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Dutch Energy Savings Monitor for the Smart Meter

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Executive Summary

In 2011, the Dutch Parliament agreed to start a small scale rollout of new electricity and gas meters for consumers and small business. These energy meters, widely known as smart meters, enable consumers to become better informed about the dynamics of their household energy consumption and to opt for cost-saving measures. In the national cost-benefit analysis by KEMA (now DNV-GL) in 2010, it was estimated that the smart meter, in combination with indirect feedback through bi-monthly energy usage and cost statements (known as home energy reports), to be delivered by energy suppliers, would result in an average reduction in household energy consumption of 3.2 % for electricity and 3.7 % for gas. In combination with more sophisticated direct (real-time) feedback interventions, these savings would have the potential of increasing to an estimated average of 6.4 % for electricity and 5.1 % for gas. To support the Parliament in the decision-making regarding the large-scale rollout of smart meters from 2015, the Minister promised to monitor the practical user experiences as they relate to energy savings, during the small-scale rollout from 2012 to 2014.

The Dutch Energy Savings Monitor for the Smart Meter, the Savings Monitor in short, reports on the practical experiences related to:

- The actual savings in households with a smart meter and indirect feedback via a bi-monthly home energy report, to be provided by the energy supplier (Effects Monitor).
- The potential savings for alternative direct (real-time) and indirect feedback interventions for the smart meter (Potential Monitor).
- The prospects for the market development of smart metering services (Market Monitor).

Effects Monitor for the bi-monthly home energy report

Research on the actual effectiveness of savings achieved with smart meters in combination with bi-monthly home energy reports, provided by the energy suppliers, took place on the basis of a quantitative consumption change measurement and a qualitative consumer experience study. The quantitative consumption change measurement pointed out that households with a smart meter and bi-monthly home energy reports used 0.9 % less gas (significant at the 95% level) and 0.6 % less electricity (non-significant) after a full consumption year, compared to a control group of 50,000 households without a smart meter. It should be noted with this consumption change effect that the households in the

experimental group did not yet have access to the final intended home energy report, in which a historic cost comparison to the same consumption period in the previous year is also presented. Although the savings at first glance lag far behind the estimates of 3.2 % for electricity and 3.7 % for gas, as mentioned in the national cost-benefit analysis, it is unrealistic to assume that these consumption effects will already be achievable during the initial rollout period. Therefore, a conclusive evaluation cannot be made, as of yet, regarding the actual effectiveness of savings.

The qualitative consumer experience evaluation showed that the home energy report is not yet being delivered to consumers to the best possible extent. The energy suppliers, for example, do not yet actively promote the home energy report. Consequently, many consumers have not noticed the home energy report or mistakenly considered it as an advertisement or spam. This was especially noticeable with clients who were referred to the energy supplier's website to access their home energy report. On the other hand, consumers did take note of the home energy reports if the reports were forwarded by regular mail. These reports also resulted more frequently in reduced energy consumption, compared to the reports forwarded by email in a PDF attachment or with a link to the energy supplier's website. Paper reports are therefore considered not only more noticeable but also more likely to result in energy savings.

The measures reported to reduce energy consumption based on home energy reports are not only behavioural changes (such as switching the lights off when nobody is in the room), but also involve longer-term measures, such as putting up weather strips, replacing light bulbs with energy-saving light bulbs and considering purchasing / replacing appliances with models that have a higher energy efficiency rating. It is expected that these changes lead to average energy savings of 3.5 %.

Potential Monitor for alternative feedback interventions

Based on the suite of trials to investigate consumers' response to improved energy feedback via smart meters, it has been concluded that smart metering in combination with direct feedback, in particular, can lead to a considerable household energy reduction. Scientific pilot research by network operator Liander, with a real-time energy management app for smart phones amongst home-owners, showed average savings of 3 % for electricity and 4 % for gas. Another trial by network operator Stedin, housing corporation Woonbron and the City of Rotterdam, testing the consumption change effects of a real-time in-home energy dashboard amongst households in the low rental segment, delivered average savings of 5.6 % for electricity and 6.9 % for gas. Whether households with smart meters and direct

feedback interventions will be able to actually meet the average savings potentials of 6.4 % for electricity and 5.1 % for gas as mentioned in the national cost-benefit analysis, deserves a cautious answer of 'yes, on condition that...' The smart meter *can* provide better information with direct and personal feedback, in particular, and this information can result in similar savings to those expected. However, the pilots also indicate that the initial achieved savings are only persistent if the feedback medium matches the user's practical preference, and if the functionality and data presentation are tailored to the consumer's interests and capability for reinforcement and habit formation with the feedback system (i.e. daily bedtime check). For this reason, sophisticated real-time web services on PC, tablet and smart phone are potentially powerful to help reduce energy demand, but more so with already committed and technology minded subsets of the population, who are actively looking to further reduce their energy consumption. The extensive data analytics and graphic presentation options, in combination with the ease of use associated with online media such as PCs, tablets or smart phones, provide the required added value for persistent use of the web tool. However, less committed and /or less technology minded consumers or less capable consumers, more often experience such systems as too complex or too demanding for reinforcement and routine use. These consumers actually prefer the accessibility of a simple yet visually appealing in-home display. In fact, for older people, those with minimal education and low levels of numeracy and computer illiterates, for example, a physical in-home display will be a necessary first step to activate consumer interest and engagement in accessing real-time energy information from the smart meter. The interface design and the interaction within the household also play an important role in reinforcement and habit formation with the monitor.

Finally, the Potential Monitor points out that direct feedback leads to quick-win measures in particular: simple behavioural changes that require little or no investment of time or money, yet contribute immediately to savings. Examples include switching the lights off in empty rooms, avoiding stand-by use, etc. Longer-term measures such as insulation (weather strips, double glazing, etc), are generally not considered as a result of direct feedback. Conversely, long-term measures do show up more often in case of indirect feedback, such as the bi-monthly home energy reports. Direct and indirect feedback are therefore not mutually exclusive, but can actually complement each other.

Market Monitor

The market for smart metering services in the Netherlands is emerging but still at an uncertain commercial level. Partly, this is due to the small scale of the rollout of

smart meters. Service providers therefore operate with caution and are careful with investments in marketing and communication.
Another uncertainty is that market parties receive no information on where grid operators are actually installing the smart meters. This makes it difficult for service providers to approach consumers at the right time. However, an important recent development is that grid operators agreed to offer transparency regarding rollout planning and to discuss the possibilities of a more area-based rollout approach at the local level. This commitment will not only level the playing field for all market parties, but also offers better momentum opportunities for targeted marketing and communication. However, the extent to which new providers of smart metering services will really stand a chance in the market remains to be seen. Existing energy suppliers for instance already have a solid market position and an existing client base from which to operate commercially, possibly for customer retention purposes. It is expected that new market entrants - many of them small start-up companies with few resources in terms of R&D, production and marketing- will find it more difficult to build a presence.

The market supply of smart metering products and services in the Netherlands is developing especially towards sophisticated web-based services for the already committed and technology minded consumers. Simple in-home displays are scarcely being offered. Other consumer groups, such as older people, those with low incomes, those with minimal education and computer illiterates, may possibly not benefit from the smart meter rollout as readily. It is therefore important to ensure that the market also offers 'stepping stone' solutions such as in-home displays to kick-start consumer interest and engagement in accessing real-time energy information amongst less committed and/ or (internet) skilled consumers.

Finally, the current intent to purchase products or services with the smart meter amongst consumers is still low. Despite the experienced financial savings, many participants showed reservations about purchasing a feedback tool or investing in a smart metering service. This demonstrates the importance of a timely and coordinated consumer engagement strategy.

International experiences
To help contextualise the headline results from the Dutch smart metering consumer behaviour trials internationally, a literature review of similar trials in surrounding countries was conducted alongside this monitoring program. Experiences in the United Kingdom are of particular interest to the Netherlands, due to similar temperate climatic conditions and comparable energy consumption patterns, based on electricity as well as natural gas.

The research findings in the Netherlands on how consumers respond to improved energy feedback via smart meters are in general consistent with the experiences in the UK. Smart meters with dedicated real-time feedback are most consistent in achieving savings. In-home displays often appear to be the more important factor and a crucial first step to activate consumer interest and engagement in accessing real-time energy information. Sophisticated real-time web-based services on PCs, tablets and smart phones are potentially powerful to help reduce energy demand, but more so with already committed subsets of the population who are actively looking to further reduce their energy use. Due to a lack of engagement amongst less committed or skilled consumers, as seen in some pilots, opt-in websites and apps should not be considered as the up-to-date substitute for in-home displays, but rather as a complementary option. The estimated potential of 6.4 % for electricity and 5.1 % for gas seems relatively high in the Netherlands, compared to the experiences with direct feedback in the United Kingdom and Ireland (average of 2 % to 4 % for electricity and 3 % for gas). Still, the various pilots in the Netherlands indicate that these potential outcomes can be realistic, provided that the application and data visualisation connect to the practical preference and interests of the consumer.
Comparable studies in the UK of the effectiveness of savings achieved with periodic home energy reports were more difficult to compare, often due to the particular schedule of the multiple interventions tested.

The market supply for smart metering services in other European Member States is generally still at an infant stage. Notable exceptions are the United Kingdom and Ireland, where the decision was made for a mandated rollout of smart meters with energy displays to ensure the consumer benefits of awareness raising and support the market development for smart metering services at the same time. It appears that an industrial branch is developing in the UK for energy monitoring and energy management systems. The decision was also made in the UK to establish an independent information institute to familiarise consumers with the possibilities of the smart meter for monitoring and energy management.
In Ireland, a similar rollout model is being prepared which will allow the consumer to obtain information through three harmonised channels: an in-home display for real-time insight and behavioural measures, periodic home energy reports with invoices for interim evaluations of the current consumption year, and a web portal for detailed analyses and services from market parties via PCs, tablets or smart phones.

Improvement opportunities

The smart meter has the potential to become a substantial stimulus for active consumer interest and engagement in accessing energy information to reduce energy. However, the conditions are not yet established for the delivery of the savings potential in the Netherlands. The effectiveness of the bi-monthly home energy report can be increased and conditions can be improved for a timely and comprehensive market supply of attractive smart metering products and services which are accessible to everyone. The following improvement opportunities should be considered.

1. The delivery of savings through the bi-monthly home energy report can be increased. If announced and promoted more emphatically and preferably forwarded by regular mail at first, the attention value for the home energy report will increase. A clear explanation of its purpose may prevent the home energy report from mistakenly being seen as an advertisement or spam. Merely offering the home energy report in a passive way, through a link on the energy supplier's website alone, clearly seems less effective. It is also important that the home energy reports are informative and comprehensible and that their design is inviting. Lessons can be learnt from the experiences in other countries.

2. For many consumers, the smart meter is only 'smart' if it is offered in combination with a suitable feedback tool. Pilots have demonstrated, for example, the instant positive impact on consumers from the installation of a smart meter and an associated in-home display. It is meaningful that many participants (incorrectly) assumed that the in-home display either is the smart meter or a standard part of it. The simultaneous offer of a smart meter and 'smart' feedback will be an important momentum to activate (latent) consumer interest and engagement in accessing energy information available from smart metering. It is up to the market to ensure a broad range of feedback tools that caters to all target groups, both for higher-income as well as lower-income groups, less committed and vulnerable consumers. Specific consideration for vulnerable consumers should be integrated, at the local level, into the design of social policy programmes, aimed at the fight against poverty or debt assistance, for example. Collaboration between grid operators, local authorities, housing corporations and market parties could lead to simple yet suitable solutions for these groups. The in-home energy dashboard PowerPlayer pilot, in Rotterdam, showed how successful this can be.

3. The market opportunities for smart metering service providers will improve if they are provided with information regarding the rollout planning for smart meters in advance and if the rollout at the local level is more area-based, by taking into

account the expected receptivity amongst the residents. A level playing field will thus be created for service providers and marketing communication can be utilised more efficiently. However, the current low intent to invest in/ purchase feedback systems amongst consumers should also be taken seriously. Without intensive communication, it will take considerably more time for the market to mature and for consumers to become actively engaged with feedback systems as an intelligent means of accessing energy information. Timely collaboration between grid operators and market parties on initiatives to promote consumer engagement can help establish a more positive attitude amongst consumers, towards smart meters and associated energy management services. This will ensure that the benefits of smart metering are realised by energy consumers, energy network operations and the environment as a whole.

1 Introduction

The Dutch Government's objective is for all residential and small business customers to have the next generation of electricity and gas meters offered to them by the end of 2020. It was agreed in the Dutch Parliament that these so-called smart meters would be introduced according to a two-phased rollout-approach, to begin on a small scale in 2012 and 2013.[1] The purpose of the small-scale rollout was to gain experience and signal possible problems at an early stage, in order to take additional measures in time for the second phase, the large-scale rollout.

During the small-scale rollout, the smart meter was only installed in the event of new construction and large-scale renovations and in case of malfunctioning existing meters. The consumer was not charged for this type of installation/ replacement. In addition, smart meters were also installed in response to consumer requests, for a reasonable fee. The experiences from the small-scale rollout will be an input for the Government decision regarding the large-scale rollout of smart meters. The goal is to have replaced at least 80 % of all traditional energy meters in households, with smart meters, by 2020, in line with EU legislation.[2]

Residential and small business customers in the Netherlands are not obliged to accept a smart meter. Customers who object to the installation of the smart meter can either have the communication of the smart meter deactivated, or even refuse the installation of the smart meter. If the meter is administratively deactivated, the smart meter will actually function like a traditional meter. In case of refusal, the old electricity meter (and gas meter) will remain in place, and the meter reading will not be done remotely. In case of acceptance, the consumer will have the choice to have the smart meter read remotely at all times or in specific situations (for the annual bill and bi-monthly home energy reports, in case of switching supplier or when moving house).

1.1 Why a smart meter

Smart meters are the next generation of meters, which can replace existing electro-mechanical meters and offer a range of benefits, both for the individual electricity and gas consumer and for the network systems in general. Through automated recording actual energy usage over short intervals and

[1] When reference is made to the smart meter, it also means the gas meter, in addition to the electricity meter, throughout. With the installation of the new electricity meter, the gas meter – if present – is also replaced and then connected to the new electricity meter (in a wired or wireless fashion). The smart meter thus applies, in general, to both electricity and gas.

[2] In 2009, the so-called Energy Package was established at the European level, which stated, amongst other things, that under conditions in 2020, at least 80 % of households must have fitted a smart meter.

automated communicating of metering data to the network operator, the smart meter eliminates the need for a home visit to manually read the meter and facilitate more cost-efficient network operations. Electricity suppliers will be able to offer innovative pricing arrangements for consumers to support the efficient use of energy (i.e. time-of-use tariffs). But the smart meter also offers potential advantages directly to consumers.[3] Smart meters can put an end to estimated billing - people will only be billed for the energy they actually use - and allow easier switching of supplier to get the best deals.
However, the most immediate consumer benefit of the smart meter is the potential to receive more frequent and more detailed information on how much energy is being used (also called feedback). For instance, households with a smart meter will be offered to receive a consumption and cost statement from the supplier every two months, hereinafter referred to as the home energy report.[4] At the specific request of the consumer, the grid operator will forward the smart metering data on a more frequent (e.g. daily) basis to the energy supplier - or another service provider - for additional analysis of the consumer's energy consumption over the previous days, weeks and months, etc.

For monitoring of real-time energy consumption, consumers can add a wireless in-home display or online application to their smart meter via the so-called P1 port.[5] Products and services are emerging on the market for this purpose. In order to support product and market development, functional requirements for the P1-port have been established in legislation.[6] The grid operators have also established technical requirements for this purpose.[7]

To conclude, smart meters can facilitate improving energy efficiency by empowering consumers with more detailed, accurate and timely information regarding their energy consumption and costs, thus helping consumers to reduce any unnecessary energy usage.

[3] Where this report refers to households or consumers, it also refers to the small business consumer throughout. Consumers and households are also called 'small consumers', together with small business consumers. With small consumers it involves electric connections not exceeding 3 x 80 A, and gas meters with an outlet up to 40 cubic metres per hour (maximum G25).
[4] The bi-monthly home energy reports are not invoices. The current system of monthly cash advance payments and an annual final statement will remain in place. Consumers who don't want home energy reports forwarded to them can inform their energy supplier.
[5] The current mechanical and digital pulse meters also provide the option for real-time information on – the evolution of – household energy consumption. These older generation meters use optical 'readers' which can also be attached to the electricity meter and possibly also to the gas meter, instead of a special connection option (also called a P1 port). However, such a system is rather prone to errors compared to when smart meters are used.
[6] In January 2012, the decree on remote-readable metering devices (hereinafter referred to as: the Decree on Meter Requirements [*Besluit Metereisen*]), came into force. This decree placed minimum requirements on the smart meter, by establishing the functionalities that are deemed important from a social perspective and in view of privacy and security.
[7] These requirements were included in the so-called Dutch Smart Metering System Requirements (DSMR)

1.2 Why this report

It is generally expected that the smart meter will trigger many consumers to monitor and manage their household energy consumption. This is quantified in terms of savings expectations and potentials in the national cost-benefit analysis for the introduction of smart meters, conducted in 2010 by KEMA, by order of the Ministry of Economic Affairs.[8] It is estimated that the smart meter, in combination with bi-monthly home energy reports provided by the supplier, can result in an average structural reduction in household energy consumption of 3.2 % for electricity and 3.7 % for gas.[9] In combination with more sophisticated real-time feedback interventions, these savings have the potential of increasing to an average of 6.4 % for electricity and 5.1 % for gas. Energy saving is thus an important consideration with the smart meter introduction in the Netherlands.[10]

The Minister of Economic Affairs committed to the House of Representatives of the Dutch Parliament that more insight would be provided during the small-scale rollout, regarding the expected savings from the smart meter in combination with the bi-monthly home energy report and alternative feedback systems. The Minister also promised to monitor the development of the market supply for smart metering products and services. This was intended to support the Parliament in the decision regarding the large-scale rollout of the smart meter.

The coordination of this monitoring programme was assigned to the Netherlands Enterprise Agency, hereinafter simply referred to as RVO.nl.[11] RVO.nl worked together with the larger energy suppliers and regional grid operators, which supplied customer consumption data and conducted pilots. Where necessary, accountancy firm PricewaterhouseCoopers (PwC) oversaw the processing of these data, in compliance with the Personal Data Protection Act (*Wet Bescherming Persoonsgegevens, WBP*). RVO.nl was supported by IVAM, a research and consultancy agency in the field of sustainability, originating from the Interfaculty Environmental Science Department (IVAM) of the University of Amsterdam, in the scientific design of the monitoring programme.[12]

[8] KEMA July 2010. Smart meters in the Netherlands, a revised financial analysis and recommendations for policy [*Intelligente meters in Nederland, een herziene financiële analyse en adviezen voor beleid*]. KEMA merged with DNV- GL 1 November 2013.

[9] When the KEMA report was being prepared, it was not yet clear exactly what the home energy report would entail.

[10] The savings referred to in the KEMA report are based on an expert assessment of a realistic potential based on literature studies. The KEMA report herewith states emphatically that it does not (merely) involve the introduction of a smart metering infrastructure or display, but that use of this metering infrastructure and the method of feedback also have a major influence.

[11] The Netherlands Enterprise Agency succeeds NL Agency as implementing body for policy regarding sustainability, innovation, and international business and cooperation for the Dutch national government.

[12] IVAM is an independent research and consultancy organisation in the field of sustainability and is specialised in statistic scientific research, amongst other things; originating from the Interfaculty Department of Environmental Science [*Interfacultaire Vakgroep Milieukunde*] at the University of Amsterdam (IVAM).

In addition to RVO.nl, the regulator, the Authority for Consumers & Markets (ACM) also conducted a monitoring programme during the small-scale rollout of the smart meter, at the request of the Minister of Economic Affairs. The regulator focused especially on the operation of the energy market, in which special attention was paid to the technical rollout aspects, the acceptance of the smart meter and satisfaction regarding installation of the smart meter.

1.3 Structure of the report

This document, also called the *Savings Monitor*, reports on the Minister's commitments to the House of Representatives of the Dutch Parliament, in turn, in connection with:

- Determining the actual average effectiveness of savings with households that received indirect feedback via a bi-monthly home energy report, to be provided by the supplier after the installation of the smart meter, compared to households without a smart meter. This is the '*Effects Monitor'*, presented in Chapter two.
- Assessing the savings potential for alternative direct (real-time) and indirect smart meter feedback interventions to change energy-related behaviour in homes. This is the '*Potential Monitor*', presented in Chapter three.
- Analysing the market developments for direct and indirect feedback products and services for the smart meter. This is the '*Market Monitor*', presented in Chapter four.

This report is concluded in Chapter five with a number of improvement opportunities for the large-scale rollout from 2015.

To help contextualise the results from this monitoring program, the experiences in surrounding countries are taken into consideration as well. The United Kingdom and Ireland are particularly relevant for the Dutch situation, due to similar climatic conditions and consumption patterns, based on electricity and a large penetration of natural gas (for heating, cooking and hot water).[13] Finally, energy savings also form an important part of the business case for smart metering in these countries.[14]

In this report, scientific jargon was avoided wherever possible, since the Savings Monitor is aimed at a comprehensive target group: members of parliament, grid

[13] Approximately 95 % of all households in the Netherlands are connected to the natural gas grid. In the UK, this is approximately 85 %, and in Ireland, approximately 25 %.

[14] DECC (2013) Impact Assessment Smart meter rollout for the domestic and small and medium non-domestic sectors (GB). Final report. In this report, the positive business case for the UK is based on average household energy savings of 2.8 % for electricity and 2 % for gas (credit), amongst other things. In Ireland, the positive business case is based on an average energy savings of 3 % for electricity, amongst other things.

operators, research institutes, consumer organisations and energy suppliers and other providers in the market, etc. Elaborate descriptions and detailed analyses were also omitted wherever possible. Reference is made to the relevant reports in the bibliography of this report.

An interim report for the Savings Monitor was published at the start of 2013 by RVO.nl, with regard to the structure, composition and division of roles for conducting this Savings Monitor. The Senate and the House of Representatives were informed of this by the Minister on 18 February, in a letter to Parliament.[15]

Acknowledgements

RVO.nl could not have succeeded in conducting this Savings Monitor without the support of grid operators Liander, Enexis, Stedin Meetbedrijf and Delta Netwerkbedrijf. These parties contributed intensively in the brainstorming for the design of the monitoring programme and also conducted research trials. Energy suppliers Eneco, Essent, Greenchoice, Nuon, Nederlandse Energie Maatschappij and Oxxio also contributed actively to this, by providing relevant customer data. In addition, interest groups and consumer organisations like Consumentenbond (the largest Dutch consumers association) and Vereniging Eigen Huis (association of home-owners), and smart metering service providers, also provided input for this report during consultation meetings. RVO.nl would like to thank all parties who have contributed to the successful delivery of this report.

[15] NL Agency (2012) Energy Savings Monitor for Small-Scale Smart Meter Rollout, Interim report [*Monitor Energiebesparing Slimme meter Kleinschalige Uitrol, Tussenrapport*].

2 Effects monitor for the bi-monthly home energy report

2.1 Introduction

For most households, the annual bill is the only feedback received for in-home energy consumption. In practice, this motivates only a few to change their consumption behaviour and to achieve persistent energy savings. The smart meter enables more frequent and improved feedback interventions to change energy-related behaviour in homes. For this purpose, a basic type of feedback intervention was established in legislation, in the form of bi-monthly energy usage and cost statement, also called home energy report. Energy suppliers are obliged by law to offer the home energy reports at least 6 times a year to customers with a smart meter.

The home energy reports are subject to minimal requirements.[16] The report must provide insight into the actual consumption at actual energy prices and must compare this to previous consumption periods and to comparable end users. The report must also be forwarded actively, either by regular mail or as a PDF attachment to an email. It is not sufficient to merely provide the report passively on the supplier's website.

It is expected that the bi-monthly home energy report will incite consumers to use energy more efficiently.[17] KEMA estimated in 2010 that this type of indirect feedback will allow Dutch households to achieve an average persistent reduction in energy consumption of 3.2 % for electricity and 3.7 % for gas. To substantiate this, the Minister promised to the Parliament that the aforementioned effects would be tested in practice. However, it was also emphasised that this would not be easy during the small-scale rollout period. The Minister stated on 17 December 2010 in a Memorandum of Reply to the Senate:

'It is difficult to make general statements regarding the savings effects of the smart meter, based on the small-scale rollout. The meter is, after all, still relatively unknown amongst consumers, and the supply of energy-saving products and services is still at an infant stage. Besides, not all situations in the small-scale rollout are equally suitable for monitoring energy-saving effects. New construction and large-scale renovation projects are less suitable, because it is not quite as possible to compare previous energy consumption under normalised conditions.'

[16] Home Energy Report Decree [*Besluit kostenoverzicht Energie*], number 116, Government Gazette [Staats Courant], 26 February 2011.
[17] Explanatory Memorandum to the Home Energy Report Decree, page 4.

Other circumstances also limit the possibility of making conclusive statements regarding the effectiveness of bi-monthly home energy reports at this stage.[18] The first home energy reports, forwarded to consumers with a smart meter, only included information on the current interim consumption; historic information could not be provided in the beginning. Also, the starting-up process of forwarding the home energy reports in 2012 was not successful in some cases.[19] These limitations meant that the effectiveness of savings achieved with the home energy report during the small-scale rollout could not be established completely, and a comparison to the estimates from 2010 would be provisional. This should be taken into consideration when reading this chapter.

This chapter

This chapter elaborates upon the results of the study of consumer experiences with smart meters and bi-monthly home energy reports. To start with, a high level description of the study design is provided.[20] The results are then examined, in terms of savings and experiences and in relation to the means by which they are forwarded to the consumers. The chapter concludes with a general assessment of the effectiveness of the home energy report, related to the national cost-benefit analysis and experiences abroad. For a comprehensive explanation of the research methodology used and for justification of the results, as described in this Effects Monitor, reference is made to the Report by IVAM, Monitoring and evaluation of the smart meter and the bi-monthly home energy report [*Monitoring en evaluatie van de slimme meter en het tweemaandelijks verbruiksoverzicht*].[21]

2.2 Research design of the Effects Monitor

The Effects Monitor focusses on the practical experiences in the area of energy savings for households with a smart meter, which received a bi-monthly home energy report for the first time in 2012. It seeks to better understand how households react to improved information through the bi-monthly home energy report and how this translates into consumption changes compared to households without a smart meter.

[18] Energy suppliers are only able to provide historical bi-monthly consumption data from the first year onwards, because the data is provided through the smart meter.

[19] NMa (2012) Monitoring Report on the Small-Scale Offer of the Smart Meter [*Monitoringrapportage Kleinschalige Aanbieding Slimme Meter*]. An initial glance at the rollout of the smart meter in the Netherlands [*Een eerste beeldvorming van de uitrol van de slimme meter in Nederland*]. This indicated that suppliers only complied with the aforementioned obligations to a limited extent. It was established, amongst other things, that - up to the summer of 2012 - suppliers did not yet provide home energy reports to a (high) majority of consumers with a smart meter.

[20] This was already dealt with extensively in the Energy Savings Monitor for the Smart Meter, Interim report [*Monitor Energiebesparing Slimme meter, Tussenrapport*]. NL Agency, November 2012.

[21] IVAM UvA BV (2014) Monitoring and evaluation of the smart meter and the bi-monthly home energy report [*Monitoring en evaluatie van de slimme meter en het tweemaandelijks verbruiksoverzicht*].

The Effects Monitor mainly consists of two parts: a quantitative consumption change measurement with an experimental group of approximately 670 households, compared to a control group of 50,000 households and a qualitative consumer experience study with a separate inquiry group of approximately 740 households.

2.2.1 Consumption change measurement

A representative experimental group was compiled from Dutch households that had a smart meter at the start of 2012 and which should have received a bi-monthly home energy report from that point forward. Only households that had the smart meter installed through 'regular' replacement (in case of malfunctioning of the old meter, for example) were selected, so changes in consumption would not be influenced due to a new home, an extensively renovated home, or an existing energy motivated request.[22] For a reliable monitoring of the changes in consumption, compared to previous years, the selected households also had a long-term consumption history, without estimated meter readings, and received their first home energy report along with the annual bill for the past year. The fact that most households already owned a smart meter for a longer period of time, appeared not to be a problem, since preliminary research indicated that a smart meter, in itself, did not lead to changes in consumption.[23]

Design of the experimental group

The larger energy suppliers Eneco, Essent, Greenchoice, Nuon and Oxxio and the largest grid operators Enexis, Liander and Stedin, contributed to putting together the experimental group.[24] The selected suppliers provided customer information about all clients who received a bi-monthly home energy report for the first time in 2012.[25] The grid operators populated the customer database files with the metering data for both the current as well as the historical annual consumption. Finally, the database files were checked for consistency and statistically analysed by IVAM.[26] After processing the aforementioned quality requirements and monitoring for the presence of information on the type of home and the construction year, the final analysis was eventually based on a limited but representative experimental group,

[22] During the small-scale rollout, the smart meter was only installed in certain cases, such as in the event of new construction, extensive renovations or replacement of the home's energy label by at least two levels, and at least category B, regular replacement, and at specific request of the consumer. For a scientifically reliable and representative measurement of the effectiveness of savings of the home energy report, only the 'regular replacement' category was deemed suitable. The reason for this is because installation was thus random in respect of this study.

[23] NL Agency (2012) Energy Savings Monitor for Small-Scale Smart Meter Rollout [*Monitor Energiebesparing Slimme meter Kleinschalige Uitrol*], Interim report.

[24] The collaboration amongst energy suppliers and grid operators took place within the context of the Personal Data Protection Act (*Wet Bescherming Persoonsgegevens, WBP*). Accountancy firm PricewaterhouseCoopers (PwC) watched over this.

[25] Pertaining to the period June through September 2012. The first five months of 2012 were not included because of lack of data. The last three months of 2012 were not included in the study period for this monitor.

[26] So-called multiple linear regression techniques were used for this purpose, in order to be able to explain possible evolution of consumption, not only based on receipt of the home energy reports, but also through other variables such as type of home and construction year.

from a scientific point of view, of approximately 670 households.[27] Individual questionnaires were not included here, to prevent participants from changing their consumption behaviour because they know they are being observed (Hawthorne effect).

Design of the control group

A control group was assembled, to determine the autonomous household consumption trend for electricity and gas, for households without a smart meter. For this consumption data, the same selection criteria were used as for the smart meter group. The analysis was conducted on the basis of a control group of 50,000 households.

2.2.2 Consumer experience study

A separate consumer survey was conducted, in order to explain the possible differences in consumption change between households with a smart meter and a bi-monthly home energy report, and households without a smart meter. The survey was conducted amongst the 8,000 Dutch households that received a smart meter through regular meter replacement in the first half of 2012, at two different points, December 2012 and June 2013.[28] This study had a longitudinal design, meaning that only respondents who participated in both surveys took part. A total of 743 respondents participated in the study from different energy suppliers, namely Nuon (31 % of respondents), Essent (22 %), Eneco (16 %), Greenchoice (10 %) and Oxxio and Nederlandse Energie Maatschappij (both 7 %). In the surveys, questions were posed regarding the receipt, appreciation and use of the bi-monthly home energy report for more conscious in-home energy consumption.[29]

2.3 Results of the Effects Monitor

From the quantitative consumption change measurement it appeared that households that had a smart meter on 1 January 2012, and that actually received a bi-monthly home energy report, consumed an average of 0.9 % less gas per year, compared to an average household without a smart meter. The effect is statistically significant at the 95% level and is attributable to the home energy report.[30] A savings of 0.6 % was calculated for electricity consumption. This effect is non-

[27] The database files were also monitored for a realistic consumption scope and evolution of consumption over a period of approximately 365 days.

[28] The relevant population for this study (households that received a smart meter during the first half of 2012, due to regular replacement) with the three larger grid operators consisted of 8,217 households, of which 1,357 households participated in the first round of questions (16 %) and 743 also participated in the second round of questions (9 % of the total population).

[29] Due to overrepresentation of certain respondent groups (higher income, larger homes, etc.), the results, by definition, are not representative of the Dutch population.

[30] The accuracy of this effect is 0.9 % +/- 0.4 %. The likelihood of this result being a coincidence is 4 % and it therefore falls within the scientific standard of 95 % reliability.

significant, because the measuring results were spread too much.[31] It is emphasised however that these results do not yet form a true measure of the overall effectiveness of savings achieved with the bi-monthly home energy report. As indicated earlier, monitoring is not yet possible to a sufficient extent, due to various circumstances and because historical consumption and cost data were not available for the home energy reports at the time of the research period.

It became also evident from the qualitative consumer experience study that the effectiveness of savings of the bi-monthly home energy report can be improved. Relatively few respondents were aware of the fact that they received the bi-monthly home energy report. In December 2012, only one third (32 %) of all respondents were aware of the fact that they were receiving this report. In June 2013, when forwarding of the home energy report was well underway, this share was still relatively low (56 %).[32] Many respondents did not know about the home energy report, or mistakenly considered it an advertisement or spam. Respondents, who were referred to a link on their website, were less likely to be aware of receiving the home energy report. On the other hand, the awareness level amongst respondents who received the home energy reports through regular mail was significantly higher.

2.3.1 *Use of the bi-monthly home energy report*

The way in which forwarding took place also had an influence on the actual use of the home energy report. Home energy reports that were forwarded by regular mail, more often led to more conscious energy consumption compared to home energy reports that were forwarded by email in a PDF attachment or with a link to the energy supplier's website. This is reflected in the figure below.

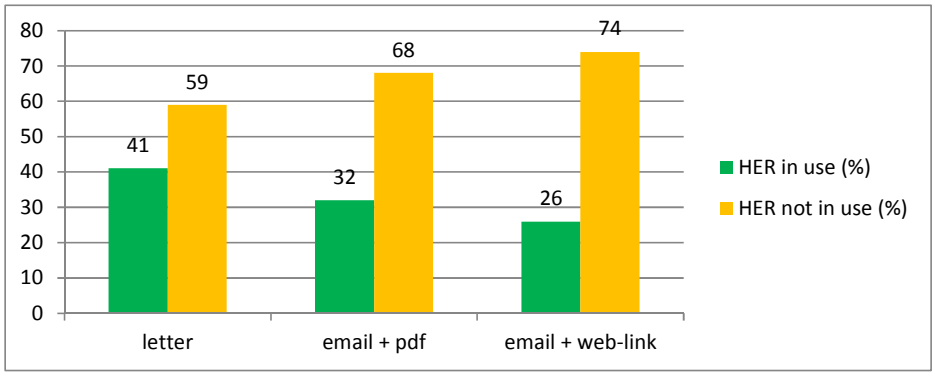

Figure 1 Actual use of the home energy report (HER) in relation to type of means: letter, email + pdf attachment, email + web-link. (%, n= 418)

[31] The accuracy of this effect is 0.6 % +/- 0.5 %. The likelihood of this result being a coincidence is 20 % and it therefore falls outside the scientific standard of 95 % reliability. This is due to the fact that the family size was not available as a variable for this analysis.

[32] It should be noted with all these percentages that forwarding of the home energy reports was off to a slow start and that it cannot be assumed that 100 % of all respondents actually received a HER.

Paper reports are clearly more noticeable and lead more often to conscious in-home energy consumption. Why this is the case is not yet entirely clear. It is conceivable that regular mail from the energy supplier is generally taken seriously by most customers. Digital forwarding is more likely to be considered spam and is deleted in one simple mouse click. This does not necessarily mean that paper reports lead to higher savings, more research is needed on this.

2.3.2 Savings measures

Bi-monthly home energy reports do not only lead to simpler behavioural changes such as switching off lights when a room is not in use. Also longer term savings, such as putting up weather strips, replacing light bulbs with energy-saving light bulbs, result from the information in the home energy report.[33] When asked, the users amongst the respondents expect to achieve an average energy savings of 3.5 % following from the home energy reports. Of the historical consumption data and cost data still lacking, two-thirds of the users estimate that this information will contribute to more conscious in-home energy use.

2.4 International experiences

Comparable foreign studies of the effectiveness of savings achieved with periodic home energy reports are scarce. Moreover, the reports often present multiple experiments, from which the influence of the home energy reports are difficult to isolate.[34] Even so, some noteworthy results were booked in the United Kingdom, with similar feedback: smart meters in combination with supplementary invoice information with historical feedback (the same period for the previous year) and general recommendations for achieving savings, forwarded by regular mail on a monthly basis.[35] In one trial, the particular combination of advice and historic feedback on consumption along with smart meters, reduced electricity consumption by 2.3% overall in the first in-trial year. The effect was persistent into the second in-trial year (4.0% saving). According to researchers, this effect was likely achieved in part due to a combination of simple and clear texts and colourful presentations.[36] This indicates that the bi-monthly home energy report in the Netherlands could result in effective savings of 3.2 % for electricity as estimated in the national cost-benefit analysis. However, other UK trials investigating similar feedback combinations found weaker evidence or proved more difficult to quantify because of the particular schedule of interventions.

[33] In this case it involves the measures taken since the first survey by users compared to non-users.
[34] Darby, Sarah (2012) Literature review for the Energy Demand Research Project (EDRP). Page 9
[35] In one of the EDRP trials, energy supplier EDF researched the effectiveness of savings with monthly home energy reports forwarded by regular mail, as supplementary information to the invoice, along with historical feedback and general recommendations for achieving savings.
[36] AECOM Building Engineering and Ofgem (2011). Energy Demand Research Project: Final Analysis. Page 121.

In the United States, experience has been acquired since 2007 with Home Energy Reports from a provider in the market, Opower, amongst others. Social benchmarking forms an important psychological element in the reports that are forwarded by Opower, because the in-home consumption is related to consumption for 100 other residential neighbours and the 5 lowest users in the group ('norm to conform'). Independent American research shows persistent average savings of 2 % compared to control groups.[37] Opower, Facebook, American environmental associations and 16 utility companies, also launched an energy app, partly on the basis of these results. Users link their energy bill to the app and compare their consumption to that of their neighbours or other participating households in the US.

2.5 Conclusions

Households with a smart meter and bi-monthly home energy reports used 0.9 % less gas (significant) and 0.6 % less electricity (non-significant) compared to an average household without a smart meter. At first sight, these savings lag far behind the estimates in the social cost-benefit analysis, of 3.7 % for gas and 3.2 % for electricity. However, the Effects Monitor can not yet provide a complete picture of the effectiveness of savings, particularly because the bi-monthly home energy report did not include all the relevant information for the consumer at the time of the effects measurement.

Moreover, the qualitative consumer experience study points out that many consumers are not aware of the home energy report being forwarded, or mistakenly consider it an advertisement or spam. This seems to be the case, in particular, with consumers who are referred to a link on the energy supplier's website for their home energy report. Forwarding the report on paper by regular mail, on the other hand, has a positive impact on the attention value for the home energy report. Home energy reports forwarded through regular mail also lead more often to conscious energy use, compared to home energy reports that are forwarded per email in a PDF attachment or with a link to the energy supplier's website. Paper reports are therefore considered not only more noticeable but also more likely to result in energy savings.

The bi-monthly home energy report, as a savings instrument, has a larger savings potential. This potential can be better realised if the home energy report is timely communicated, better positioned, and preferably offered through regular mail at first. This not only will have more impact on the attention value for the home energy report, but also on its actual use for energy demand reduction. The experiences in studies with comparable home energy reports forwarded by regular mail in the

[37] Allcott, H and Mullainahan, S (2010) Behaviour and Energy Policy. Science: 327 (5970) page 1204 – 1205.

United Kingdom also indicate that a 3.2 % effectiveness of savings, as stated in the cost-benefit analysis, can be achieved for electricity, with the bi-monthly home energy report.

3 Potential Monitor for alternative feedback interventions

3.1 Introduction

Consumers can use other forms of feedback through the smart meter, either as an alternative to or in addition to the bi-monthly home energy report. The national as well as the international research literature suggests that the more immediate and frequent the feedback, the greater impact on consumption behaviour.[38] In the national cost-benefit analysis from 2010 it was estimated that Dutch households could save an average of 6.4 % for electricity and 5.1 % for gas with real-time feedback through an in-home display. In response to parliamentary questions, the Minister promised to take a closer look at the potential effects on the energy consumption of consumers with alternative direct and indirect feedback systems, in combination with the smart meter.[39]

This chapter

This chapter reviews trial research on smart meters with alternative direct as well as indirect feedback interventions, conducted to date in the Netherlands. Firstly, a review is included of previously conducted experiments in the Netherlands.[40] This is followed by reporting on the pilots that were conducted by grid operators Liander, Enexis and Stedin, during the small-scale rollout.[41] An online savings programme for consumers with a smart meter, introduced by environmental organisation Natuur & Milieu at the start of 2013, is also reviewed. This chapter concludes with a short evaluation of the most important findings.

In reading this chapter, it should be noted that most experiments and pilots relate to relatively small populations, and were conducted by way of self-selection amongst participants who know they are being studied (the so-called Hawthorne effect). This means that the results of this Potential Monitor are more indicative than representative for the Dutch population.

3.2 Review of previous experiments

In the Netherlands, various studies have already been conducted to better understand how consumers react to improved feedback from smart meters, prior to the small-scale rollout. These studies are listed below and briefly explained thereafter.

[38] Note following the report 'novelle' Market Model and Energy Efficiency [*Marktmodel en Energie-efficiëntie*], 3 September 2010. Page 4.

[39] Response to parliamentary questions for the Draft decree on remote-readable metering devices [*Ontwerpbesluit op afstand uitleesbare meetinrichtingen*], 23 May 2011, page 7.

[40] Remarkably enough, these studies enjoyed little attention in the past, although they already provided important initial insights, which is why these studies are also included in the Savings Monitor.

[41] Wherever possible, commercial products and / or services were not included in these pilots. They mostly pertain to justification of the extent to which the smart meter, in combination with other forms of feedback, can help households be even more conscious and reduce energy consumption, compared to similar households without a smart meter.

Name Period: study duration	Type of feedback: instrument	Quantity Global typification of participants	Electricity savings	Gas savings	Savings compared to:
Oxxio 2008 / 2010: 24 months	Indirect feedback: PC-web (MijnOxxio [*MyOxxio*])	- 2,513 - Oxxio clients - Home owners - Energy-conscious	1.5 %	1.8 %	Smart meter owners who don't use the system actively
TU Delft 2008 / 2010: 15 months	Direct feedback: in-home display	- 54 - Home owners	1.7 % - 7.8 %	N/A	Forecast based on historical consumption
Nuon 2009 / 2010: 4 months	Direct feedback: in-home display (PowerPlay)	- 40 - Home owners - Both energy-conscious and not so energy-conscious	6 %	12 %	Households with a smart meter, but without the display
Amsterdam Smart City 2010 / 2011: 12 months	Direct feedback: in-home display	- 400 - Home owners	4.6 %	4.5 %	Control group (without smart meter)

Chart 1. Overview of studies and pilots on smart meters and feedback prior to the start of the small-scale rollout in 2012

Energy supplier Oxxio was the first, in 2008, to conduct trial research on the effectiveness of savings achieved with the smart meter, in combination with indirect feedback through an online self-service platform.[42] This supplier web service, called MijnOxxio, provided clients insight into their (historical) energy and gas consumption, as well as information on the evolution of rates and costs, through a personal web page via their own PC / laptop. Research and consultancy agency Rescon and the Universities of Amsterdam and Maastricht conducted research on 2,513 of Oxxio's clients for a period of two years. The researchers found that clients who used the web application, consumed on average 1.5 % less electricity and 1.8 % less gas compared to other Oxxio clients with a smart meter, but without using the website.[43] Three-quarters of the examined group still visited their personal area on

[42] ResCon research & consultancy (2011) Customised energy advice through the use of smart meters [*Energieadvies op maat via gebruik van slimme meters*].

[43] A comparison to households without a smart meter, as a control group, was not included in this study, which means that statements could not be made in this respect.

the website after a year to obtain insight into their in-home changes in consumption.[44] The researchers assumed that the savings with new smart meter users would potentially be higher, since the clients that were studied also had a smart meter for a longer period of time, and likely formed part of a select group interested in energy savings.

In 2009, energy supplier Nuon was the first, in conjunction with Eindhoven University of Technology, amongst others, to conduct trial research on the development of consumption behaviour amongst consumers with a smart meter and a real-time in-home energy display.[45] It involved a small-scale experiment in Arnhem, of approximately 40 households with a smart meter, where one half received a real-time energy display and the other half did not. Both groups were equal in terms of composition, domestic environment and environmental motivation – after scientific selection – and were given the same instructions and recommendations for achieving savings.[46] After four months, the researchers found that a considerably higher portion of participants with a display appeared to be able to save energy, compared to households without a display.[47] The display group also succeeded in saving considerably more energy (average of 9 % for electricity and 14 % for gas) than the group without a display (3 % for electricity and 2 % for gas, respectively). To conclude, the display group had a more positive feeling about the test and complained less about the (time) effort. After some time, the participants started to understand their own consumption patterns better and felt less need for daily consulting of the system.[48] The participants without the display clearly had less positive experiences, and considered their participation to be more of a hassle. The researchers concluded that a real-time display can contribute significantly to willingness to reduce energy demand as well as to the success to be achieved with it.

In 2010, the same study was conducted on a larger scale, under the name West Orange, in the context of Amsterdam Smart City.[49] Amongst approximately 400 households – mostly home owners – the researchers from the University of Amsterdam, amongst others, also found an increased energy awareness and

[44] The frequency, with which the personal area of the website was visited, is not known.
[45] PowerPlay pilot 2008/2009, Nuon / NL Agency / TU Eindhoven / Home Automation Europe and UC Partners, May 2009.
[46] The participants were scientifically selected from a large group of 50,000 households and were divided into two groups by way of invitation (1,000 households) and questionnaires (approximately 200 households), equally on the basis of environmental motivation and behaviour.
[47] In the display group, 81 % achieved savings for electricity and 100 % for gas. In the group without a display, 47 % succeeded in achieving savings for electricity and 65 % in achieving savings for gas.
[48] Also refer to Home energy monitors, impact over the medium-term, S. S. van Dam e.a., Building Research & Information (2010) 38(5), page 460.
[49] Noort, Henk e.a. (2011) West Orange. Save energy with EMS [*Energie besparen met het EMS*], results of in-home pilot 2010 – 2011 [*Resultaten in-home pilot 2010 – 2011*]. Participants in this pilot were IBM, Amsterdam Innovation Motor, CISCO, Home Automation Europe, Liander, Nuon, University of Amsterdam, Ymere and FarWest.

development of energy-saving behaviour. According to the researchers, the in-home display ignited a pre-existing need by consumers to monitor energy consumption as well as the effects of savings measures. This resulted in a significant reduction in energy consumption, of 4.5 % for electricity and 4.6 % for gas, which was not observed in the control group.[50] Moreover, the researchers believe that these savings only represent the lower limit, because not all displays functioned to the best possible extent.

According to the researchers, the positive attitude towards the display also resulted in a more positive perception of the service provider (in this case Nuon), which participants considered to be more sympathetic and more innovative. Despite the prototype aesthetics of the display, the majority of participants (58 %) were interested to have such a device at their disposal. However, the uptake price would be low at €40. Therefore, the researchers suggest not to charge up-front for the display, but to recover the cost via the bill.

Another important finding was that the savings were mostly the result of simple behavioural changes that required little or no investment of time or money (low cost quick-win). Longer-term investments aimed at energy savings, were not or hardly taken into consideration.[51]

Finally, the researchers noticed that the consulting of the energy display declined as time went on. However, this was due, in part, to the technical 'growing pains' (error messages) and partly because the need for daily monitoring decreased, because of the learning effect.[52]

Doctoral research at Delft University of Technology, on the effectiveness of home energy management systems between 2008 and 2012, showed that a lack of habit formation with the use of the feedback system in the longer term can also result in declining savings.[53] In this experiment, researchers installed a real-time electricity monitor which provided information on actual consumption, daily consumption and a comparison with a savings goal, at 54 households (with a traditional meter).[54] After four months, the households were split into a group of 28 households that returned their display (in exchange for € 25) and a group of 26 households that wanted to keep the display. After 11 months, it was evident that the savings achieved in both

[50] The control group consisted of approximately 3,000 households, drawn randomly from Nuon's client base in the Amsterdam region.

[51] This observation may also be due to the fact that the majority of the participants reside in homes that are better insulated (wall insulation and double glazing, in particular).

[52] Some displays did not function to the best possible extent, due to technical problems. The impact hereof on the interim evolution of consumption is unknown.

[53] Van Dam, Sonja (2013) Smart Energy Management for Households, Doctoral Thesis, Delft University of Technology, Faculty of Architecture and the Built Environment, Real Estate and Housing Departement.

[54] It involved an electricity display named Wattcher, manufactured by Innovaders in Amsterdam. All participants were also offered to use an online advisory and registration system for processing of the meter readings that were taken individually. The study participants had a traditional electricity meter.

groups, in the first four months, declined.[55] With the households that returned the display, the previous savings of 3.9 % dropped to a negative savings of -1.0 % (a consumption increase over the original level of consumption). With the display group, the savings also decreased, depending on the extent to which the display was used routinely. Irregular users of the display (12 households), experienced a 6.3 % level of savings after 4 months, dropping to 1.7 % after 15 months. The users who kept to their daily routine of consulting the display (most common use was the 'bed-time' base level check) also experienced a reduction in savings, but maintained significant savings of 7.8 % after 15 months. The survey pointed out that the magnitude of savings depended on the persistence and intensity of households' use of the feedback device. It was also concluded that an energy display is only an effective trigger in the long term amongst consumers who are more receptive to energy savings.[56] Furthermore it is emphasised that the feedback should not be limited to a single user alone as is often the case with (mobile) web based services. The importance of family dynamics, as a stimulus for the acceptance and use of home-energy management systems, should not be underestimated.[57] An energy display at a convenient location in the home, which is amenable to all members of the household, can trigger more family discussions and a greater chance of acceptance and persistent use.[58]

The national home owners association, Vereniging Eigen Huis, and grid operator Liander, conducted a comparative study in 2011 and 2012, on the user experiences from consumers with a real-time energy display compared against others with a web portal.[59] The experiences of a user panel of 40 group members were evaluated: 11 members with a smart meter and feedback through an energy display, and 28 members with a smart meter and indirect feedback through a web portal. Between September 2011 and September 2012, both groups, including members with a high degree of energy motivation and those with a low degree of energy motivation, were questioned at different intervals regarding the user experiences of the two different feedback systems.[60]

[55] The evolution of consumption for the different groups is based on the meter readings provided by the participants, divided over 5 research periods. Since many errors were made during this process, the study of the effects was eventually conducted with 54 of the original 264 participants.

[56] Van Dam, Sonja e.a. (2010) Home energy monitors, impact over the medium-term. Building Research & Information 38(5). Page 467.

[57] Van Dam, Sonja (2013) Smart Energy Management for Households, A practical guide for designers, HEMS developers, energy providers and the building industry, Delft University of Technology, Faculty of Architecture and the Built Environment, Real Estate and Housing Department.

[58] Reference is made in this regard to persuasive technology, a concept from psychological examination, which anticipates the supposition that consumers don't usually operate based on their environmentally-friendly values and lack in terms of making definitive daily decisions (Thaler and Sunstein, 2008). From this perspective, persuasive technology can stimulate consumers, with assistance from direct evaluative feedback. The Human-Technology Interaction [*Mens-Techniek-Interactie*] Interfaculty Department at TU Eindhoven is currently conducting more detailed research on this.

[59] Ruigrok Netpanel (2012). The smart meter put to the test [*De slimme meter op de proef gesteld*].

[60] The display intended here is the Quby energy display, developed and supplied by Quby BV in Amsterdam (previously Home Automation Europe). The web portal is based on the web application

At the end of the panel study, most participants stated their preference for the real-time energy display.[61] This was true not only due to the real-time character, but also because of the convenient location in the living room and the option to deduce real-time consumption data for individual appliances. Although the web portal scored well in terms of graphic presentation and analysis options, it appeared to be less up-to-date and required more commitment and discipline for persistent use. Researchers also noted that the attention value amongst users of the web portal waned most. Based on this, most participants voiced their preference for the display after the trial.

Similar to the West Orange experiment, the researchers found a pre-existing need amongst consumers to monitor their actual energy consumption. For this purpose, the participants considered the feedback instrument and the smart meter to be inseparable: the smart meter only provided added value to the participants through the direct feedback. Although the research by Vereniging Eigen Huis did not include an energy saving measurement, the researchers did find an increase in awareness, in combination with simple behavioural changes, in particular. Longer-term measures such as insulation, for example, were not or hardly taken into consideration.[62]

3.3 Pilots during the small-scale rollout

The above studies did not provide a complete picture of the current available feedback methods or the responses to these from various target groups. On the one hand, the previous trials did not include sophisticated real-time web based services on modern mobile media, such as tablets and smart phones. On the other hand, most participants in the previous studies appeared to be home-owners with higher incomes and / or education levels and more than average interests in energy savings. Consumers from lower income groups and / or consumers with minimal education, or low levels of numeracy or internet skills, were generally underrepresented or not represented at all in these studies. In order to draw conclusions in this regard as well, three additional pilots were conducted. These pilots are listed and further explained hereafter.

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www.liandermeetenweet.nl. The study also experimented with a monthly email, but this instrument was closed down due to the limited actuality of the feedback during the study.

[61] This, despite the initial technological problems, the fact that a reference was not yet in place, and the prototype which was still relatively unattractive in terms of the display's housing mechanism.

[62] This may also be related to the fact that a majority of the members are already energy-conscious and have already undertaken the necessary steps in terms of energy savings, such as properly insulating the home.

Name Period: study duration	Type of feedback: instrument	Quantity Global typification of participants	Electricity savings	Gas savings	Savings compared to:
Enexis: 'Smart energy savings ' 2011 / 2013: 24 months	'Smart plugs' vs. 'smart thermostat'	- 3 x 300 - Higher incomes - Larger homes	Unknown	Unknown	Savings with 'smart thermostat' compared to other groups
Stedin: PowerPlayer 2012 / 2013: 9 months	Direct feedback through energy dashboard	- 140 - Low incomes - Lower rental sector - E-G energy label	5.6 %	6.9 %	Own historical consumption
Liander: 'Energy Warriors' 2012 / 2013: 12 months	Direct feedback through app on smart phone	- 330 - Higher education - Higher incomes - Energy-conscious	3 %	4 %	Own historical consumption

Chart 2. Overview of pilots on smart meters and feedback during Small-Scale Rollout

3.3.1 Smart plugs vs. smart display [Slim besparen op energie]

In 2011 and 2012, Enexis conducted a comparative study of the user experiences and effectiveness of savings of different feedback systems, amongst approximately 900 home owners. In this study, named 'Smart Energy Saving', the user experiences and energy demand reductions for two types of intervention, were compared:

- 'Smart plugs': an online energy management system for appliance-specific feedback and control ('smart plugs'), in combination with real-time information on the overall energy consumption (also for gas) on a PC;[63]
- 'Smart thermostat': a centrally located energy display and heating thermostat, providing real-time information on the overall consumption of gas and electricity and options for target setting and for budgeting.[64]

[63] The Smart Plugs product consisted of a package of 9 Smart Plugs and a web application produced by the firm Plugwise. These Smart Plugs are readable and controllable through a web environment. Through the connection with the Smart Meter, it is also possible to obtain insight into the overall energy consumption.

A third group of participants with a smart meter and non real-time information through a personal web page, served as the control group.[65] The groups with 'smart plugs' and a 'smart thermostat' could also visit a personal web page for more information. In all groups, most participants represented households with higher incomes and larger homes.

Consumption change evaluation

Due to technical problems, this pilot could not deliver reliable consumption data for a scientific analysis of the changes in energy consumption between the feedback systems. Although, after correction for relevant psychological and sociodemographic variables, it was likely that users with a energy display used (up to 15 %) less electricity than users from the other groups, this could not be scientifically attributed to the feedback system.[66] The robustness of the reported energy savings is therefore limited.

Consumer experience evaluation

The results of the user study, conducted by market research and consultancy agency Intomart GfK in collaboration with Delft University of Technology, were more usable.[67] Similar to the previous described studies by West Orange and Vereniging Eigen Huis, the provision of smart meters and feedback interventions ignited a pre-existing need for real-time feedback, amongst participants. It became also evident that the energy display was used more frequently than the web-based service. This is true not only due to the real-time character, but also because of the strategic location in the living room, serving as a regular reminder. During the research period, most energy display users (70 %) looked at the energy display more often, even on a daily basis, compared to the web-based service which was consulted only once a month, on average.

The energy display users also seemed more satisfied with the energy display than those who used the web-based service: nearly 70 % of the users were satisfied with

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[64] This energy display was developed by the private company Quby. The central heating installation can be operated through this display, but insight into energy consumption is also possible because this display communicates with the smart meter. In addition, the display also provides information through the internet file, as well as weather-related information.

[65] The provision of information after the fact, with regard to in-home energy consumption, in combination with savings tips, was facilitated by means of a personal page on the service website www.slimbesparenopenergie.nl.

[66] A baseline measurement lacked, which made it difficult to analyse energy savings. An actual control group also lacked, because the control group did not appear to be representative of the research group. Instead, the choice was made for a consumption comparison between the different test groups and a group with only the smart meter. Also, it may not be concluded that this involves a structural reduction in consumption.

[67] Market research and consultancy agency Intomart GfK conducted a survey study, amongst other things, on three different occasions, with an average response of approximately 50 % from the roughly 900 participants.

the energy display, especially in terms of ease of use and design. Only a minority of the users were positive about the web-based service, due in part to technical glitches. The users of the energy display also expressed a more positive attitude towards the potential for saving, in terms of financial savings: when asked, they estimated their annual savings for energy costs at € 55. The users of the smart plug web-based system clearly expected less savings in terms of energy and money: an average of € 16 per year.

As in other pilots, most savings measures taken by participants on the basis of direct feedback required little or no investment of time or money (low cost / quick-win), such as switching the lights off in empty rooms, changing thermostat settings, avoiding stand-by mode, air-drying laundry rather than using the tumble-dryer, and also cutting down on showering time. Longer-term saving measures such as insulation were not or hardly taken into consideration.

Despite the financial benefits to be gained, the willingness to purchase such a feedback system was relatively low amongst the participants: a mere four out of ten users would consider purchasing the energy display and pay € 115 for the device. For the smart plug web system, the willingness to purchase seemed even lower: just two out of ten users considered purchasing this device and pay an average of € 58 for it.[68]

3.3.2 Energy management app for smartphones and tablets [Energiekrijgers]

In 2012 and 2013, grid operator Liander conducted a 12-month consumer behaviour trial, using a smart meter and a feedback tool for smart phones, named 'Energy Warrior". Liander developed an app for this pilot, which provided live data on energy consumption in energy-units and in costs for electricity and gas. The app also enabled comparison of the household's consumption against previous periods or with a reference group of households (benchmarking). Finally, the app provided the option to set a savings goal, to continue the incentive for consumers to lower their energy consumption.

Consumption change evaluation

The field trial started in June 2012, and included approximately 500 residents in the city of Arnhem, mainly home owners with a higher income, education and environmental motivation. A quantitative consumption change measurement based on meter readings amongst approximately 330 participants, showed an average

[68] If consumers chose to have the system installed professionally, the average purchase price for the energy display would increase from € 115 to € 159. For the PC-web system, the average purchase price increases from € 58 to € 86.

reduction in consumption of 3 % for electricity and an average of 4 % for gas over a year, compared to the forecast consumption for this group.[69]

Consumer experience evaluation

The consumer experience survey, covering approximately 160 participants, pointed out that the app had a high effect on raising energy awareness, but a relatively low effect on the energy-saving behaviour. A mere 18 % drew a connection between the measures that were taken and the provided app, 35 % did not see any connection, and 47 % only saw a partial connection.[70]

Also the frequency of using the app dropped during the pilot period: by the end of the pilot period approximately two-third of the respondents used the direct feedback app only once a month or even less frequently. As seen in the other direct feedback pilots, most measures had a low cost / quick-win character. Longer-term measures were not or hardly taken into consideration. Although the respondents wanted to keep the app, only 14 % appeared to be willing to pay for it.

3.3.3 Energy dashboard monitor (PowerPlayer)

Network operator Stedin, housing corporation Woonbron and the City of Rotterdam joined forces to conduct a trial investigating the consumer responses to a smart meter in combination with a real-time energy dashboard called PowerPlayer, by 140 households in the low rental segment. This trial involved an in-home energy monitor for smart meters with a non-numerical dual fuel user interface, resembling a car dashboard.[71] Users obtained insight into changes in consumption at a glance, both in real time and for past periods (month and year), and could compare this information with a self-set savings target and/or previous consumption periods. Despite their often less positive attitudes, this target group was chosen deliberately, to build more understanding of how to best support the fuel poor during the smart meter roll-out. Unemployed, low-income groups, minimal educated, immigrants, older people or computer illiterates, etc. face fuel poverty due to increased energy prices, stagnating incomes and rising housing costs.

[69] The forecast consumption of electricity and gas is based on quantitative research through a historical trend line analysis, where this consumption is compared to the smart meter measurements. This provides an average savings of 3 % for electricity and 4 % for gas (both indicative). The results of the effects measurement were checked by independent research agency IVAM, using a multiple regression analysis (MRA) and the non-active participants as a control group check.

[70] According to the researchers, this could be due to the already higher environmental motivation amongst most participants, which meant that many measures were already taken in the past.

[71] This model was developed further from the energy monitor version which was used in the pilots by Nuon (2009) and West Orange. The functionality and interface are based on the results of international research and were derived from the design choices for the standalone in-home display (IHD) to be offered with each smart meter, which was laid down in legislation in the United Kingdom. The firm Quby from Amsterdam is the software developer of the display based on which the PowerPlayer monitor was developed for pilot purposes.

Consumption change evaluation

Following a local information campaign, approximately 325 residents of rental homes in the Rotterdam residential area IJsselmonde, mostly insulated in a moderate to poor fashion, were invited for the pilot.[72] The interest to participate in the pilot seemed high with this target group, which was previously thought of as difficult to motivate: nearly half of the invited residents wished to participate in the pilot, and of these nearly 90 % completed the pilot, which lasted nine months.[73] Furthermore, a majority (60 %) of the participating households used the energy dashboard actively throughout the pilot and succeeded in achieving substantial energy savings; average of 5.6 % for electricity and 6.9 % for gas, compared to the multi-annual historical consumption data. However, more than half of the participating households achieved savings of more than 10 % on electricity and gas. Since roughly half of the participants developed a daily or weekly habit to use the energy dashboard even after nine months, it appeared that many users experienced continuous reinforcement and continued to take up the challenge to consult the energy dashboard to persist in their energy savings.

Consumer experience evaluation

Additional consumer research at the initial stage and at the end of the pilot, which involved 75 % of the participants, reflected a high recognition for the PowerPlayer. Three-quarters of the respondents experienced the PowerPlayer display as a missing link to activate consumer interest and engagement in in accessing energy information from smart metering. Most respondents highly appreciated the energy dashboard because the resemblance to a car dashboard for electricity (and a gas burner for natural gas) was well understood. Most participants also found the PowerPlayer easy to operate and that the display did not contain any superfluous functions.[74] This appreciation is evident from the fact that 70 % of respondents wanted to recommend the dashboard to others. Similar to the user study by Vereniging Eigen Huis, the participants considered the smart meter and the energy monitor to be one system. The researchers concluded that appreciation for the smart meter will increase when offered in combination with a display.
Similar to the other real-time feedback studies, most savings measures required little or no investment of time or money. The most frequently taken savings measures were turning down the thermostat, turning heat off in unused rooms,

[72] It pertains to residential areas Hagenbuurt, Tuinenbuurt and Krekenbuurt. In these areas, rental homes were also sold to owners, which meant that was a certain degree of home owners in the lower segment. The residents that were approached for this pilot lived in the relevant home for at least 2 years, so a reliable consumption history would be available. Households with changes to family situations or with any other noteworthy major consumption differences were not included for calculation of the evolution of consumption.

[73] Of the approximately 325 households that were approached, 142 households (45 %) participated in the pilot. Of the initial 142 participants, nearly 90 % (roughly 125 households) completed the pilot programme. In addition, approximately 75 % of the participating households (105 households) also contributed to the final survey.

[74] Some older participants felt that operation was still rather difficult. The older generation formed a relatively large part of the pilot participants (23 % of the participants were older than 70).

switching lights off in unused areas and unplugging chargeable devices from outlets, avoiding stand-by mode and also cutting down on showering time. Longer-term measures directed at energy savings were (expectedly) not or hardly taken into consideration.

As already mentioned in the consumption change evaluation, the use frequency of the energy dashboard display did not decline over time as in other trials. After nine months, more than half of the respondents still checked the energy dashboard every day to every week. The decline in the use of the display amongst the active users seemed to be the logical result of habituation, the learning effect and the 'running out' of (behavioural) quick-win measures. As consumption patterns continue to become more familiar, the need for frequent display consulting and initiating behavioural measures becomes less. Then the emphasis turns from (daily to weekly) consumption monitoring and initiation of measures, to a (weekly to monthly) habit of consumption checking and consolidating of the lower consumption. Despite the positive user experiences, again in this pilot the willingness to purchase a display still appeared relatively low, arguably because of difficulties to assess the return on investment.[75]

Based on these results, grid operator Stedin, housing corporation Woonbron and the City of Rotterdam called for:

- Strategic collaboration between grid operators and local intermediaries with the offer of the smart meter.
- A combined rollout of smart meters and displays.
- Explanation during installation on how to use the smart meter and the display.

3.3.4 Online reward for energy savings programme [Pilot Goeie Peer]

From March 2013, environmental campaign organisation Natuur & Milieu offers an online monitoring and reward for energy savings programme for consumers with a smart meter. This reward programme encourages consumers to save at least 10 % energy and collect saving points that can be exchanged for gifts. The programme, marketed as Goeie Peer ('Good Pear'), also hosts a social media platform to exchange user experiences. The ultimate goal is to commercialise the savings programme, when the rollout accelerates and national smart meter coverage comes in sight. Until then, the savings programme remains a campaign service of Natuur & Milieu.

[75] Approximately 30 % of the respondents were willing to pay an amount between € 10 and € 50 and only 5 % were willing to pay more than € 50.

Consumption change evaluation

The savings programme was opened up as pilot for selected clients from grid operators Enexis and Liander until January 2014. The participants to the pilot totalled 787, predominantly energy motivated, consumers with higher education and residing in larger homes. Research showed that 39 % of the participants used the savings programme actively (i.e. logged in at least once a week) and 61 % did so less often or not at all. The active participants saved 5.9 % more on electricity than the non-active participants, in this pilot period, compared to their historical consumption. No significant differences were established in consumption of gas.[76] However, similar to the Enexis' pilot, no firm conclusions can be drawn from these results, partly because of a lack of actual historical consumption data. Furthermore, the consumption change measurement took largely place in the summer period, which is usually a less reliable scientific research period. Finally, it was not clear whether the non-active participants in the control group were indeed comparable to the actual active users.[77]

Consumer experience evaluation

In an additional online survey (28 % response) showed that 60 % of the respondents stated they have become more aware of their energy consumption and considered energy-saving measures. However, the reward and gifts element in the pilot appealed only to a minority: 35 % of the respondents exchanged their rewards for gifts in the web shop. This supports the general finding in the survey: most respondents took part in the pilot programme to obtain an understanding of their energy consumption and to save on energy bills. Furthermore, many respondents found that the feedback tool had some functional limitations: the energy savings tips were too general and there was a greater need for real-time feedback into consumption and the capability to obtain insight into energy consumption changes over a long period (a month, half a year, or even a year) at a glance. Finally, respondents had a desire for comparison to similar households.

3.4 Results of the Potential Monitor

Despite the mostly small-scale research and the possible influencing of participants through trialling (Hawthorne) effects, it appears that the smart meter, in combination with sophisticated feedback, can have a significant impact on in-home energy consumption and to the savings to be achieved with it. The opportunities for savings are most promising in case of real-time feedback. Even so, long-term success is not guaranteed: the development of engagement and habit formation through continuous reinforcement are important conditions for persistent effects. Consumers who are not receptive will not change their behaviour based on direct

[76] The pilot was not conducted during winter and therefore does not take the heating season into account.
[77] The final report for the Goeie Peer pilot is available on the website of Natuur & Milieu from March 2014.

feedback either, whether it involves in-home energy monitors or advanced management systems on PC, tablet or smart phone.

3.4.1 Engagement

However, if the feedback tool takes the practical user preferences into account and tailors the functionality and data presentation to the consumer's interests and capability, persistent savings are more likely. Advanced applications on PC, tablet or smart phone have a better chance of succeeding with already committed, technology-oriented and internet savvy consumers. For these consumers, the comprehensive data analytics and graphic presentation options, in combination with the ease of (mobile) multimedia devices, offer the desired added value from use of the system. In the study by Oxxio, it was evident, for example, that many participants - customers with a predominantly higher education and environmental motivation - also visited the personal section of the website after a year, to keep detailed track of their in-home energy consumption progress.

However such applications may require too much discipline for persistent use amongst less committed consumers or those who are less technology minded, or simply those who can't commit to much effort. The product test studies by Vereniging Eigen Huis and Enexis demonstrated that the attention value dropped most significantly with web portal users. Many participants voiced their preference for a physical monitor, a logical first step to activate consumer interest and engagement in accessing energy information from the smart meter, due to the greater accessibility of the energy data.[78]

However, not only the functional and physical aspects, also the interface design and - last but not least - interaction within the household will play an important role to deliver reinforcement and persistent savings. It was evident from the PowerPlayer study that simple functionality as well as an intuitive and self-explanatory user interface were important for the persistent use of the real-time feedback system. For certain customer groups, a simple yet visually appealing energy monitor can thus already be an effective instrument for the development of energy awareness and an initial step towards persistent energy savings. In addition, according to the Technical University of Delft, an important role is identified for the creation of positive family dynamics for reinforcement of engagement.

3.4.2 Habit formation (reinforcement)

Research by the Technical University of Delft also pointed out that the development of routine use of the feedback system is essential for persistent savings. Although

[78] Ruigrok Netpanel (2012). The smart meter put to the test [*De slimme meter op de proef gesteld*]. Page 14.

some decline in the use of the feedback system seems logical, as became evident from the Power Player study, decreased interest may also result if the feedback system does not match the user's practical preferences. Then the feedback system will fade into the background and even might be forgotten, which will also result in declining savings, as was demonstrated by the Technical University of Delft.

3.4.3 Nature and impact of the savings measures

The last headline result mentioned here, as most case studies demonstrated, is that the achieved savings originate especially from simple behavioural changes that require little or no investment of time or money. Most behavioural measures concentrate particularly on the limiting of unnecessary energy consumption or breaking of 'bad' energy consumption behaviour habits (such as switching lights off in empty rooms) and reducing base load consumption (such as turning the thermostat down and checking the monitor before going to bed). These quick-win measures require little effort, yet contribute to savings immediately. Longer-term measures, such as insulation or double glazing, rarely follow from direct feedback. Otherwise, longer-term energy saving measures do more likely follow from indirect feedback systems. The MijnOxxio researchers for instance established that users carried out energy-saving home investments more often than non-users, such as high-efficiency boilers, double glazing, roof insulation and solid wall or cavity wall insulation.[79]

As a result, direct and indirect feedback are therefore not mutually exclusive, but can actually complement one another quite well. A real-time display can be the most convenient tool for immediate monitoring and consumption behaviour change at the operational level. Online long view consumption analytics and indirect feedback tools, such as the bi-monthly home energy report, have the potential to become a tactical instrument for interim evaluation and forecasting of annual consumption. Finally the annual bill could become a strategic benchmark for final evaluation of the past consumption year and the determination of a next year's savings goal and / or longer-term investment decisions.

3.5 International experiences

To help contextualise the headline results from the smart metering consumer behaviour trials in the Netherlands, an international literature review of similar trials was conducted alongside this monitoring program. A number of leading international review studies exist and especially point at the potential impact of real-time feedback for awareness raising and energy savings. In 2010, the American Council

[79] ResCon research & consultancy (2011) Customised energy advice through the use of smart meters [*Energieadvies op maat via gebruik van slimme meters*]. Determinants and study of the effects. Page 36. The study was unable to propertly clarify the extent to which this is the result of MijnOxxio.

for an Energy-Efficient Economy (ACEEE) conducted a comprehensive meta-analysis of 57 (mostly small-scale and short-term) studies in nine different countries, and found that feedback with smart metering led to an average reduction between 4 % and 12 % in energy consumption, in which case systematically higher savings (9 %) were established in pilots with real-time feedback.[80] In 2011, another large literature review was released by VaasaETT, by order of the European Smart Metering Industry Group (ESMIG), with a global analysis of more than 100 smart meter pilots, with more than 450,000 households in total.[81] The review suggested that smart meters in combination with in-home displays (IHD) were most effective in achieving involvement amongst consumers and most successful in achieving savings, with an average of 8.7 %. Moreover, VaasaETT and ACEEE both demonstrate that the savings were persistent compared to control groups, and could increase even more through the purchase of more energy-efficient appliances, for example. Other feedback instruments, such as websites and extra informative invoices, showed lower savings (5 to 6 %). In general, the international literature suggests that the more immediate and frequent the feedback, the greater impact on energy consumption.[82]

However, not all international research is applicable to the Dutch situation. Much comes from the USA, Canada and Australia, where extreme climate conditions (and potential problems with regard to security of supply) and different consumption patterns (use of large electric equipment / appliances, such as pool heating, air conditioning, etc.) play an important role. It applies, in general, that countries with the highest peak consumption periods are also observed as the largest outliers in terms of savings achieved.[83]

Even research from other European countries in the field of smart meters can only be used to a limited extent for the Netherlands. In Scandinavia, for example, nearly all of the energy consumption is based on electricity (especially for heating and saunas), unlike the Netherlands, where a large part of the household energy consumption is related to natural gas.[84] Research from other countries such as Italy, Spain and Portugal is also only comparable to a limited extent, due to the larger

[80] Karen Ehrhardt-Martinez, Kat A. Donely, John A. Laitner (2010). Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities. American Council for an Energy-Efficient Economy (ACEEE)

[81] VaasaETT (2011).The potential of Smart Meter enabled programs to increase energy efficiency (Empower Demand I). This study was ordered by the European Smart Metering Industry Group (ESMIG), A European organisation of energy meter manufacturers.

[82] Kyle MacLaury, Paul Cole, Emily Weitkamp and William Surles, Tendril (2012). Lessons from the Field: The Contribution of Active and Social Learning to Persistent Energy Savings. American Council for an Energy-Efficient Economy (ACEEE)

[83] Examples hereof are the pilots conducted in Ontario, Canada in 2006 and 2009 (7 % savings for electricity achieved by frequent users), Eco Pioneer Programme in Victoria, Australia in 2009 (15 % electricity and 18 % gas, multiple intervention part). Also, the smart meter was not used in all of the studies.

[84] The electricity consumption in these countries is therefore higher than that in the Netherlands, by an average of 5 times.

number of air conditioners, which has a major effect on the average reduction in electricity consumption. However, this is not a major issue in the Netherlands at present.

Surrounding countries such as Belgium, Germany, the United Kingdom and Ireland are more suitable for benchmarking for the Netherlands, due to more similar climatic conditions and consumption patterns, and a dual fuel energy mix based on electricity and natural gas for room heating, cooking and hot water.[85] However, only the United Kingdom and Ireland have conducted scientific research at a national level on the effectiveness of savings achieved with the smart meter, in combination with additional feedback systems. Important findings are described below.

The United Kingdom (UK)

In the UK, the largest consumer study to date in the world, was the Energy Demand Research Project (EDRP), from 2007 to 2010, on the effectiveness of savings achieved with the smart meter, in combination with different feedback systems.[86] In this research programme, which comprised multiple trials, including approximately 18,000 households with a smart meter, experiments with smart meters and real-time displays showed a consistent and persistent savings of 2 % to 4 % on average for electricity, compared to households with just a smart meter.[87] According to the researchers, the savings that were achieved seemed mostly the result of simpler (behavioural) changes.[88] This was also observed in the Dutch trials as highlighted in the previous sections of this chapter.

Pilots with web-based services did not show any demonstrable savings in the EDRP.[89] However, this technology is developing rapidly and real-time applications for online use on PC, smart phone and tablet (apps) have since been introduced to the market. Online applications are potentially promising, especially due to the comprehensive graphic analysis and presentation options and in combination with the ease of use associated with modern mobile media. It remains to be seen, however, whether online systems will also live up to these expectations in reality. According to Sarah Darby from Oxford University, an international authority in the field of consumer behaviour change studies on energy savings, in-home displays with an appealing and intuitive interface at an easy accessible location in the house

[85] In England, approximately 85 % of all households use natural gas for heating purposes, on average. In Ireland it is approximately 45 %. Approximately 50 % of households in Germany and Belgium also use natural gas for heating. The Netherlands has the highest percentage of households connected to natural gas, with approximately 98 %.

[86] AECOM Building Engineering and Ofgem (2011). Energy Demand Research Project: Final Analysis.

[87] These results correspond to the estimates from the national Cost-Benefit Analysis (Impact Assessment) for the UK in 2013, where the savings through introduction of the smart meter were estimated (by way of precaution) at 2.8 % for electricity and 2 % for gas.

[88] AECOM Building Engineering and Ofgem (2011). Energy Demand Research Project: Final Analysis.

[89] AECOM Building Engineering and Ofgem (2011). Energy Demand Research Project: Executive Summary. Page 6.

will be a crucial first step for many consumers to attract active consumer interest and engagement in accessing energy information from the smart meter.[90] Advanced online systems on PC, tablet and smart phone must then not necessarily be seen as an up-to-date substitute for in-home displays, but rather as a complementary option.[91]

A similar conclusion was also drawn in the EDRP with regard to the mutual relationship between direct and indirect feedback.[92] This was phrased as follows in the EDRP final report:

> '*The distinction is important because, although there is a general finding that households take a positive view of feedback, it matters how detailed it is and how closely linked to specific actions, in time and in level of disaggregation. Logically, aggregated feedback (e.g. quarterly or annual consumption) is more relevant to one-off changes that have a persistent impact, such as installing insulation or upgrading a heating system. More fine-grain, real-time feedback is more relevant to routine behaviour and purchases of equipment used intermittently (e.g. washing machines, televisions). By extension, aggregated feedback may be more relevant to the fuel used for heating (most often gas) and real-time feedback to electricity.'*

Ireland

A consumer study was conducted in Ireland on the impact of the smart meter in combination with different feedback interventions, in the context of the National Smart Metering Programme (NSMP). In the so-called Customer Behaviour Trials (CBT), the responses from a representative group of 7,000 consumers to the introduction of the smart meter in combination with time-of-use pricing and different feedback intervention types such as periodic home energy reports and a real-time electricity display (developed especially for this study), were observed.[93] The combined offer of smart meters, home energy reports with bi-monthly invoices and real-time displays in this study led to the highest average electricity savings of 3.2 % overall and 11.3 % at peak consumption intervals.[94] The in-home display led to an extra savings of 2.1 % (4.4 % at peak consumption intervals), compared to households that only received the periodic home energy reports.[95] The combination

[90] Darby, Sarah (2010). 'Smart metering: what potential for household engagement?' Building Research and Information 38: 5, 442 – 457.
[91] Darby, Sarah (2012) Literature review for the Energy Demand Research Project, Sarah Darby. Environmental Change Institute, University of Oxford. December 2012. Page 24.
[92] AECOM Building Engineering and Ofgem (2011). Energy Demand Research Project: Final Analysis. Page 121.
[93] CER Comission for Energy Regulation (2011). Consultation on the proposed National Rollout of Electricity and Gas Smart Metering.
[94] For comparison to the Dutch experiences, it should also be taken into consideration that these results were also influenced through the application of variable supply rates for electricity and gas.
[95] Foster, B, S.M . Mazur-Stommen (2012). Results From Recent Real-Time Feedback Studies. American Council for an Energy-Efficient Economy (ACEEE) Page 14- 15.

of home energy reports and displays also provided the highest savings effect for gas, of 3.6 % compared to households with just a smart meter.[96]

3.6 Concluding remarks

The Potential Monitor points out that the smart meter, in combination with direct feedback, in particular, can significantly change energy-related behaviour in homes. Whether households with smart meters and direct feedback interventions will be able to actually meet the average savings of 6.4 % for electricity and 5.1 % for gas as mentioned in the national cost-benefit analysis, deserves a cautious answer of 'yes, on condition that...' The smart meter can provide better information with direct and personal feedback, in particular, and this information can result in similar savings. However, the pilots also indicate that the initial achieved savings are only persistent if the feedback medium matches the user's practical preference and if the functionality and data presentation are tailored to the consumer's interests and capability for reinforcement and habit formation with the feedback system (i.e. daily bedtime check). Sophisticated real-time web-based services on PC, tablet and smart phone are potentially powerful to help reduce energy demand, but more so with already committed subsets of the population who are technology minded and looking to further reduce their energy consumption. The extensive data analytics and graphic presentation options, in combination with the ease of use associated with an online media such as PC, tablet or smart phone, provide the required added value for persistent use of the web tool. Otherwise, less committed and technology minded consumers or less capable consumers, more often experience such systems as too complex or too demanding for reinforcement and routine use. These consumers actually prefer the accessibility of a simple yet visually appealing in-home display. In fact, for older people, those with minimal education and low levels of numeracy and computer illiterates, for example, an in-home display will be a necessary first step to activate consumer interest and engagement in accessing energy information from the smart meter. The interface design and the interaction within the household also play an important role in reinforcement and habit formation with the monitor.

Finally, the Potential Monitor points out that direct feedback leads to quick-win measures in particular: simple behavioural changes that seem effortless and don't cost much time or money to implement, yet contribute immediately to savings. Examples include switching the lights off in empty rooms, avoiding stand-by use, etc. Longer-term measures such as insulation (weather strips, double glazing, etc.), are generally not considered as a result of direct feedback. Conversely, long-term

[96] CER Comission for Energy Regulation (2011). Consultation on the proposed National Rollout of Electricity and Gas Smart Metering. Page 33-34. The savings calculated in the national Cost-Benefit Analysis (CBA) with the rollout of the smart meter is estimated at 3 % for electricity, based in part on these research results.

measures show up more often in case of indirect feedback, such as the bi-monthly home energy reports. Direct and indirect feedbacks are therefore not mutually exclusive, but can actually complement each other.

These trial experiences in the Netherlands are fairly consistent with the international research literature. Although all practical research is not equally suited for the purpose of comparison to the Dutch situation, the international consensus is also that the smart meter, in combination with accessible real-time feedback, in particular, can provide the most effective stimulus for awareness raising and the development of motivation amongst consumers to monitor and manage their energy consumption. Compared to the experiences with feedback through displays in the United Kingdom and Ireland (roughly 3 % on average for electricity and gas), the estimated potential in the cost-benefit analysis for the Dutch consumer (6.4 % for electricity and 5.1 % for gas), due to direct feedback, is rather high. Even so, various pilots indicate that these potentials are realistic, on condition that the feedback tool meets the practical user preferences and the functionality and data presentation fit the consumer's interests and capability. In doing so, habit formation and family dynamics with the tool will become more likely, as well as the persistence of the achieved energy savings.

4 Market Monitor for smart meter feedback systems

4.1 Introduction

To maximise the energy saving benefits of smart metering for all households, a broad range of convenient feedback products and platforms must be available to deliver high resolution consumption data in (near) real-time and help consumers take informed decisions on their energy use. If this supply does not keep up with the smart meter rollout, the momentum might be missed by some and leave opportunities energy savings unutilised for a longer period of time. Nevertheless, the provision of smart metering feedback systems in the Netherlands is left up to the free market.[97] According to the Minister, smart metering products and services will enter the market as soon as the large scale rollout of smart meters gets underway.[98] During the small-scale rollout, RVO.nl kept track of the pace at which feedback systems that are suitable for the smart meter enter the market, and the extent to which this supply anticipates the needs of various population groups.

This chapter

At first, a more detailed explanation is provided of the technical feedback channel options provided by the smart meter for feedback. Also an overview of the actual market supply of smart metering services per feedback channel is given, followed by a short review of the comparable market developments abroad, in the United Kingdom in particular. This chapter concludes with an evaluation of the results of the Market Monitor.

4.2 Options for smart meter feedback

The current market for smart metering services in the Netherlands can best be presented by way of differentiation between the two communication channels along which metering data can be read from the meter:

1. Non real-time meter readings through the so-called P4 port or grid operator port;
2. Real-time meter readings through the so-called P1 port or consumer port.

Both data communication channels are pictured and further explained hereafter.[99]

[97] However, legislation does guarantee good interoperability between smart meters and additional information systems.

[98] Response to parliamentary questions regarding the Draft decree on remote-readable metering devices [*Ontwerpbesluit op afstand uitleesbare meetinrichtingen*], 23 May 2011, page 5.

[99] In this overview, the P2 port reads the metering data from other meters, such as the gas meter, and in some cases also the water meter and / cogeneration.

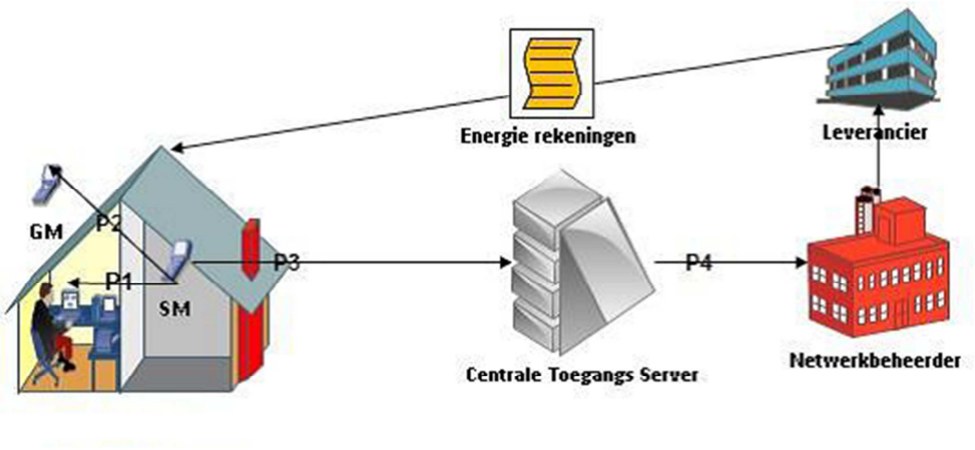

Image 1: Schematic overview of the two options for smart meter readings (where the smart meter is indicated with the letters SM and the gas meter with the letters GM)

4.2.1 *Meter reading through the P4 port*

The 'P4 port' is used by the grid operator to send metering data from the smart meter to a Central Access Server. This port will only be activated for licensed duties and, subject to data protection requirements, specific opportunities, such as for annual billing, the bi-monthly home energy reports and in case of switching supplier or moving house.[100]

The consumer may also choose to have the meter readings forwarded on a daily basis via the grid operator to the energy supplier or an independent service provider for energy management purposes through a personal and secure internet page on the commercial (energy) supplier's website. This type of energy management is only legal if the consumer has signed a contract with the supplying party for the use of metering data. The smart metering services via the P4-port are restricted to deliver indirect feedback by definition, since the metering data are provided to the consumer afterwards (a delay of at least one day).

4.2.1.1 Market supply for indirect energy management systems

The following indirect feedback systems for electricity and gas, used for taking smart meter readings through the P3 / P4 port, are currently available on the Dutch market:

Supplier web-based services:

- Oxxio (EnergyMonitor [*EnergieMonitor*])

[100] Upon request from the consumer, this P4 port can be deactivated (administratively deactivated), which means the smart meter will only function like a traditional meter. In that case, the consumer still has use of the P1 port.

Other web-based service providers:

- Enelogic basis
- Enepa (Slimmemeteruitlezen.nl)
- Online Energy Manager [*Energiemanager Online*] (energiemanageronline.nl)
- EnerGQ (i-Care Basic / i-Care Advanced)
- Energy Alert (SlimmemeterPortal.nl)
- Inter-on (Meter-online)
- Watch-E (Basic portal [*Basisportal*])

These energy management systems are described in more detail for consumers on the website www.energieverbruiksmanagers.nl, developed by Milieu Centraal, a public funded consumer information organisation for energy and the environment. This website provides an up-to-date overview of products and services that provide additional insight into in-home energy consumption for consumers with a smart meter.

4.2.2 Meter reading through the P1 port

Consumers can also directly retrieve meter readings from their smart meter at any time via the P1 port. Metering data is forwarded through the P1 port to an in-home device or web-based application at an interval of once every 10 seconds for electricity and every hour for gas. Smart metering feedback services via the P1 consumer port are direct or (near) real-time feedback, because of the high update frequency for electricity, in particular.

Image 2: Example of consumer port (P1 port) for real-time meter readings from the smart meter

Basically, two different types of feedback systems can be connected to this port: a transmitter for a wireless in-home display or a so-called 'bridge' for online

connection to a PC, tablet or smart phone (or even integrated heating controller). Both types of devices and systems and currently known providers in the market are briefly described below.

4.2.2.1 In-home display

The in-home display is a simple plug-and-play device, designed for real-time visualisation of the energy consumption from the (smart) meter at a self-chosen or central location in the home. The most important aim in general is awareness raising through real-time data visualisation and comparison to previous consumption periods and / or a self-set savings target. A contract or subscription with an (energy) supplier is not required, to guarantee independent operation. Connection to the internet is not needed either to guarantee privacy and enable simple and robust operation. An in-home display is therefore a particularly accessible means to interest and engage inexperienced or less capable consumers in accessing energy information from the smart meter through appealing visualisations.

In-home displays, providing only basic information from the smart meter, are considered a 'stepping stone' channel, in particular, for consumers who are less technology-oriented and:

- don't yet feel committed to energy savings;
- don't have access or the skills needed to use the internet;
- have a higher need for simplicity, rather than comprehensive functionalities for subsequent consumption analyses or monitoring of own generation of electricity, for example.

These consumers are more prevalent in low-income groups, those with minimal education, older people and computer illiterates.

The choice on the market for in-home displays associated with smart meters in the Netherlands is currently very small. Despite the experience acquired with the PowerPlayer in-home display, for the time being this system has only been developed for research purposes (as described in chapter 5).[101]

4.2.2.2 Online direct energy management systems

In-home displays do not tell consumers what to do with their feedback. This is where web-based energy management comes in. Through connecting the smart meter with the consumer's router, metering data is sent via internet to a commercial supplier, for additional analysis and graphical presentation on the consumer's PC, tablet or smart phone and tailored advice. Apart from visualisation of the (real-time)

[101] Another example is the Wattcher, an electricity monitor which displays the electricity consumption for the entire house. However, the Wattcher does not (yet) provide information on gas consumption and does not (yet) work with the smart meter.

consumption, customised graphical consumption analyses and comparisons to neighbours or other consumers (benchmarking) are also possible. A contract and / or a subscription with a commercial (energy) supplier are generally needed for this, as well as provision of information on household characteristics. Some energy management systems also provide additional (non-energy related) services via the internet, such as weather forecast and remote control for central heating. In such cases, the smart meter is only one element in a more comprehensive (energy) management system. The consumer interface for such a system could be an in-home display as well or thermostat (Toon® by Eneco, for example), but in most cases, is a PC, tablet or smart phone.

Energy management systems operating either directly through the P1 port and indirectly through the P4 port will appeal more to technology-oriented consumers who:

- Take interest in regular analysis of their in-home energy use and are committed to energy savings and / or own energy generation;
- Have access to the internet and have the skills to work with modern media.

At this moment, the service providers - energy suppliers and other market parties - of real-time management systems working with the P1 port of the smart meter, are:

Supplier web-based services:

- Eneco (Toon®)
- Delta, Comfort Wijzer (Fifthplay)
- Nuon (E-manager)

Other service providers:

- Aurum (from 2014)
- BeNext (iHome)
- Enelogic P1
- EnerGQ (i-Care Premium)
- Greeniant (Greeniant)
- Net2Grid (Smart Bridge / Smart Reader)
- Plugwise (Smile P1)
- Quby
- Qurrent (Q-box)
- Watch-E (Watch-E portal)

These energy management systems are described in more detail for consumers on the website www.energieverbruiksmanagers.nl.

Smart meters even more real-time?

The more direct the smart meter feedback, the greater the impact can be on more conscious in-home energy consumption, as is evident from international research literature.[102] Various providers of energy services in the market - energy suppliers and other service providers – are calling for more frequent refreshes of electricity and gas data via the P1-consumer port with the smart meter in the new Dutch Smart Metering Requirements (DSMR) 5.0.
It is recommended, for example, that the current real-time presentation of electricity consumption should be increased from a 10 second data interval to once every five seconds. This frequency is considered, in general, to be sufficient for a true real-time effect and appliance-specific monitoring.[103] Moreover, a higher update frequency for current gas consumption is also called for. Although gas consumption determines a far higher portion of the energy bill, more than 40 % of all households do not know how much they pay per month for their gas consumption, and 27 % of all households leave their thermostat at the same day-time temperature, at night.[104] Despite the more static nature of gas usage, the hourly data interval should be increased to every five minutes, to allow future applications to differentiate between gas consumption for cooking, hot water and central heating, according to the Vereniging Energie Inzicht.[105] This should not to pose a technical problem for future wired and wireless smart gas meters, given the latest battery life technology developments.[106]

4.3 Results of the Market Monitor

Although the Potential Monitor (chapter 3) stressed the importance of a broad range of feedback instruments for the smart meter to be available on the market during the large-scale rollout, a review of the current market supply shows that simpler in-home displays are not yet or hardly being offered. For the time being, supply is mostly aimed at 'high-end' solutions: advanced management systems with detailed analysis and comprehensive graphic presentation options for the most committed consumers. Simpler yet appealing in-home displays for electricity and gas, as a 'stepping stone' channel for less motivated or skilled consumers, are almost absent on the market as yet. If the market does not cater to this, especially less capable

[102] Kyle MacLaury, Paul Cole, Emily Weitkamp and Wiulliam Surles, Tendril (2012). Lessons from the field: The Contribution of Active and Social Learning to Persistent Energy Savings. ACEEE. Page 2.
[103] An update frequency per second is not deemed technically feasible at this moment, with the current architecture of the P1 port.
[104] Brounen. D, Kok. N, Quigly. J (2012). Residential Energy Literacy and Capitalization. Universities of Tilburg, Maastricht and California Berkeley
[105] Vereniging Energie Inzicht is an industry interest group which was founded recently for providers of energy services in combination with the smart meter, in the market.
[106] An update frequency of once per minute, for example, is not possible yet, because it is still too detrimental to the lifespan of the gas meter's battery. However, an update frequency of 5 minutes is possible, based on current technological developments. It is possible that an update frequency of once per minute will be possible in the new future.

consumers might not profit immediately from the smart meter offer. These consumers are generally those in low-income groups, those with minimal education and low levels of numeracy and elderly. According to the national tenant organisation Woonbond, these consumers find it more and more difficult to cope with increasing energy prices.[107] Quite a large number of computer illiterates are also part of this group. It is evident from the Trend Report on Computer and Internet Use [*Trendrapport Computer- en Internetgebruik*] 2011, that approximately 40 % of the individuals in the 65-plus group and 17 % of those with minimal education do not or hardly use the internet, or are unable to use it.[108] These consumers might prefer a simpler local energy monitor as an initial step, in order to also be able to save on energy costs successfully, as was reflected in the PowerPlayer pilot with an energy dashboard. It is therefore important that the market also provides products for low-income groups and consumers who aren't internet skilled.

Conditions for market development of smart metering services

Energy suppliers, service providers and other stakeholders were consulted about the current market conditions for feedback systems tailored to the smart meter.[109] This consultation pointed out that the actual market for smart metering services is still at an uncertain commercial phase. Three important developments contribute to this.

Firstly, due to the - longer than expected - parliamentary process of decision-making for the large scale rollout, the installation of smart meters still takes place on a small-scale. Service providers therefore operate with caution and are careful with investments in marketing and communication. As a transitional arrangement, some providers have introduced feedback systems to the market which work with optical reading systems for traditional electricity meters. Since these options are less accurate by definition, the large-scale rollout of smart meters will also be relevant for these providers.

Secondly, smart metering service providers receive no information where the network operators actually install the smart meters. This makes it difficult for market players to approach consumers. This lack of transparency with the rollout thus means both that a level playing field is not in place for market parties, and also that smart meter installation momentum cannot be utilised. However, an important

[107] RIGO Research en Advies BV (2013). Residential costs for renters, Rental and energy costs in the regulated rental sector [*Woonlasten van huurders, Huur- en energielasten in de gereguleerde huursector*], by order of Woonbond.

[108] University of Twente / Centre for e-Government studies (2011). Trend report on computer and internet use 2011, a Dutch and European perspective [Trendrapport computer- en internetgebruik 2011, een Nederlands en Europees perspectief]. Page 57.

[109] On 23 June 2013, an information and consultation meeting was held in Utrecht, for the rollout of the smart meter, and was attended by grid operators, energy suppliers and most of the providers in the market for energy services related to the smart meter.

recent development is that grid operators agreed to offer transparency regarding rollout planning and to discuss the possibilities of a more area-based rollout approach at the local level. This will not only level the playing field for all market parties, but also offer better momentum opportunities for targeted marketing and communication. However, the extent to which new providers of smart metering services will really stand a chance in the market remains to be seen. Existing energy suppliers for instance already have a solid market position and an existing client base from which to operate commercially, possibly for customer retention purposes. It is expected that new market entrants, many of them small start-up companies with few resources in terms of R&D, production and marketing will find it more difficult to build a presence.

Finally, a market factor which should not be underestimated is the current low consumer interest to purchase energy services with the smart meter. Despite the savings experienced, many participants show reservations to purchase such a device or service.[110] This seems to be attributable, for the most part, to the unfamiliarity with these new systems and uncertainty regarding the financial benefits and return on investment. Although the large-scale smart meter rollout is yet to kick off, it does indicate that households might not be inclined to purchase an additional feedback system quickly, which means that potential savings will remain undelivered. Additional consumer engagement communication will be needed to assist accelerated development for the market demand and to keep up with the rollout penetration of smart meters.

4.4 International experiences

In most other European countries, the market for feedback systems tailored to smart meters is for different reasons also still at an infant stage. The United Kingdom and Ireland are notable exceptions to this rule, since the decision in these two countries was made to provide in-home displays to all energy consumers as part of the full rollout of smart meters.

The United Kingdom (UK)

To ensure immediate impact on consumer behaviour and support the market development for smart metering services at the same time, the UK Government decided in 2009 that the energy suppliers (responsible for the rollout of the smart meter in Great Britain) must also offer consumers a wireless in-home energy display along with the smart meter. This in-home display, equipped with legal minimum

[110] The West Orange study also did research on this, and the results were more or less the same.

requirements, is deemed to be an effective instrument in promoting increased awareness in terms of in-home energy consumption.[111]
It seems like a market for in-home displays and energy management systems is developing in the UK, based on this mandate. Various parties have since become active on the British market, such as Wattson, Onzo, Alertme, Current Cost, Owl, Navetas, GEO, Efergy, Eco Eye, Ewgeco and EcoMeter. To promote the development of a strong branch of industry, many of the UK's manufacturers and service providers of in-home displays and online energy services have united under sector organisation Consumer Energy Display Industry Group (CEDIG). Developments and products are also brought to consumers' attention actively, by way of reviews, e.g. by the British consumer organisation Which?.

The formation of a national body aimed at increasing consumer involvement with the rollout of smart meters is also worth mentioning: the Central Delivery Body (CDB). An important task of the CDB is to familiarise the consumer with the smart meter and the innovative possibilities in terms of monitoring and management, for example. The CDB has been mandated to stimulate the development of energy awareness and willingness to take action to achieve energy savings, in general, and serves as an independent source of information. Finally, the CDB is mandated to help the vulnerable, including those in low-income groups (fuel-poor) and consumers with prepaid contracts to also benefit from the opportunities and advantages of the smart meter. The CDB does not focus on marketing activities, since these activities must be conducted by the market parties. The energy regulator Ofgem, market parties and consumer organisations have also developed a code of practice to control the basis on which energy suppliers can sell extra products and services to consumers during installation of the smart meter.

Ireland

In Ireland, a similar decision was made for a combined rollout of smart meters and in-home displays to secure the energy saving benefits. A rollout of smart meters is now being prepared to provide every consumer the opportunity to receive information through three harmonised channels: an in-home display for real-time insight and comparison to previous periods, extra informative bills for interim evaluations of the current consumption year, and a web portal for detailed analyses and energy services from market parties on PC, tablet or smart phone.[112] Similar to the UK, the role of the regulated in-home display in this so-called Steady State Model is transitional, so market development for alternative information systems can

[111] DECC, Ofgem (March 2011) Smart Metering Implementation Programme. Response to Prospectus Consultation. Overview Document.
[112] The Steady State Model (SSM) is a model with which the back office utility systems take care of most of the data processing for the smart meter, which also has a limited functionality at this level.

also be promoted. Time-of-Use pricing for electricity (and gas) is also being introduced and pre-payment is made possible, in conjunction with the smart meter rollout.

4.5 Market Monitor evaluation

In order to realize the full savings potential of smart metering by allowing all population groups to make informed decisions on their energy use and reduce consumption, a broad range of convenient products and online platforms must be available on the market during the large-scale rollout. However, the current supply of smart metering services is tailored, for the most part, to advanced management systems with detailed analysis and comprehensive graphic presentation options for the most committed consumers. It is important that the market also provides simpler in-home displays for less committed and, especially, low-income groups, less educated and other vulnerable consumers.

Providers of feedback services for the smart meter in the Netherlands currently operate - as in many other European countries - in an early and uncertain market. It is not clear whether the market conditions will improve once the large-scale rollout of the smart meter in the Netherlands starts. Important preconditions are that grid operators offer more transparency in the rollout planning and develop a area-based rollout approach at the local level. This in order to allow service providers to take optimal advantage of the installation momentum. A possible complication in this matter is the unequal competitive positions of energy suppliers and the other providers in the market. Finally, a market factor which must not be underestimated either is the currently low consumer interest to invest in feedback services with the smart meter. Additional consumer engagement communication will be needed to ensure accelerated market demand and to keep up with the large scale rollout penetration of smart meters.

5 Recommendations

5.1 Introduction

Achieving the full energy savings potential is an important reason for the introduction of smart meters in the Netherlands. The Savings Monitor analysed the extent to which these savings were actually achieved during the small-scale rollout. Quantitative and qualitative research was conducted to investigate consumer responses to improved feedback on their energy use from the smart meter, via:

- The bi-monthly home energy report;
- Alternative feedback interventions.

The current market developments for smart meter feedback systems were also analysed. In this final chapter, a number of recommendations for the large-scale rollout are listed to help ensure that the benefits of smart metering are realised by energy consumers.

5.2 Recommendations

In combination with more frequent and improved feedback, the smart meter can be an important stimulus for more conscious in-home energy consumption. However, market conditions are not yet optimum for achieving the savings potential, both through the bi-monthly home energy report and through alternative direct and indirect feedback interventions. In the national cost-benefit analysis of 2010, KEMA already issued a number of policy recommendations at this level, aimed at **maximum acceptance** of smart meters when offered and at their **effective use** in combination with an **efficient rollout**. In this respect, the following suggestions for improvement are added by RVO.nl.

5.2.1 Bi-monthly home energy reports

The effectiveness of the bi-monthly home energy report can be increased in three ways:

1. More active communication

Many consumers are not aware of the forwarding of the bi-monthly home energy report following installation of the smart meter, and is possibly even labelled as spam. This is a matter of communication. If the bi-monthly home energy report is assigned a more prominent role in the communication from grid operators (with installation of the smart meter) and especially energy suppliers to consumers, at the time of meter installation, it may have a positive effect on the attention value for the report, without it being labelled as spam. The consumer will thus be aware of the incoming report and will be better informed of the value of this resource for interim evaluation and forecasting for the annual statement.

2. Forwarding through regular mail at first

The means by which the home energy report is delivered to the consumer, also influences the attention value and the actual use of the home energy report. By forwarding the home energy report initially through regular mail, and possibly giving the consumer the option to choose how they want to receive the report in the future, may also have a positive effect on the actual use of the report for more conscious energy consumption. Merely offering the home energy report in a passive way, through a link on the energy supplier's website alone, clearly seems less promising.

3. More attention to design and data presentation

Appreciation of the bi-monthly home energy report seems to vary between energy suppliers. It would be worthwhile to conduct further research on which information parts and visualisations are most appealing to consumers, and to then make this knowledge widely available, so that based on this market parties can develop improved home energy reports in the future. Experiences from abroad can be used as a basis for learning, like in the US, where service provider Opower has a great deal of experience in the development of effective persuasive and psychological mechanisms in periodic home energy reports.

5.2.2 Simultaneous offer of the smart meter and 'smart feedback'

For many consumers, the smart meter is only 'smart' if it is offered in combination with a suitable feedback tool. Pilots have demonstrated, for example, the potential for an instant positive impact to be made on consumers from the installation of a smart meter and an associated in-home display, many of whom (incorrectly) assumed that the in-home display either is the smart meter or a standard part of it. The simultaneous offer of a smart meter and 'smart' feedback will kick-start consumer interest and engagement in accessing energy information available from smart metering. By encouraging the consumer to 'deploy' the smart meter immediately after installation, the installation momentum is used to the best possible extent. Large-scale rollout of the smart meter in the Netherlands is therefore generally considered to a unique and cost-efficient moment at which to make the consumer more aware of the dynamics and associated costs of in-home energy consumption, on a large scale.

The simultaneous offer of a smart meter and 'smart' feedback is therefore important for the **acceptance** and **use** of the smart meter by consumers, many of which are still inexperienced. If this tactical moment is not used properly, there is a risk of 'fit and forget': the consumer's interest in feedback options is expected to disappear again soon after the installation of the smart meter.

As mentioned before, it is up to the market to provide a wide range of convenient smart metering products and services for this, in good time, varying from advanced energy management systems to simpler in-home displays. The current market supply is developing primarily towards more sophisticated online management systems for the most committed and technology minded consumers. In-home displays, a stepping stone channel to kick-start consumer interest and engagement in accessing energy information amongst less motivated and/ or skilled consumers, are scarcely being offered. Ultimately, specific population groups, such as consumers with a low income, those with minimal education or low levels of numeracy, older people and computer illiterates, may potentially not benefit from the smart meter offer as readily. To support less capable consumers to immediately benefit from the smart meter rollout as well, considerations and dedicated solutions should be integrated into social policy programmes from municipalities and housing corporations, aimed at care for the elderly and the fight against poverty, for example. Collaboration amongst grid operators, municipalities and housing corporations and market parties, could lead to simpler yet suitable solutions for specific groups. This approach would also enable local authorities and community groups to play a greater role in the rollout. This is important as consumers are more likely to see local authorities and community groups as trusted entities in this respect. The pilot with the energy dashboard PowerPlayer from Stedin, the City of Rotterdam and housing corporation Woonbron, with residents in the low rental segment, showed that this can be successful.

5.2.3 Transparant rollout planning and area-based rollout approach

The installation of the smart meter to all households is an infrastructural operation which is unique in terms of scale, size and costs. In the national cost-benefit analysis, cooperation between network operators and timely provision of information to the consumer, are considered crucial for an **efficient rollout** process. Additionally, in order to provide the best conditions for simultaneous offering of smart feedback services, the grid operators should also offer non-discriminating transparency to all market parties regarding the rollout planning for smart meters. This will contribute to a level playing field for all market parties and an optimal use of the installation momentum. In addition, a more area-based approach in the smart meter rollout at the local level is advocated. Network operators should, for instance, base the rollout planning for the smart meter at the local level on a district- or neighbourhood-based classification, where the expected receptivity amongst the residents, for additional energy services, will determine the order in which the smart meter is offered to districts or neighbourhoods.[113] A more transparent and local neighbourhood-based approach to the way in which the smart meter is offered will

[113] Similar marketing techniques, differentiated by postal code, have been carried out in Direct Marketing (DM) for quite some time, based on refined segmentation methods.

thus provide grid operators as well as market parties with more options for effective communication, and thereby a greater chance for success with installation and savings. Agreements between network operators and market players, with regard to a transparent and area-based local rollout, can thus create more favourable conditions which will make it more inviting for providers to operate.

5.2.4 Communication and the provision of information

Collaboration in the area of communication is extremely important. The currently low consumer interest to invest in or purchase additional energy services is a factor that should not be underestimated. This places extra demands on consumer engagement communication. Without intensive communication, it will take considerable more time for the market to mature and for consumers to become actively engaged with the feedback systems as an intelligent means of accessing energy information. Timely collaboration between grid operators and market parties on initiatives to promote consumer engagement can help to establish more positive attitudes towards smart meters and associated energy management services. This will ensure that the benefits of smart metering are realised by energy consumers, energy network operations and the environment as a whole.

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