raised that required further investigation. These were mainly:

- ✓ energy efficiency
- ✓ privacy/security
- ✓ additional functional requirements
- ✓ introduction smart grids
- ✓ other benefits for the consumer.

The Ministry of Economic Affairs has therefore instructed KEMA to perform a revised cost-benefit analysis to gain insight into the consequences of the changed circumstances with respect to the business case for the introduction of smart meters in the Netherlands. The Ministry of Economic Affairs also wants to get an understanding of the possible measures the Dutch government could take to influence the social costs and benefits into the direction desired by the Dutch government. The starting point of the analysis is a status study into the introduction of smart meters in Europe and the opinions about this subject. The results have been included in the review of the cost-benefit analysis.

In figure 1.3 the three main elements of the study have been converted into main questions. The mutual cohesion is also reflected and the figure indicates in which chapters of this report these main questions are answered. The scenarios desired by the Ministry for, among other things, consumer acceptance of the smart meter, the potential energy savings and cost developments (for instance communication costs) have been worked out in themes.

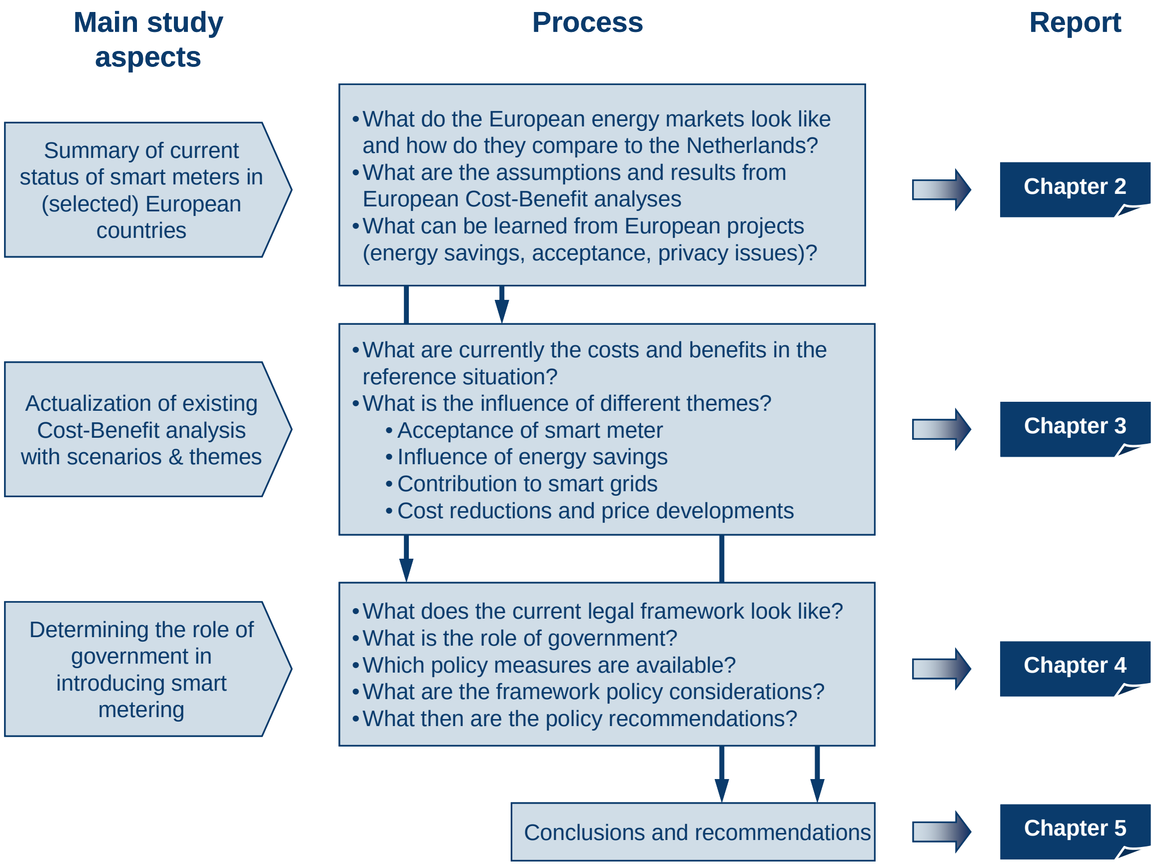

Figure 1.3: Definition of the questions for this study

An important source of verification within this project was a market consultation in the form of two meetings of a *consultation group*. During these meetings the starting points, approach and interim results of the cost-benefit analysis and policy advice, among other things, were presented and discussed. A large proportion of the parties involved were represented in a consultation group (grid operators, suppliers, metering companies, consumer organizations etc). A list of the members of the consultation group is included in Appendix A.

Parallel to this study the Ministry of Economic Affairs instructed TNO to perform an assessment. This concerned the writing of a 'reassurance letter'. The reassurance related to the future proofing of the smart meter and the way in which the Ministry deals with the various interests[12]. To this effect TNO conducted an assessment of the implementing regulations[13] in question. This assessment included the following aspects:

- ✓ security and privacy
- ✓ future proofing
- ✓ economic and legal aspects
- ✓ verification against international developments.

Notes and references to relevant literature are included in Appendix D.

2 SMART METERING INFRASTRUCTURE: A TOUR OF EUROPE

The energy policy currently being conducted by the European Union (EU) is an important catalyst for the introduction of smart metering systems, as the EU aims for a competitive and transparent market with an adequate technical infrastructure, where *sustainability* and *energy efficiency* are of high priority.

2.1 The European energy market

Until recently, most European energy markets could be characterized as local monopolies. Energy consumers were dependent on the local (city or regional) electricity or gas distribution company to purchase their electricity or gas. These companies were characterized by so-called *vertical integration*: production, transmission, distribution, supply and metering services were supplied by one and the same energy company.

A few years ago the European Union (EU) developed directives aimed at deregulating[14] the European energy markets with the objective of using market forces to realize lower prices and improved customer orientation (see also paragraph 2.2). The Netherlands has developed legislation to comply with these directives: the Electricity Act 1998 and the Gas Act. As a result of these two Acts, which fall under the responsibility of the Minister of Economic Affairs, our country now has a 'free' energy market. This market was deregulated in a number of phases: first the large - mostly industrial - customers, followed by the middle segment and the market for green electricity and finally, from 1 July 2004, the market for *all* low-volume users.

Since the introduction of the deregulated energy market there are more parties than before. The old energy companies were legally divided into a minimum of two new parties, namely the party involved in supplying the energy (the *supplier*) and the party operating the distribution grid (the *grid operator*). The distinction between the supply of energy (electricity and gas) and the transportation of energy was made to ensure fair competition. All energy suppliers are entitled to use the existing grids. Suppliers supply the energy to the consumers via agreements that are realized through the free market principle (regulated third party access to the grids). Electricity and gas are transported and distributed by the grid operators. Among other things it is the responsibility of the grid operators, which are region-bound, to maintain the grids they operate. There is usually not any competition between grid operators - consumers cannot choose between different parties. An independent regulatory authority appointed by the government - in the Netherlands the *Office of Energy Regulation* (part of the *NMa*) - supervises the entire energy market.

2.2 The energy policy of the European Union

Energy is high on the European political agenda: it is one of the areas in which the European Union aims for a common legislative framework. An important starting point is the so-called '*20-20-20 program*' of the EU*.* This program sets objectives for reducing CO_2 emissions in the EU by 20%, achieving 20% energy efficiency and having a 20% share in sustainable energy (compared to 2006) by the year 2020.

Traditionally, the various member states of the EU had their own energy markets. However, in the past two decades the EU has been implementing a strategy aimed at realizing a deregulated energy market in all the member states and creating a single European energy market. To achieve this a number of preconditions are required, including:

1. an adequate market structure with room for competition and transparency, and
2. an adequate (technical) infrastructure,

which is enforced in an EU context through common legislation. To this effect the EU has a large number of legislative instruments, of which the *regulation* and the *directive* are the main ones[15].

2.2.1 A market structure for competition and transparency

The directives in respect of common rules for the internal market for electricity and gas (directive 2003/54 and 96/92 for electricity and directives 2003/55 and 98/30 for gas) are the two main directives that define the first pre-condition and relate to creating a market structure aimed at competition. As a result, freedom of choice was created within the EU for all consumers (including households). In the Netherlands these directives were implemented in the Electricity Act 1998 and the Gas Act respectively, which deregulated the energy markets in the Netherlands in phases.

On 25 June 2009 the European Council unanimously adopted the so-called 'Third Energy Package'. The main reason this package was on the table is that a number of the bigger EU member states (like France and Germany) and a number of large companies (like E.ON, RWE and EDF) were not complying with all the rules in all the aforementioned directives. The third package therefore follows on from these directives and contains a series of measures to improve and promote the functioning of the energy markets. The package relates to different legislative proposals (two directives and three regulations) for the internal European electricity market and gas market. The two directives (2009/72 and 2009/73) are amendments to the existing directives 2003/54 and 2003/55. One of the regulations relates to the establishment of an EU Agency for the collaboration between national regulatory authorities for energy and to a European collaboration of transmission grid operators.

2.2.2 A sound infrastructure in Europe

The second precondition relating to an adequate technical infrastructure was the basis for a number of directives aimed at encouraging investments in energy grids in Europe. Directive 2005/89 contains measures to guarantee the security of the electricity supply and the infrastructure investments. This directive was (partially) the result of a large number of power outages in various European member states, including Italy, Denmark and Sweden. One of the measures in this directive relates to the objective of interconnection between the grids of the various member states in order to prevent so-called 'energy islands' and reducing the chances of power outages.

Another directive that falls in the second category is the directive 'in respect of energy efficiency in end usage and energy services' (2006/32). This directive, which stems from 2006, has established a clear objective for all the member states when it comes to energy savings. Each member state is expected to take measures to improve energy efficiency.

2.2.3 Are smart energy meters compulsory in the EU?

The energy policy conducted by the EU is an important catalyst for the introduction of smart meter systems in Europe. In the aforementioned directive 2005/89 advanced meter systems are already expressly named as a tool in the real-time management of energy demand. Directive 2006/32 instructs member states to let energy companies supply services to help the end users save energy.

This must be realized by supplying energy services and other measures to improve energy efficiency: the member states must take *cost-effective*, *workable* and *reasonable* measures that are aimed at ensuring that these savings are achieved. One of the possible measures is '*providing end-users with individual meters that accurately reflect the actual energy usage of the end user and provide information about the time in which energy was actively used*' (art. 13 of 2006/32). However, each member state is individually responsible for the implementation (and success) of this directive.

The way article 13 of directive 2006/32 is phrased does leave some room for interpretation, as each member state has the freedom to determine for itself whether investments in individual energy meters are financially feasible and proportionate to the potential energy savings. Neither does the directive make clear how smart such metering systems have to be. Either way, it is an important indication that smart metering systems are considered an important link in the future European energy supply.

As part of the aforementioned Third Energy Package directive 2009/72 was recently published. This directive goes beyond the previously described directive 2006/32 and stipulates that *80% of electricity consumers must have access to smart metering systems by 2020*. However, it must be *possible* to base the introduction of smart metering systems on an economic evaluation. If the evaluation shows that the introduction of such metering systems is only economically viable and cost-effective for consumers who use a certain amount of energy, the member states must be able to take this into account in the introduction of smart metering systems.

Does this mean that a member state may be exempt from the introduction of smart metering systems and a smart infrastructure in the event of a negative economical evaluation?

In theory, yes. However, other measures in the Third Energy Package will indirectly still result in the use of smarter metering systems. For instance, end users will have the right to switch energy suppliers more quickly, after switching energy suppliers the customer will get a final bill no later than six weeks after he has notified his original supplier, and the customer will be properly informed about his actual electricity usage and costs thereof, *and* sufficiently frequently to enable him to regulate his own electricity usage. It remains to be seen whether such requirements can be met *without* smarter metering systems.

Appendix B.1 contains a brief overview of the aforementioned European regulations.

2.3 A closer look at five European countries

Based on the current themes listed in paragraph 1.3, we will now take a more detailed look at *Germany*, *Belgium*, *the United Kingdom*, *Spain* and *Sweden*. We will consider the following questions:

- ✓ What does the energy market in these countries look like?
- ✓ Who is responsible for reading the meters?
- ✓ Has the country opted for a national implementation of smart meters?
- ✓ Were cost-benefit analyses performed and what were the results?
- ✓ What functionality and technology do the smart meters provide?
- ✓ What are the results of pilots with smart meters?
- ✓ How much energy efficiency is expected to be realized with smart meters?
- ✓ Have there been problems relating to privacy?
- ✓ What is the relation between smart meters and smart grids?

In the answers to these questions the focus is on the electricity and gas market.

2.3.1 What does the energy market look like?

As a result of the deregulation the energy sector in Europe has changed drastically in recent years. The production, trade and sales of energy have become commercial activities, while the management of the energy grids has become more subject to market forces. To enable freedom of choice, the supply of energy and the grids ownership have been separated. This is a direct consequence of European legislation. The energy markets in all the EU countries had to be fully deregulated with effect from 1 July 2007, which means that customers must be able to choose between different suppliers. As a result, new suppliers have entered the energy market throughout Europe.

In the recent past, the energy market could be classified as a true monopoly market: vertically integrated monopolies (production, physical distribution and supply in a single company) dominated the market. In the countries of the EU energy consumers were traditionally limited to the supplier who had the (national or regional) monopoly for their supply of energy, which de facto meant the customer had no choice.

However, there are minor differences between the various energy markets in the countries of the EU; these differences may relate to the speed of deregulation, the structure of the market, the way in which metering is regulated etc. Appendix B.2 gives a brief description of the energy market in the five investigated countries: Germany, the United Kingdom, Belgium, Spain and Sweden.

2.3.2 Who is responsible for reading the meters?

With regard to the metering of energy usage; Germany and the United Kingdom have a deregulated metering market - also for households - like in the Netherlands. In Belgium, Sweden and Spain the grid operator is responsible for the meter readings of households.

For low-volume users with a traditional meter the meter is, in principle, read every year, either by a meter reader or by the customer. If a customer moves house or switches supplier the meter must be read in the interim; this is usually done by the customer. The meter reading process in **Belgium** is sometimes outsourced to specialist companies (subsidiaries of the different grid operators), such as *Metrix* and *Indexis*.

In **Spain** and **Sweden** the grid operators are the owners of the metering equipment. They are also responsible for the installation, maintenance, reading of energy meters and for data management. The collected meter data is subsequently reported to the interested parties (e.g. the suppliers). In Sweden the grid operator is allowed to outsource these services to a separate company, but it retains the ultimate responsibility. Energy suppliers are *not* involved in the meter reading process.

In **Germany** it is standard practice for the grid operator to have the ultimate responsibility for the metering equipment for electricity and gas and for the metering itself, *except* in cases in which the consumer has instructed a third party to perform these services. Germany has had a deregulated market for metering equipment since 2005, at which time the market for energy metering was also opened up. With the deregulation of metering in Germany two new market roles have been created, namely the so-called *Messstellenbetreiber*, the party that is responsible for the metering equipment, and the so-called *Messdienstleister*, the party that reads the meters. If desired a consumer can contract two different parties for these services (unless the consumer has a smart meter).

In the **United Kingdom** the meter market has also been opened up to competition. As in Germany, new market roles were created in the United Kingdom, namely the *meter operator*, the party responsible for the metering equipment, and the *data collector*, the party doing the meter reading. The customer is, in principle, free to choose the *meter operator*. In general it tends to be mainly *multi-sites*, consumers with a large number of sites, who choose to do so.
In the United Kingdom the energy suppliers have the ultimate responsibility for purchasing metering services for their customers. For this reason it is usually the supplier who chooses the *data collector*. Energy suppliers increasingly try to perform this metering service *themselves*. However, there are also a number of large independent providers of metering services, such as *AccuRead*, *Onstream*, *IMServ* and *Siemens Energy Services*. If the customer switches supplier the *data collector* will normally also change.

A large proportion of the meter 'fleet' in the United Kingdom is outdated. Many places don't even have a meter. As a result, every year around 1.5 million electricity and 1 million gas meters are being replaced as part of re-certification program, or installed in new locations within the United Kingdom.

For large industrial customers *telemetrics*, the remote reading of energy meters, is already being used in all the aforementioned countries. In the Netherlands this is the case (compulsory) for electricity connections with a minimum contract capacity of 100 kW and gas connections with a minimum annual usage of 170,000 m^3.

2.3.3 Toward a national implementation of the smart metering infrastructure

In addition to Italy, **Sweden** is currently the only country in Europe that has an (almost) 100% penetration of smart meters.

In the early years of the energy deregulation in Sweden the usage of large electricity connections was measured per hour using remote reading. During this period remote reading for households was only compulsory if the customer wanted to switch suppliers. However, such remote reading systems were comparatively expensive (approximately 1,000 euro), certainly compared to the potential energy savings achievable by such a system. A statutory maximum price of approximately 270 euro was later introduced. This was still not very attractive, which is the reason the free market for low-volume users did not get off the ground very well in the early years, providing a reason to abolish this arrangement in 1999.

As a result of strongly rising energy prices in Sweden, incomprehensible and inaccurate energy bills and wishes relating to energy savings, a demand for improved correlation between energy costs and energy usage emerged. As a result the ‘smart meters’ topic was put back on the political agenda. In 2002 the Swedish Energy Agency STEM conducted a cost-benefit analysis for the introduction of monthly reading of electricity meters. This analysis came up with a positive result (see paragraph 2.3.4). STEM subsequently suggested that all 1.5 million electricity connections with an annual usage in excess of 8,000 kWh shall be read monthly starting from 2006. From 2009 this would apply to *all* users.

The STEM proposal ultimately resulted in a law presented in 2003, which was adopted by the Swedish government: from 1 July 2009 all electricity meters in Sweden had to be read *monthly*. The actual law only stipulates that electricity meters must be read 12 times a year. In other words, *the law does not make smart meters compulsory*. In practice this requirement *does* however result in remote meter reading, as physically reading over 5 million meters every month is impossible in practical terms.

The law also reduced the limit for hourly readings. For connections with a load (fuse) in excess of 63 Amp, hourly values must be collected. These are mostly small business connections. The meter must also be read when switching supplier or changing homes (on the actual day of the switching or move). Gas and district heating have specifically *not* been included in this law, so here the compulsory monthly (or hourly) meter reading does not apply.

A quick look back on the implementation of smart meters in Sweden

In Sweden the process of replacing all 5.1 million meters in the country took around 6 years (from 2003 - 1 July 2009). Most grid operators waited quite a long time before replacing the meters, although there were some forerunners, such as Vattenfall. At the start of 2008 still only 1.5 million domestic meters had been replaced. By the end 2008 this number had already increased to 4.7 million meters. The remaining 400,000 meters were replaced in the first six months of 2009. Consequently, approximately 70% of all meters were replaced in the final 18 months. For most distribution grid operators the progressive development toward more advanced technical systems, with increased functionality at a lower cost price, was a reason to wait with the roll out. In addition they needed time to properly perform all the required activities in the logistical process.

In **Germany** there is no official or legally regulated implementation plan for the introduction of smart meters. Neither has a nationally coordinated roll out been provided for. The legislator works on the premise that the creation of legal preconditions (among other things through the introduction of a free meter market - see paragraph 2.3.1) supports a *market-driven roll out of smart meters*. It *is* however an expressed objective of the legislator[16] that within a six-year period all meters in Germany must be smart meters and, in addition to time-based usage, must also be able to record the instantaneous power capacity, provided this objective falls within economically acceptable limits.

European directive 2006/32 has already been implemented in Germany: taking into account the economical and technical feasibility, smart electricity and gas meters must be installed in new constructions and major renovations from 1 January 2010 onward. Furthermore, upon request the consumer is entitled to a final bill from the supplier *more frequently than once a year*: if desired by the customer the supplier must prepare a monthly, quarterly or 6-monthly invoice, whereby the supplier must use the so-called supplier model. The costs of the grid operator and that of the metering services are also listed on the invoice from the supplier. Finally, no later than 30 December 2010, suppliers are obliged to introduce tariffs that depend on the used capacity and on the time of use.

There are a number of companies in Germany that have already started a roll out of smart meters or that sell smart meters. One of the best-known suppliers of smart meters is *Yello*. This subsidiary of EnBW, which is also a supplier of electricity and gas, sells a smart meter for electricity throughout Germany, called the *'Sparzähler'.* They are planning to do the same for smart gas meters, but currently these are still in a pilot phase. Yello is comparable to the company Oxxio in the Netherlands: Oxxio is also an electricity and gas supplier and offers smart meters to low-volume users in the Netherlands. Customers who use the Sparzähler can use an Internet application to see their actual meter data by means of diagrams and tables.

The current meter 'fleet' in **Spain** is very antiquated. To still be able to cope with the challenges relating to the growing energy demand, the security of supply and the desire to realize energy savings, all of which are important in Spain, the Spanish government has developed a policy to bring meter reading practices to a higher level in the coming decade. Two laws make the introduction of a smart metering infrastructure compulsory[17]: since July 1st, 2007 *new* domestic meters (with a capacity up to 15 kW) must already be smart meters. This ensures compliance with EU directive 2006/32. As a result of the second regulation *all* households in Spain with a capacity of 15 kW - a total of some 24 million meters - must be able to have a smart, remotely readable meter by 2018.

Effective from 2014 all grid operators must have a so-called Automatic Meter Management system (AMM system) in place for data collection. The regulatory authority CNE will be in charge of supervising the roll out. Incidentally, the Spanish government has not given any financial support to the distribution companies for their high investments during the roll out. Expectations are that the full roll out of smart meters in Spain will start in 2010 in order to meet the formulated government targets (30% penetration in 2011, 50% in 2013 and 100% in 2018). To achieve these percentages an average of 3 million meters must be installed per year.

In the **United Kingdom** smart metering infrastructure was put high on the political agenda through the publication of the Energy White Paper[18] in May 2007, in which the British government outlined its future energy strategy. In this White Paper the British government formulated a number of objectives that are related to the themes 'smart metering systems' and 'informative invoicing' and are therefore a means of complying with EU directive 2006/32. Other important objectives in the White Paper related to reducing CO_2 emissions, improving the reliability of the energy supply and stimulating a competitive energy market.

After an initial consultation round in the period 2007-2008 the British government, in 2008, expressed the *intention* to install smart meters for electricity *and* gas. The objective is to have this target realized for the entire United Kingdom by 2020[19]. In May 2009 a consultation round was started[20]. The objective of this consultation was to further specify requirements for the implementation and roll out of smart meters by means of questions to relevant market parties (and other parties involved). The questions covered the roll out method and the associated responsibilities of the different market parties, the way in which the metering information was to be channeled, the required (high-level) specifications for smart meters and the question how the (approximately 2 million) small business connections were to be handled.

The background to this consultation was the fact that the British energy market is extremely complex. Whereas in other European countries it is usually the grid operator that has the responsibility for the roll out of smart meters, the United Kingdom is faced with competition in the meter market. Furthermore (and this is also different in most countries), the grid operators for the electricity and gas used by a household are different parties. The latter introduced an additional complication, because the government wanted to be able to use the same communication infrastructure for both gas and electricity. Finally, the large number of connections is a complicating factor; we are talking about a total of approximately 50 million electricity *and* gas meters.

By order of the Department of Energy and Climate Change (DECC[21]) the company Baringa Partners identified and evaluated three different approaches for a possible roll out and for the distribution of roles and responsibilities within the energy value chain[22]. The model that was ultimately selected is the so-called *Central Communications Model*, whereby a national provider is responsible for the infrastructure and for the data exchange. Energy suppliers remain responsible for the meters, but they *have* to use this provider[23].

The final report, outlining the results of the consultation round of May 2009, was published in December 2009[24]. A large proportion of the recommendations from the consultation document, such as the timeline for the implementation, were confirmed in this report. Smart meters will also be used for most of the non-domestic (business) connections; for the moment the timeline is the same as the timeline for households. In the coming period a large number of matters will be defined further by DECC in the so-called *Implementation Program*.

Belgium does not yet have any legislation regarding the (compulsory or otherwise) introduction of smart energy meters. The EU directive regarding energy efficiency for end users and energy services (2006/32) has not yet been implemented either. This does not mean that the subject of smart meters is not a current issue in Belgium. This theme is high on the agenda of nearly all stakeholders in the market. The three regional regulators have held a number of consultations, organized study days and started work groups.

The trigger for these developments in Flanders was the fact that there were many complaints about late or erroneous invoices. This translated into (excessively) high costs for the energy suppliers and ultimately also for the energy consumers. By order of the Flemish regulator VREG, KU Leuven conducted a study into the communication methods that could be used to communicate with smart meters[25]. In 2006 VREG also performed a comprehensive analysis of the market forces in Flanders[26], in which the subject of smart energy meters played an important role[27]. Cost-benefit analyses have also been performed. In addition, a number of grid operators are currently conducting pilots.

Recently a vision document relating to the market model in Flanders was published[28]. According to the document a roll out in Flanders over the period 2012 – 2020 is feasible. The roll out of smart grids should also be completed by 2020. According to this vision document there is consensus about the need to introduce smart meters for the future functioning of the energy market, where by 'functioning of the market' is broadly defined so that both technical (grid) and commercial (market processes and services) aspects are included. There is also consensus about the fact that the installation of the smart meters is a task for the grid operators. However, the energy suppliers do want to have input in the (technical) specifications of the smart meters. The idea behind this is the fact that they want to offer commercial services using the smart meters.

At the end of 2008 the Walloon regulator, CWAPE, published a four-stage plan relating to the introduction of smart meters[29]. It is envisaged that the functionality required for an infrastructure with smart meters will be defined in the first phase. The second and third phases will deal with the preparation and realization of a pilot project. In the fourth phase the pilot project will be analyzed and a decision must be made about the large-scale introduction of smart meters in Wallonia. However, a timeline is not provided.

Figure 2.1 shows the timeline for the implementation of smart meters in the five selected European countries.

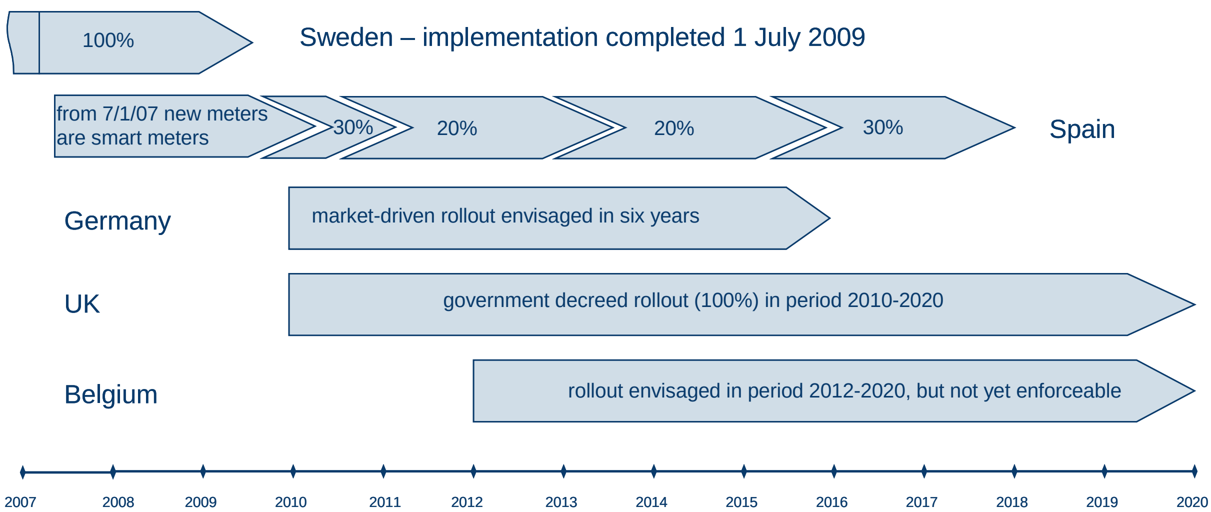

Figure 2.1 The timeline for the implementation of smart meters in the five selected countries.

2.3.4 What have the result of the cost-benefit analyses been?

In May 2002 **Swedish** Energy Agency STEM performed a cost-benefit analysis of the introduction of the monthly reading of electricity meters[30]. This analysis shows that more frequent reading of electricity meters will lead to a net gain for the economy of Sweden of around 60 million euro per year, among other reasons because of a 1 to 2% reduction in electricity usage and because electricity suppliers will be able to considerably reduce their administration costs. According to the report this would more than offset the higher costs of electricity distribution (after all, the meters would have to be read more frequently). STEM subsequently proposed to start the monthly reading of the meters of all the electricity consumers in phases. This has resulted in a law that made monthly meter reading compulsory. All electricity meters in Sweden can now be read remotely.

The roll out of smart meters in the **United Kingdom** will be a major national infrastructural program. A total of around 50 million electricity and gas meters will be replaced and the accompanying communication infrastructure will be installed. The cost of the national roll out has been estimated at 8.6 billion pounds, and expectations are that the total revenue in the next 20 years will be around 14.6 billion pounds. The result of the cost-benefit analysis for the United Kingdom is therefore positive: the net revenue of the smart meter program will be around 6 billion pounds. This revenue is distributed among the suppliers, customers and the government[31].

In **Belgium** KEMA performed a societal cost-benefit analysis regarding the financial feasibility of the introduction of smart meters in Flanders[32] by order of Flemish regulator VREG, in 2008. The objective of this analysis was to obtain insight into the costs and benefits of a large-scale introduction of a smart metering infrastructure for the gas and electricity usage of consumers in Flanders. The conclusion was that, from a societal point of view, there appears to be a *negative* business case. The net present value of the reference alternative shows a *negative* balance of minus 389 million euro. In 2009 comparable analyses were performed for Wallonia and Brussels by order of a private party, with comparable results[33].

Over time, various cost-benefit analyses regarding the introduction of smart meters have been performed in **the Netherlands**. The main ones were those by Frontier Economics, Accenture and KEMA[34]. The Frontier study was performed by order of the Office of Energy Regulation. The objective of this study was to use it as the basis for a decision on how to regulate metering tariffs in the period from 2009 onward, and on how high these tariffs should be. The Office of Energy Regulation has a deciding vote in this matter. In the study performed by Frontier the metering tariffs were incorporated by using the 2005 tariffs and then correcting them for inflation over the years for which the analysis was performed. This study therefore *focused exclusively* on how smart meters would affect the grid operators.

This is an important difference between the Frontier and KEMA studies. The study done by KEMA focused on a *societal business case*. The objective was to investigate whether there was a positive business case for the Dutch society as a whole. In the KEMA study the costs and benefits that can be distinguished upon the introduction of smart meters are allocated to various parties. These parties include: grid operators, energy suppliers, users and the government. In the KEMA study, topics like ‘energy savings’ and ‘reduced energy prices through improved competition' were included, in the Frontier study they were not.

Another important difference is the fact that the KEMA study was performed on the basis of additional costs (a ‘differential study). It looks at the costs of an alternative (introduction of smart meters) compared to the cost of *business as usual* (continuing with ‘dumb’ meters). The Frontier study focuses on the *cash flow*. It looks at the actual costs and benefits of a smart meter introduction scenario for the grid operators. For this reason the two studies are not comparable when it comes to the end result!

With respect to the approach there are similarities. For instance, the information used in both reports originates from international desk research (figures from other studies) and from the different stakeholders. These stakeholders – e.g. grid operators, suppliers and meter manufacturers – were interviewed by Frontier and KEMA. Needless to say, the actual numbers for the costs and benefits differ between the Frontier and KEMA studies, but they are in the same ballpark.

The Frontier study is based on a best-case and a worst-case scenario. An upper and lower limit was found for all the costs and benefits. In the best-case scenario the lower limits of the costs and the upper limits of the benefits were used; in the worst-case scenario these limits were reversed. The KEMA study also included a sensitivity analysis, but this was done per parameter and the effects of the change are reflected in a tornado diagram. This is looking at the matter from a different angle; scenarios versus influencing individual parameters.

The Frontier study also uses the timeline for the implementation of smart meters planned by the Ministry of Economic Affairs at that time; this means that in 2009 and 2010 trials would still be conducted and a priority roll out would take place, and that the national roll out would then take place over the next six years (between 2011-2016). At the time of the KEMA study this planning had not yet been published, which is why KEMA implemented a different roll out model.

The result for the best-case scenario in the Frontier study is a net present value of 822 million euro and for the worst-case scenario a net present value of minus 933 million euro (negative). The net present value of the reference situation in the KEMA study is 1,310 million euro.

In 2005 Accenture also performed a cost-benefit analysis for the introduction of smart metering systems. The reason for this study was a question of the Ministry of Economic Affairs regarding the extent to which the legal framework would need adjusting to stimulate the roll out of smart meters. The choice between different meter market models, such as the supplier model or the grid operator model was relevant in this context. Sector organization

EnergieNed wanted to give direction to this discussion about the desirability of the introduction of the smart meter, linked to the implementation method. EnergieNed subsequently instructed Accenture to work out the business case with respect to the introduction of smart meters in the Netherlands.

The results of the various cost-benefit analyses are outlined in Appendix B.3

The data from the different cost-benefit analyses has been compiled in the table below. In **Germany** and **Spain** cost-benefit analyses were also performed. However, no public sources for these analyses are available.

In summary the following comments can be made about the different cost-benefit analyses:

- ✓ *Type:* mostly societal cost-benefit analyses based on the additional costs of the smart meter (differential studies).
- ✓ *Commodities:* usually electricity *and* gas; in the case of Sweden electricity only.
- ✓ *Roll out time:* 5 years (not including pilots) appears to be an acceptable period for fairly small countries.
- ✓ *Party doing the roll out:* in most cases the distribution system operator; only in the United Kingdom the supplier.
- ✓ *Horizon:* differing periods, often linked to one or more periods of the life of the smart meter.
- ✓ *WACC:* the use of a regulated WACC for the energy sector appears to correspond with the social character of most of the cost-benefit analyses.
- ✓ *Scenarios:* there is no clear line in the definition of scenarios; there are a lot of differences.
- ✓ *Communication technology and costs:* mainly GPRS and PLC and, to a lesser extent, ADSL. The costs for PLC are low and reasonably uniform, the costs for GPRS are relatively uncertain.
- ✓ *Investment in meter hardware:* very big differences in the costs of meter hardware.
- ✓ *Main benefits:* mostly energy savings, the elimination of physical meter reading and process improvements.
- ✓ *% energy savings:* percentages appear low in view of recent research by, for instance, Darby, Fischer and Abrahamse (see also chapter 3).
- ✓ *NPV:* major differences as a result of uncertainty regarding costs and benefits.

2.3.5 What smart functionality is envisaged?

In many countries in Europe, including the Netherlands, a range of functional requirements will be imposed on the smart meter (and on the smart infrastructure). Only in Sweden is this *not* the case.

Physical rather than remote meter reading is still permitted in **Sweden** (but is not really economically viable because monthly meeting readings have to be collected). Still, many meters in Sweden have 'smart' functionality. In approximately 85% of households the meters are capable of collecting hourly values as well. Incidentally, in reality this is only done in 15% of cases. A proposal was recently submitted suggesting the collection of low-volume user market hourly values in the near future. Around 40% of the meters can control the load remotely ('remote load control') and 32% of the meters can be turned on and off remotely ('remote (dis)connect'). *In-home displays* are also used, but this is definitely not done on a large scale. With regard to the communication between the meters and the data collection system, PLC is used in 58% of cases, GPRS in 22% of cases and RF in 20% of cases[35].
In Sweden there are no rules for *third-party access* with respect to the usage data of consumers. Neither are there legal obligations for the interoperability of smart meter systems or for the exchangeability of meters. For the compulsory exchange of the (aggregated) data[36] from the grid operator to the various suppliers, the program responsible parties and other involved market parties such as the national transmission system operator, a standard data format (EDIEL) *is* used.

The **Spanish** legislator has formulated a set of minimum (general) functional and technical requirements for the smart metering infrastructure[37] to be implemented in the country. However, these general functional and technical specifications only fill in the main outlines and must be worked out into more specific requirements by the relevant grid operators. These requirements can roughly be divided into the following categories:

- ✓ registration and documentation of usage
- ✓ switching and load shedding ('squeezing')
- ✓ monitoring of the security of supply, fraud and grid parameters (power quality)
- ✓ communication.

At present the requirements of the Spanish legislator are not comparable with the requirements formulated in the Netherlands (NTA 8130 and DSMR), as the latter are much more detailed. For gas and water no functional and technical requirements have so far been formulated. The main functional requirements of the electricity metering infrastructure to be implemented in Spain have been summarized in AppendixB.4.

Communication protocols have not been specified in Spain; these are the responsibility of the grid operator. However, it is deemed important that these protocols are 'open'[38]. The meter must also have an optical port for local communication and a display to allow for local reading of the consumption. Meters must also comply with the metrological requirements of EU directive 2004/22 (the Metering Instrument Directive), implemented in Spain by means of law RD 889/2006 (comparable to the Dutch Metrology Act).

In the **United Kingdom** DECC has suggested functional requirements for meters in the consultation document dated May 2009. In addition to the standard function for meter reading and *load management*, functions have been included for remote connection and disconnection, linking to *Home Area Networks* (HANs) for in-home displays and for other equipment that may be linked to the energy meter. There must also be an option that makes it possible to measure and communicate local energy generation (gross production). The communication between the meter and the centralized system must be bidirectional (and therefore enable communication from the customer to the energy company and vice versa). After the consultation it became clear that the functional requirements have broad support. An exception is only made for the gas valve that enables the remote connecting and disconnecting of gas meters; a number of practical implications require further research. Most of the parties that were consulted go so far as to consider the in-home display *essential*. The British government therefore feels that such a display must *come with the smart meter as standard*.

In the Implementation Program previously referred to in paragraph 2.3.3 a number of issues relating to the functionality will be worked out further. The aforementioned functional requirements will be converted into more specific technical requirements, whereby interoperability (e.g. through the use of open standards) plays a role. Attention will also be paid to *security and privacy issues*. The Implementation Program will also look at the development of smart grids.

In **Germany** the legislator has so far not formulated any official functional requirements for the smart meters. Of course the meters *are* subject to the rules governing calibration. The German legislator prefers market-driven standardization of the technology instead of government-prescribed standards. However, in November 2009 the German regulator *did* submit a model including the basic requirements for a metering installation to the market for consultation[39]. This model only lists a few requirements the meter must comply with, such as usage registration and the visualization of meter data. Interoperability with other equipment is also named as important. However, the model does not contain technical requirements and/or requirements relating to standardization.

In Germany there is general consensus among the companies in the metering industry that a certain level of standardization of the technology for a national implementation of smart meters is inevitable. The necessary standards are being discussed and specified in workgroups established specifically for this purpose, among others the OpenMeter Group[40]. Some results of these activities include the *MUC Lastenheft* and the *eHZ-Lastenheft*, in which an attempt is made to standardize the communication and the metering instruments respectively. The MUC – an acronym of *Multi-Utility Controller* – plays a central role in a large number of pilot projects in Germany. The MUC can process meter data originating from different sources (e.g. the electricity, gas, water and/or heating meter) and forward the information to the centralized infrastructure.

In **Belgium** the VREG has formulated an overview of possible functions in smart meters (both for electricity and gas). The functionality is divided into *basic functions*, which the smart meter must have as standard, and *optional functions*, which are not (yet) envisaged in the basic meter but which are deemed interesting in the long term. An overview of the basic and optional functions for the metering infrastructure to be implemented in Belgium is included in Appendix B.4.

Lessons from Sweden

One of the lessons that must be learned from the situation in Sweden is that of the possibility of *vendor lock-in*. This means that grid operators can become too dependent on a single supplier, because in Sweden the metering infrastructure does not have to comply with a certain standard (compare in the Netherlands: DSMR). This is why it is important to use open systems (open communication protocols). The grid operators have been very aware of this and have always tried to prevent vendor lock-in. The bigger companies did this by buying their meters from different suppliers whilst, at the same time, ensuring that these meters could be read via the same infrastructure. The smaller companies worked together through the SAMS-consortium[41]; among other things they ensured that common meter and protocol specifications were used that were supported by the various suppliers.

2.3.6 Where in Europe have pilots already been conducted?

At present some 100 pilot projects in which smart energy meters are tested are being conducted in **Germany**. These pilot projects are not only realized by grid operators, but also by energy suppliers, meter manufacturers and metering companies, producers of energy meters and by the *Stadtwerke* (or combinations thereof). The focus is mainly on the *technical evaluation* of the metering technology, the interoperability of the different meters, and the communication technology and infrastructure. In these pilot projects the potential effects on the energy usage among end users and the potential of binding consumers by making smart meters available play a secondary role.

One of the biggest pilot projects in Germany is the RWE *'Mühlheim zählt'* project. This project is the first of its kind in which the biggest number of meters with accompanying communication infrastructure is being installed. From 2008 until the end of the 2011, 100,000 smart electricity meters are being installed in households in the town of Mühlheim an der Ruhr; the accompanying communication infrastructure is being expanded simultaneously.

In the **United Kingdom** a pilot of 40,000 households was conducted in July 2007 in order to assess the effect of the feedback on the energy consumption of customers, and to evaluate the attitude of customers with respect to smart meters and other tools. Since 2007 four major pilots have been started, all of which are scheduled to be completed in 2010. The pilots were co-financed by the British government, which reserved an amount of 20 million pounds for this purpose[42].

In **Belgium** a number of different pilot projects are in progress or under preparation. Grid operator Sibelga in Brussels recently completed a pilot project[43]. In collaboration with three meter suppliers (namely Landis, Actaris and Siemens) around 200 electricity meters (no gas meters) have been installed since the autumn of 2008. The communication technology was based on GPRS and PLC. A total of between 1,000 and 2,000 meters will be installed. The objectives of this pilot are, among other things, evaluating the interoperability, testing the communication technologies and accumulating general know-how. Grid operators Infrax and PBE have also formulated plans for pilot projects. Flemish grid operator Eandis will be installing smart meters in three phases[44]. An evaluation will follow each phase to decide whether the project will be continued. In the second quarter of 2010 around 4,000 meters will be installed in the cities of Leest and Hombeek, near Mechelen. In 2012 the pilot project will be expanded to 40,000 households and the rest of the coverage area is expected to follow from 2014 onward. Eandis has developed a smart electricity meter under its own management. For the communication between the meter and the centralized data server Eandis uses a proprietary invention for the real-time exchange of information. The company has applied for a patent.

In addition to these technical aspects, economical and ecological aspects are also included in the pilots. Among other things Eandis expects it will be able to resolve power outages more easily and that more accurate and correct invoices can be formulated when people move home. Eandis also hopes that energy fraud, which is currently estimated at around 1.5%, can be reduced considerably. Approximately 135 million euro has been budgeted for the first two phases. The cost for the complete introduction of smart meters in the Eandis coverage area - approximately 2.5 million electricity meters and 1.5 million gas meters - is estimated at around 1.5 billion euro. It is expected that the entire coverage area will have been provided with smart meters by around 2019.

After the publication of the government plans relating to smart metering systems in **Spain**, Endesa and Iberdrola started a number of large-scale R&D projects, the main objective being the formulation of technical specifications that will make it possible to buy interoperable smart meters from a large group of suppliers. Iberdrola plays a leading role in both the Prime Project, financed by the EU, and the so-called OpenMeter Consortium. Companies from 19 different countries participate in the OpenMeter Consortium, including Endesa, German company RWE, French company EDF and other (energy) companies, including companies from the Netherlands. The objective of both projects is to specify a European, open, public standard for automatic meter reading. The emphasis of the Prime Project is on the use of ‘high performance PLC’.

Iberdrola is planning to implement the first 100,000 electricity meters on the basis of the Prime specifications in the first pilot in Spain. As part of a project with smart meters Endesa was also working on the development of the specification for a communication infrastructure based on PLC. However, after Italian company Enel acquired a majority share in Endesa the project was stopped. It is now likely that the solution chosen by Enel in Italy will be adopted in Spain as well. Enel recently supplied 100,000 PLC meters to its former subsidiary Viesgo. In 2008 Viesgo became the property of E.ON España (as part of the agreement with Endesa). The Viesgo implementation is currently the biggest project in the area of smart electricity meters for households in Spain.

It is likely that smart metering systems will soon also be introduced in the gas sector. In 2009 the company Gas Natural started a pilot with 10,000 meters. The objective of the pilot is the evaluation of two different wireless meshed communication solutions, one by Coronis Systems and one by NURI Telecom.

In **Sweden** the roll out of smart meters has now virtually been completed.

In Europe there are also various examples of projects aimed at stimulating the development of smart grids. These are discussed in Appendix B.5.

2.3.7 What energy savings are anticipated?

In a number of countries studies are being conducted into the effect that the feedback of meter data has on energy consumption. In some cases price information is also provided. By using a clearly higher tariff during peak hours attempts can be made to shift energy consumption to the lower-rate hours. This is referred to as demand management (active demand response).

In the cost-benefit analysis that was performed in **Sweden** (see paragraph 2.3.4) the Swedish energy agency STEM assumes that monthly reading of electricity meters results in a 1 to 2% reduction of the energy usage. However, an accurate analysis of this assumed reduction is not available.

Swedish studies by the Market Design Research Program[45], comparable to the Dutch Agentschap NL, have looked at the effect that price has on consumer behavior (among others in customers of Skånska Energi and Vallentuna Energi). Peak electricity rates increased considerably. Every day the customer would get advance notice (for instance by e-mail) about the rate (these were ‘Code Red tariffs’ of 300 to 1000 euro per MWh) and the times at which the tariffs would apply. All the participating customers (several dozen) had a meter with hourly readings. The pricing was structured in such a way that if a customer did not take any measures the final bill - despite the higher tariffs during a number of peak hours - would still stay the same as normal. However, if the customer *did* take certain measures (changing consumption to off-peak hours) the final bill would be much lower (up to 240 euro per year). This study has shown that hourly metering combined with variable tariffs can increase the price elasticity of the market demand and that this can make a considerable contribution to the security of supply and a properly functioning electricity market.

The cost-benefit analysis in **Flanders** took into account a potential energy savings (as a result of feedback of meter data) of 1.5%. In the **United Kingdom** a variable range between 1.5 - 4% is used.

The **German** *Intelliekon* project focuses on sustainable energy consumption through the use of smart meters, communication and tariff systems. The objective of the project is to evaluate various feedback tools for the energy user, whereby meter data from smart meters is visualized. The **Spanish** GAD project investigates how the electricity consumption of various categories of low-volume users can be reduced, among other means by providing information about the energy price, energy sources and environmental effects. Thanks to this kind of information consumers have the option to come to contractual agreements that best suit their personal consumption profile.

2.3.8 Have there been problems relating to privacy?

It is generally acknowledged that there is a potential privacy risk associated with the use of smart metering systems. After all, such meters can give detailed insight into the energy usage of consumers. Private information about the user could be directly and indirectly derived from the meter data. In this context the Consumers’ Association lists[46]:

- ✓ personal habits
- ✓ when someone is (usually) at home
- ✓ when someone is away for an extended period of time, for instance on vacation
- ✓ the electrical appliances in the home
- ✓ what someone is doing, when electrical appliances are being used
- ✓ whether the electrical appliance is at the start or the end of its life cycle.

Although it is debatable whether the last three items of information can be derived based on 15-minute metering of the electricity usage, the first three items on the list are indisputable. The Consumers’ Association also warns of the risks associated with the provision and storage of the meter data. The energy suppliers want to make the information easily accessible to consumers via web pages. This creates a real risk that *hackers* may be able to access this personal information. It would be interesting to find out if these potential privacy issues have resulted in problems in other countries.

Based on the available information it appears there have been no debates about privacy and the possible infringement of people's personal privacy before or during the implementation projects of smart meters in **Sweden**. This does not alter the fact that the right to privacy, among other things as associated with the use of the Internet, receives a lot of attention in Sweden. In 2006 a political party was established (the Pirate Party - *Piratpartiet* in Swedish) that has put the right to privacy high on its political agenda. The *Piratpartiet* has considerable support in Sweden and is even represented in the European Parliament. However, the same basic concerns relating to electronic privacy have had different political consequences in Sweden and the Netherlands. One explanation may be the fact that in Sweden only the collection of monthly readings (and not 15-minute or hourly values) has been made compulsory. Still, in around 85% of households hourly values can also be collected (although this is only actively done in 15% of cases).

In the **German** attempts at standardizing all the communication interfaces and communication media the theme of ‘protecting meter data’ is certainly also being taken into account. In Germany there is general consensus that meter data derived from energy readings is private information that must be protected in accordance with the *Bundesdatenschutzgesetz* (comparable to the Dutch Personal Data Protection Act). As a result the exchanged meter data can only be transferred to the grid operator and/or the parties responsible for the metering *in encrypted form*. From a point of view of data protection even the question to what extent a meter that lists actual usage data of a consumer may be installed in a room that is accessible to other persons (such as the cellar of an apartment complex) remains open at this point.

In **Belgium** the introduction of smart meters is still in the research phase. Expectations are that the protection of the privacy of end users will play a role. In **Spain** and the **United Kingdom** privacy and security aspects will also be incorporated in the implementation phase.

2.4 Learning points from Europe

The first lesson that can be learned from the European overview is that in virtually all of (Western) Europe the transition toward more smart energy meters has been started. The speed at which this is happening differs in the various countries. There are countries, like Sweden and Italy, where the penetration level of these meters is virtually 100% already. In other countries, like the United Kingdom and Spain, the express choice to replace the existing meters with smart meters at a certain rate was made only recently. The envisaged timeline runs to the middle of 2020; a choice inspired by the European legislation. There are also countries where smart meters are still being researched; Belgium is one of them. However, in Belgium there is so much activity surrounding smart meters that it would seem safe to assume that nearly all ‘dumb’ meters will have been replaced with smart ones within the aforementioned timeline.

The above timeline (all meters replaced by smart ones by the middle of 2020) is certainly not unrealistic. We can see from the situation in Sweden that the meters can be replaced very quickly, certainly once the decision regarding the preferred technology has been made and all the logistical processes required for the roll out are in place. After all, in Sweden 70% of all meters were replaced by smart meters in a period of just 18 months!

Major similarities can be seen within Europe when it comes to technology. The functional requirements for smart energy meters can roughly be divided into four categories, namely (1) registration and documentation of usage; (2) switching and limiting the load (‘squeezing’); (3) monitoring of the security of supply, fraud and grid parameters (such as power quality) and (4) communication. In-home displays are not envisaged everywhere. In the United Kingdom the in-home display is considered an essential tool for monitoring energy usage. In Flanders this display is also considered a basic function. However, in Spain the display is not included in the main functional requirements. In-home displays are rarely used in Sweden, either. However, (international) standardization is still a point for attention.

Cost-benefit analyses have been performed in many countries. Most of these analyses come out positive. The main revenue items in these analyses tend to correspond. These are: energy savings, the elimination of physical meter reading and process improvements. In those cases where the cost-benefit analyses had a negative result a conscious choice was made for a worst-case scenario (analysis by Frontier) or a cautious approach (analysis in Flanders: a deliberate decision was made to estimate the percentage of achievable energy savings as very low).

The savings expected from the introduction of the smart meter are estimated differently by the various countries. Estimates range from a few percent to over 10 percent.

In the studied countries (with the exception of Sweden) there is plenty of attention for smart grids and pilots are being conducted. From a *qualitative* point of view there are many benefits to smarter grids (such as facilitation of decentralized electricity generation and optimal load behavior of electric vehicles). However, not enough studies have been conducted into the *quantification* of the advantage of the smart metering infrastructure for a future smart grid.

3 COST-BENEFIT ANALYSIS SMART METERS

3.1 Why a new cost-benefit analysis?

In 2005 KEMA performed a societal cost-benefit analysis for SenterNovem (now Agentschap NL) in respect of the national introduction of a smart metering infrastructure. This cost-benefit analysis resulted in a positive net present value of approximately 1.3 billion euro. In addition to this cost-benefit analysis a number of other cost-benefit analyses were performed for the Dutch situation, which gave no cause to revise the analysis performed for SenterNovem (see paragraph 2.3.4).

As explained in paragraphs1.2 and 1.3, the situation in the Netherlands has now changed to such an extent that a new cost-benefit analysis proved necessary. The reason is that the original proposal for changes to the Electricity Act and the Gas Act was not approved by the Senate. This has resulted in an amendment to the legislative proposal by means of a proposal to amend the bill. This amendment proposal is based on a smart meter that can be used in three settings:

- ✓ administrative off,
- ✓ standard reading and
- ✓ detailed reading.

The three different settings are explained further in paragraph 3.2.

A major difference compared to the 2005 analysis is that the point of departure is now a meter that is only read once every two months in the standard situation. Only if express and unequivocal permission has been obtained from the consumer can a detailed reading be taken. In the 2005 analysis detailed reading was still the standard situation.

Another important change is the option the consumer has of refusing the smart meter. This means that the consumer in question will keep his traditional meter. In the case of new construction and renovations it *does* become compulsory to install a smart meter, and there is no obligation to replace it with a traditional meter at the request of the consumer. In this case the consumer can have the smart meter treated like a traditional meter by registering it as ‘administrative off’.

Among other things, this chapter looks at changes that have been made in the cost-benefit analysis. The consequences of this changed situation for the cost-benefit analysis have been worked out in seven themes. The results are discussed after the overview of the changes.

3.2 What stays the same and what has changed?

The legislator's starting point is still a large-scale roll out of the smart meter. This means that the number of refusers must be small. In this report 2% is used as the limit value and the starting point for the reference situation. This is approximately the current percentage of consumers where the grid operator does not have access to the meter for various reasons. At this percentage of refusers the grid operator does have to make separate arrangements to service this group of consumers, but this does not incur significant additional costs. At this percentage a national roll out can still be completed efficiently.

The starting point is also a meter that complies with a single set of functionalities and therefore also has one fixed price. Figure 3.1 shows a schematic overview of the smart metering infrastructure as provided for in the current Dutch standards. The law does not stipulate a specific communication infrastructure; the grid operator is free to decide on the infrastructure, provided it complies with the privacy and security regulations.

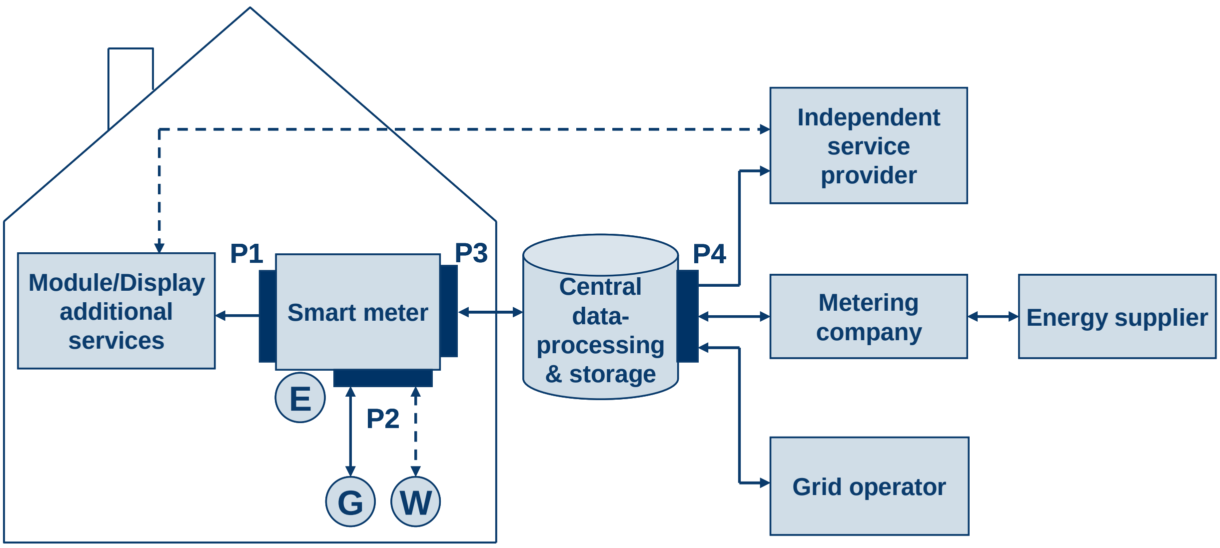

Figure 3.1 Structure of the smart metering infrastructure. P1 is the so-called consumer port which, among other things, gives access to the meter readings and actual usage. E, G and W stand for the metering parts for electricity, gas and water.

An important change is the option to have the meter turned to 'administrative off', or to take a detailed reading. These are the other two 'settings' described in the proposal to amend a bill, in addition to the standard reading and the option of refusing the smart meter altogether. Table 3.1 gives an overview of the different options and the associated functionalities. The option to have the meter turned to 'administrative off' should minimize the number of refusers. In the 'administrative off' setting the consumer port (P1) can still be used, so that the consumer himself *does* have access to accurate meter data. However, in this setting the consumer can not be disconnected remotely. The option to select ‘administrative off’ will undoubtedly lower the threshold for choosing a smart meter. However, the drawback is that there is little reason for the consumer to have his smart meter turned on, especially because that means he *can* be disconnected remotely. This point is being debated within the energy sector.

Table 3.1 Overview of the functionalities of the smart meter in the various settings defined in the proposal to amend a bill.

functionality	conven-tional meter	smart meter		
		Administrative off	standard reading	detailed reading
remote disconnection or usage limitation	✘	✘	✓	✓
metrological control of the meter	✘	✓	✓	✓
technical control of the grid	✘	✘	✓	✓
bi-monthly reading and at the time of moving house or changing suppliers	✘	✘	✓	✓
frequent reading (e.g. 15-minute values) and tariff management	✘	✘	✘	✓
meter data locally available (P1)	✘	✓	✓	✓
Connection to other meters (P2)	✘	✓	✓	✓

Functionalities that are not self-explanatory are explained briefly below:

- ✓ *remote disconnection and usage limitation*: the grid operator has the option to centrally control the meter so that it will allow no electricity or only a limited amount of electricity to get through
- ✓ *metrological control*: control and maintenance of the meter (among other things reading of the meter status (battery, alarms, error messages), firmware updates, date and time synchronization and recording changes between the various settings ‘administrative off’, ‘standard reading’ and ‘detailed reading’
- ✓ *technical control of the grid*: reading the metering values and the fault register to monitor the quality of the electricity supply (power quality, short and long-term interruptions of the energy supply)
- ✓ *tariff management*: the possibility to charge a variable, time-dependent tariff and to remotely control domestic appliances (demand side management).

Another important change in the current study is the increased focus on feedback to the consumer regarding the energy usage. Compared to the 2005 analysis a lot more studies have been performed or made accessible that quantify the effect that feedback of consumption data has on energy usage. This effect appears to be greater than previously estimated and is included in this new analysis as a separate theme. Among other things a distinction is made between the effect of direct feedback and indirect feedback.

Another theme in the new analysis is the focus on smart grids. It is generally assumed that a smart metering infrastructure is an essential step in establishing a smart (distribution) grid. This theme represents a value that is included in this cost-benefit analysis. More details in paragraph 3.7.

Compared to the 2005 analysis, a lot more insight has been obtained into communication, hardware and installation costs. There is also a better understanding of the lifespan of smart meters for gas and electricity and the costs associated with data storage and processing systems. These new insights have been incorporated in the current analysis. The interest rate has also been adjusted to the current value of the regulated real WACC. This is the average cost of capital for the grid operators. The use of the regulated WACC is based on the social character of the cost-benefit analysis. On the one hand the general cost level has gone up, but on the other hand this is somewhat compensated for by the use of the regulated real WACC.

The costs for additional measures to ensure privacy and security have been included in the increased cost level, even though this is only a very general estimate. It may be argued that the level of privacy and security should also result in a social benefit as it appears to be an important and valued aspect of the introduction of a smart metering infrastructure in the Netherlands. On the other hand it may be argued that this is a kind of 'hygiene factor': it has to be regulated but, once that has been done, it does not provide added value. Such a benefit is hard to quantify in any case and, partly for this reason, has not been incorporated in this study.

The standard situation is based on bi-monthly meter readings. The frequency of the usage and indicative cost overview is adjusted accordingly. The trend towards increased digital invoicing is also included in the analysis (linked to the current internet penetration of 80%). This means that 80% of the bi-monthly statements will be sent digitally.

3.3 Approach to cost-benefit analysis on the basis of themes

The differences between the current situation and that of 2005 have been summarized in seven themes, each of which clarifies one aspect of the changes.

Based on the changed situation as described in paragraph 3.2 the approach to the cost-benefit analysis has also been updated. To be able to clearly present the changes compared to the situation in 2005, we opted for a summary of these changes in seven themes. These themes are summarized in figure 3.2.

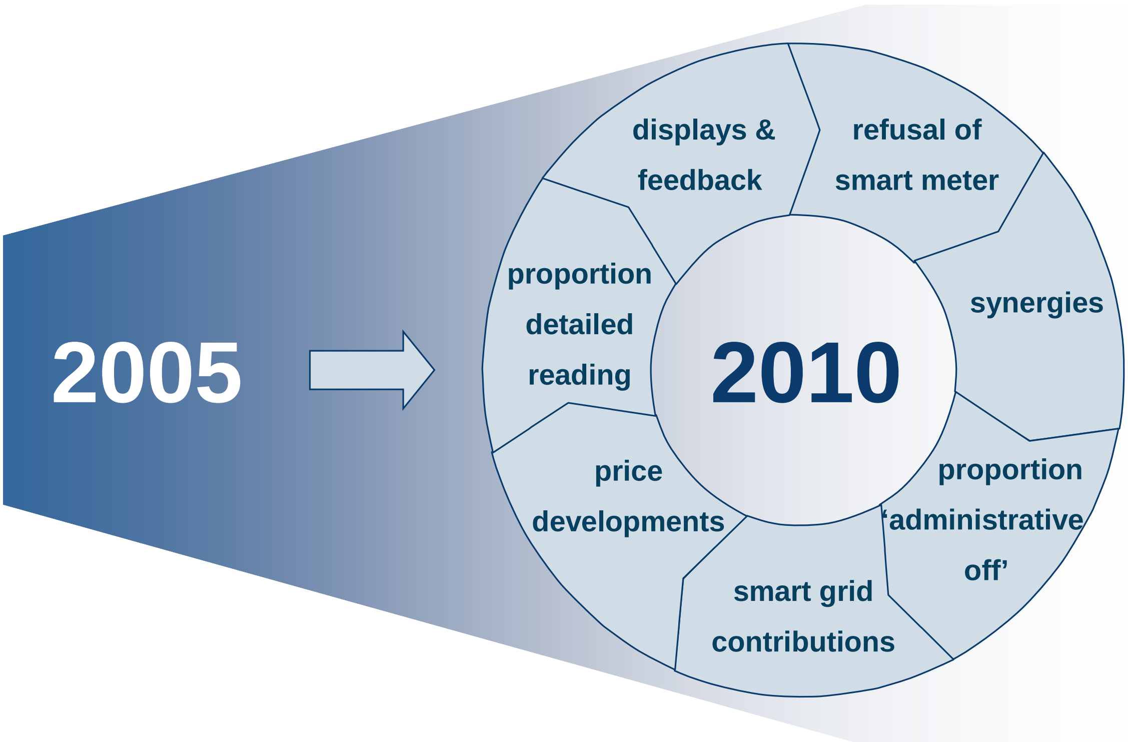

Figure 3.2 Themes of the changes compared to the 2005 analysis.

Three of the themes relate to the acceptance of the smart meter, namely the number of consumers who will refuse the meter, those who will have the meter set to 'administrative off' and those who will opt for detailed reading. These will be discussed in paragraph 3.5. Energy savings as a result of feedback and the use of smart grids are discussed in two separate paragraphs (3.6 and 3.7). The remaining two themes relate to cost reductions and are discussed in paragraph 3.8. This concerns future price developments of hardware and energy and synergy advantages in the case of coordination between the grid operators.

In addition to the updated approach based on seven themes, part of the approach has stayed the same:

- ✓ it remains a differential study that highlights the difference between a statistical baseline 'zero' situation (business as usual: traditional meters only, negligible service provision in the area of feedback of energy data and the like) and a 'one' situation (introduction of smart metering infrastructure)
- ✓ costs and benefits are quantified separately and allocated to the relevant parties per cost-benefit item

- ✓ the starting point is a single type of meter with ‘standard’ functionality and therefore also a single meter price
- ✓ the choice of communication infrastructure options remains, in other words a mix of different communication options has been taken into account.

3.4 Description of the reference situation

An important change in the policy compared to the first cost-benefit analysis is that a standard situation is assumed in which the meter can only be read to a limited extent and in which privacy aspects do not play a significant role. This is also the reference situation for the cost-benefit analysis. The reference situation results in a positive net present value of approximately 770 million euro. Important benefits are the realized energy savings, improved competition because of more consumers switching suppliers, and efficient operational processes among the grid operators and suppliers (for instance in call centers).

The reference situation for the large-scale implementation of the smart metering infrastructure is the standard reading of the smart meter. The starting point is that all smart meters are read as standard. A small percentage of consumers (2%) will refuse the smart meter and will be given a traditional meter. 80% of smart meters will be read via PLC and 20% via GPRS.

The starting point is also that no displays are installed in the homes and that only the benefits of indirect feedback of the energy usage by means of a (digital) usage and indicative cost overview (including historical comparisons, comparisons to a reference group, saving tips etc.) can be included. A usage and indicative cost overview is sent once every two months. Furthermore, 80% of consumers opt for a digital statement.

The costs of the smart meters and of the structuring of the data storage and processing systems have been adapted to the latest insights, which, in most cases, means an increase compared to the 2005 cost-benefit analysis.

The effect of the smart metering infrastructure on the market mechanism has been analyzed in a different way. The starting point is a study by the NMa[47], which indicates that households can save more than 100 euro (depending on the contract format) on their gas and electricity by switching to a different supplier. In actual fact this means that the market is not yet completely Pareto-efficient and that there is room for efficiency improvements and social optimization. The price advantages achieved by a consumer are not at the expense of other parties in the chain but result in a social benefit.

The assumption is that, thanks to the smart meter and the guarantees it offers for a simple and problem-free switch of supplier, the number of people switching supplier will increase from approximately 9% per year at present to 15% by 2050. Compared to a country like the United Kingdom, where nearly 20% of customers switch supplier every year[48], this is a moderate assumption.

Other social costs and benefits are the offsetting of the time spent by the consumer (waiting for the meter to be installed, telephone calls to call centers) and the value of the avoided CO_2 emissions.

A timeline of 10 years has been assumed for the current roll out period; a 2-year trial period followed by the further roll out of the smart metering infrastructure over the next 8 years.

The reference situation results in a positive net present value of approximately 770 million euro. With the current starting points a positive business case can be realized in the reference situation. Figure 3.3 shows the factored-in cash flows per year. This figure shows that both the incoming and outgoing cash flows increase strongly in the roll out period. With everything factored in, the investment will be recouped approximately 15 years after the roll out.

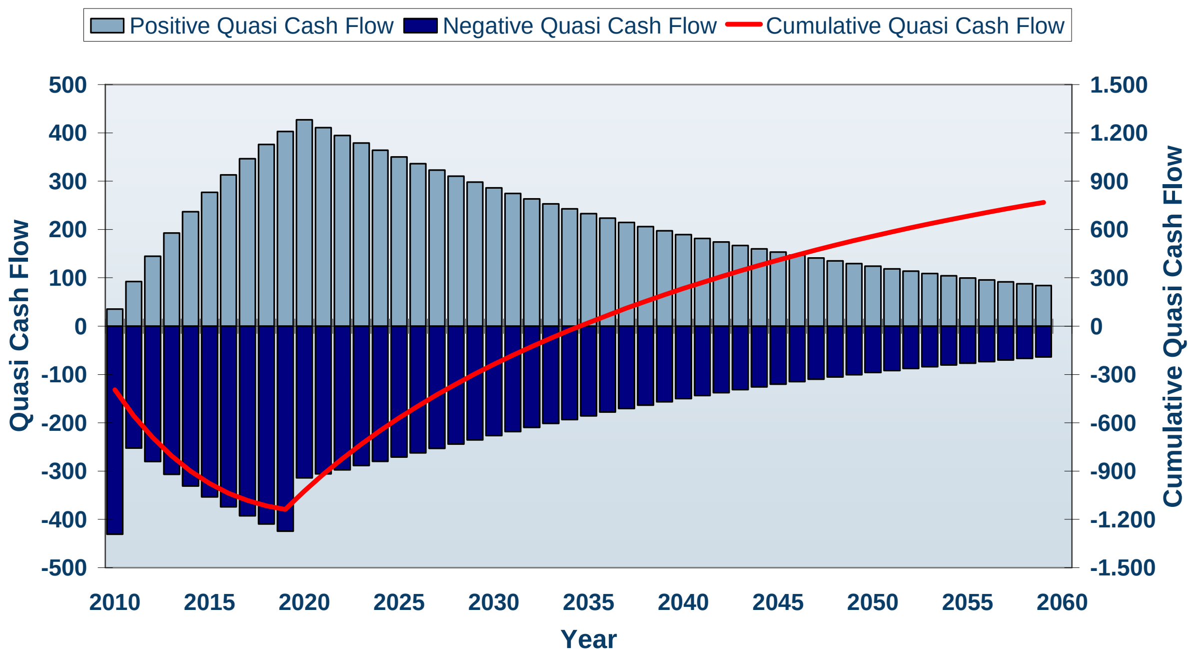

Figure 3.3 **Development of the quasi cash flow (the incoming and outgoing 'money streams' corrected for their time value) during the completion time of the project.**

The distribution of the project value per involved party is shown in figure 3.4. As in the previous analysis, the biggest benefit appears to go to the consumer, as the advantages of energy savings and efficiency improvements in the market largely benefit the consumer. The metering company (on behalf of the grid operator) will also see net benefits because the meter data is collected in an efficient manner. Other parties will lose revenue, for instance through lost tax revenue (government) and lost margin on unsold electricity as a result of savings made by the consumer (suppliers). The costs of the roll out will be at the expense of the grid operator and that can be clearly seen in this figure.

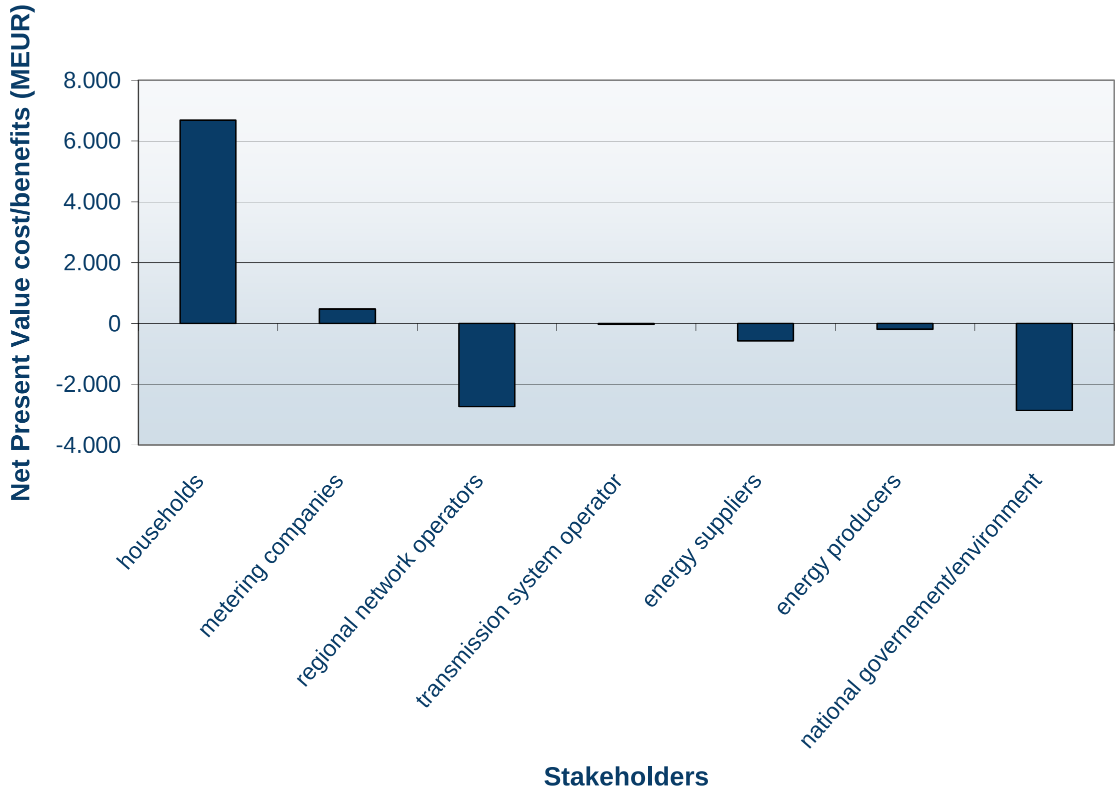

Figure 3.4 Distribution of the net present costs and benefits among the different parties. 'National government' relates mainly to lost tax revenue, 'environment' relates to the reduction in CO_2 emissions.

Figure 3.5 shows a likely distribution of the net present value of the reference situation, based on a realistic range of input parameters for the reference situation (meter costs, installation costs, realizable energy savings etc.). This shows that in an unfavorable situation a negative business case is possible (indicated in dark blue), but that in approximately 85% of the situations the business case is positive.

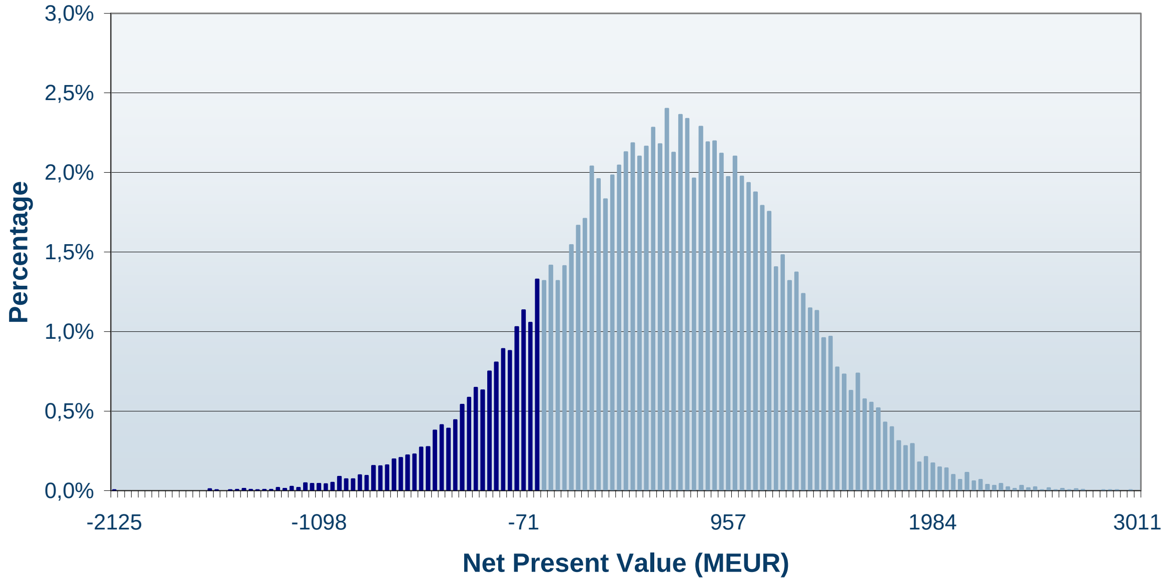

Figure 3.5 Likely distribution of the net present value of the reference situation. The dark blue section reflects situations with a negative business case.

The main cost item in the business case for the reference situation is the cost and installation of the meters. Important benefit items in this situation are (in order of relevance, in terms of their contribution to the net present value) are:

1. energy savings (1470 million euro)
2. savings on call center costs (930 million euro)
3. a lower cost level as a result of the market mechanism (increase in the number of supplier switches, 680 million euro)
4. savings on meter reading costs (500 million euro).

It may be expected that, as a result of the introduction of a smart meter, the number of calls from consumers to call centers will increase temporarily. For the duration of this project this temporary increase has not been taken into account.

3.5 Acceptance of the smart meter

The acceptance level of the smart meter is relevant for achieving a positive business case. The level of acceptance is determined by the number of consumers who refuse the smart meter, the number of consumers who opt for the ‘administrative off’ setting and the number of consumers who choose detailed meter readings with additional services. An acceptance level of approx. 80% (standard reading) has been shown to be high enough to achieve a positive business case.

In the new situation (proposal for amendment of a bill) the consumer can choose between a number of options (see also table 3.1):

- ✓ he can refuse a smart meter
- ✓ he can opt to have the meter turned to 'administrative off'
- ✓ he can opt for detailed reading and, consequently, the possibility of additional services from the supplier or other parties.

Every choice influences the costs and benefits that apply in the situation in question. Table 3.2 provides an overview of how this was incorporated in the cost-benefit analysis. Some costs, such as communication and the exchange of (metering) data (nearly) always have to be incurred in their entirety, even if only a proportion of the consumers opt for a smart meter. The consumer’s opportunities for saving energy depend on the meter choice. It is important that even with a meter that is turned to ‘administrative off’ additional services via the P-1 port and the installation of a display are still possible. The starting point is that a standard reading also provides standard indirect feedback. With detailed meter readings additional services are possible, such as time-based tariffs (detailed time of use tariffs, ToU), variable price contracts (real-time pricing, RTP) and demand management (demand side management, DSM). The starting point is that direct feedback must always be via the P1-port.

Table 3.2 Overview of costs and benefits in relation to the condition of the meter. P1 is the consumer port, P3 is the port read by the grid operator.

costs and benefits	conventio-nal meter	smart meter		
		administrative off	standard reading	detailed reading
smart meter hardware	none	full	full	full
communication and exchange of data	full	full	full	full
savings on processes of grid operator and supplier	none	partial	full	full
opportunities for energy savings for the consumer	none	direct feedback only (P1)	direct feedback (P1) and indirect feedback (P3)	direct feedback (P1), indirect feedback (P3) and other contracts (ToU, RTP, DSM)
smart grid advantages	none	partial	partial	full

If a significant number of consumers choose a conventional meter the installation costs for the smart meter will increase because the national roll out will be less efficient.

It is notable that detailed meter readings will not have a great many extra benefits compared to the standard reading, because the consumer port already offers detailed meter readings. This also becomes apparent if a number of variations on the reference situation are calculated. If 20% of consumers opt for detailed reading this will result in a net present value of 875 million euro. Compared to the reference situation this is an extra 105 million euro. Detailed meter readings via P3 (see figure 3.1) *do* result in savings amounting to an extra infrastructure for the supplier if the supplier wants to have access to detailed information. This has not been included in this study, also because it is assumed that the internet connection that is usually available can be used without incurring major costs.

If 20% of consumers opt for the ‘administrative off’ situation the consequences are more dramatic. In this case the net present value will be negative (minus 15 million euro). Important causes are the reduction in the savings on energy consumption as a result of the missing indirect feedback, costs for more frequent manual meter reading etc. From the starting point of the standard situation a minimum of 80% of consumers (rounded off) would need to choose a smart meter with standard reading. This percentage can be lower if other benefits (see other themes) are included in the business case. For instance, a consumer who has a meter that is ‘administrative off’ but who does have a display in his home (connected to the P1-port) will still be able to save energy as a result of direct feedback.

If 20% of consumers opt for a traditional meter the net present value of the project is approx. 40 million euro. This is higher than in the situation with 20% of meters set to 'administrative off' because fewer investments have been made in the smart meter. A significant increase in the installation time *has* been taken into account, because the roll out will proceed less efficiently in the case of 20% refusers. If a smart meter still needs to be installed at some point in the future this will of course incur extra costs that will negatively impact the net present value of approx. 40 million euro. Among other things these extra costs depend on the question whether the replacement of these remaining traditional meters will take place within the regular meter replacement process, and when this will happen.

In summary the net present value for the discussed situations is:

✓ reference situation (100% standard reading)	770 million euro
✓ 20% detailed reading	860 million euro
✓ 20% administrative off	minus 15 million euro
✓ 20% traditional meter	40 million euro.

3.6 Energy savings

Energy savings is one of the main benefit items. Direct feedback will result in more energy savings than indirect feedback, but direct feedback requires an investment in an in-home display. In order not to exceed the savings resulting from direct feedback (from a societal point of view) the display can cost no more than 140 euro.

Energy savings is the main benefit item resulting from the introduction of a smart metering infrastructure. The energy savings to be realized is therefore an important subject for this study and is one of the determining factors for a positive result of the business case. Appendix C looks at energy savings and the energy usage of consumers in more detail and provides an overview of studies that have been performed in that area. The main conclusions from this appendix are:

- ✓ feedback is essential to realize energy savings. This has been shown in dozens of studies based on practical experiments, although these studies were largely done in other countries
- ✓ the feedback method has a major effect on the potential energy savings percentage. A distinction is generally made between direct feedback and indirect feedback. Direct feedback (via an in-home display which also shows the current usage) is more effective than indirect feedback (via websites, usage statements and the like). An energy savings percentage of 0-10% is generally used for indirect feedback and 5-15% for direct feedback
- ✓ people learn (from feedback) in different ways. Some people learn from experiencing, some people learn from thinking things through and some people learn from doing.

Linking information and feedback for these different ‘learning styles’ is important to reach the biggest possible group of consumers. Furthermore, in practice it takes around three months before new (energy savings) behavior is ‘embedded’, and even after this ongoing attention is needed.

- ✓ the reasons for saving energy may differ. Surveys show that consumers give cost savings as the main reason, and the environment the second. However, if we look at the actual behavior of Dutch households we see that they recycle paper and plastic and give to charity on a large scale (social motivation) but switch energy suppliers or insurance companies relatively infrequently, even though in many cases they could save significant costs by switching. A complicating factor is that surveys show that consumers often think they are already achieving considerable energy savings when in practice this is not the case (the so-called *‘attitude-behavior gap’*)
- ✓ important attention points for effective (in)direct feedback are:
  - ✓ information about real-time consumption
  - ✓ sufficient frequent and long-term feedback
  - ✓ offering choices and action options
  - ✓ comparison with a usage standard (historical usage, reference group)
  - ✓ letting the consumer set targets for energy savings
  - ✓ where possible, specifying usage per individual appliance
- ✓ savings in energy usage can be achieved both through *using existing (domestic) appliances differently* (shorter showers, thermostat one degree lower, using on/off switch instead of stand-by mode etc.) and through the *purchase* of different (energy-efficient) appliances.

These conclusions provide starting points for policy (these are used in chapter 4) and for estimates of the true energy savings that are achievable in the Netherlands. However, when translating the savings percentages from the experiments into a realistic percentage for all of the Netherlands, the following three points must be taken into account:

1. Most of the experiments are based on voluntary participation and it is therefore safe to assume that the people involved were relatively committed and energy-conscious. It is not realistic to regard these savings figures as representative for the whole of the Netherlands.
2. Some of the savings figures for electricity relate partly to electrical heating. These are mostly foreign studies that are not representative for the Netherlands, as electrical heating is not used very much here. These figures should be ‘disentangled’ to show usage for electrical heating and other usage.
3. The experiments show a large spread in energy savings percentages, with differences between electricity and gas. Most of the experiments relate to electricity.

So how do we arrive at realistic potential savings figures for all of the Netherlands? To this effect a distinction has first been made between savings resulting from indirect feedback and savings resulting from direct feedback, whereby the savings resulting from direct feedback are higher than those from indirect feedback. We have also assumed that, in line with the market segmentation model developed by Motivaction for this purpose[49], there are different population groups in the Netherlands that deal with energy savings differently. The study by Motivaction distinguishes:

- ✓ *those who are already convinced (25%):* this group is already serious about energy savings and is driven by social responsibility and environmental awareness. The savings potential in this group is average, as this group is open to energy savings but has already done a lot in that area
- ✓ *those who are hard to reach (30%):* this group is relatively individualistic, has little environmental awareness and is mainly interested in comfort and convenience. Costs only play a very limited role. The potential for energy savings in this group is low
- ✓ *those who can be reached (45%):* this group has more environmental awareness than the previous group, but is certainly also cost-conscious. Both the environmentally aware behavior and the cost-conscious behavior can be enhanced and the savings potential is the greatest in this group.

Figure 3.6 is a graphical depiction of the classification of types of savers. For each type of saver a savings percentage is assumed for both types of feedback (indirect and direct), based on studies and experiments (see Appendix C). This is an estimate based on expertise whereby the savings area as provided by Sarah Darby (0-10% for indirect feedback and 5-15% for direct feedback) is the leading factor. It is also assumed that direct feedback is more effective for reducing electricity consumption. For electrical appliances the link between the use of an appliance and the electricity consumption is fairly direct. In the use of gas, for instance for heating, external influences like the weather play a role. For this type of use, indirect feedback, over a longer period and corrected for weather conditions where necessary is considered more effective. These considerations have resulted in savings percentages[50] as outlined in table 3.3.

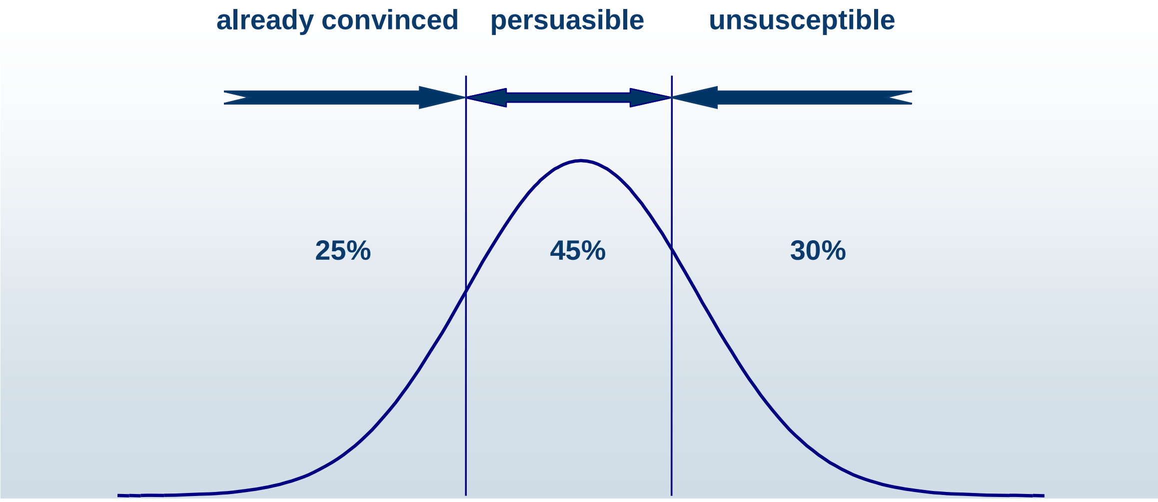

Figure 3.6 Classification of Dutch consumers into types of savers (source: Motivaction).

Table 3.3 National savings figure compiled from the available information.

savings	feedback	savers			national average
		unsusceptible	already convinced	persuasible	
electricity	indirect	0.0%	2.0%	6.0%	3.2%
	direct	0.0%	5.0%	11.5%	6.4%
natural gas	indirect	0.0%	3.0%	6.5%	3.7%
	direct	0.0%	4.0%	9.0%	5.1%

Based on table 3.3 consumers with a display save an additional 3.2% electricity and 1.4% gas compared to indirect feedback. Consumers who have a meter set to 'administrative off' but who do have a display (via the consumer port), will save the full 6.4% for electricity and 5.1% for gas. If 20% of consumers (compared to the reference situation) opt for a display this will result in a net present value of 875 million euro, an added value of 105 million euro compared to the reference situation.

This added value applies to a display price of 50 euro, taking into account the electricity usage of the display itself. It is remarkable that from a consumer point of view a display can cost many hundreds of euros before the consumer's business case becomes negative. From a societal point of view the break-even price is lower, namely around 140 euro per display, because the effects of loss of income of the energy supplier and other parties are also taken into consideration.

3.7 Smart meters and smart grids

It is generally assumed that a smart metering infrastructure is needed to be able to make the transition to smart grids. As a result, future investments in the grid can be avoided, reduced and/or postponed. However, the benefits included in this study are not the avoided investments in the network infrastructure, but the avoided costs of a dual communication infrastructure. The fact that the current smart metering infrastructure will have to be (considerably) amended to be able to meet the requirements of a future smart grid has been taken into account. It must also be noted that this is a very uncertain benefit that requires further research.

Paragraph 1.1 already gave an introduction to smart grids and the role of the smart metering infrastructure. A smart metering infrastructure is considered an indispensable part of a smart grid. The big question, however, is to what extent the smart metering infrastructure *currently* being installed meets the requirements of a *future* smart grid, and to what extent this will save costs in the future. For this purpose we first looked at the ways in which a smart grid can contribute, and when this becomes relevant. Next we look at which part of the current smart metering infrastructure will result in cost reductions in the future.

What contribution can smart grids make? At distribution level (homes) this contribution lies specifically in the area of the development of decentralized power generation (CPH boiler and solar panels), electric heat pumps and electric transport (battery-powered vehicles or plug-in hybrids). Smart grids can facilitate these developments in a number of ways:

- ✓ through smart control of these decentralized options the supply capacity and power generation capacity can be utilized more effectively; investments in grid and power generation capacity can be reduced, postponed or avoided
- ✓ the consumer can participate in the electricity market more actively, for instance by selling his own supply and demand flexibility in the market, or by purchasing energy at the lowest price (where applicable, from the lowest bidder)[51].
- ✓ this same flexibility can be used to get maximum benefits from the supply of sustainable energy and to prevent part of this potential being lost through disconnection.

The investments that can be avoided are potentially high. An average of 600 million euro per year is currently being invested in regional distribution grids for electricity, and 300 million euro for gas. This includes both replacement investments and expansion investments.

The question is to what extent the current investments in the smart metering infrastructure will render future investments in a smart grid unnecessary. What part of the current smart metering structure will still be usable in the future? In the optimal case the entire investment in the current infrastructure can be considered an avoided investment in the future smart grid, but this is unlikely because the current functionality is not yet fully focused on smart grids. There is also the added factor that the effective prices of electronics are going down and that a future investment for the same functionality will be lower.

One approach is to assume that only the data communication infrastructure (interfaces, modems, gateways etc.) and centralized data processing have future value, whereby the gateway functionality of the electricity meter (link between P1, P2 and P3) is considered a separate function, belonging to the data communication infrastructure.

It cannot yet be determined at which point in the future investments can be avoided. This is associated with the penetration speed and penetration level of the aforementioned decentralized options. Only after a certain penetration of decentralized options in households does the evolution to a smart grid make sense.

Based on a number of studies the penetration curves of the aforementioned decentralized options (heat pumps, electric transport, solar panels and micro-CHP) have been composed[52]. As a reference the penetration curve for the High Efficiency boiler is also shown.

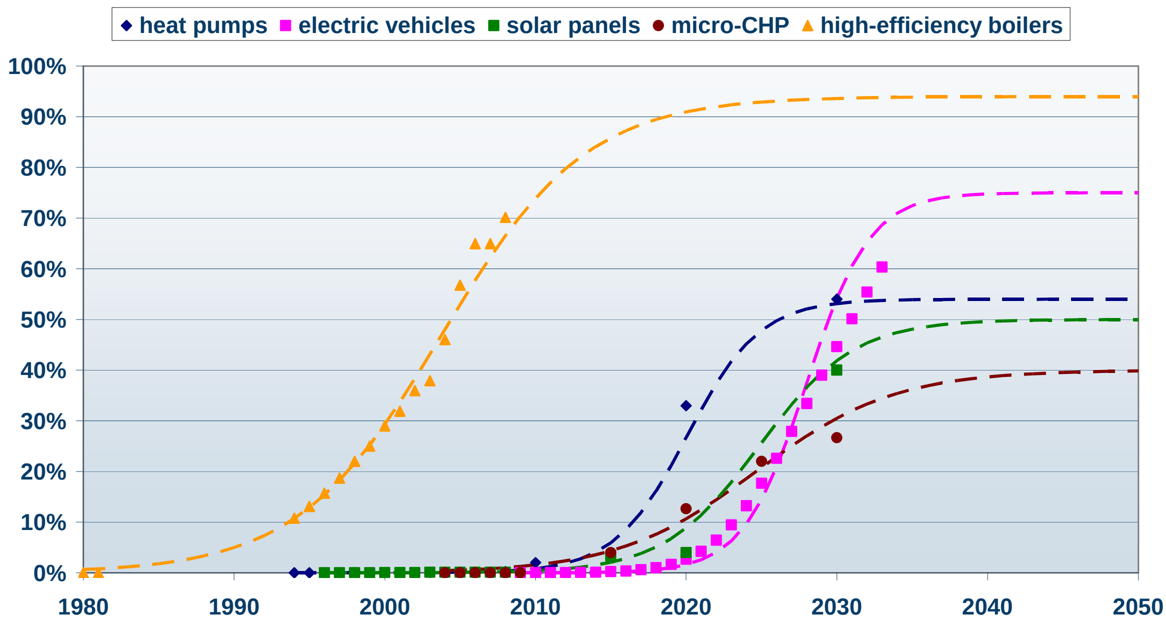

Figure 3.7 Penetration curves for decentralized options with the HR-boiler as a reference. Data from before 2009 is actual data, the other data is estimated. Percentages are relative to the number of households.

The penetration curve of the High Efficiency boiler indicates that it took around 25 years to get from a 10% share to a 90% share. The scenario for the micro-CHP has a similar penetration speed; the heat pumps, solar panels and electric transport show a much faster penetration. The penetration of heat pumps and electric transport in particular, reach a large proportion of households very quickly and the question is to what extent this speed can be realized in practice. In part this may be associated with the lifespan of systems; the shorter the lifespan, the faster the penetration can proceed.

In view of these penetration speeds and the side note that the scenarios for a number of decentralized options appear very optimistic, it is the question at what share of decentralized options a smart grid is needed to manage them. No specific level can be given but an estimated penetration level of 20% before the development of a smart grid becomes necessary would seem realistic based on earlier studies and pronouncements. The recently completed ITM study[53], for instance, names a limit value of 20% of heat pumps or electric cars before grid problems occur.

Based on a limit percentage of 20%, steps toward smart grids will have to be taken with respect to heat pumps from 2020 and with respect to electric cars, micro-CHP and solar panels from 2025. The accompanying assumption is that the current investments in interfaces, modems, gateways and centralized data processing will result in an equal avoided investment for the period 2020-2025. This avoided investment is a benefit item which, when converted to net present value, equals approximately 325 million euro. Compared to the annual investments in the electricity and gas distribution grid (900 million euro) this is a modest amount, but it is a significant contribution to the total net present value.

It must be noted that this is a very uncertain benefit with a number of question marks:

- ✓ the speed at which decentralized options will ‘conquer’ households is uncertain and the relevant data used in this paragraph appears very positive. If the 20% limit value, which is deemed essential, is reached a number of years later the benefits will also be reduced
- ✓ with respect to capacity the current communication infrastructure, and particularly PLC, is not yet equipped for the anticipated future information flows for a smart grid. It is very likely that considerable investments are still needed in this area
- ✓ the lifespan of ICT Systems is typically much shorter than 10-15 years.

The benefit item of 325 million euro in smart grid advantages is therefore relatively uncertain.

3.8 Cost reductions and price developments

> There is no doubt that synergy advantages may be achieved if the roll out is coordinated by the grid operators; this also concerns coordination in the establishment of data and communication infrastructures. However, this must be considered against a possible reduction in the effectiveness of the standard regulation. An expected significant decrease in hardware costs (e.g. costs of the smart meters) is in line with a reduction in the prices of (consumer) electronics and provides a considerable benefit.

It is to be expected that synergy advantages can be achieved in a large-scale roll out if the grid operators coordinate the roll out between them. Consider, for instance, the joint purchasing of hardware and software for data communication, storage and processing and the sharing of experiences and expertise. Such a collaboration must be considered against standard regulation that can become less effective in the case of far-reaching collaboration between grid operators. The joint issue of a tender for hardware and/or software does, at first glance, not appear to impede a standard regulation. Consultation with grid operators indicates that a synergy advantage of several dozen percent should be feasible. This analysis assumes a synergy advantage of 30%, among other things for the establishment of datacenters.

In addition to synergy advantages, price developments also influence the cost-benefit analysis. In the reference situation a realistic price increase of 1% per year for electricity, gas and CO_2 has been used. Energy taxes and the tariffs increase by this same percentage. As an alternative a price increase of 1.2% is assumed with a (one-off) 20% price decrease for data and meter hardware and communication costs in the year 2020 (after the large-scale roll out). This results in a considerable increase of the net present value.

In summary, with a reference value of 770 million euro, the following results for the net present value are achieved for these themes:

- ✓ synergy advantages 925 million euro
- ✓ 1.2% price increase/20% price decrease 1175 million euro.

The future price developments in particular have a major influence on the net present value of the national roll out of a smart metering infrastructure. Furthermore, this would indicate that a certain level of uncertainty cannot be ruled out.

3.9 Conclusions and attention points for policy formulation

The main policy attention points arising from the cost-benefit analysis are the realization of the energy savings potential among consumers and the acceptance of the smart meter. Because a smart meter in the 'administrative off' position has a functioning consumer port but, under the current (draft) legislation, cannot be remotely disconnected there is a realistic risk that many consumers will choose this option. For the same reason detailed meter readings have a relatively low benefit because many services can already be supplied via the consumer port and detailed meter readings add very little extra.

From the above analysis we can draw the important conclusion that in the reference situation with a roll out of virtually 100% smart meters with standard reading, a positive business case is possible. The analysis also indicates that there is a moderate likelihood (approx. 15%) that the business case may end up negative, among other reasons because costs may end up higher than anticipated and the savings potential among consumers may not be entirely realized. The major influence of future price increases of energy and price decreases of hardware underline that there will always be a certain level of uncertainty.

Looking at the influence of the different themes (see figure 3.8) we can see that the percentage of refusers and the percentage of consumers who will opt for an 'administrative off' meter setting, in particular, have a big impact on the business case. In the reference situation (standard reading) the business case becomes negative at approx. 20% of meters in 'administrative off' or approx. 20% refused smart meters. As more costs and benefits from the aforementioned themes are incorporated this percentage will change, but for the moment it appears that the 80% roll out required by the European Union is a good limit value for a positive business case.

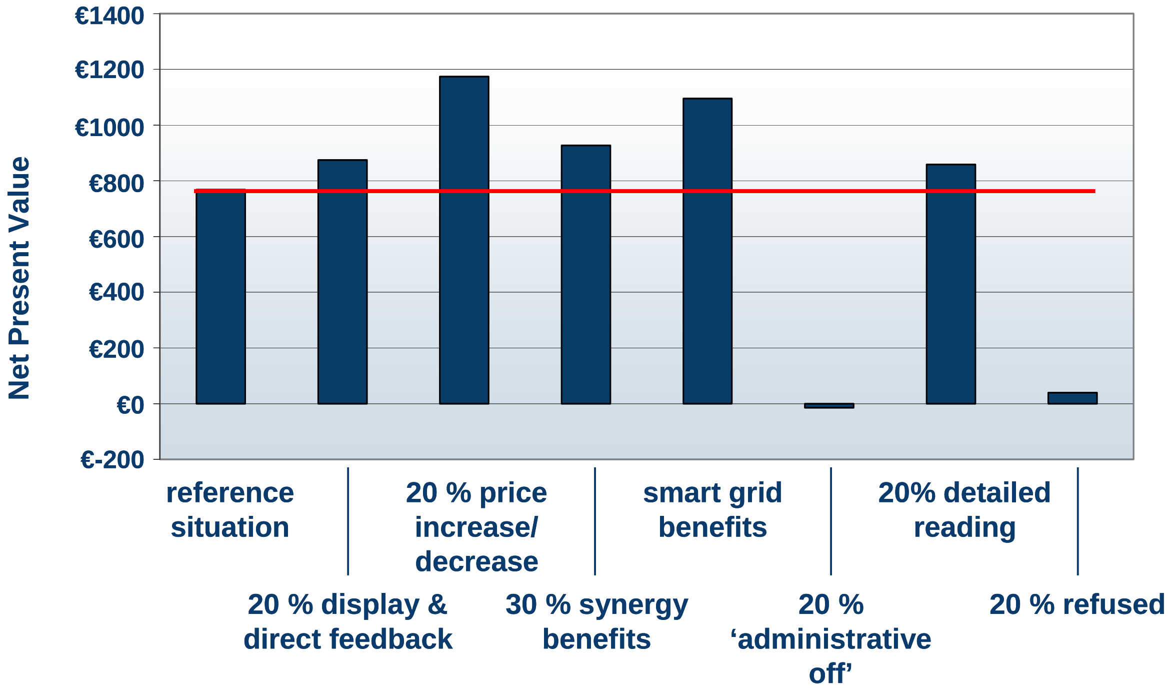

Figure 3.8 Net present value of a (large-scale) roll out for the seven aforementioned themes.

The cost-benefit analysis provides two access points for the identification of attention points for policy formulation. The first is the relative contribution of the various cost-benefit items in the reference situation; the second is the aforementioned themes.

The main cost-benefit items are energy savings by consumers, savings on call center costs, efficiency improvements as a result of the number of supplier switches and savings on the meter reading costs. Expectations are that the savings on call center and meter reading costs will be realized even without additional government policy. The free market or the current regulation framework will ensure this happens. The same applies to the efficiency improvements as a result of the number of supplier switches. This is a free market matter, although the government may be able to play an informative role.

Policy attention points also emerge from the themes we have discussed. By far the most important one is preventing the consumer from choosing to refuse the smart meter or to opt for the 'administrative off' setting, or encouraging consumers to choose a meter with standard or detailed meter readings. Cost developments and synergy advantages have an obvious impact. Detailed meter readings combined with new contract formats (detailed time of use tariffs, real time pricing, demand side management) is another attention point for policy formulation, but the benefits of detailed meter readings appear limited because many services can already be provided via the consumer port.

The advantage of smart grids is also considered an attention point for policy formulation. It follows from the analysis that the current smart metering infrastructure being installed appears to be capable of making a contribution to a future smart grid and, consequently, makes a significant contribution to the business case for smart meters. So far it is uncertain exactly how and when this advantage will be realized; this will require further research.

4 SMART METERING INFRASTRUCTURE AND THE GOVERNMENT

4.1 From attention points to recommendations

The government can play an important role in the implementation of a smart metering infrastructure in the Netherlands. The question is how the government can best fulfill this role. To this effect we will first outline the legal framework that currently exists (in draft form) for the smart meter (paragraph 4.2).

The general role of the government within the energy sector is further explained in paragraph 4.3. We will also provide an overview of policy instruments the government (in this case mainly the Ministry of Economic Affairs) has at its disposal and how they can be used (paragraph 4.4). These are existing policy instruments. Needless to say, there is a strong link between the (existing) roles of the government and the (existing) policy instruments it has available.

In addition to the role of the government and the policy instruments at its disposal we also need to understand the obstacles and risks that may arise in the implementation process of the smart metering infrastructure. These obstacles and risks provide attention points for policy formulation (paragraph 4.5) and are derived from the results of the cost-benefit analysis, the review of the status in Europe and the market consultation in the form of two complimentary feedback group meetings in which, among other things, the results of the cost-benefit analysis were discussed.

These identified attention points result in policy advice (paragraph 4.6). The recommendations will fit in with the prevailing views of the role the government must play in such processes. Figure 4.1 shows the main outlines of this process.

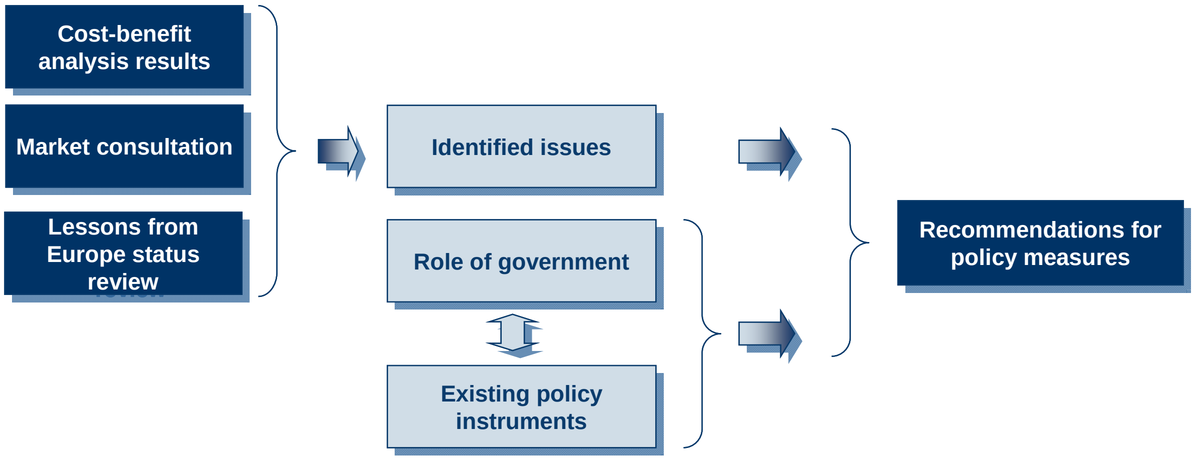

Figure 4.1 Relationship between the roles of the government, policy instruments and attention points (issues) in the implementation

4.2 Existing legal framework

There is already a legal framework for smart meters. This existing legal framework, part of which is still in the draft stage, is the starting point for the current policy advice.

The basis for the framework is the European legislation which is discussed in chapter 2, among others. This European legislation is implemented in the Netherlands by means of legislative changes. The legislative change 'Improvement of the functioning of the electricity and gas market'[5] implements the European regulations in respect of smart meters. The proposal to amend a Bill[11] makes a number of amendments to this legislative change. The 'Decree in respect of electricity and gas measuring apparatus and cost specifications'[13] (a so-called governmental decree) further documents a number of matters. The latter two documents were submitted to the House of Representatives in April 2010.

In addition to the legislation shown in figure 4.2 other legislation also applies. For instance, in the context of privacy the Personnel Data Protection Act is explicitly referred to when it comes to using meter data regarding the consumption of electricity and gas.

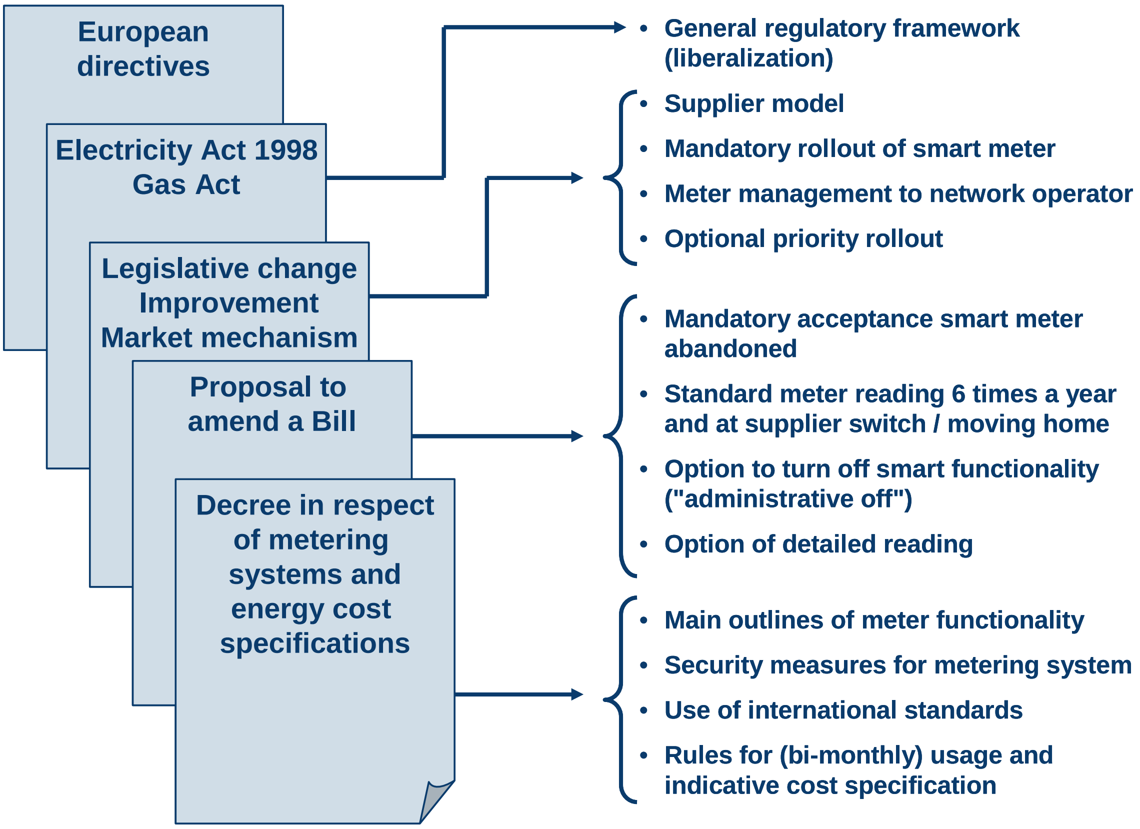

Figure 4.2 The current legal framework for the smart metering infrastructure

4.3 The role of the government

Upon the introduction of the smart metering infrastructure there are a number of important areas of attention for the government. These are the three public interests relating to the provision of energy as outlined in the Energy Report 2008[4]:

- ✓ affordable
- ✓ clean
- ✓ reliable.

The first area of attention for the government, ***affordability***, means an optimum service at a minimum price. The market mechanism (properly functioning energy markets) is essential in this context. The framework for the market mechanism in the energy market is imposed by the European Union[54], whereby the interests of the consumer are given a prominent place. Important areas of attention with regard to consumers in this European legislation are:

- ✓ feedback of energy data to enable energy savings
- ✓ a consumer *checklist* which clearly outlines the consumer's rights
- ✓ a transparent, competitive market in which it is easy to switch suppliers
- ✓ clear and easy-to-understand bills based on actual energy usage

- ✓ these bills are sent frequently (or soon after a supplier witch)
- ✓ the energy supplier is the only point of contact
- ✓ a smart metering infrastructure to allow consumers to actively participate in the market (for instance through decentralized energy generation).

Where a free market is not practical regulation will be used, once again for the protection of the consumer. Effectiveness is a key concept in this context. Figure 4.3 reflects the energy market for low-volume users, and shows which activities come under which domain (e.g. the free market or the regulated domain) in the current market model. The management of the grids has always been regulated. The pending legislative proposals regarding smart meters show that the management of the meters, as well as the roll out of the smart metering infrastructure, will also be regulated. The other activities listed in the figure are part of the free market.

Also of interest is the discussion about demand side management (should this be brought into the regulated domain like the smart meter, or left up to the market?) and the display for direct feedback (should this be installed together with the smart meter?). We look at these issues in more detail in paragraph 4.5.

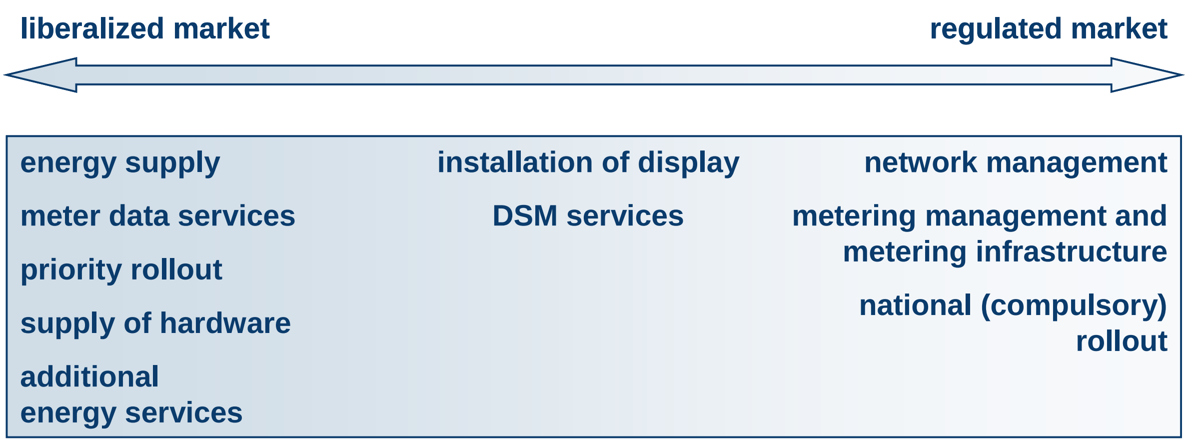

Figure 4.3 Market for low-volume users in the Netherlands

A second area of attention for the government is the realization of a ***clean energy supply***. Among other things, this means reducing greenhouse gas emissions and limiting the emission of other harmful substances. The European Climate Plan has put down clear targets for this[55], including objectives for the percentage of energy savings, the proportion of renewable energy and the reduction of greenhouse gas emissions. For the smart metering infrastructure energy savings are particularly important, although it is also expected that the smart metering infrastructure can contribute to the decentralized (sustainable) generation of electricity and heat. Specifically for the introduction of the smart metering infrastructure the government wants to increase the involvement of the consumer through awareness and acceptance of this infrastructure.

The third area of attention for the government is the ***reliability*** of the energy provision. The reliability of the energy supply must be guaranteed in the long term as well. Part of this, for instance, is the transition to a smart grid. The government uses the starting point that no blueprint is given for the energy mix, i.e. all options are open. The market parties invest in energy production and ultimately provide the energy mix demanded by the consumer. Energy savings and sustainability are areas that are strongly stimulated by the government because they contribute to a reliable (and clean) future energy supply.

In this playing field of public interests the government plays a number of roles. These can be divided into:

- ✓ a regulating role
- ✓ an informative role
- ✓ an initiating role
- ✓ a financing role
- ✓ a supervisory role
- ✓ a correcting role.

In its regulating role the government must ensure that there is a sound legal framework for a healthy market mechanism, but also for the implementation of European legislation. The government has an informative role, for instance toward the consumer to advise him of his rights in this market. The government also has an important initiating role and a financing role where required. This may consist of initiating and financing research (for instance to stimulate innovation in the market) but also the development of norms and standards and collaboration between parties. The government also has a role as a regulatory authority and must ensure that the free market actually functions as such, or that the regulation framework is being adhered to properly. Finally, the government may also take corrective action, for instance by withdrawing licenses or imposing penalties.

4.4 Policy instruments

To be able to properly fulfill its roles the government has a number of policy instruments at its disposal. These are generally classified into communication instruments, financial instruments and legal instruments[56]. In this report we use an alternative classification that gives a better picture of the different types of instruments and their potential effectiveness. We distinguish between the compulsory and the financial nature of a policy instrument.

Compulsory legislation and regulations and financial stimuli can generally have more effect than things like information or training. Figure 4.4 gives an overview of policy instruments that may be relevant in the introduction of a smart metering infrastructure.

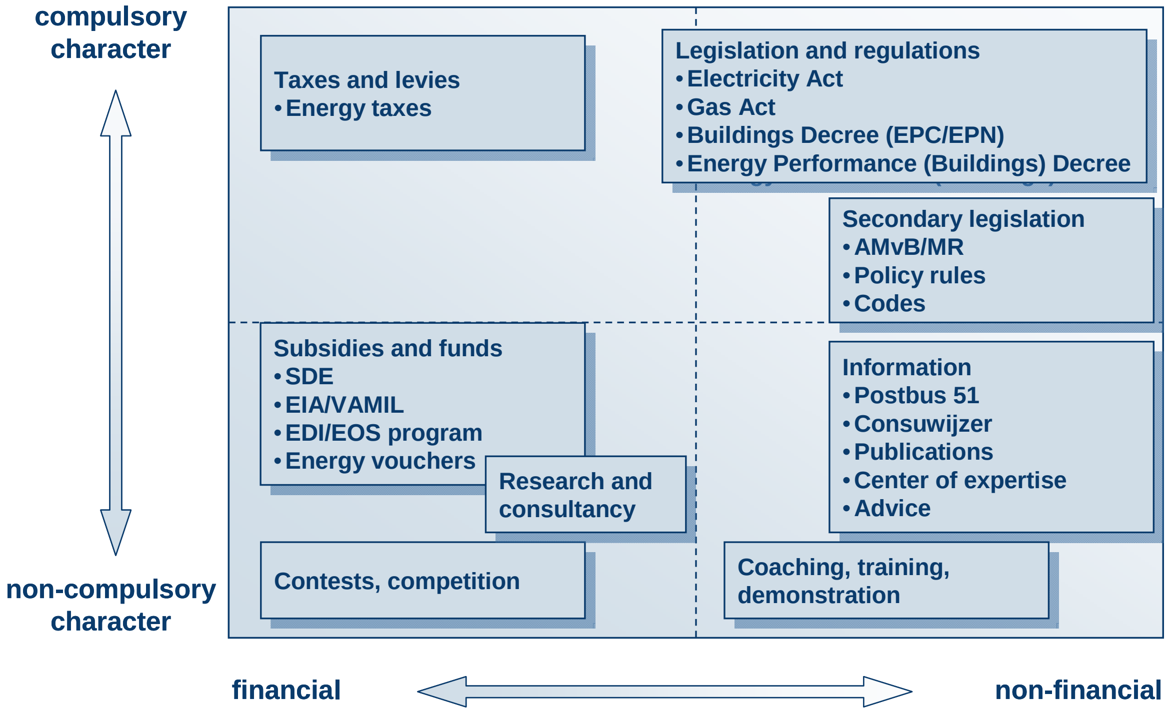

Figure 4.4 Overview of generic policy instruments of the government, classified by their financial and compulsory (legal) character.

The use of compulsory instruments is mainly documented in the aforementioned proposal for changes to the Electricity Act and the Gas Act, in the enclosed proposal to amend a Bill and the Decree in respect of electricity and gas measuring apparatus and cost specifications. The House of Representatives has also been promised that the meter tariff will not increase as a result of the introduction of the smart meter. The choice of policy instruments for this situation is therefore limited.

4.5 Policy starting points

Attention points (obstacles and risks) in the implementation and use of a smart metering infrastructure provide policy starting points and an inventory of attention points is therefore important. A number of attention points are identified on the basis of national and international experiences as well as on the basis of the cost-benefit analysis and the discussions with the feedback group. In general these are:

- ✓ acceptance of the smart meter
- ✓ effective use of the smart meter
- ✓ efficient roll out.

The ***acceptance of the smart meter*** by the Dutch consumer is an important attention point. A smart metering infrastructure is only effective if the consumer actually uses it and does not opt for the 'administrative off' situation, for instance. However, the Dutch consumer undeniably has a certain level of skepticism in respect of (large) government projects[57]. Consumer organizations emphasize the privacy and security aspects of meter data. This requires a good balance toward the consumer. Both too much information (may be perceived as obligatory) and too little information (''little known is little loved') can have a negative effect on the acceptance of the smart metering infrastructure. At this point it is particularly important to explain the standard situation, the advantages the smart meter offers in this situation and the difference compared to the situation in 2005, when detailed meter readings were still standard. Consultation with and support from consumer organizations[58] is important in this context. It must also be clear to the consumer what the status of his meter is (administrative off, standard reading or detailed meter readings) and it must be possible to demonstrate that the meter complies with the restrictions in respect of the information exchange in these various situations. It must also be clear how privacy and security are being guaranteed.

In addition to acceptance the ***effective use of the smart metering infrastructure*** is also an important attention point. The consumer must *want* to use the options provided by his meter. He must therefore be *motivated* as well as *informed* about the use of 'his' meter. The way in which feedback on energy data is provided is important and needs to correspond with the consumer's learning behavior. He must have action alternatives for his energy usage.

An important tool to allow the consumer to make the most effective use of the opportunities provided by the smart meter is the in-home display for direct feedback. This is currently not rolled out as standard but does provide potential energy saving benefits. The position of this display in the regulations must be clear. Based on the free market philosophy the display should be part of the free market. Suppliers will have to come up with propositions that will tempt the consumer to accept a display in his home. For a supplier of (energy) services an in-home display provides excellent opportunities for narrow casting, for instance, also because the target group is relatively well known and the message can be tailored accordingly. However, if this market is not taken up, a large potential for energy savings resulting from direct feedback will also disappear. From an efficiency point of view it may be better to install the display at the same time as the smart meter. This is the option that was chosen in the United Kingdom; however, in that country the supplier is responsible for the roll out. A clear choice on how the display is handled, which will be able to put an end to discussions, is important.

An important assumption in the cost-benefit analysis is that a smart meter ensures that the process of changing suppliers runs more smoothly, that this gives the consumer more confidence in the change process and that he will therefore gradually start changing suppliers more often. This forces the market to operate efficiently. In previous chapters we have seen that among consumers in the Netherlands there is some reticence to switch suppliers. The percentage of ‘switchers’ in the Netherlands is considerably (by a factor of 2) lower than that in the United Kingdom (where the percentage is approximately 20% per year), but is comparable to the switch percentage in countries like Belgium, Sweden and Spain.

Efficient use of the smart meter also means making use of the possibilities for demand management, also called load management or demand side management. Demand management is important to both the energy supplier (purchasing strategy) and the grid operator (capacity management). For the supplier, demand management falls in the free domain and the supplier is therefore at liberty to come to agreements with the consumer. For the grid operator the possibility of demand management to offset the need to replace or increase the production capacity is embedded[59] in the law. In this context coordination will be required, among others between the energy supplier and the grid operator.

The role of the smart metering infrastructure in smart grids must become clearer. At present it is still uncertain to what extent the current smart metering infrastructure can contribute to a future smart grid, particularly the size of this contribution and when this contribution will become significant. This is also an important point for an efficient roll out.

And finally, an ***efficient roll out*** is a policy attention point. One attention point for an efficient roll out is the functionality of the smart meter. The government has chosen the angle of a ‘reasonably’ smart meter with functionality that is described in general terms without express reference to, for instance, an external standard or directive. However, consumer organizations and the House of Representatives are asking for more comprehensive functionality, for instance a USB port, a hardware-based on/off switch to allow for the reading of meter data, a chip card for identification and data encryption etc. Consultation with meter manufacturers has shown that these additions would incur disproportionately high costs. The Netherlands is a small market seen against the whole of Europe and deviating from a

European (de facto) standard for a relatively small volume of meters will inevitably increase the costs.

For the grid operators and suppliers the priority roll out is an attention point. This priority roll out is realized by order of the suppliers (after reporting to the grid operator) and the meter is transferred to the grid operator at a regulated tariff. A balanced tariff and clear acceptance criteria on the part of the grid operator are essential so that the supplier can initiate a priority roll out without uncertainties.

An efficient roll out can also mean that a form of collaboration is needed between the parties involved. The joint purchasing of meter hardware and software is an example of such collaboration, as is the joint education and training of the persons involved. Different levels of collaboration are possible, which must fit in with the current legislative framework.

The table below gives an overview of attention points in relation to the three aforementioned areas of attention.

Table 4.1 Attention points in relation to the three aforementioned areas of attention

attention points	area of attention		
	acceptance	effective use	efficient roll out
information about the benefits of the smart meter	✓		
information about disconnection and privacy	✓		
status information on the meter	✓		
encouraging the use of the display		✓	
position of demand management		✓	
reticence regarding switching suppliers		✓	
certainty about priority roll out			✓
collaboration between the parties involved			✓
benefits of a smart grid		✓	✓
additional functionalities			✓

4.6 Policy advice

In the previous paragraph three (main) areas of attention were identified that serve as starting points for policy formulation. A number of attention points were listed for each area of attention. Based on this analysis, a number of proposals for policy development are made in this paragraph, whereby the overview of policy instruments in paragraph 4.4 and the policy starting points in paragraph 4.5 are used, namely:

- ✓ the acceptance of the smart meter
- ✓ the effective use of the smart meter
- ✓ an efficient roll out.

With regard to the consumer's ***acceptance of the smart meter***, (the provision of) information appears to be the most important. Important aspects are:

- ✓ Open and transparent information about the benefits:
  - draw attention to the benefits of the smart meter in a clear and objective manner, especially the element of energy savings and the reliability of changing suppliers. Aim to support consumer organizations, for instance.
  - find the balance between too much ('pushing') and not enough. Take into account a certain level of skepticism among consumers with respect to the government.

- ✓ Clear indication of the status of the meter:
  - for instance by showing the last reading date by the grid operator on the meter display (or in the home if an in-home display has been installed)
  - stimulate this functionality of the status indicator
  - have this functionality guaranteed by an independent, recognized institute.

- ✓ Clarity about the use of meter data:
  - provide information about the protection of privacy-sensitive metering values
  - audit regimen for grid operators with regard to the reading and handling of meter data
  - information about the security level of data (for instance the same level as Internet banking)
  - information about the consent obligation of third parties.

- ✓ Avoid the consumer opting for the 'administrative off' situation:
  - provide information about the information exchange in this situation
  - show the consumer clear advantages he has in the standard situation, such as not having to manually provide meter data
  - outline the conditions under which the consumer can be disconnected and explain that these are no different from what they are now

- pass on the savings made on meter reading to the consumer's meter tariff (lower tariff) or increase the tariff for 'refusers' by including the cost of manual reading; this is simply a matter of shifting the costs and does not affect the societal business case.

Influencing the consumer to accept the smart meter and standard reading involves more than just providing information; it's about influencing behavior. One aspect has already become clear in the current process: behavior results in counter-behavior (Leary[60]). If the government wants to implement something and people consider it as being enforced/ compulsory it may engender resistance as a response. It is therefore advisable to expertly prepare and realize the communications to the consumers, whereby the key message regarding the introduction of the smart meters must be particularly clear. The above attention points can serve as a guide.

It is advisable to coordinate the communications to the consumers with the other parties involved, particularly the grid operators and the energy suppliers, at least with regard to content.

The ***effective use of the meter*** means that the government can encourage the consumer to make maximum use of his meter and stimulate the market to come up with a good and cheap in-home display, for instance.

✓ Promote direct feedback to the consumer:
- promote the development of in-home displays (e.g. by means of innovation subsidy)
- stimulate the market for in-home displays (e.g. by means of purchasing subsidy)
- include the presence of a display in the energy label for homes
- create clarity about the legal position of the display (free domain).

✓ Increase the awareness and energy knowledge of the consumer:
- regular information provision (Postbus 51, MilieuCentraal)
- one-off promotions, such as a national savings action.

✓ Inform the consumer about the rights and obligations associated with switching suppliers (encouraging consumers to switch suppliers is part of the free market):
- make it clear that this does not require a 'new meter box' and that there will be no interruption in the supply (Consuwijzer)
- further research into barriers that stop people from switching suppliers.

✓ Create clarity about the status of the remote load management (load shedding) and the benefits of detailed meter readings

- research into the legal aspects of load management
- promote load management in the free domain
- information about the benefits of detailed meter readings.

The focus on the acceptance level and the effective use of the smart meter must be in balance, as the combination of the two determines the effectiveness of the smart meter at a national level.

And finally, an ***efficient roll out of the smart metering infrastructure***:

✓ The most economical purchasing of hardware and software:
- encourage initiatives to achieve advantages of scale in the roll out phase (e.g. joint purchasing) within the current regulation frameworks
- avoid the Netherlands-specific functionality of the meter and stimulate the use of the current Dutch standards at European level (where needed)
- stimulate the finalization of the specifications of the consumer port (P1).

✓ The most efficient and effective roll out process possible:
- create clarity about the replacement refund in the priority roll out by suppliers and/or other parties
- promote collaboration between grid operators in the roll out phase, within the existing regulation frameworks
- provide the consumer with early information about the imminent roll out, avoid surprises.

✓ More insight into the smart grid advantages:
- more research into the usability of the current smart metering infrastructure that is being rolled out with respect to a future smart grid, particularly the extent to which functionalities overlap and the extent to which other factors can play a role
- more research into the moment at which a smart grid will be essential to accommodate decentralized options, second opinion regarding the current (optimistic) introduction scenarios.

5 CONCLUSIONS AND ADVICE

5.1 Conclusions

5.1.1 Learning points from Europe

It is clear from the country inventory that the transition to smart metering systems has been started through all of (Western) Europe. The tempo differs per country. In Sweden and Italy the penetration level of smart meters is already virtually 100% and in other countries like the United Kingdom and Spain a deliberate choice has been made for a large-scale roll out. These countries are assuming that a complete roll out will be realized by 2020. This is not an unrealistic tempo when looking at the speed at which the smart meters were rolled out in Sweden, for example. The current roll out schedule in the Netherlands can therefore also be considered realistic.

With regard to functionality there is generally considerable similarity between the requirements that the different countries impose on the smart meter, for instance when it comes to disconnecting consumers, registering the quality of the supply, the storage of meter data and the supply of meter data upon request. However, in the reviewed countries there is less consensus about the importance of an in-home display. In Sweden this was not an issue, in the United Kingdom it definitely is.

Cost-benefit analyses were performed in many countries and they are fairly similar with respect to cost and benefit items. In these analyses the anticipated energy saving percentages range from a few percent to more than 10%. In most cases a societal cost-benefit study is used. To determine the interest rate a regulated WACC for the grid operators is used in most cases. This was also the starting point for this study.

Privacy issues are acknowledged throughout Europe, but these issues have not (yet) played such a prominent role elsewhere in Europe as they do in the Netherlands. It is not clear what the reason for this is, and whether the focus on security and privacy in the Netherlands is the start of a new awareness of this aspect in Europe.

About the acceptance of the smart meter we can only say that in Sweden and Italy there appear to have been no problems regarding the acceptance of the smart meter, in view of the nearly 100% roll out. Whether this percentage can be translated directly to the Dutch situation is not certain, also in view of the debate about privacy and security.

5.1.2 Review of cost-benefit analysis in the Netherlands

The cost-benefit analysis that was performed in 2005 by order of SenterNovem (now Agentschap NL) was updated in the light of, among other things, the current situations relating to the proposal to amend a Bill. The method has remained largely the same, but important changes have been incorporated. Among others, these are the opportunities to refuse a smart meter or having it turned to ‘administrative off’. The cost level has also been updated based on the current insights (including the costs associated with privacy and security). The energy saving percentage has been substantiated in more detail and the possible contribution of a smart metering infrastructure to a future smart grid has also been considered. More than before, the smart meter is now looked upon as a lever to put important developments in the supply of energy in motion.

In the standard situation (virtually 100% acceptance of the smart meter and also virtually 100% standard reading) we have a positive business case with a net present value of 770 million euro. The main benefit items are energy savings, savings on call center costs, a lower cost level as a result of the market mechanism (more supplier switches) and savings on the costs of reading meters. The advantages will mainly benefit the consumer, the costs will mainly be at the expense of the grid operator and the national government (lost taxation revenue).

The benefits of energy savings are the greatest. A lot of attention has been given to this benefit item, particularly in order to substantiate the percentage of energy savings. However, a certain level of uncertainty in determining the national average savings percentages remains unavoidable.

If approximately 20% of all households refuse the smart meter or have it turned to ‘administrative off’ the net present value will be reduced to around nil euros. This is an important point of attention for policy formulation: how to prevent consumers from refusing the smart meter, for instance because they have an erroneous image of it. A specific attention point in this context is that a consumer who accepts a smart meter but has it turned to ‘administrative off’ cannot be disconnected but will enjoy the advantages of the consumer port.

Future price reductions of items like meter hardware, increases in energy prices, making use of the possibilities of detailed meter readings, synergy advantages during the roll out and potential smart grid advantages all make a positive contribution to the net present value of one hundred to several hundreds of millions of euros.

5.1.3 The role of the government in the introduction of the smart meter

The legal framework for the introduction of the smart meter is documented in the proposed legislative change 'Improvement of the functioning of the electricity and gas market', the proposal to amend a Bill and the 'Decree in respect of electricity and gas measuring apparatus and cost specifications', which were recently submitted to the House of Representatives. For privacy-related aspects we refer to the Personal Data Protection Act. This legal framework does not leave any room for compulsory measures for acceptance of the smart meter. The role of the government will therefore rather have to be stimulating, informative and persuasive.

Areas of attention for policy efforts are the *acceptance* of the smart meter, the *effective use* of the smart meter and an *efficient roll out* of the smart meter.

5.2 Policy attention points

The policy advice has been comprehensively discussed in paragraph 4.6. This advice focuses on the aforementioned areas of attention (acceptance, efficient use and efficient roll out).

It is important that the consumer is approached properly and with a convincing 'story'. This is a matter of marketing and communication and it is advisable to pay sufficient attention to getting the key message regarding the smart meter, and the distribution of this message, exactly right. The consumer will require reassurance in a number of areas (he cannot be disconnected without notice, he can trust that 'administrative off' actually means no metering data is being exchanged, he can rely on the security and privacy measures that are in place, etc).

To be able to use the smart meter as efficiently as possible it is advisable, among other things, to stimulate the introduction of an in-home display. Increasing energy awareness among consumers is also an attention point.

The realization of synergy advantages in the roll out process is an attention point for an efficient roll out, as is further research into the possible future smart grid benefits of the current smart metering infrastructure.

APPENDIX A CONSULTATION GROUP

A summary of members of the consultation group. Attendance levels at meetings of the feedback group have varied depending on the day and the time of day. Consultation meetings were held on 21 January 2010 and 4 March 2010. The table below provides detail of all individuals (in addition to TNO and KEMA employees) who participated a whole day or part of a day, or who were invited.

Table A.1 Summary of consultation group

Name	Organization
Henk van Elburg	Agentschap NL
Jos Poot	Alliander
Erik Linschoten	Alliander
Rob Maathuis	Alliander
Michiel Karskens	Consumentenbond
Jan Hofman	Delta NWB
Mark Ossel	Echelon
Josco Kester	ECN
Pieter Wijnmalen	Elster
Frank Jacobse	EnergieNed / Nuon
Fons Jansen	Enexis
Marcel ten Cate	Itron
Tjakko Kruijt	Landis+Gyr
Christien Stoker	Dutch Ministry of Economic Affairs
Jeroen van Bergenhenegouwen	Dutch Ministry of Economic Affairs
Niels van Campen	Dutch Ministry of Economic Affairs
Han Damsté	Netherlands distribution system operator
Edwin Edelenbosch	NMa – Energiekamer
Ton Buitelaar	NMa – Energiekamer
Frank Jacobse	NUON
Hilbrand Does	Oxxio
Arjan Donker	Stedin
Arjan Gelderblom	Stedin
Simone Pront	Universiteit Amsterdam
Theo Fens	Universiteit Delft
Egon Berghout	Universiteit Groningen
Jan Oosterhaven	Universiteit Groningen

Name	Organization
Bart Jakobs	Universiteit Nijmegen
Marko van Eekelen	Universiteit Nijmegen
Claudia Umlauf	Vereniging Eigen Huis
Elliot Wagschal	Vereniging voor Marktwerking in Energie

APPENDIX B EUROPEAN DEVELOPMENTS IN GREATER DETAIL

B.1 Extracts from EU energy legislation

A number of EU directives make specific reference to the use of advanced measuring systems. A number of examples are cited below.

Article 5 of *2005/89* states:

> *Article 5*
> **Balancing supply and demand**
> 1. Member States shall take appropriate measures in order to ensure that there is a balance between the demand for electricity and the available generation capacity.
> (…)
> 2. Without prejudice to Articles 87 and 88 of the Treaty, Member States <u>may</u> also take additional measures, including but not restricted to, the following:
> (…)
> d) Promoting the introduction of technologies for demand management in real time, <u>such as advanced measuring systems</u>;
> e) Promoting energy-conservation measures;
> (…)
> 3. Member States shall publish the measures taken pursuant to this Article ensuring the widest possible dissemination of this information.

Article 13 of *2006/32* contains a regulation with regard to metering and informative billing of energy consumption:

> *Article 13*
> **Metering and informative billing of energy consumption**
> 1. 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 for electricity, natural gas, district heating and/or cooling and domestic hot water <u>are provided with competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use</u>.
>
> When an existing meter is replaced, such competitively priced individual meters shall always be provided, <u>unless this is technically impossible or not cost-effective</u> in relation to the estimated potential savings in the long term. When a new connection is made in a new building or a building undergoes major renovations, as set out in Directive 2009/91/EC, such competitively priced individual meters shall always be provided.
>
> 2. Member States shall ensure that, where appropriate, billing performed by energy distributors, distribution system operators and retail energy sales companies is based on actual energy consumption, and is presented in clear and understandable terms. Appropriate information shall be made available with the bill to provide final customers with a comprehensive account of current

energy costs. Billing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption.

Member States shall ensure that, where appropriate, the following information is made available to final customers in clear and understandable terms by energy distributors, distribution system operators or retail energy sales companies in or with their bills, contracts, transactions and/or receipts at distribution stations:

a. Current actual prices and actual consumption of energy;
b. Comparisons of the final customer's current energy consumption with consumption for the same period in the previous year, preferably in graphic form;
c. Wherever possible and useful, comparisons with an average normalized or benchmarked user of energy in the same user category;
d. Contact information for consumers' organizations, energy agencies or similar bodies, including website addresses, from which information may be obtained on available energy efficient improvement measures, comparative end-user profiles and/or objective technical specifications for energy-using equipment.

Annex A of the new Electricity Directive from the Third Energy Package (*2009/72*) states:

Member States shall ensure the implementation of smart metering systems that shall assist the active participation of consumers in the electricity supply market. The implementation of those metering systems may be subject to an economic assessment of all long-term costs and benefits to the market and the individual consumer or which form of smart metering is economically reasonable and cost-effective and which timeframe is feasible for their distribution. (…) Subject to that assessment, Member States or any competent authority they designate shall prepare a timetable with a target of up to 10 years for the implementation of smart metering systems. Where roll-out of smart meters is assessed positively, at least 80% of consumers shall be equipped with smart metering systems by 2020. The Member States, or any competent authority they designate, shall ensure the interoperability of those metering systems to be implemented within their territories and shall have due regard to the use of appropriate standards and best practice and the importance of the development of the internal market in electricity.

B.2 Overview of the energy market

Germany has around 48 million electricity connections and 13.5 million gas connections. The German energy market is dominated by four major economic operators who together occupy 50% of the market. The "big four" in this case are *E.ON*, *RWE*, *Vattenfall* and *EnBW* (EnBW is part-owned by the French energy company EDF). The country is also notable for its large number of distribution system operators (around 860 for electricity and around 680 for gas). The majority of these distribution system operators are locally-operating energy companies (referred to as Stadtwerke). National high-voltage electricity grids are also in the hands of the "big four"[61], while national gas transport grids are owned by 18 different distribution system operators. A liberal approach has prevailed in the German energy market for some time. There are currently around 800 energy suppliers and approximately 120 power traders. Consumers without access to the gas supply use district heating. The heating market in Germany displays a high level of heterogeneity with a large number of submarkets, generally characterized by a decreasing demand for heat brought about by statutory requirements with regard to insulation.

Spain has approximately 26.3 million electricity consumers, and a further 6.8 million gas consumers. Electricity distribution is dominated by three main economic operators (namely *Endesa*, *Iberdrola* and *Union Fenosa*) who together control around 94% of the market. With around 11 million customers, Endesa is the largest company in Spain and has recently transferred ownership to the Italian company Enel. In addition to these three, there is a large number (>300) of smaller operators. In many cases, these are owned by municipal authorities. Two dominant economic operators are active when it comes to gas distribution, *Gas Natural* and *HC Energy*, who together control around 94% of the Spanish gas market. The Spanish energy market has been fully liberalized since 2003, which was much quicker than the compulsory timeframe that had been imposed by the EU. As a result, a range of new operators have surfaced, such as *Nexus Energía*, *Factor Energía*, *EGL*, *Detisa*, *Acciona* and *Atel Energía*, all of whom are operators that do not form part of a traditional company, but are "simply" suppliers.

It should be noted that Spain is considered as an "energy island", in so far as there are very few links with Portugal and France, and so few options for import and export. Nevertheless, consumption of electricity in Spain has increased by 5% per year since 1980, almost twice the growth rate seen in the EU. The annual rate of electricity consumption per household is around 4,200 kWh. The increasing demand for energy has pushed *conservation of energy* up the agenda. The major challenges facing energy policy are currently *security of supply* and *reducing* CO_2 *emissions*. Spanish politicians are tackling these challenges through energy-efficiency and the introduction of renewable energy.

There are around 29.1 million electricity consumers in the **United Kingdom**. A number of acquisitions and mergers have left just eight distributions system operators for electricity, three of which are currently under foreign ownership[62]. The largest is *EDF Energy* (also part of EDF), whose operating regions include London. The second largest distribution system operator is *Central Networks*, now part of German operator E.ON. *Scottish Power*, owned by Spanish Iberdrola, is the operator in Scotland and Wales and is the fourth largest company in the UK by size. The other distribution system operators are *CE Electric*, *Scottish & Southern Energy*, *Western Power Distribution*, *Electricity North West* and *Northern Ireland Electricity*. The British gas market, with a total of 21.7 million consumers, is operated by just four operators, being *National Grid*, *Scotia Gas Networks*, *Northern Gas Networks* and *Wales & West Utilities*. A number of new economic operators have also appeared on the market in the UK, some of whom are "niche" operators who only supply energy (such as *First Utility*, *Good Energy*, *Green Energy*, *Ecotricity* and *Haven Power*). Others are more dominant, such as *Centrica*, *nPower* and *RWE.*

In **Sweden** there are approximately 5.2 million electricity consumers. Around 2.6 million consumers are connected to a heating grid. Gas is not used widely in Sweden, and there are only around 60,000 households connected to a gas grid. Where gas is used, it is usually for cooking purposes. Furthermore, Sweden has particularly high average household electricity consumption at approximately 9,200 kWh per year. This can primarily be attributed to the fact that Swedes heat their homes using electricity, which means that they are one of the leading European consumers[63].

The Swedish energy market is characterized by a mixture of a number of large national operators, and a larger number of smaller local operators. There are more than 150 distribution system operators for electricity in Sweden. The largest three are *E.ON Sweden*, *Vattenfall* and *Fortum*. Together, they occupy around 18% of the market and operate on a national basis. The fourth distribution system operator is *Göteborg Energi*, which operates in and around Gothenburg with a market share of around 5%. All other operators are local operators with fewer than 100,000 customers. Ownership of these companies varies greatly. Vattenfall (also the owner of NUON in the Netherland) is owned by the Swedish government. E.ON Sweden (previously Sydkraft) is owned by the German company E.ON, while Fortum is a private Finnish company whose shares are even listed on the Helsinki Stock Exchange. Virtually all small local operators are owned by the municipality/municipalities in which they operate. The Swedish energy market has been liberalized since the end of the 1990s. A number of independent energy suppliers also operate in the market, all of whom are new starters. None of these form part of an integrated company. Examples include *Uppsala El*, *BestEl*, *OKQ8*, *Yello Strom* (owned by German EnBW), *7H Kraft* and *Kraft & Kultur i Sverige*.

Belgium is characterized by the somewhat traditional domination of one party, Electrabel (part of the major energy company GDF-Suez). Electrabel remains the largest energy producer and energy supplier with the most customers in Belgium. Electrabel is also a shareholder in a large number of distribution system operators. Belgium has approximately 5.3 million electricity consumers and approximately 2.6 million gas consumers. Not all electricity consumers also have a gas connection. Those who do not use gas (around 50%) heat their homes electrically or with heating oil.

Belgium has a total of around 25 distribution system operators for electricity, and around 15 for gas. Over time, a number of operators have combined their activities and placed them into operating companies, the most important of which are *Eandis* and *Infrax* in Flanders, and *Ores* in Wallonia[64]. Alongside these, a number of (smaller) distribution system operators also operate independently in both Flanders and Wallonia. *Sibelga* operates as the only operator in Brussels. Electricity and gas suppliers are separate entities to distribution system operators, the most important of which are *Electrabel*, *SPE* (Luminus), *Distrigas* and *Gaz de France* (GdF). A number of smaller suppliers also exist in addition to a limited number of new arrivals (some from abroad), such as *NUON Belgium*, *Essent Belgium*, *Eneco Energie*, *E.ON Benelux* and *Endesa*.

Table B.1 provides an overview of the energy market in different countries.

Table B.1 Summary overview of the European energy market

	Netherlands	Germany	United Kingdom	Belgium	Spain	Sweden
Population	16.5 million	82.3 million	61.1 million	10.4 million	46.7 million	9.1 million
Number of electricity consumers (*)	7.7 million	48 million	29.1 million	5.3 million	26.3 million	5.2 million
Number of gas consumers (*)	6.9 million	13.5 million	21.7 million	2.6 million	6.8 million	60,000
Average electricity consumption	3,550 kWh	3,500 kWh	unknown	5,750 kWh (**)	4,200 kWh (**)	9,200 kWh (**)
Average gas consumption	1,625 m^3	23,260 kWh	unknown	24,000 kWh	unknown	n/a
Full opening of energy market for private customers	2004	1998 (elec) 2003 (gas)	unknown	2003 (Flanders) 2007 (other)	2003	1999 (E) 2006 (G)
Number of distribution system operators	8 (elec) 11 (gas)	862 (elec) 686 (gas)	8 (elec) 4 (gas)	25 (elec) 15 (gas)	325 (elec) >300 (gas)	158 (elec) 8 (gas)
Number of transport system operators	1 (elec) 1 (gas)	4 (elec) 18 (gas)	unknown	1 (elec) 1 (gas)	1 (elec) unknown (gas)	1 (elec) n/a (gas)
Meter reading for private customers	annually, if changed	annually, if changed	annually, if changed	annually, if changed	annually, if changed	monthly, if changed
Telemetry for commercial connections?	yes	yes	yes	yes	yes	yes
Supervisory authority	Energiekamer (NMa)	Bundesnetz-agentur	Ofgem (Office of the Gas and the Electricity Markets)	CREG (national) VREG (Flanders) CWAPE (Wallonia) Brugel (Brussels)	Comisión Nacional de Energía (CNE)	Energimarknads-inspektionen (EI)

(*) The number of private consumers.

(**) In Belgium, Spain and Sweden, electric heating of homes is common; average electricity consumption is therefore higher.

B.3 Overview of cost-benefit analyses in Europe

The table below provides an overview of the cost-benefit analyses carried out in the countries under investigation.

Table B.2 Summary overview of cost-benefit analysis in Europe (E: electricity, G: gas; DSO: Distribution System Operator; MDM: Meter Data Management; 1 MEUR is 1 million euro).

	Flanders	Netherlands (1)	Netherlands (2)	Netherlands (3)	United Kingdom	Sweden
Year	2008	2005	2005	2008	2009	2002
Executive party	KEMA	KEMA	Accenture	Frontier Economics	DECC	St. Energi-myndighet
Cost-benefit analysis type	SCBA for roll-out for private customers on basis of extra costs	SCBA for roll-out for private customers on basis of extra costs	SCBA for roll-out for private customers on basis of extra costs	Partial SCBA for DNO's comparison with meter tariff	SCBA for roll-out for private customers on basis of extra costs	SCBA for roll-out for customers >8 MWh, on basis of extra costs
Commodities	E and G	E and G	E and G	E and G	E and G	E only
Roll-out party	DSO	DSO	DSO	DSO	E-supplier	DSO
Roll-out time	5 years	10 years	5 years	6 years + 2 year pilot	7.5 - 9 years + 2.5 - 4 year pilot	5 years
Horizon CBA	20 years	50 years	30 years	17 years (2009-2025)	Roll-out time + 20 years	15 years
WACC	5.4%	7%	10%	5.5%	unknown	6%
Main scenarios	• Reference alternative • Variation on reference alternative	• Reference alternative • Variation on reference alternative	• Large-scale roll-out • Target group roll-out	• Pessimistic scenario • Optimistic scenario	• Roll-out in 2020 • Roll-out by end-of-life replacement	• Monthly reading of meters • Other read frequencies
Communication technology used	ADSL, GPRS, PLC or combination (depending on scenario)	ADSL, GPRS, PLC or combination (depending on scenario)	ADSL and/or PLC (depending on scenario)	GPRS and PLC or combination	GPRS	PLC, GPRS and RF, depending on population density
Annual communications costs per connection (*)	GPRS: €9 PLC: €1.50	GPRS: €20 PLC: €0.65	GPRS: €6-10 PLC: €1	GPRS: €10-20 PLC: €0.31-1	GPRS: €6	€0.25-40
Key cost entries	• MDM investment and data collection systems • Investment in meter hardware	• Investment in meter hardware • Monthly billing • MDM investment	• Investment in meter hardware • GPRS communication costs	• Investment in meter hardware • Installation costs • Communication costs	• Investment in meter hardware • Installation costs	• Investment and installation of meter hardware and MDM
Investment in meter hardware €/connection (*)	GPRS: €333 PLC: €312	GPRS: €170 PLC: €180	GPRS: €143 PLC: €153	GPRS: €268-304 PLC: €255-304	GPRS: €143	€200 (only E, system on basis of hourly values, mixture of communication technologies used)
Key benefits	• Fraud reduction • Savings on physical meter reading • Energy conservation	• Improved competition • Savings on call-centre costs • Energy conservation	• Process improvement • Savings on physical meter reading • Energy conservation	• Meter tariff (other benefits are for DSO and marginal)	• Saving on physical meter reading • Energy conservation • Savings on debt settlement	• Energy conservation • Savings on physical meter reading
Energy saving percentage	1.5% E and G	4% E 2% G	2% E and G	not included	1.5-4% E 1.3-4% G depending on scenario	1-2% E
NPV	-389 MEUR	1,310 MEUR	800 MEUR large-scale roll-out 440 MEUR priority roll-out	822 MEUR optimistic scenario -933 MEUR pessimistic scenario	2,850-4,490 MEUR depending on scenario	+60 MEUR per year

B.4 Functional requirements and the status of smart energy meters

The functional requirements for smart energy meters can be roughly sub-divided into four categories:

- ✓ Recording and displaying consumption;
- ✓ Switching and limiting the throughput value ("squeezing");
- ✓ Monitoring security of supply, fraud and grid parameters (power quality);
- ✓ Communication.

The most important functional requirements for the measurement infrastructure to be implemented for electricity in **Spain** are:

- ✓ Active and reactive registration of consumption in each direction;
- ✓ Active and reactive hourly energy load profiles, minimum data storage of three months;
- ✓ Registration of faults longer than three minutes;
- ✓ Measurement of the nominal voltage;
- ✓ Measurement of power quality;
- ✓ Load control, remote deactivation or connection/activation;
- ✓ As many as six different programmable registers for active, reactive and maximum demand;
- ✓ The distribution company is the only organization who may program the secret passwords;
- ✓ Bi-directional communication;
- ✓ Remote reading of data, e.g. via RF, GSM or PLC;
- ✓ Remote synchronization with concentrators and a central system;
- ✓ The ability to amend tariffs remotely;
- ✓ Alarm and events registration and storage.

In **Flanders**, VREG has drawn up an overview of the possible functions of a smart meter (for both electricity and gas). Functionality is sub-divided into *basic functions* which must be provided on the smart meter in all cases, and *optional functions*, that are not (yet) available on a basic meter, but which shall be deemed to be of interest in due course. *Basic functions* include:

- ✓ Measurement of electricity acquisition and electricity provision to the grid;
- ✓ Measurement of (temperature-adjusted) gas acquisition;
- ✓ Transmission of meter status (measurement registers) on request;
- ✓ Periodic transmission of measurement status (measurement registers);
- ✓ Saving of meter status and/or load curve;
- ✓ Remote adjustment of the electricity supply power;
- ✓ Remote collective restriction or deactivation of meters;

- ✓ Remote disconnection/connection of the gas supply;
- ✓ Registration of consumption in different tariff periods;
- ✓ Remote adjustment of tariffs/tariff periods;
- ✓ Remote firmware upgrades;
- ✓ Registration of power quality (voltage level, interruptions and grid status);
- ✓ Communication with other meters (for example gas meters) possible via the electricity meter;
- ✓ Prepaid function, the meter may be used as a budget meter;
- ✓ Display on the meter;
- ✓ Local port for external display.

Optional functions referred to include: real time and on-demand availability of quarterly values, phase-sequence control, the option to choose the phase for grid balance and euro values on the meter display.

Table B.3 provides an overview of the status of smart meters in the European countries under investigation.

Table B.3 Summary overview of smart meters in Europe

	Germany	United Kingdom	Belgium	Spain	Sweden
European Directive 2006/32 implemented?	Yes	De facto via an Implementation Program	No	Yes	De facto via law from 2003
Large-scale roll-out of smart energy meters anticipated?	Yes, market-driven roll-out anticipated	Yes, government-controlled roll-out	No, still in research phase	Yes, government-controlled roll-out	Full roll-out complete
Periodic implementation of smart energy meters?	2010 – 2016 (anticipated)	2010 – 2020 (statutory)	Completed in 2020 (anticipated)	Completed in 2018 (statutory)	Completed in July 2009
Intended roll-out scheme	Market initiative (incl. customer)	Linear	n/a Eandis anticipates roll-out from 2014	30% in 2011; 50% in 2013; 70% in 2016 and 100% in 2018	Complete
Who shall be responsible for implementation?	Customer, supplier or distribution system operator	Supplier	Distribution system operator	Distribution system operator	Distribution system operator
Functionality requirements of the smart meter	Left to the market; supervisory authority has proposed a design with basic requirements	Basic requirements have been established, which are detailed further in an Implementation Program.	Minimum requirements have been established[1].	Minimum set of functional and technical requirements has been established. DSO to elaborate requirements more concretely.	n/a
Status of smart energy meter projects	Many (major) pilots, implementation in new-build and renovation	A number of pilots	A number of pilots	A number of pilots; implementation in new-build and renovation	Full roll-out complete
Use and development of domotics applications	Included in the MUC concept	n/a	not part of discussion on functional requirements	n/a	n/a
Acceptance of smart meter	Not obligatory	Obligatory	Not obligatory[2]	Obligatory	Not obligatory[3]
Privacy protection	German law on protection of personal details applies	Included when drawing up functional specifications	Not yet an issue; under consideration	n/a	Was not an issue
Position of consumer organizations	Involved in standardization	n/a	n/a	n/a	n/a
Expected energy savings	5-10% saving expected	3-13% saving E and G	1.5% E and G without display; 2.5% E and 3.5% G with display[4]	n/a	1-2% saving on electricity
Energy saving mechanism	Direct feedback	Incl. in-home displays	Incl. in-home displays	n/a	Monthly billing

[1] The specification referred to was investigated on a regional level (Flanders) and not officially published.
[2] In Belgium, no decision has yet been made on whether or not to implement an obligatory roll-out.
[3] Monthly readouts are obligatory in Sweden.
[4] These data originate from the cost-benefit analysis in Flanders as referred to in the report.

B.5 Smart grids in Europe

A number of European examples may be cited as examples of projects where the development of smart grids is being promoted. Details of these are provided in the Annex.

In **Germany**, *E-Energy* and *Intelliekon* constitute two examples of projects that have been financed by the government[65]. *E-Energy* is a promotional program where an energy system of the future, based on ICT, under the motto *"Smart Grids made in Germany"* is being developed and researched. An important component of this project is *"Internet of Energy"*, within which the various parties in the energy system, from generation to consumption, are linked together in a smart manner. This allows the energy system to be managed, regulated and checked more easily, ultimately leading to the optimum use of resources. Smart energy meters form an integral part of this smart grid, and allow the domestic consumers to coordinate supply and demand for energy with their supplier via bi-directional communication. A total budget of €260 million has been reserved for this project.

The *Intelliekon* project focuses on sustainable consumption of energy by using smart meters, communication and tariff systems. The aim of the project is to assess a range of feedback instruments for energy consumers, visualizing the measurement data provided by smart meters.

In the **United Kingdom**, various organizations are currently in the process of developing strategic visions around the subject of "smart grids", including the Electricity Networks Strategy Group (ENSG). ENSG is an advice committee, comprising stakeholders from the electricity distribution companies, jointly chaired by the DECC and Ofgem, with the aim of advising the government with regard to the risks of climate change and sustainability. ENSG has been commissioned to develop a *high level* vision on how a smart grid might manifest itself in the UK, and the challenges that this kind of grid could help to overcome. The ENSG has recently published[66] its vision document, which indicates the way in which smart meters can contribute to achieving benefits and future possibilities.

DECC also published a document concerning smart grids in December 2009[67]. This document suggested that major changes to the entire electricity system will be necessary in the near future, including indicating that more electricity should be produced without CO_2 emissions. In order to support these developments, it is necessary to modernize the electricity grid so that it is able to provide more capacity and to build in options to absorb significant fluctuations in demand for energy, whilst at the same time ensuring security of supply. A larger and smarter grid of this nature, combined with new elements in the electricity system such as smart meters, micro generation brought about by electricity generation by individuals or commercial parties, smart resources, electric cars etc., shall provide consumers with the opportunity to take control over their energy in an entirely new way. The most important conclusion by the DECC is that the smart grid must be central to this vision to allow a transformation to a *low-carbon* electricity system to take place. It shall form the backbone of the new system, being smart, flexible and reactive at the same time.

Initiatives concerning "smart grids" are rare in **Sweden**. System operators invest primarily in overhead infrastructure since considerable damage was sustained to the infrastructure, causing severe power cuts, due to several years of successive storms. Smart meters are used for optimization, but little discussion takes place on the subject of smart meters in Sweden (in a number of small initiatives, including from ABB and Fortum).

The **Spanish** government published its Energy Efficiency Action Plan 2008-2012[68] at the end of 2007, intended to contribute towards the implementation of the Spanish Energy Efficiency Strategy (E4) 2004-2012. The action plan comes in response to the current high level of dependency on foreign energy supplies, increasing demand for energy, which is higher than the increase in Gross National Product, the need for new management instruments to impact on energy demand and options with regard to meeting the objectives to generate 12% of energy from renewable (alternative) sources in 2010.

The plan covers a range of measures which should give rise to energy savings, and a reduction in CO_2 emissions in the period 2008-2012. It is clear that a new grid model is required to support all measures. The most notable components of the plan are localized generation of electricity, distributed energy storage, control of demand and efficient supply of electricity to electric vehicles. Spanish energy companies expect that these requirements shall ultimately lead to the use of a smart grid. A range of research projects, such as the GAD and the ADDRESS project have been started by Iberdrola for the development of smart grids[69].

As part of the GAD project (Gestión Activa de la Demanda - Active Demand Management), research has been conducted into how electricity consumption in a range of private consumer categories can be restricted, including providing information with regard to energy sources and environmental effects. Information of this nature allows consumers to make contractual agreements that best suit their own consumption profile. The ADDRESS project (Active Distribution grids with full integration of Demand and distributed energy RESourceS) is a European project, with 25 European members such as producers, suppliers, technology centers and universities. The project also looks at new energy infrastructure, to which the consumer is central. The objective is to make consumers aware of the costs of energy consumption by using real-time price incentives, to which people must respond within a very short time frame (20-30 minutes). This is known as *active demand control*. The project is a contributor to security of supply.

Endesa also operates in the field of smart grids. In Summer 2009, Endesa began the project *Malaga SmartCity*[70], in which a new urban energy-management model is applied. Objectives include increasing energy efficiency, reducing CO_2 emissions and promoting renewable energy. 300 industrial customers are participating in the project, together with 900 small business and 11,000 households. The project is due to last for 4 years.

Renewable energy sources shall be connected to the electricity grid so as to better match with demand. Renewable energy sources that shall be used include *solar panels* (to be installed on government buildings), the use of *micropower generation* (in some hotels) and the installation of *micro-wind energy generators* across the region. In addition, energy storage systems in the form of batteries shall be constructed so that generated energy can be used at a later stage, for example, for climate control in buildings, for lighting public spaces and for electric transport. By way of promotion of electric vehicles, a range of charging stations shall be constructed and a small fleet of electric vehicles provided.

All participating customers in the project shall be provided with smart meters to allow them to regulate their energy consumption. The installation of smart telecommunications and systems to allow remote control will provide additional functionality for *real-time* and automated adjustments to the distribution grid to facilitate a new form of energy management and to contribute towards an increase in service levels. Analysis of consumption data shall take place at a later stage. The objective of the project is to achieve an annual electricity saving of 20%, and a reduction of 6,000 tonnes of CO_2 emissions. The SmartCity budget is being partly financed by the EU through the European Regional Development Fund (ERDF).

In **Belgium**, 2007 marked the beginning[71] of the Flemish government's "Flanders in Action" program, which aims to provide socio-economic impetus to Flanders. Flanders aims to be a European top-region by 2020 and has seen the launch of the "Pact 2020" which contains 20 objectives, each with concrete target figures. The Pact states the following with regard to the energy sector: *"Flanders is promoting the introduction of smart electricity meters and the development of active and smart electricity grids which enable control of supply and demand".*

The Pact's energy paragraph states: "In 2020, Flanders will have made substantial progress with a view to stable access to energy. This shall benefit security of supply and price competitiveness. To this end, efficiency returns shall be achieved in order to limit demand for electricity on the one hand. By doing so, and in accordance with European-level agreements, energy efficiency will have increased by 2020, and accordingly, (relative) energy consumption will have fallen. As a result, CO_2 emissions will have decreased by 2020 to fall into line with European-level agreements. On the other hand, the capacity for electricity generation will be improved, achieved in part by involving an appropriate number of operators, which will see the percentage of electricity generated from renewable sources of energy and qualitative cogeneration increase significantly, as will be required in Flanders within the context of implementing the European Directive for Renewable Energy. In addition, the electricity grid will be transformed into a fully-interconnected and smart international grid, to which decentralized production units and new applications can be connected".

The aim of Flanders in Action is to be one of the five most prosperous regions of Europe by 2020. There do not appear to be any comparable actions in Wallonia or Brussels.

APPENDIX C ENERGY BEHAVIOUR AND ENERGY CONSERVATION

C.1 The role of consumer behavior in energy conservation

A smart measurement infrastructure in itself does not conserve energy, but using this infrastructure correctly does. Important issues are therefore whether or not the consumer will accept the smart measurement infrastructure, the way in which he will use it and how both of these aspects can be influenced.

The Ministry of Economic Affairs deems the introduction of a smart measurement infrastructure a means of promoting the desired developments, which include:

- ✓ Improving free market processes
- ✓ Improving security of supply
- ✓ Increasing consumer participation
- ✓ Increasing awareness and acceptance of methods that support the fulfillment of European energy objectives.

These last two aspects, increasing both consumer participation and awareness have an underlying purpose, to help consumers to adopt the desired "energy behavior", for example, conserving energy or shifting energy consumption so as to better utilize power stations and grids.

The introduction of a smart measurement infrastructure in itself does not conserve energy or give rise to different energy behavior. It is the consumer's *use* of the smart measurement infrastructure, direct or indirect, that must give rise to different energy behavior and energy conservations or more efficient use of our energy infrastructure. Key questions for this introduction are as follows:

- ✓ How does the consumer respond to the smart measurement infrastructure; to what extent will he accept it?
- ✓ How will the consumer use this smart measurement infrastructure (if he has accepted it) and in what way will this influence his energy behavior?
- ✓ In what way can both of the aforementioned aspects (acceptance and use) be influenced?

All three of these questions are vital to the successful introduction of a smart measurement infrastructure in the Netherlands. Few studies have been conducted concerning the acceptance of the smart meter, but some practical experience has been gained. The majority of studies focus on the way in which the use of a smart measurement infrastructure might influence consumers' energy consumption. The first question is also more of a marketing question: how do I go about selling the smart meter to the consumer? This Annex shall therefore focus more on the second question. The third question is dealt with in section 4 concerning the role of the government in the successful introduction of a smart measurement infrastructure in the Netherlands. This annex looks primarily at the theoretical framework behind learning styles and the relationship with feedback, and at experience with practical experiments at home and abroad.

C.2 The smart measurement infrastructure as a learning tool

Feedback on energy consumption should give rise to (improved) energy-conserving behavior. This is a learning process, but because every person learns differently, feedback must be provided in a way that is consistent with the different ways of learning.

Feedback on energy consumption is seen as the most important influencing factor on consumers' energy behavior. The basic principle behind the European legislation is that a smart measurement infrastructure gives rise to more and improved feedback on energy consumption and so gives rise to (improved) energy-conserving behavior amongst consumers.

A theory to illustrate this notion is that of Kolb[72]. On the basis of a number of learning theories, Kolb has developed a learning cycle comprising continuous progression through four learning styles, which is necessary to arrive at sustainable learning and a sustainable change in behavior. These four learning styles overlap one another, the result of one learning style forms the basis for the next style. Figure C.1 depicts the four learning styles.

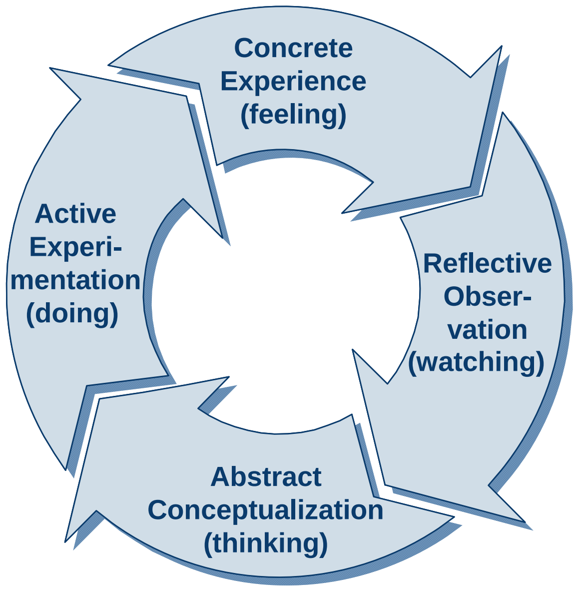

Figure C.1 The four learning styles according to Kolb

Everyone learns differently and shall have a preference for one or more of these learning styles to allow them to enter the learning circle. For example, one person is more susceptible to experience, the other to concepts and image formation. In concrete terms, what this means for the smart measurement infrastructure is that feedback must be consistent with all of these learning styles.

For example:

- ✓ Concrete experience is consistent with a prepaid solution for the smart measurement infrastructure. Not paying will lead to a reduction or disconnection of the energy supply which will be immediately noticeable to the household. This form of learning would also serve as an argument for bills based on current actual usage, so that the effects of energy consumption are immediately experienced in the consumer's bank account.
- ✓ A consumer who prefers observation must possess sufficient material to allow this to happen. Frequent feedback on energy consumption is important in this respect, which should be linked to the circumstances under which the energy was consumed (day, night, weekday, and weekend, consumer at home or away) and which will provide "food for thought" when it comes to energy consumption.
- ✓ The next stage in the learning circle is abstract conceptualization based on experience and observations: Is there is a relationship between experience and observation? Does this occur often and do others experience it too? In this case, feedback on energy consumption from the past or from similar groups of consumers (bench marking) is important. An explanation may also be important to this group of

consumers: how does a smart measurement infrastructure work and in what way is this used? This may support their image formation.

- ✓ The final learning style is based on experimentation. Consumers who prefer this learning style are the ones who want to do something about their energy consumption and want to see that they can influence it. These consumers primarily need information on how their energy consumption is made up (for example for each appliance or depending on the presence of people in their home). Consumers with this preference of learning style can be tempted with opportunities to experiment with switching off appliances. A display that shows current energy consumption would be of importance to this group of consumers.

As one might expect, it is interesting whether these preferred learning styles are randomly distributed amongst all consumers or whether they depend on the type of consumer (age, education, income etc.). A greater understanding of this would lead to a better understanding of the best ways to provide certain consumer groups with feedback. All consumers can be approached by all learning styles at all times.

C.3 The motivation to learn

Consumers must be motivated enough to participate in the learning process. Feedback must not therefore only be geared towards the different learning styles of consumers, but also to the motivation consumers need to adapt their behavior. Focusing solely on cost savings by changing behavior is not the correct approach.

Kolb's theory talks about the way to learn, not motivation to begin learning. If there is no motivation, feedback that is solely geared towards the correct learning style is of little use, while feedback that focuses on consumers' motivation is very important. Feedback with this aim may also take on a more information-based character, for example, to focus attention on the social importance of energy conservation.

It should be noted in this respect, that study was carried out in ten European countries, including the Netherlands[73], by LogicaCMG. As part of this study, around 1,000 consumers in each country were asked about their energy-conservation behavior and their attitude toward smart meters. One of the outcomes of the study was that consumers in Europe would expect to save an average of around 22% in energy costs by adopting a more economical attitude. In the Netherlands, the figure was 17%. But, the reasons for not adopting more energy-conservational behavior appear varied, with the most important reason for Dutch consumers being the notion that they already do enough when it comes to energy conservation. Other popular reasons were that the government does not offer enough incentives and that they are insufficiently aware of their own energy consumption (see figure C.2).

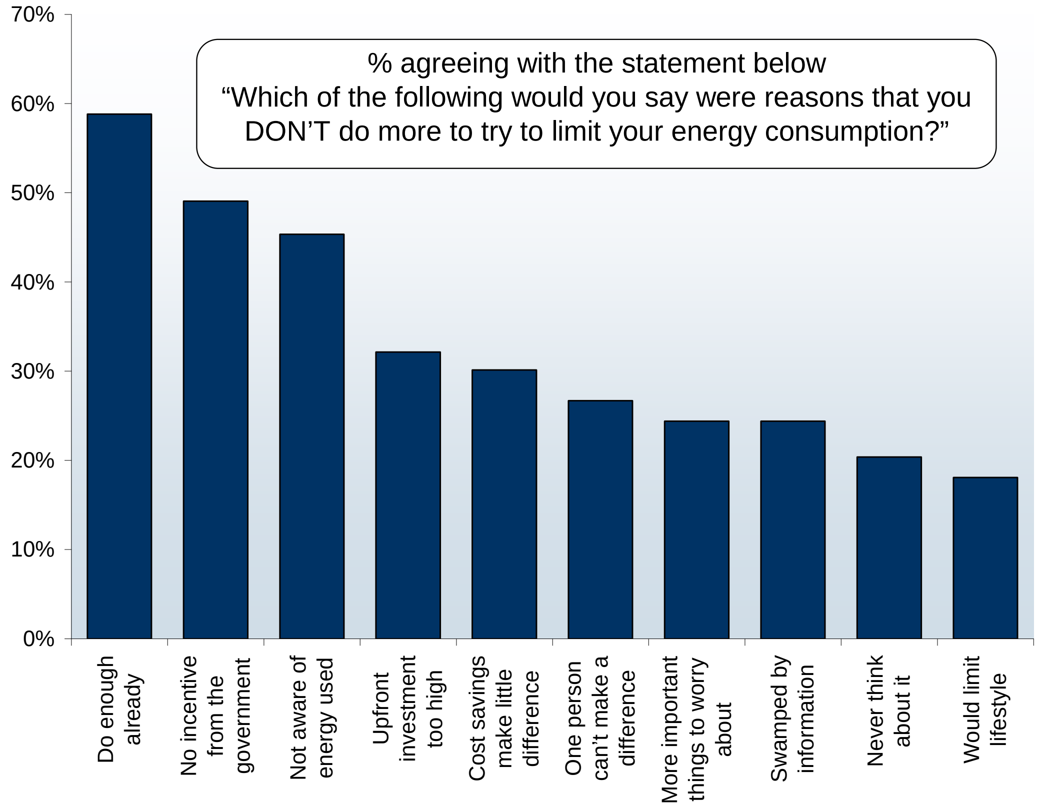

Figure C.2 Motivation not to contribute more to energy conservation (source: LogicaCMG).

It is also important to note that while many consumers in Europe claim to contribute enough to energy conservation, they only identify with an average of fewer than two of the six important energy-conservation options referred to in the study. There exists an "*attitude-behavior gap*": a major difference between how consumers see their own behavior and the reality of their behavior.

The same also appears to be true when looking at responses to the question as to what motivation is most important when it comes to conserving energy. In Europe, 58% said costs, 37% the environment. In the Netherlands, the figure for costs was higher at 60%. But, if we look at a number of actions carried out by consumers (figure C.3), then we see that, the percentage of households taking glass to bottle banks or separating paper is far higher than the percentage who switch health insurer or energy supplier, although there is a financial advantage in the latter two. It is quite possible that the environmental aspect of energy conservation is more important, but social factors (everyone does it) and devoting time and effort play a role. The social norm is important[74].

A recent study by the Vereniging Eigen Huis[75] has shown that there is still a reluctance to switch energy supplier despite the fact that annual financial savings in the hundreds of euros are possible, according to the NMa. On the basis of the aforesaid, focusing on costs as the only motivator does not appear to be the correct approach.

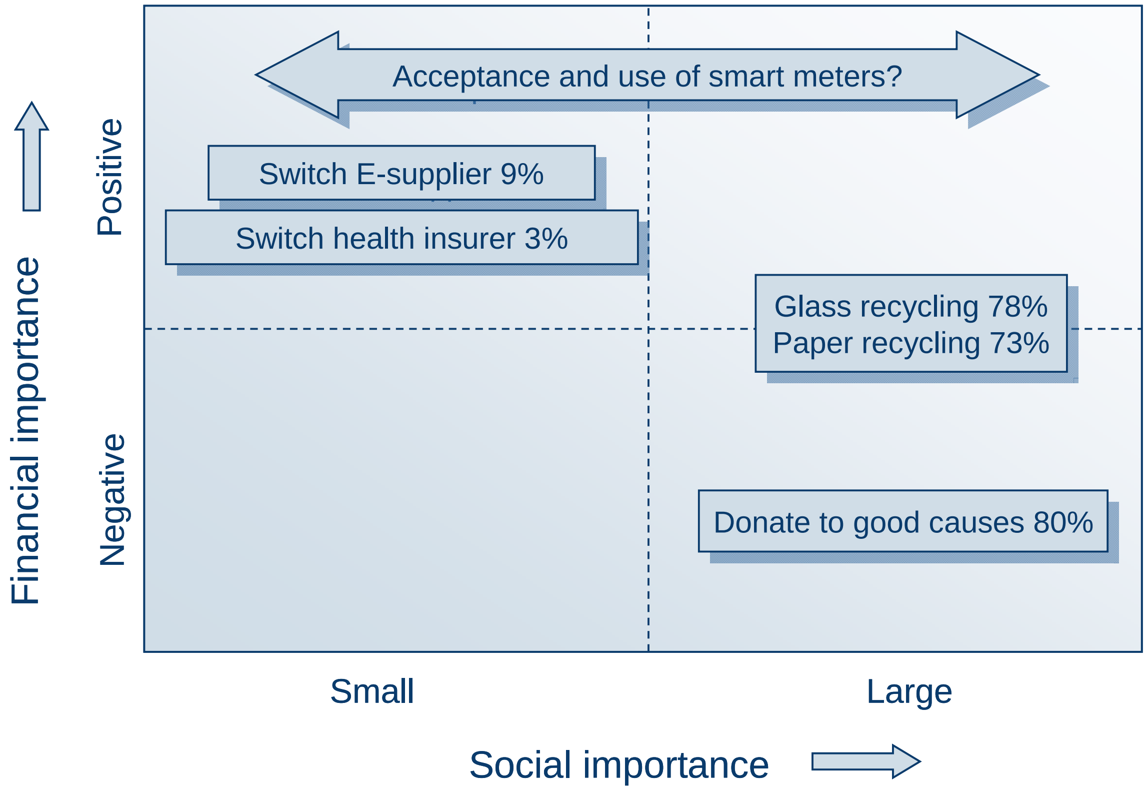

Figure C.3 Percentage of households taking annual action in certain areas (source: KEMA).

C.4 Forming feedback

Broad distinction is made between direct feedback and indirect feedback. Recent studies appear to suggest that direct feedback is more effective and is preferred by consumers over indirect feedback. Dutch consumers display a certain amount of skepticism over feedback provided by the smart meter.

Feedback can be provided in a variety of ways. Figure C.4 provides an exploratory overview of options for providing feedback on energy consumption. Available literature (e.g. Sarah Darby[76], ESMA[77]) distinguishes between two types of feedback:

- ✓ Direct feedback
- ✓ Indirect feedback

In the case of direct feedback, immediate information on energy consumption is fed back to the consumer in a certain way. This may be using an in-home display or by means of prepayment (insufficient balance gives rise to an immediate response) or time-sensitive tariffs (use at a certain time has an immediate effect on the tariff). In the case of indirect feedback, energy consumption information is fed back at a later time, such as on the bill or via the website.

Availability	Medium	Accessi-bility	Frequency	Allocation	Presen-tation	Target group
Always	Display (in view)	Instantly (display)	On-line data	n/a	Energy (kWh, MJ)	All residents
On demand	Display (out of view)	Activate/ deactivate display	Quarter afterwards	Day/night	Energy saving (kWh, MJ)	Head of household
Periodically	Computer	Retrieve letter	Day afterwards	Peak / off-peak	Cost (euro)	Bill payer
	Letterbox	Computer start-up	Month afterwards	By appliance	Cost saving (euro)	
			Year afterwards		Emission reduction (kg CO_2)	

Figure C.4 Exploring options for feedback (source: KEMA).

The advantage of direct feedback is that the consumer can immediately see the effects of certain actions on energy consumption. In general, direct feedback is considered to be more effective than indirect feedback, at least for electricity.

In the case of both direct and indirect feedback, different forms of presentation are possible. Some consumers may require information on costs, while others may prefer kWh of electricity or m^3 of gas. Displaying kg of CO_2 emission would presumably suit a different type of consumer.

Comparative feedback is also important. There are a number of possibilities in this respect:

- ✓ Comparison with own past consumption (adjusted for external influences where appropriate)
- ✓ Comparison with standard consumption on the basis of type of building or number of residents, for example
- ✓ Comparison with a comparable group of consumers

Different things have been reported on the effectiveness of this type of feedback. In some cases, comparison with own use has been seen as most effective, while sometimes, comparison with a similar group of consumers ("peer group") has been seen as effective. Comparison with a peer group may work the other way around however, particularly if consumption is lower than that of the peer group. On the basis of the comparison, the consumer may decide that he is already doing enough, and discontinue further energy-conservational behavior.

Finally, figure C.5 depicts the result of the poll referred to above, also carried out in the Netherlands, on smart meters. The results show that the Dutch prefer a display as a means of providing feedback. The investigation also showed that the Dutch were less enthusiastic about choosing one of these options, 37% of those asked chose none of the four methods stated. The score for the personal webpage is relatively low, certainly when compared to other countries with a high penetration of internet connections at home. An interesting outcome of the investigation was that the Dutch score the lowest when it comes to concern about climate change, but the highest when it comes to their own estimation of the extent to which they already contribute towards energy conservation.

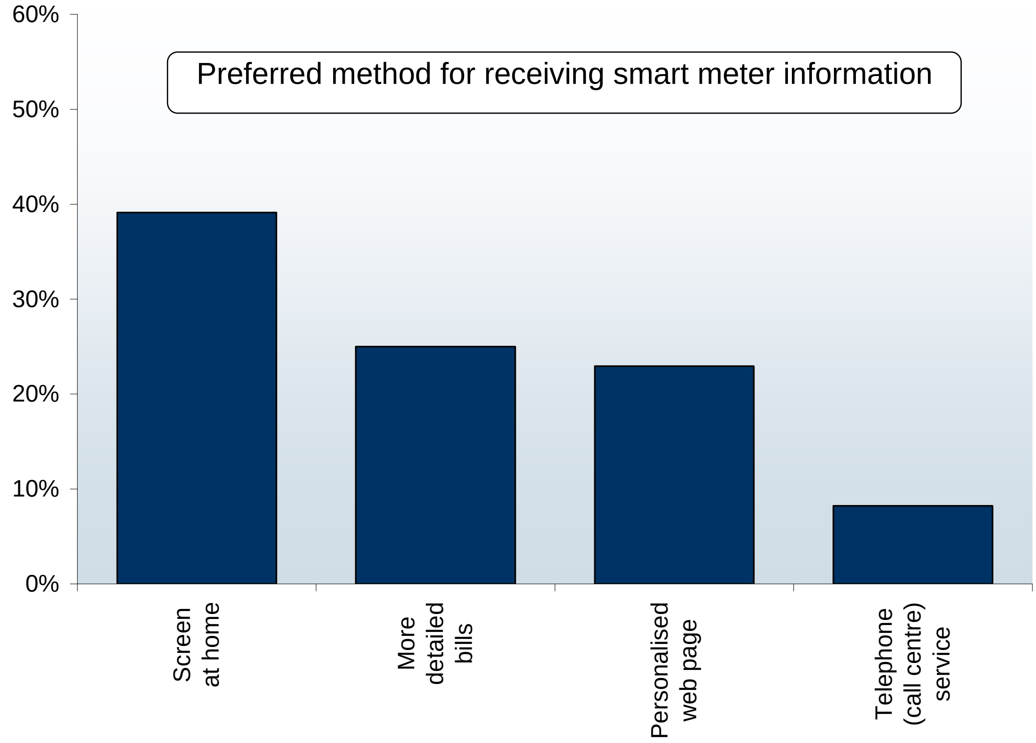

Figure C.5 Feedback preferences in the Netherlands (source: LogicaCMG).

C.5 How do consumers conserve energy?

In order to effectively stimulate consumers' behavior, it is important to know exactly how consumers conserve energy. This partly lies in one-off awareness and action, and partly in continuous behavioral change.

If the consumer does not have or does not see the opportunity to reduce his energy consumption, no energy will be conserved, irrespective of the level of feedback that is provided. In light of this, it is very important to understand how consumers have decided to conserve energy or can conserve energy, for example, in the practical experiments detailed below.

Roughly speaking, energy conservation is achieved in two ways:

- ✓ Different usage of (household) appliances[78]
- ✓ Use of other (household) appliances

In the first case, existing appliances are used differently, e.g.:

- ✓ Lighting in rooms that are not being used are switched off;
- ✓ Washing is hung to dry rather than dried in the drier;

- ✓ The second refrigerator in the shed is turned off during winter;
- ✓ The computer room is fitted with a mains switch to reduce stand-by consumption;
- ✓ The television is powered off instead of put on stand-by;
- ✓ Heating is set a degree lower;
- ✓ Curtains are closed earlier;
- ✓ Showers are shorter.

In the second case, different appliances are used/purchased, e.g.:

- ✓ The purchase of a new, energy-efficient refrigerator;
- ✓ The purchase of energy-saving light bulbs and LED bulbs;
- ✓ The purchase of a heat-pump drier;
- ✓ The installation of insulation;
- ✓ The installation of a water-saving showerhead.

The key is therefore different purchasing behavior and different usage behavior. Both types of behavioral change feature a one-off element (e.g. switching off the second refrigerator in the shed and discontinuing use, purchasing a more efficient drier) and a continuous element (e.g. switching off lights when not needed, not leaving appliances in stand-by, automatically looking for an A-label when purchasing new appliances), see figure C.6. The full potential of energy conservation in the home can only be reached if all four possibilities for conservation as depicted in figure C.6 are stimulated, e.g. by means of feedback and information. This approach provides points of departure for the manner of providing feedback on energy data from the smart measurement infrastructure and for government policy making.

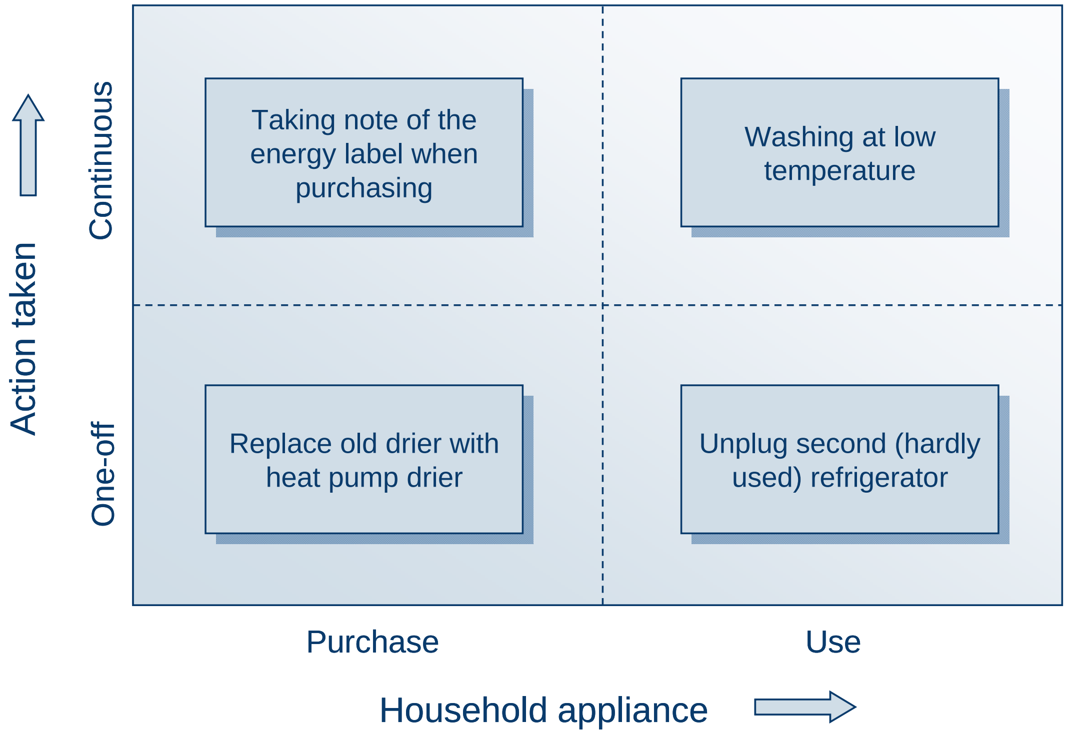

Figure C.6 Examples of the ways in which energy can be conserved

C.6 Studies and practical experiments

Practical experiments have demonstrated that feedback does lead to energy conservation. Conservation percentages of 0-10% (indirect feedback) and 5-15% (direct feedback) have been achieved. Careful conversion of these percentages into national percentages must take place as practical experiments are frequently carried out on a voluntary basis amongst the relevant consumers. This does not have to be representative for the Netherlands as a whole.

Various studies have been conducted into energy conservation on account of feedback, and a number of studies have already appeared that provide a very good overview of the studies conducted. This report examines only a number of studies and practical experiments that are considered of direct importance to the cost-benefit study.

In 2006, Sarah Darby, referred to above, carried out an extensive literary investigation, on the basis of which she has stated that direct feedback can deliver a conservation percentage of 5-15% and indirect feedback, 0-10%. She argues for a display showing current energy consumption in the home, allowing the consumer to immediately understand the use of individual appliances from the difference in energy consumption in the "on" and "off" position. She underscores the importance of energy conservation as a new behavioral practice. Broadly speaking, it takes around three months to instill new behavior, but even after that period, feedback is still necessary to prevent this behavior from ebbing away. Additional information and incentives may help to support this.

Wokje Abrahamse's study[79] is also of interest. In addition to the fact that this study provides an overview of literature in the field of feedback, the study also examines the results of an experiment conducted on 219 households into energy conservation by "tailored recommendation". Households receive information and feedback on a personal webpage. The householders themselves were required to enter their energy consumption on the webpage. This experiment resulted in energy conservation of approximately 5.1%. Important instruments in this experiment were:

- ✓ Information concerning the need for and benefits of energy conservation;
- ✓ Concrete tailored information concerning energy conservation options;
- ✓ Feedback on the savings made;
- ✓ Requiring the commitment of residents (setting an energy-conservation target).

Abrahamse has also concluded that her study has shown that household energy consumption is dependent on socio-demographic characteristics (income, size of household), but also that willingness to conserve energy and the energy savings achieved do not appear to be dependent on these characteristics.

On the basis of an overview study based on 26 projects in the field of energy conservation and feedback, Corinna Fischer[80] has concluded that there are a number of success factors when it comes to feedback. These are:

- ✓ Information over current usage;
- ✓ Sufficient frequency and long-term feedback;
- ✓ Households must be given choice and action options;
- ✓ Splitting information into individual appliances must be possible;
- ✓ Comparison with other consumption (historical, reference group);
- ✓ Understandable and attractive presentation.

She envisages an important role for a smart measurement infrastructure, especially with regard to the first three points.

Between 1993 and 1995, an experiment was conducted on 250 households in Amsterdam[81]. As part of the experiment, feedback was provided with regard to current consumption and reference consumption (on the basis of historical data), expressed in energy and monetary terms. One group of households received a display in their homes, while the other group was provided with a monthly bill showing the same information. In addition, attention was given to the *extinction period* (what happens if feedback stops?). What was striking was that users with a display did not conserve a significant amount of energy, while those receiving monthly feedback did (6-13% electricity, no significant gas conservation). The fact that the display did not give rise to energy conservation has been attributed to the limited information on the display (incl. no current consumption). Analysis of energy consumption during the extinction period showed continuing energy conservation, although energy consumption during the period did increase as quickly as before the experiment. It can therefore be concluded that a display on its own is not enough, and that the information on the display must be consistent with the needs of the user. Moreover, continuous feedback is required for optimum energy conservation.

An evaluation of the project "To measure is to know"[82] that households could save around 7% in energy by measuring the energy consumption of appliances in their home using an energy meter. Awareness at appliance-level plays a part here, resulting in, for example, PCs and TVs being switched off instead of left on stand-by, and replacing light bulbs with energy-saving light bulbs. The energy meter was provided for a period of 3 weeks, after which it was passed on to the next participant. The project was thus one of energy conservation as opposed to continuous feedback.

In her thesis, Diana Uitdenbogerd states that only information concerning energy-conservation measures will lead to more environmentally-friendly behavior in a small number of households[83]. Households pay more attention to costs and effort. Experiencing a problem and having a choice also play a role in willingness to change. She has also concluded (see paragraph C.3) that calculations of one's own energy-conservation behavior are not consistent with the reality of the situation. Awareness is therefore important.

A study has recently been completed into the effect of using a display showing real-time energy consumption (PowerPlayer). The study was relatively small scale (36 households), where 18 households received information feedback from a display connected to a smart meter, and 18 households received the same information on the basis of meter readings submitted themselves. Both groups achieved energy savings, but the savings made by the "display group" (9% electricity and 14% gas) were higher than those of the other group (3% electricity and 2% gas). This supports the notion that direct feedback, without the need for residents to have to go to effort themselves to receive the information, is crucial to energy conservation.

An important marginal note to the energy conservation percentages given is that these are based on a group of households who, in general, took part in the experiment voluntarily or who were chosen on account of their environmental awareness. Therefore, it is unrealistic to assume that these savings will be achieved across the Netherlands as a whole. Furthermore, the study referred to does not make reference to the degree of acceptance of smart meters that provide feedback. Experience in the Netherlands has shown that current positioning of smart meters has given rise to almost no refusals. The issue is whether or not this will change, taking into account the privacy aspects associated with smart meters. Good, balanced information from a reliable source is therefore very important in this respect.

APPENDIX D REFERENCES

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2 NTA 8130, *'Basisfuncties voor de meetinrichting voor elektriciteit, gas en thermische energie voor kleinverbruikers'* (Basic functions for metering equipment for electricity, gas and thermal energy for low-volume users), Netherlands Standardization Institute, Delft, August 2007.

3 See, among others, *Visiedocument Smart Grids* (Smart Grids Vision Document) by Netbeheer Nederland and the report *'Reflections on Smart Grids for the Future'* prepared by KEMA by order of the Ministry of Economic Affairs.

4 *Energy report 2008*, Ministry of Economic Affairs, June 2008 (issue no.: 08 ET 14).

5 This actually concerns two legislative proposals: nl. 31320 and nl. 31374. See also Parliamentary Document I, 2008/09, 31320, no. A, 'Regels omtrent energie-efficiënte (Wet implementatie EG-richtlijnen energie-efficiënte *(Rules regarding energy efficiency (Act for the implementation of EU energy efficiency Directives)*)' and Parliamentary Document I, 2008/09, 31374, no. B, ('Wijziging van de Elektriciteitswet 1998 en de Gaswet ter verbetering van de werking van de elektriciteits- en gasmarkt' (*Change to the Electricity Act 1998 and the Gas Act for the purpose of improving the functioning of the electricity and gas markets*). The two proposals were jointly processed in the Senate.

6 R.J.F. van Gerwen, S.A. Jaarsma, F.T.C. Koenis, *'Domme meters worden slim? Kosten-baten analyse slimme meetinfrastructuur'* (Are dumb meters getting smart? Cost-benefit analysis for a smart metering infrastructure), KEMA report 40510016-TDC, August 2005.

7 Colette Cuijpers and Bert-Jaap Koops, *'Het wetsvoorstel 'slimme meters': een privacytoets op basis van art. 8 EVRM'* (The 'smart meters' legislative proposal: a privacy evaluation based on Art. 8 of the European Convention on Human Rights), University of Tilburg, October 2008.

8 The following were referred to, among others: the cost-benefit analyses performed by KEMA in the Netherlands and Flanders and the study conducted by Frontier Economics by order of the Dutch Office of Energy Regulation. Further questions that arose in the processing of the legislative proposals referred to under (i) with regard to

the cost-benefit analysis performed by KEMA in the Netherlands, were answered by KEMA by order of the Ministry of Economic Affairs. The Minister of Economic Affairs submitted the answers to these questions to the Senate in his letter with reference number ET/EM/9027656, entitled *'Nadere vragen SP fractie inzake het wetsvoorstel wijziging van de Elektriciteitswet 1998 en de Gaswet ter verbetering van de werking van de elektriciteits- en gasmarkt (31 374)'* (Further questions by the Socialist Party in respect of the legislative proposal regarding the change to the Electricity Act 1998 and the Gas Act for the purpose of improving the functioning of the electricity and gas markets (31 374)), dated 12 February 2009.

9 The *Samsom-Six* requirements are: (1) providing registration and communication of local gross production; (2) a display for in the living room; (3) an alarm function for unusual fluctuations; (4) a facility for real-time registration and payment of energy purchases and deliveries; (5) automated supply of electricity to specific equipment, linked to external factors (e.g. washing machines on at low tariff); and (6) extra communication ports for other metering installations upon connection, such as heating, cooling and production meters.

10 Johan Boekema and George Huitema, *'Belemmering innovatie in energiemarkt door implementatie voorgestelde 'slimme meter' '* (Obstruction of innovation in the energy market as a result of the implementation of the proposed 'smart meter'), TNO Groningen, October 2008.

11 'Wijziging van de Wet houdende wijziging van de Elektriciteitswet 1998 en de Gaswet ter verbetering van de werking van de elektriciteits- en gasmarkt' (*Change to the Act constituting change to the Electricity Act 1998 and the Gas Act for the purpose of improving the functioning of the electricity and gas markets*), under preparation, April 2010.

12 Johan Boekema, '*Beoordeling uitvoeringsregelingen Slimme Meter'* (Evaluation of Smart Meter implementation arrangements), TNO report draft version 0.6, 16 March 2010.

13 Among others, see: *'Besluit meetinrichtingen en kostenoverzichten elektriciteit en gas'* (Decree in respect of electricity and gas measuring apparatus and cost specifications) (a Governmental Decree), under preparation, April 2010.

14 The term *deregulation* must be distinguished from the term *privatisation* which, in the Netherlands, has a somewhat negative connotation. Deregulation means: opening up the market in order to encourage competition through the entry of third parties.

Privatisation means: the assets of a company being transferred to private parties by a public authority (municipality, province, state).

15 It is characteristic of a *Regulation* that it has a direct effect and, consequently, creates law that has the same force in the EU as a member state's national law, without the national legislator having to do anything about it. A Regulation is binding in all its aspects, which expresses the supra-national character of the EU: once a Regulation comes into effect the member state loses the power to issue binding regulations regarding the legal area the Regulation refers to. A *Directive*, however, must first be implemented in national law. This is usually done by means of an Act that is submitted via the parliament of the member state in the usual manner. Directives are used to coordinate the different national legal systems and therefore often occur in relation to the harmonization of the common internal market. A Directive obligates member states to adapt their legislation in such a way that they are aiming for the same, clearly defined, end result. However, the choice of method is left up to the individual member state.

16 See the clarification of the *'Gesetzentwurf der Bundesregierung – Entwurf eines Gesetzes zur Öffnung des Messwesens bei Strom und Gas für Wettbewerb'*, Bundesdrucksache 16/8306, 28 February 2008.

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18 *'Meeting the Energy Challenge - A White Paper on Energy',* Department of Trade and Industry, United Kingdom, May 2007. (NB: The Department of Trade and Industry is a predecessor of the current Department for Business Innovation & Skills, the British Ministry of Economic Affairs.)

19 See *House of Lords Hansard*, 28 October 2008, Column 1516: ' (…) Our aim is then to ensure that the subsequent roll-out happens over a period of 10 years. This would see delivery of smart meters by the end of 2020 to align with our renewables targets (…)'.

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21 The United Kingdom has a separate Ministry for energy affairs, the Department of Energy and Climate Change (DECC). Previously DEFRA (Department for Environment, Food and Rural Affairs), the British Ministry for the Environment, Food

and Agriculture, and BERR (Department for Business, Enterprise and Regulatory Reforms) and the British Ministry of Economic Affairs were active in the field of energy, but this has now been centralized under DECC. The DECC website contains a lot of valuable information about the developments in the British energy market. Among others see:
http://www.decc.gov.uk/en/content/cms/publications/publications.aspx and
http://www.decc.gov.uk/en/content/cms/consultations/smart_metering/smart_metering.aspx.

[22]. *'Smart Meter Roll Out: Market Model Definition & Evaluation Project'*, Baringa Partners, 8 April 2009.

[23] The two options *not* recommended were a continuation of the current free meter market model (the so-called *Competitive Model*) and a fully centralized model with a national communication infrastructure and local *franchises* to provide metering services to energy suppliers by means of a license (the so-called *Fully Centralized Model*). At a later stage Baringa Partners also analyzed three alternative models, in which the network managers played a leading role. See also *'Smart Meter Roll-out: Energy Network Business Market Model Definition & Evaluation Project'*, Baringa Partners, 27 November 2009.

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[25] Geert Deconinck et al, *'Studie communicatiemiddelen voor slimme meters'* (Study on means of communication for smart meters), VREG 2006/0192, KU Leuven, ESAT/ELECTA, May 2007.

[26] *'Advies van de Vlaamse Reguleringsinstantie voor de Elektriciteits- en Gasmarkt met betrekking tot de voortzetting van de studie 'Naar een marktmodel voor de Vlaamse energiemarkt' en reacties uit de consultatieronde over de eerste fase van deze studie'* (Advice from the Flemish Regulation Authority for the Electricity and Gas Market regarding the continuation of the study entitled 'Toward a market model for the Flemish energy market' and responses from the consultation round in respect of the first phase of the study), VREG, Brussels, ADV 2006-4, 21 November 2006.

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38. An *open protocol* means that the protocol is available to anyone free of charge, and that no license costs are associated with the protocol. 'Open protocol' also refers to the way in which a manufacturer has defined the liberties/freedoms within a protocol. For a protocol to be truly open the manufacture has to make all the essential information for reading the protocol available. Furthermore, the manufacturer must only use methods that are described in open protocols and not use liberties/freedoms allowed by the protocol if they impose limitations on the basic functionality.

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40 See http://www.openmeter.com/.

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42 The Guardian, see: http://www.guardian.co.uk/environment/2007/jul/13/energy.business, 13 juli 2007.

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51 See, for example, the intelligent network in Hoogkerk recently realized by KEMA, Essent, ECN and Humiq (PowerMatchingCity).

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53 *Intelligent E-Transport Management*, KEMA project in conjunction with ECN, Essent, Alliander and IWO, March 2010.

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55 In 2020 20% energy savings, 20% share renewable energy and 20% reduction in greenhouse gas emissions (approval European Council March 2007).

[56] See, for example, the website of the *Administrative Burden Advisory Board* (www.minderadministratievelasten.nl).

[57] Consider, for instance, the Noord-Zuidlijn (*North-South railway line*), the kilometer charge and the public transport chipcard, but also the action *'Slim meten = slinks weten'* (Smart metering = deviously knowing) by the Vrijbit Foundation and the Stichting Meldpunt Misbruik ID-plicht (*Foundation for Reporting Abuse of the ID Obligation*).

[58] See, for example, the role of the ANWB (Royal Dutch Touring Club) in the introduction of the kilometer charge.

[59] Electricity Act 1998, Article 16, par. 1c.

[60] Timothy Leary classified behavior ('Leary's rose') and demonstrated that behavior results in counter-behavior. He also gave suggestions on how to influence behavior.

[61] This concerns *Transpower Stromübertragungs GmbH* (subsidiary of E.ON), *Vattenfall Europe Transmission*, *Amprion GmbH* (formerly RWE Transportnetz Strom) and *EnBW Transportnetze AG*. Effective 1 January 2010 Transpower Stromübertragungs GmbH will be owned by the Dutch TenneT.

[62] In the United Kingdom – unlike in most countries – the water companies are privatized as well as the energy companies. In order to prevent water companies generating monopoly profits, a special water regulator, *Ofwat* (Water Services Regulation Authority), determines a maximum price for each water company.

[63] *'Energy in Sweden 2007'*, Swedish Energy Agency, ER 2007:51, November 2007.

[64] Seven Flemish distribution network managers (with participation by Electrabel; in Belgium such network managers are called *mixed* network managers) have combined their operational activities in the operating company *Eandis*. Three other Flemish network managers (without participation by Electrabel; in Belgium such network managers are called *pure* network managers) have combined their operational activities in the operating company *Infrax*. In Wallonia *Ores* is the operating company in which a number of 'mixed' network managers collaborate. Electrabel is also a shareholder in Brussels Network Manager *Sibelga*.

[65] E-Energy is the result of a collaboration between the German Ministry of Economic Affairs (Bundesministerium für Wirtschaft und Technologie) and the Ministry of Housing, Spatial Planning and the Environment (Bundesministerium für Umwelt,

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78 In this context the home itself can also be considered an 'apparatus'.

[79] Wokje Abrahamse, *'Energiebesparing door gedragsverandering, onderzoek naar de effectiviteit van een advies-op-maat benadering'* (Energy savings through behavioral changes, study into the effectiveness of a customized advice approach), Doctoral thesis University of Groningen, 2007.

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