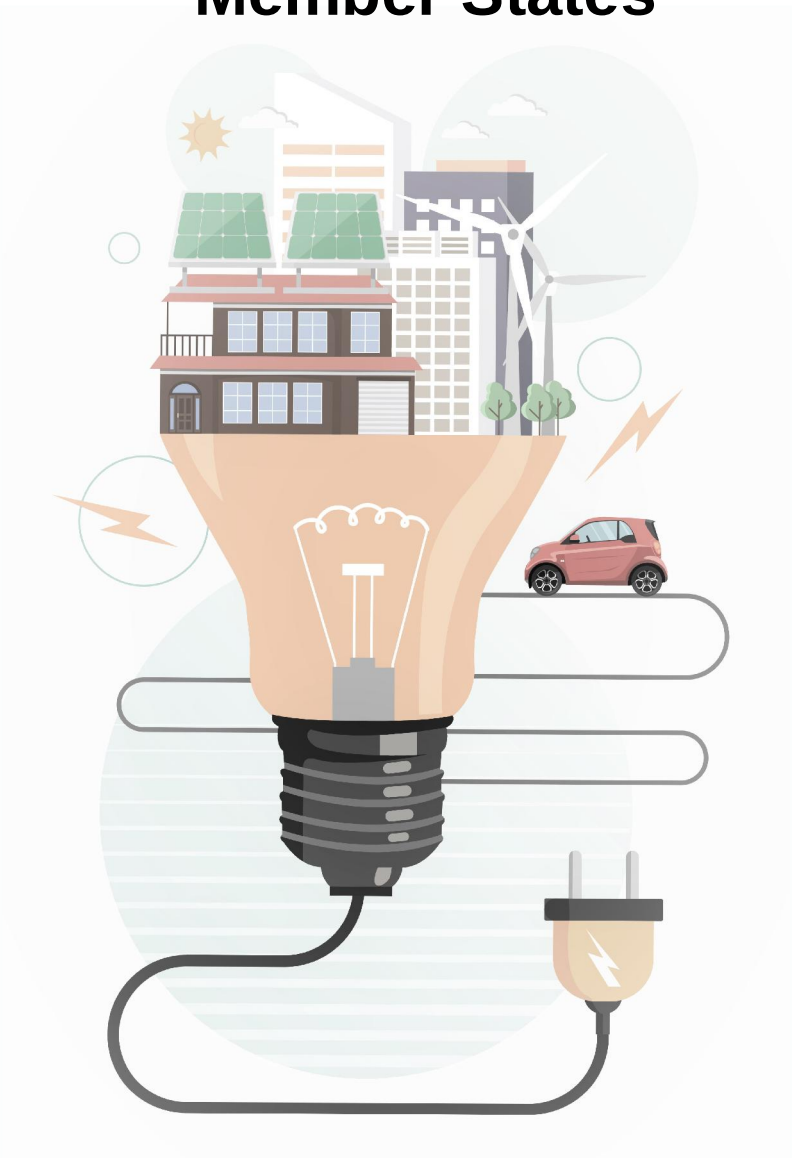
European Commission

ASSET STUDY on
Consumer Satisfaction KPIs for the roll-out of Smart Metering in the EU Member States



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About the ASSET project About the ASSET project

The ASSET Project (Advanced System Studies for Energy Transition) aims at providing studies in support to EU policy making, research and innovation in the field of energy. Studies are in general focussed on the large-scale integration of renewable energy sources in the EU electricity system and consider, in particular, aspects related to consumer choices, demand-response, energy efficiency, smart meters and grids, storage, RES technologies, etc. Furthermore, connections between the electricity grid and other networks (gas, heating and cooling) as well as synergies between these networks are assessed.

The ASSET studies not only summarize the state-of-the-art in these domains, but also comprise detailed qualitative and quantitative analyses on the basis of recognized techniques in view of offering insights from a technology, policy (regulation, market design) and business point of view.

Disclaimer

Authors

This study has been developed as part of the ASSET project by Tractebel Impact.

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Executive summary

The Third Energy Package Electricity and Gas directives are calling on Member States to ensure the implementation of smart meters for supporting the active participation of consumers in the European energy markets. Member States, who decide on the overall deployment strategy and the functional coverage of the smart metering systems they deploy, hold the keys for the success of the deployment.

Scope & objectives:

In this study, we focus on the consumer perspective, assuming that success of smart metering deployment rests on the ability to deliver direct benefits to consumers and ultimately to support their active participation in the energy markets.
Our objective is to design a comprehensive monitoring framework made of key performance indicators that can systematically and transparently assess the success of smart metering deployment from a consumer perspective. Keeping in mind that some Member States have already achieved a significant level of smart metering deployment, this study also intends to use the best practices and lessons learned to develop a monitoring framework that is both relevant and likely to be put in practice. The focus of this study is more on electricity smart meters than gas smart meters since more value propositions are available for the electricity smart meters.

Monitoring framework design:

Value propositions

The cornerstone of our work is the so-called “value propositions”, which designate a specific service developed thanks to the deployment of a smart metering system. These value propositions will emerge in the energy market since smart meters will facilitate consumer access to third parties’ services. To assess both the positive and negative outcomes of smart meters for consumers, we will first assess the availability of those value propositions – through the definition of a dedicated maturity model to differentiate Member States- and, in a second step, identify the key factors that influence the ability of consumers to reap smart metering benefits.

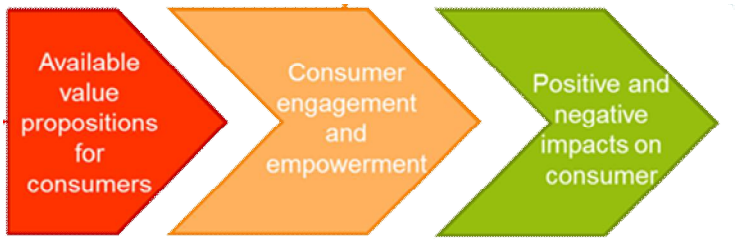

Figure 1: Key factors that influence the ability of consumers to reap smart metering benefits

These value propositions have been put in place by the industry and the Authorities to enable a consumer to directly benefit from smart meters. Direct benefits imply that a significant share of the value created has been captured by the consumer, in opposition to indirect benefits that are socialized through the whole customer base. These benefits can be both monetary and non-monetary.

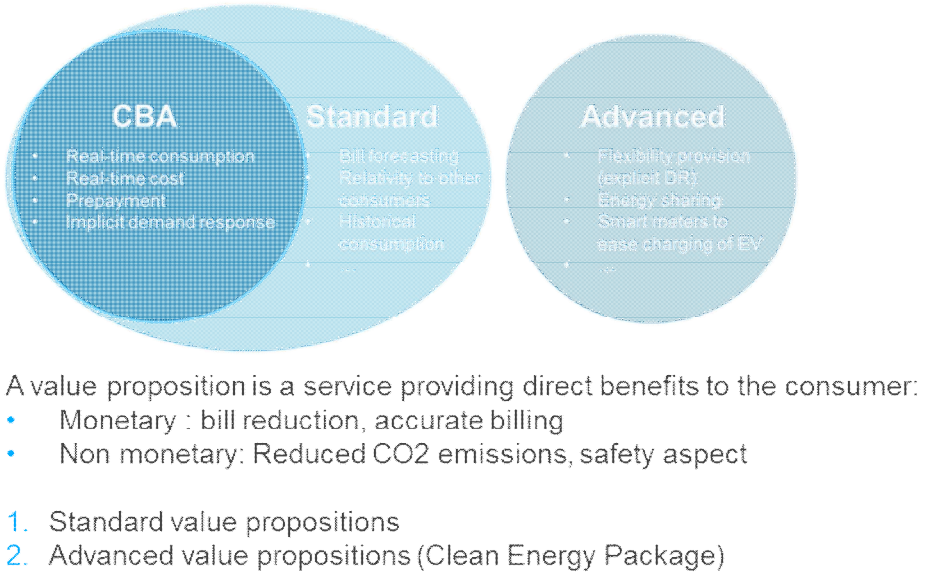

Figure 2: The different domains of value propositions identified

As the previous figure illustrates, three different sets of value propositions have been identified. The first set is related to the National Cost Benefit Analysis (CBA) that have been carried out pursuant to 2009/72 electricity directive and its conditional (based on a positive CBA) obligation to roll out smart meters. The standard set is merely a functional extension of the previous set, while the advanced value propositions are based on the Clean Energy Package proposal[1] [1].
As a matter of fact, this *yet to be adopted* legislative package, including directives, regulations and communications, provides a clear positive signal to Member States wishing to properly integrate decentralised energy resources (such as e-mobility charging points, demand response, storage…) into their smart metering system. The smart metering provisions are included in the recast of the Electricity Directive of the Clean Energy Package[2] [2]. This advanced set of value propositions is therefore likely to evolve in the future as a growing number of Member States are adopting specific regulatory accommodations that allow consumers to capture the benefits of their active participation in the energy markets.

Maturity model

Availability of those value propositions depend on the strategic choices made by the National Authorities and the industry. To deal with the diversity of national contexts, we designed a dedicated maturity model focusing on the ability to deliver benefits to consumers. The underlying figure illustrates its application to the EU-28 Member States and the underlying criteria.

[1] Clean Energy Package: https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition
[2] Proposal for a Directive of the European parliament and of the Council on common rules for the internal market in electricity (recast) – February 2017 – European Commission, Brussels

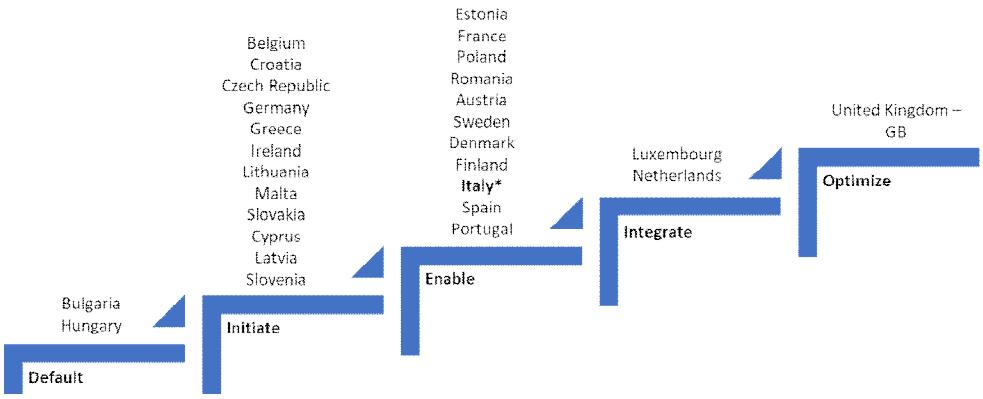

Figure 3: Benchmark of Member States for the maturity model

Maturity level	Default	Initiate	Enable	Integrate	Optimize
Criteria: Member state		1. Conducted a cost benefit analysis	3. Has an existing legal framework in place	5. Has its smart meter compliant with EC recommended functionalities a, b and f	7. Has commercial offers available
		Or	*And*	*And*	*And*
Criteria: Member state		2. Realized a roll-out of > 1%	4. Realized a roll-out of > 10%	6. Proactive communication of consumer benefits to the general public	8. Implemented commercial offer

Table 1: Maturity levels criteria

Consumer concerns, motivations and abilities to benefit

Consumers ability to reap benefits from smart meter deployment is determined by several factors:

§ Perceived risks, fears and concerns expressed by consumers should be dealt with at the earliest stage of deployment as a prerequisite for further engagement.

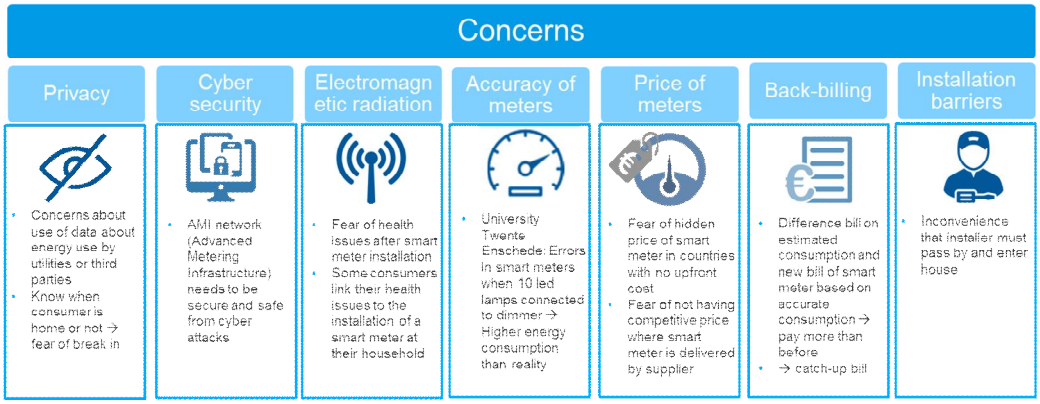

Figure 4: Perceived concerns of the consumer

§ Motivations and abilities to effectively benefit from smart meter show a high degree of diversity that call for tailor-made solutions. One size does not fit all. We have identified three dimensions to map consumer motivations, from which we derived 6 consumer archetypes that have been further characterized based on their abilities to collect smart meter benefits.

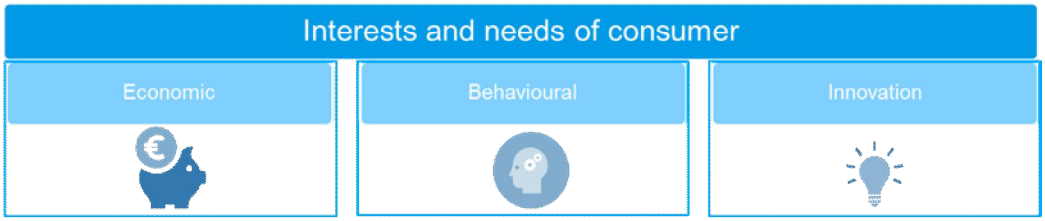

Figure 5: Interests and needs of the consumer

		Motivated achievers	Ecological forward movers	Convenience conformers	Unmotivated consumers	Barely getting by	Non-economic vulnerable consumer
Age	20-39	✓	✓✓	✓	✓	✓	✓
	40-59	✓✓	✓	✓	✓	✓	✓
	>60			✓	✓✓	✓	✓
Income household	<35,000€				✓	✓	✓
	35,000-50,000€		✓	✓			✓
	>50,000€	✓					
Yearly electricity consumption	<1000 kWh					✓	✓
	1000-2500 kWh		✓	✓	✓	✓	✓
	2500-5000 kWh	✓	✓	✓	✓	✓	✓
	> 5000 kWh	✓✓					✓
Housing tenure	Owner	✓	✓	✓	✓		✓
	Private renter			✓			✓
	Social renter					✓	
Environment	Focus environment		✓				
	Environment neutral	✓		✓	✓		✓
	Not important				✓	✓	
ICT skills	Good	✓	✓	✓		✓	
	average			✓✓		✓✓	✓
	bad			✓	✓	✓	✓
#Persons household	1		✓		✓	✓	✓
	2		✓	✓	✓	✓	✓
	3	✓	✓	✓		✓	✓
	4	✓	✓	✓		✓	✓
	>5	✓		✓		✓	✓
Health impairment	No	✓	✓	✓	✓		
	Chronical sickness						✓
	Disability						✓

Figure 6: Six identified consumer archetypes

Key Performance Indicators

As a last step, we defined a limited set of KPIs that cover the four dimensions suggested by the European Consumer Organisation ANEC, further refined into Transition KPI – depending on the national context- and Consumer KPI – depending on how consumers have been embracing the new smart energy system put at their disposal. Each KPI has been properly defined, illustrated and characterized (relevance, computability, comparability across MS).

	Domain	1. Transition KPI	2. Consumer KPI
1	Consumer awareness	§ Communication campaign level	§ Awareness of installation § Awareness of available value propositions
2	Consumer satisfaction	§ Response to consumer concerns § % bills based on actual meter readings	§ Ratio of complaints § Deactivation ratio
3	Active engagement	§ Maximal allowable switching time § Availability of detailed load curve	§ Switching rate § Number of consumers changing to different tariff
4	Benefit realisation	§ Available value propositions	§ Energy consumption reduction § Peak demand reduction

Stakeholders engagement

Throughout the duration of this study, we have sought the feedback of the most relevant stakeholders by using an online survey and organizing a dedicated workshop. National regulatory authorities, consumers and industry representatives have expressed a strong interest for our study and have delivered insightful comments and suggestions, ensuring that the proposed monitoring framework will remain both relevant and easy to implement.

Conclusion

This study has carefully analysed the effect of smart metering on consumers in terms of context, demographics, including potential consumer vulnerabilities. It should be viewed with the broader perspective of delivering the new deal for consumers as envisioned in the Energy Union Strategy “Clean Energy for All”.
This study can be a contribution to this strategy as we hope to guide Member States to timely design their own national monitoring scheme for assessing progress and effectiveness of smart metering deployment from a consumer perspective.
We recommend considering the KPI defined in this report as a starting point in the discussion that the European Commission and the relevant stakeholders will engage in the near future to define a shared and comprehensive framework to monitor and

compare the consumer impact of smart metering roll-outs across Member States. The proposed monitoring framework could potentially serve the regulators (ACER/CEER) in tracing, as part of their annual monitoring exercise, consumer satisfaction with smart metering deployment and the underlying key factors of influence.

List of Abbreviations and Acronyms

1G and 2G	First and Second Generation smart meters, term often used in Italy
ACER	Agency for the Cooperation of Energy Regulators
ANEC	The European consumer voice in standardisation
ASSET	Advanced System Studies for Energy Transition
CBA	Cost Benefit Analysis
CEDD	Centre for Studies on Sustainable Development
CEER	Council of European Energy Regulators
CNIL	Commission nationale de l'informatique et des libertés
DECC	Department of Energy and Climate Change
DSO	Distribution System Operator
DNV	Det Norsk Veritas
DPIA	Data Protection Impact Assessment
DR	Demand Response
DSR	Demand Side Response
EC	European Commission
ESMIG	European Smart Metering and Management Industry Group
EU	European Union
FR	France
GB	Great Britain
GDPR	General Data Protection Regulation
ICT	Information and Communication Technology
IHD	In-house display
KEMA	Keuring van Electrotechnische Materialen Arnhem, now know as DNV
KPI	Key Performance Indicator
MS	Member States
NL	The Netherlands
PHE	Public Health England
SM	Smart Meter
SMETS	Smart Meter Equipment Technical Specification
SMMM	Smart Metering Maturity Model
ToU	Time of Use (energy tariffs based on the time in which the energy is consumed)
UK	United Kingdom
VP	Value Proposition

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Introduction

The Third Energy Package Electricity and Gas Directive are calling on Member States to ensure the implementation of smart meters, which may be subject to a cost-benefit analysis, for supporting the active participation of consumers in the energy markets.
In the case of electricity, so far 17 Member States, mainly following a positive cost-benefit assessment, are proceeding with a wide-scale roll-out (at least 80% penetration rate) by 2020 and 2 Member States with a selective (up to 23% penetration rate) roll-out.
The success of the exercise is largely in the hands of the Member States who decide on the overall design and the functional coverage of the smart metering systems they deploy, and therefore their ability to deliver benefits also to consumers and support their active participation in the energy markets.
As the roll-out of smart meters is still in an early phase, very few EU Member States (for instance UK-GB, the NL, FR) plan or are already systematically monitoring progress regarding delivery of such consumer benefits, or have an information and consumer engagement strategy in place. They do acknowledge though that this is a critical success factor for the deployment of smart meters, and should be an integral element of every roll-out.
Moreover, current monitoring activities by the responsible authorities may be including certain aspects of consumer satisfaction with smart metering, but are not as comprehensive or robust as desired.
There have been some first reflections on potential indicators for a systematic monitoring of the consumer satisfaction with smart metering going beyond mere collection of data regarding number of installed and activated smart metering units.
ANEC, in their recent position paper[3] [3], identified a number of desired outcomes of smart metering from a consumer perspective and discussed possible measures to monitor and ultimately establish success of deployment.
To this respect, ANEC recognises that related metrics and measures must be developed, preferably building on existing ones, for measuring progress and ultimately success in reaching these outcomes. In doing so, ANEC argues that different classes of consumers must be considered along with a reflection on what has worked well and what needs to be done.
The objective of the proposed study is to design, building on available best practices, a comprehensive framework with key performance indicators (KPIs) to systematically and transparently monitor progress and impact from a consumer perspective as to ultimately assess the success of smart metering deployment in the EU.
To this respect, the study will carefully analyse the effect of smart metering on consumers in terms of:

- *context*, I.e. influence of specific conditions in different Member States on the impacts brought by smart metering functionalities/ services;
- *demographics, including potential consumer vulnerabilities* – I.e. influence of specific socio-economic conditions of consumers to their ability to capture the potential benefits enabled by smart meters (e.g. how to adjust information provision and smart metering services to address energy poverty, but also different levels of ICT literacy/ability to use technology, as shown in recent studies).

[3] Position Paper: Monitoring the success of smart metering deployment from a consumer perspective – June 2015 – ANEC (Katrin Behnke)

The study should be viewed in the context of supporting actions for delivering the "new deal" for consumers as described in the Energy Union strategy, and the new Market Design Initiative under the "Clean Energy for All" Package [4].
The results of the study could be used to:

- guide Member States, in anticipation of the planned roll-outs, to timely design or further refine their own national monitoring scheme for assessing progress and the effectiveness of smart metering deployment from a consumers' perspective;
- support the regulators (ACER/CEER) in tracing, as part of their annual monitoring exercise, consumer satisfaction of the roll-out which should be considered an integral element of the respective cost-benefit assessments for deployment and a critical success factor for the roll-out of smart meters.

In terms of content, the study will also:

- benchmark existing and emerging practices in Smart Metering deployment in Member States and relevant trends;
- taking stock of the state-of-the art, identify the smart metering related consumer impacts, benefits and desired outcomes (for instance access to information and accurate billing; easier, in terms of timescales/process, supplier switching; supporting energy savings/shifting and net financial savings; supporting use and connectivity of end devices and the development of new energy and data-driven services
- develop a framework with indicators to systematically and transparently measure these impacts/benefits/desired outcomes and assess progress (in terms of target and schedule) for delivering them.

[4] https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition

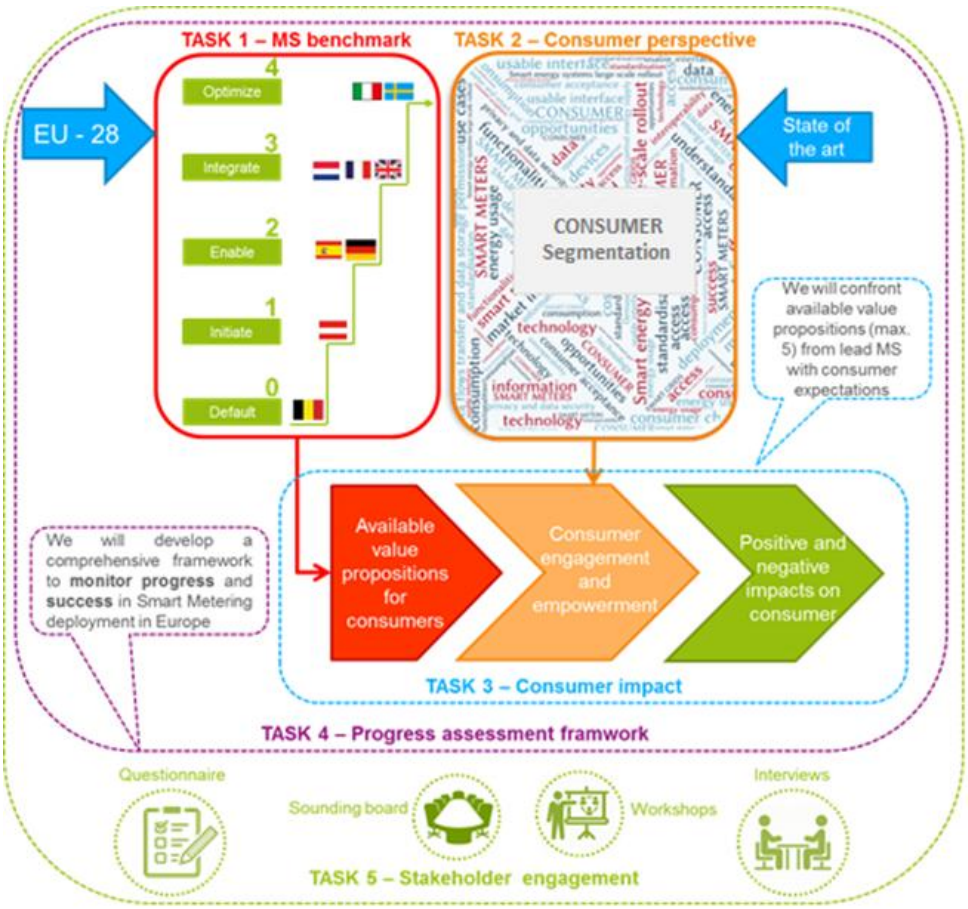

Figure 7: Overview of the study

Benchmark of Member States Practices

Introduction

Under EU energy market legislation in the Third Energy Package, Member States are required to roll-out smart meters to consumers; this decision may be subject to a cost-benefit analysis (CBA). For the positively assessed cases, the obligation is to roll-out 80% by 2020. Negatively assessed cases do not have such an obligation. Because of this legislation, many Member States made a commitment to roll-out which will result in a total of almost 200 million smart meters for electricity. By 2020, it is expected that almost 72% of European consumers will have a smart meter for electricity.[5]

As every Member State has an individual smart meter roll-out strategy, the stages of deployment are diverse. In this chapter, five maturity levels, that represent different stages of deployment, are explained in more detail. Maturity levels – as opposed to Key Performance Indicators – focus on all the required investment in asset, people and process to enable new businesses and value propositions rather than real outcomes and benefits.

Furthermore, based on the maturity levels, a benchmark is created of the 28 Member States of the European Union. Benchmarking Member States practices in their smart metering deployment goes beyond comparing deployment rate and naming laggards and leaders. A strong assessment framework is designed to cope with the transition underlying the smart metering deployment and that goes far beyond renewing the electricity meter.

A closer look is taken at the most mature Member States. For these States functionalities and services designed to provide benefits directly to the individual consumer are identified, also called 'value proposition'.

Smart meter Maturity model

In this section of the report the Smart Meter Maturity Model (SMMM) is defined. First, the different maturity levels are described in general and the method of increasing in maturity level is visualized. Secondly, an overview is provided of the SMMM. Finally, the criteria that are part of the SMMM are explained in more detail.

Maturity levels

Maturity models have been designed by the US information technology industry in the early 90s. They provide a useful way to situate one organization on the evolutionary path that digitalization enabled. In the recent years, they found a natural way of expansion in the power sector with maturity models dedicated to Smart Grids and Smart Meters.

[5] COM(2014)356 Smart Metering Benchmarking Report and accompanying Staff Working Documents; http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2014%3A356%3AFIN
European Smart Metering Landscape Report – Utilities and consumers, 2016, Co-funded by the Intelligent Energy Europe Programme of the European Union

In the SMMM, five levels are defined to pave the way for smart metering deployment, from the first level (default) to the final level (optimize). In Figure 8 the different maturity levels are visualized. For a Member State to make a step toward a higher maturity level, it needs to fulfil all the criteria of that level. This means that Member States in the level 'Optimize' need to fulfil all the criteria of the other levels as well. A detailed description of the model and criteria is given in the following section.

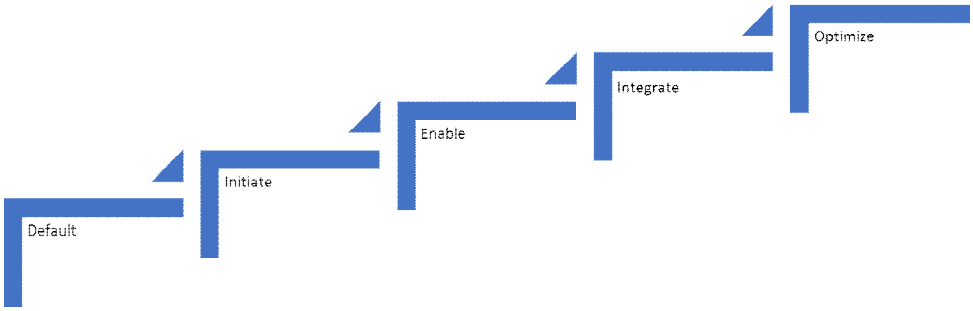

Figure 8. Maturity levels

Smart Meter Maturity Model

The table below summarizes the SMMM that is designed to benchmark 28 Member States. The model has a similar set-up as the Smart Grid Maturity Model (SGMM), which is developed by the Carneggie Melon's Software Engineering Institute[6]. However, the assessment criteria are completely different. In the SMMM the criteria are mostly based on publicly available information of the deployment of the smart meter roll-out. Most of this information is provided by the European Commission. As a result, the criteria of the SMMM are very different than those of the SGMM.
In the table, the five maturity levels are given on the top row. Moving up to a higher level requires meeting the criteria underlying that maturity level. The criteria are further described in the next section.

Maturity level	Default	Initiate	Enable	Integrate	Optimize
Criteria: Member state		1. Conducted a cost benefit analysis	3. Has an existing legal framework in place	5. Has its smart meter compliant with EC recommended functionalities a, b and f	7. Has commercial offers available
		Or	*And*	*And*	*And*
Criteria: Member state		2. Realized a roll-out of > 1%	4. Realized a roll-out of > 10%	6. Proactive communication of consumer benefits to the general public	8. Level of subscription of commercial offers

Table 2. Smart Meter Maturity Matrix

[6] http://www.sei.cmu.edu/smartgrid/

Criteria

The eight criteria used in the smart meter maturity model are described below. For each criterion, a description is given. Secondly, the literature used for evaluation is given. The Maturity Model is intended to be flexible and be able to accommodate new information about each Member States' context. In other words, the maturity model evaluation is supposed to be regularly updated.

Criterion 1: Conducted a cost benefit analysis

Description:	§ The first step for a Member State is to show some interest in the potential value of smart meters. By conducting a cost benefit analysis, a Member State shows the first step of this interest.
Literature used for evaluation:	§ Benchmarking smart metering deployment in the EU-27 with a focus on electricity, 2014, European Commission [7] § http://my-smart-energy.eu/my-country/

Criterion 2: Realized a roll-out of 1%

Description:	§ A Member State that has started undertaking investments in smart meters is inclined to realize the benefits of smart meter deployment. These Member States, with or without cost benefit analysis, are therefore at least in the 'Initiate' level.
Literature used for evaluation:	§ Impact assessment study on downstream flexibility, price flexibility, demand response & smart metering, 2016, European Commission DG Energy

Criterion 3: Has an existing legal framework in place

Description:	§ For a smooth out-roll of smart meters it is important to have a legal framework. A legal framework is used for deployment and/or regulating specific matters such as timeline of the roll-out, or setting technical specifications for the meters, etc.
Literature used for evaluation:	§ Benchmarking smart metering deployment in the EU-27 with a focus on electricity, 2014, European Commission

Criterion 4: Realized a roll-out of 10%

Description:	§ Another criterion is the realization of 10% of the roll-out of smart meters. Without a larger number of installed smart meters, fewer benefits for consumers can be realized.
Literature used for evaluation:	§ Impact assessment study on downstream flexibility, price flexibility, demand response & smart metering, 2016, European Commission DG Energy

[7] Report from the commission: Benchmarking smart metering deployment in the EU-27 with a focus on electricity – COM(2014) 356 final

Criterion 5: Smart meter compliant with EC recommended functionalities a, b, f

Description:	§ For the next level, 'Integrate', the ability of a smart metering system to deliver benefits directly to the consumer is considered. The functionalities that a smart meter system should comply with are extracted from the COM Recommendation 2012/148/EU. These functionalities are set to ensure a smart meter can benefit all stakeholders — the consumer, the metering and system operator — while it enables, in a secured and safe environment, commercial aspects of supply/demand and the integration of distributed generation. § In these recommendations, ten minimum functional requirements for electricity smart metering systems are included. Functionalities a, b and f are the most critical ones to provide direct benefits to the consumers. (a: Provide readings directly to consumer and/or any 3rd party; b: Update reading frequently enough to use energy saving schemes; f: Support advanced tariff system). § Article 20 in the proposal for a revised Electricity Directive (COM(2016) 864) instructs amongst others that smart metering systems should be able to meter and settle at periods that match the imbalance settlement period in the national market (which could currently be 15-30-60 min depending on country) and as of 01.01.2025 it becomes 15 min everywhere (reference: proposal for a revised Electricity Regulation - COM(2016) 861). § Functionality b (metering frequency) is translated in a metering frequency of less than 1 hour. § An overview of these functionalities can be found in ANNEX A.
Literature used for evaluation:	§ Interoperability, Standards and Functionalities applied in the large scale roll out of smart metering, 2015, Smart Grids Task Force

Criterion 6: Proactive communication of consumer benefits to the general public

Description:	§ Besides the required functionalities, a Member State should also show interest in the benefits for consumers. In the Cost Benefit Analysis, Member States could include the benefits for consumers and communicate benefits to consumer. Member States that have not included this are not accepted to the maturity level 'Integrate'.
Literature used for evaluation:	§ Country fiches for electricity smart metering, 2014, European Commission

Criterion 7: Has commercial offers available

Description:	§ For the level 'Optimize' only Member States are accepted that have a wide range of smart-meter enabled commercial offers available for different consumer archetypes. The availability of commercial offers shows that the right conditions are in place for market actors to propose value propositions to consumers.
Literature	§ No literature available, research was based on available commercial

used for evaluation:	information which has been submitted to Member States § Member states have been evaluated based on the information they provided in return. § For this report, a minimum amount of 2 commercial offers is used to quantify this criterion. One stakeholder argued that 2 was not an appropriate criterion to ensure long term representativeness. We suggest to update and possibly modify this criterion depending on the uptake of commercial offers enabled by smart meters.

Criterion 8: Level of subscription of commercial offers

Description:	§ Another criterion for the level 'Optimize' is that a considerable number of consumers with a smart meter (>50%) within a Member States have actually subscribed to an available commercial offer. The implementation of commercial offers is the last step in achieving the highest maturity level.
Literature used for evaluation:	§ No literature available § Member states will be evaluated based on the information they provide

Benchmark of Member States

For the Benchmark, all 28 Member States are evaluated per criterion. The scoring per criterion per Member State can be found in Annex A: Functional Requirements. In this section only the result is given, see *Figure 9* In this figure, the levels are visualized as steps. Before entering a higher step, or level, all criteria need to be fulfilled.

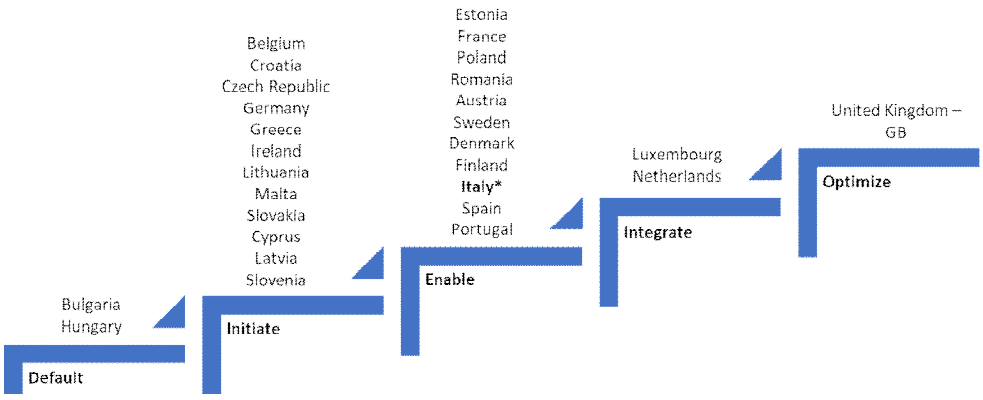

Figure 9. Benchmark of Member States

The Member States with the highest maturity level is the United Kingdom. Only this Member State fulfils all criteria. The Netherlands has commercial offers available, but these are not implemented with more than 50% of the consumers. For Luxembourg, we have not identified the availability of different types of commercial offers targeting multiple consumer archetypes. This keeps Luxembourg and the Netherlands (for now) in the level 'Integrate'.
Most Member States are still in the maturity level 'Enable'. It is worth mentioning that Italy has started the implementation of the new generation of smart meters, which is expected to support the development of new commercial offers and thus bring Italy forward in the maturity level (illustrated by the * sign in the figure above). Today, Italy

has already installed about 1 million 2nd Generation Smart Meters. In 2021, the Italian DSO E-Distribuzione are planning to have more than 20 million 2G Smart Meters installed.
Even though Austria and Sweden did consider consumer benefits, they only partly meet the criteria for functional requirements.
For Estonia, France, Poland and Romania it is the other way around, they do meet all the functional requirements, but consumer benefits are marginally analysed and addressed in their cost-benefit analysis. One Spanish DSO claims implementation of functionality (b) without complying to the update frequency of at least 15 minutes and another indicates that it is under development. Denmark and Finland do not meet both criteria. However, it is important to note that obligatory elements are listed in the recast Electricity Directive, Article 20 in the framework of the Winter Package Proposal published by the European Commission. Required functionalities are put forward that provide information to consumers frequently enough (close to near real time). Nowadays, the metering and settlement frequency depends on the national market context and may vary from 15 to 60 minutes. As of 01/01/2025 it should become 15 min for each Member State.
For many Member States at the level 'Initiate', it is the criterion of the realization rate that is keeping them back. Only Slovenia met the realization rate criterion, but does not have a legal framework in place.

Benefits in Smart metering CBAs

In this chapter, we present in more detail the benefits that have been considered in the CBAs of Member States which have ranked at level 4 and 5 of the Maturity Model (I.e. United Kingdom – GB, Netherlands and Luxembourg)
It is worth mentioning that in this chapter we are considering all possible benefits, including those that are not related to direct value propositions for consumers (e.g. indirect benefits like reduced meter reading costs, which should lead to consumer value via the reduction of grid tariffs).

United Kingdom - GB

Based on the Impact Assessment that was published in 2014, the Department of Energy & Climate Changed published an updated version with the latest available evidences on the cost and benefits of a smart meter roll-out in 2016. In this study, the benefits are classified in three broad categories:

- Consumers;
- Businesses (energy suppliers, network-related and peak load shifting) and;
- Carbon & air quality.

Some of the benefits for businesses are expected to be passed down to consumers. For example, avoided meter readings are a direct, first order, cost saving to energy suppliers. As energy suppliers operate in a competitive environment, we expect these to be passed on to consumers.
The total value of the benefits of a smart meter in the UK is in €377 per metering point.[8] The benefits exceed the cost significantly with €161 per metering point. The distribution of the total benefits is visualized in Figure 10[9]. This overview is based on

[8] Country fiches for electricity smart metering, 2014, European Commission
[9] Smart meter rollout cost-benefit analysis – Part 1, 2016, Department for business, energy & industrial strategy

the Impact Assessment of the DECC[9] and the total value as calculated in the European Commission report[8].

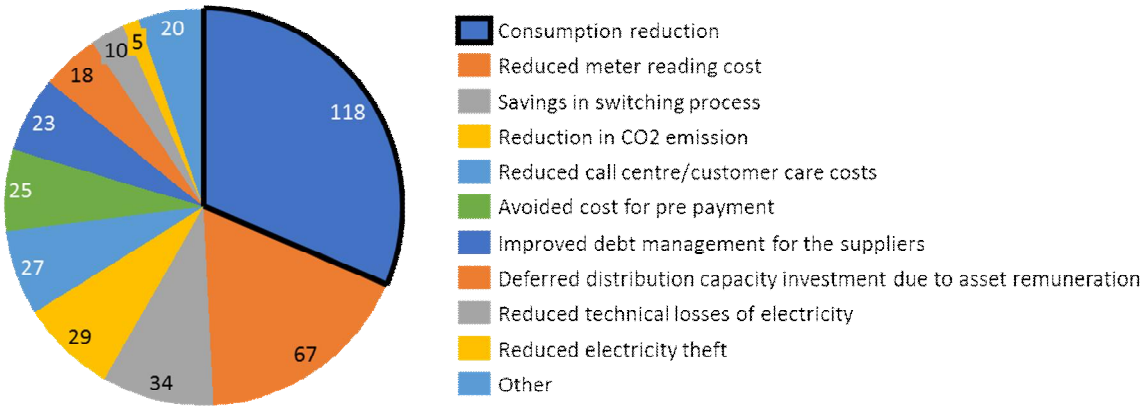

Figure 10. Benefits of roll-out in United Kingdom - GB

With a share of almost 50%, the benefits of smart meters are the highest for the suppliers. The benefits that are considered for suppliers are cost savings made possible by remote meter readings and the expected reduction in suppliers' call centre traffic, because of fewer queries about estimated energy bills. In addition, smart meters are expected to make the consumer switching process cheaper and simpler, because of more accurate billing and streamlined interaction between involved parties through on-demand meter readings at the point of switching and consolidated data bases. Suppliers will most likely also see improved detection and debt management. In addition, consumers will be enabled to proactively avoid the accumulation of debt because of the data that is available for them.

For consumers, the only significant benefit is the realization of consumption reduction. This results in a share of 32% of the total benefits of smart meters. The assumed energy savings in the CBA of the UK is conservative with a gross annual reduction in energy demand of 2.8% for electricity and 0.5% for gas. The reduction in energy savings brings additional value as the carbon emission will also reduce.

In addition to energy savings, consumers will also be enabled to change their energy demand profile and shift energy demand from peak to off-peak times. For consumers with Time of Use tariffs this shift will likely result in a reduction of their energy bill. However, the savings for some customers may be offset by an increase in cost for other customers, as the existing cross-subsidy across time of use unwinds. Thus, the benefits from load shifting in the CBA are accounted to the UK economy. This benefit is allocated as a first order benefit to various agents in the energy market, and hence it is discussed under the "business benefits" heading.

Since smart meters can be used to deliver export information, the final benefit for consumers is the reduction in the need to install an export meter for microgeneration devices. In the assessment, no increase of microgeneration deployment post 2020 is assumed. The microgeneration benefits amount to £49m in present value terms over the appraisal period.

The benefits that are considered in the CBA for network operators are improved outage management and increased efficiency to resolve any network failures. Furthermore, because of more targeted and informed investment decisions network operators can reduce their cost. In addition, smart meters are also expected to generate savings both in terms of distribution as well as generation capacity investment because they enable load shifting. In the CBA only the benefits from load shifting as a result of static TOU tariffs are considered. However, there is significant additional

potential from dynamic TOU tariffs and other more sophisticated demand side response (DSR) measures, for which the presence of smart meters is an important enabler.

The Netherlands

In 2005 the Ministry of Economic Affairs asked KEMA to perform a societal cost-benefit analysis of the national introduction of the smart meter. In 2010, KEMA was asked to revise the cost-benefit analysis to gain insight into the consequences of the changed circumstances (among others, increased attention for energy efficiency and smart grids, and the elimination of the obligation to accept a smart meter). These reports are used as input.
Figure 11 visualizes the distribution of the benefits of the roll-out of smart meters. The total benefit per metering point is €270, following EC calculation[10]. The benefits are higher than the costs which are €220. The distribution of the benefits is based on the Study on cost benefit analysis of smart metering systems[11] since the original study of KEMA is not publicly available.

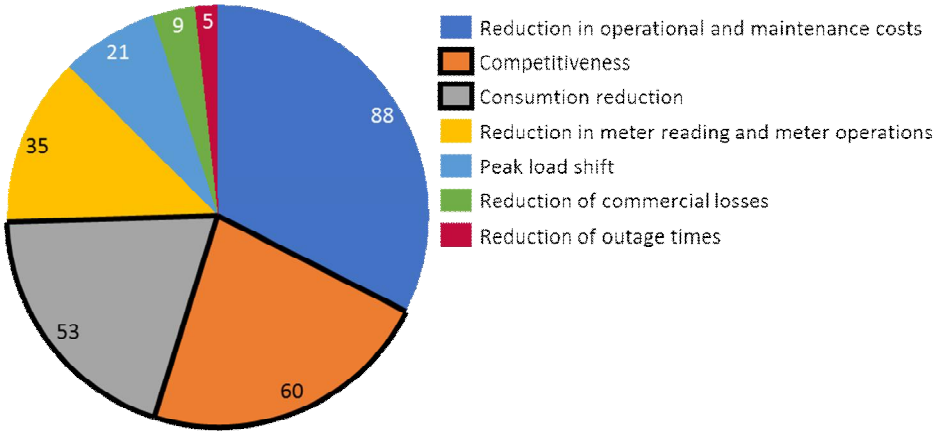

Figure 11. Benefits of roll-out in the Netherlands

The benefits for consumers are almost 40% in total. The benefits include consumption reduction and competitiveness. The consumption reduction accounts for 20% of the total benefits. In the Dutch CBA, the benefits of the reduction of CO_2 emissions and air pollution are included. A notable feature of the benefits is the important role of greater competitiveness of 20%. It is assumed that the introduction of smart metering will promote customer switching and competition by inducing innovation, and hence result in lower prices in the market.
It should be noted that the in-home display is not implemented in the Netherlands. With this display, an increase of energy saving could have been realized. It was however decided to not implement the in-home display to reduce the costs of the smart metering roll-out.
Other benefits that are considered, which are mostly for the network operator, are savings on call centre costs. Because of better data provision for consumers it is expected that consumers are less in need of help of a call centre. Furthermore, because of better data provision and management it will also be easier for consumers to switch

[10] Country fiches for electricity smart metering, 2014, European Commission
[11] Study on cost benefit analysis of smart metering systems, 2015, AF Mercados, ICCS-NTUA

suppliers, which also results in savings. Finally, savings will be realized on meter reading costs because site visits will not be required anymore.

Luxembourg

In Luxembourg, the national law describes that 95% of the electricity consumers should be equipped with a smart meter by the end of 2018. A detailed cost-benefit analysis (CBA) has not been made publicly available. The data used for our study has been provided by the national authorities following smart metering activities.
The value of the benefits per metering point is €162, which is higher than the cost, €142. The share of consumer benefits is calculated to be 17% which will mostly be based on the reduced energy consumption.[12] The main benefits are categorized as follows:

- Reduced meter reading and operating cost
- Reduced energy consumption
- Non-replacement of old meter

Available value propositions (Return from questionnaire)

To update the information provided by the National CBA, a dedicated questionnaire has been submitted to Member States and their National Regulation Authorities. The CBA did not put a specific focus on consumers while our scope of work requires to investigate the direct benefits provided to them thanks to the deployment of a smart metering system.
We have therefore requested the NRA to submit the most promising value propositions that could materialize into direct benefits for the consumers.
The following figures highlight both the available and the most promising value propositions that NRA are considering nowadays or for the near future.

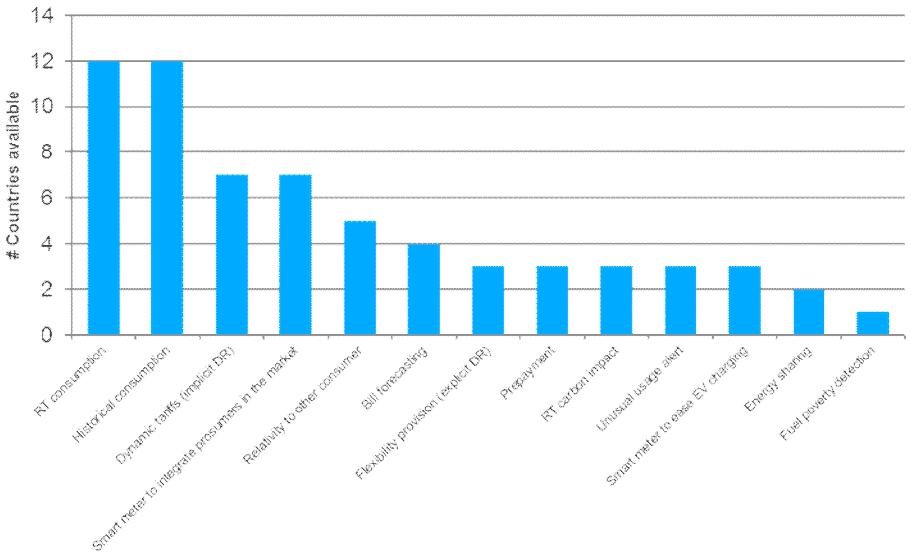

Figure 12: Amount of value propositions available

[12] Country fiches for electricity smart metering, 2014, European Commission

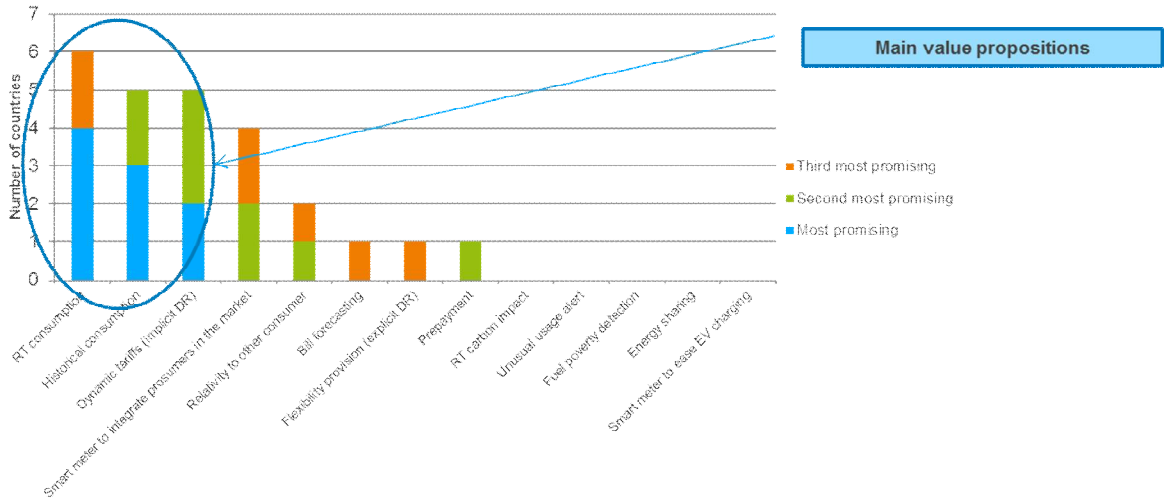

Figure 13: Amount of chosen promising value propositions

Starting from these value propositions, we will further investigate the key factors of influence for the consumer to reap benefits from the smart meter.

Consumer's motivations and Abilities to Benefit from Smart Meters

Introduction

The previous chapter highlighted the state of advancement of MS regarding deployment of smart meters, and the value propositions for consumers that these are expected to enable.

In this chapter, we take a look at the consumer side, identifying consumers' characteristics (e.g. age, revenue and ICT skills) that might determine their ability to effectively profit from the identified value propositions and to obtain the projected benefits.

To be able to assess consumer benefits from smart metering deployment and use in the European Union, we propose to adopt the following approach (see Figure 14):

- "Supply side", i.e. the potential value propositions related to Smart meters, delivering benefits to consumers
- "Demand side", i.e. the characterization of the interests, needs and concerns of consumers, and their segmentation according to socio-demographic characteristics
- Matching 'supply/demand', i.e. looking under which conditions consumers can actually reap benefits from the value propositions enabled by smart meters. These conditions include:
    - the characteristics of the 'context' of a given MS (e.g. information campaign in place, regulatory framework, development of energy market.)
    - the socio-demographic characteristics of consumers

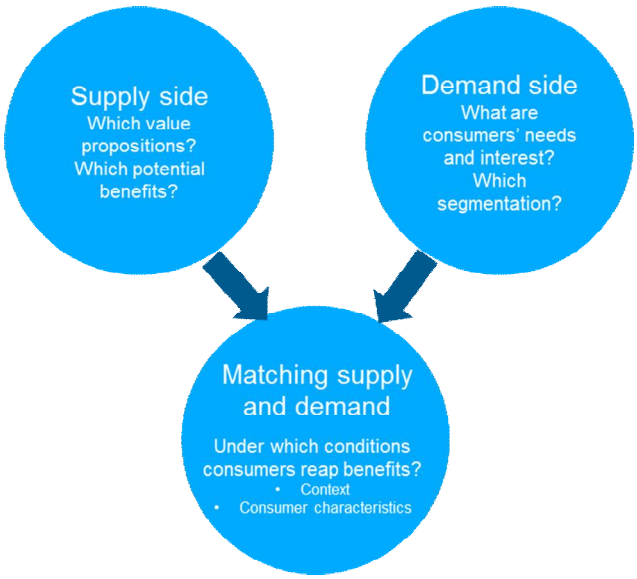

Figure 14: Synthetic view of the analysis for task 2

Potential value propositions and benefits for the consumer enabled by Smart Meters

In this section, we will focus on the value propositions enabled by smart meters that bring direct benefits to consumers, both in terms of monetary (e.g. bill reduction) and non-monetary value (e.g. reducing environmental footprint; having better energy efficiency performance than neighbours).
The value propositions will be divided in two groups: standard and advanced/future value propositions. However, it is important to note that these direct benefits are possible benefits and will depend on the consumer's motivations and abilities if he or she will benefit.

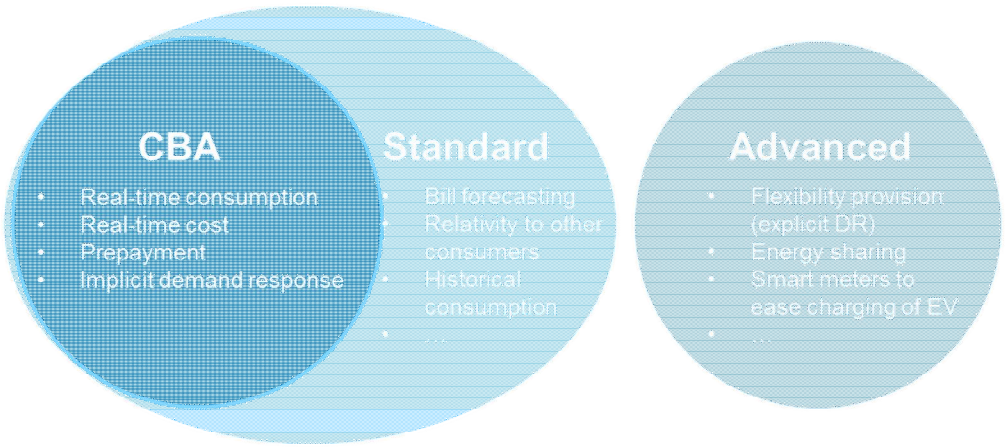

Figure 15: Standard and Advanced set of Value propositions enabled by Smart Meters and relationship with the main value propositions included in the CBAs carried out by Member States

Standard value propositions

In the following we describe the set of most common value propositions enabled by smart meters (herein defined as "standard') and the associated benefits for end-consumers, which can be found in Figure 16. Each value proposition brings one or several benefits to the consumers.
The benefit 'Accurate billing' is a benefit that is associated with the roll-out of the smart meter and not related to a specific value proposition. Basically, all standard value propositions allow consumers to better understand and control their energy consumption. Another benefit which derives from better understanding one's consumption, is the comfort in one's home. This can be of importance to consumers who think they need to consume as little as possible because they are apprehensive of the electricity cost.
It is worth mentioning, that not all "standard" value propositions have been considered in the CBAs carried out by Member States. The CBAs have mainly focused on real time consumption display, real-time cost display, prepayment and implicit demand response.

		Achieved benefits					
		Bill reduction	Energy consumption reduction	Lower CO2 emissions	Accurate billing	Understand and control energy consumption	Safety
Standard value propositions	Comparison with peer consumers	✓	✓				
	Bill forecasting					✓	
	Real-time consumption	✓	✓			✓	
	Real-time cost	✓			✓	✓	
	Unusual usage alerts		✓				✓
	Historical consumption		✓			✓	
	Real-time carbon impact			✓			
	Pre-payment					✓	
	Implicit demand response (ToU)	✓					

Figure 16: "Standard" value propositions enabled by smart meters and associated benefits

- Comparison with peer consumers: This value proposition refers to the possibility to leverage smart meters data to allow consumers to compare their energy consumption with comparable peers. For example, the Trio smartbox Display by EWE AG (Germany), which includes a smart meter, internet portal and variable tariffs, allows the consumer to compare its annual consumption with reference households or even previous values[13]. [4] This can result in energy consumption reduction and electricity bill reduction. One stakeholder highlighted the risk of a side effect: if the relative peers are consuming significantly more than the consumer under comparison, there is a risk to see his/her consumption rise.
- Bill forecasting: This value proposition refers to the possibility to use historic smart meter data consumption and on-going consumption level to forecast the amount of the bill at the end of the month. This can help consumers to better understand their bill and also energy consumption. In the Netherlands, there exists a service that is free, called UMeter. This is a website that shows your gas and electricity consumption in graphs, it can predict the consumer's costs until the end of the year and also the possibility to compare with other consumers [14]. This helps consumers to understand their electricity bill and their consumption patterns. [5]
- Real-time consumption: This value proposition relates to the possibility to make accessible to consumers energy consumption data in real-time. For example, in the UK, the consumers receive an In-house display IHD (or application on smart phone) with their installed smart meter. This IHD provides real-time consumption data (kWh) and also possibly real-time cost. This can help reducing the energy consumption and the associated bill. An additional benefit would be increased consumers' awareness over their energy consumption and possible actions to have it under control. The UK consumers have seen savings in the range of 2-3% and at least 80% have taken steps to reduce their electricity consumption.[15] [4] [16]

[13] European Smart Metering Landscape Report - "Utilities and Consumers" – Usmartconsumer (2016)
[14] https://www.energieverbruiksmanagers.nl/producten/umeter/ , accessed 24/07/2017
[15] European Smart Metering Landscape Report - "Utilities and Consumers" – Usmartconsumer (2016)
[16] In order to have real-time information value propositions for the consumers, the Advanced Metering Infrastructure system is of importance in order that the communication system is put in place.

- Real-time cost: Real-time cost displayed on a digital application or IHD can help the consumer reduce the electricity bill and also better understand the bill. As mentioned above, with the IHD from the UK it is possible to obtain such a service.
- Unusual usage alert: This service alerts the consumer when an unusual high consumption occurs during a longer time period. For example, in Finland the Asema E Smart Home system, in addition to monitoring real time electricity consumption, gives consumption alerts.[17] [4] This can help reduce the energy consumption. It can also increase safety, particularly for vulnerable consumers (e.g. seniors). In this case, the analysis of smart metering data can detect unusual consumption patterns which signal possible health problems (fall; loss of conscience) of the occupant.
- Historical consumption: In the UK it is required that historical consumption can be viewed. This can be helpful for comparing consumption during a week with the week before or a certain month with this same month a year before. This can help consumers understand and reduce their energy consumption.
- Real-time carbon impact: This value proposition consists in making the energy consumption CO2 footprint, expressed in tCO2 eq., available to the consumer. Some IHD in the UK can display the CO2 emissions even though it is a not a mandatory capability. This capability helps consumers understand the impact of their energy consumption on the environment and enables CO_2 emission reduction.
- Pre-payment: In the UK, people who take a pay-as-you-go tariff can use their IHD to display their credit balance, their outstanding debts and status of emergency credit. This helps vulnerable consumers understand and control their energy consumption.
- Different tariffs (implicit demand response): Consumers with a smart meter and a time-of-use tariff can benefit from it as smart meters provide them with better information and enable them to react accordingly. This can enable a bill reduction.

Advanced value propositions

Beside the physical installation of smart meters, the implementation of advanced value proposition requires further developments in technologies (e.g. data analytics) and market/regulatory contexts (e.g. set-up of flexibility market; penetration of EVs,etc.). The following table provides the advanced value propositions:

		Achieved benefits					
		Bill reduction	Energy consumption reduction	Lower CO2 emissions	Accurate billing	Understand and control energy consumption	Safety
Advanced value propositions	Implicit DR (Spot pricing)	✓			✓	✓	
	Flexibility provision (explicit DR)	✓				✓	
	Fuel poverty detection	✓					✓
	Energy sharing	✓	✓				
	Smart meter to integrate prosumers in the market	✓		✓			
	Smart meter to ease charging of EV at home	✓					

Figure 17: The consumer benefits related to the smart meter and its enabling advanced value propositions

[17] European Smart Metering Landscape Report - "Utilities and Consumers" – Usmartconsumer (2016)

- Flexibility provision (through implicit demand response with dynamic pricing): Consumers with a smart meter and a tariff with variable dynamic tariff (spot based, peak pricing, …) can benefit since smart meters will provide them with better information and enable them to react accordingly. This value proposition enables the consumers to understand and control their energy consumption and can result in bill reduction.
- Flexibility provision (through explicit demand response): This value proposition has the ability to provide and valorise flexibility to the power markets, either through existing suppliers or by signing a new service agreement with a new and independent aggregator. This value proposition can result in bill reduction, typically via remuneration by aggregators.
- Fuel poverty detection: Data analytics can be used to detect fuel poverty (deprivation) for households who have not yet applied for help or do not have access to social protection. This can increase safety for vulnerable consumers. Today, fuel poverty in the UK is determined with the household income, their energy requirements and the fuel prices, combined in a low income high costs indicator (LIHC) [18]. [6] However, the implementation of this functionality needs to be well aligned with the requirements of the Data Protection rules of the European Commission, where it is stated that consumer have control over their personal data [19]. [7]
- Energy sharing: The implementation of smart meters has an enabling role for the local energy communities value propositions, like virtual metering and collective self-consumption. [20]
- Smart meter to integrate prosumers in the market: The smart meter can be used either as a prerequisite to install decentralised generation[21] or as a way to introduce new tariffs, for instance to promote self-consumption, reduce network usage or provide economic signals that are consistent with energy markets. These economic signals can be price signals of the energy market, that can push for more self-consumption or the opposite, selling the produced PV energy on the market.
- Smart meter to facilitate smart charging of electric vehicles at home: depending on the local regulation a smart meter can reduce the system impact of EV charging by enabling smart charging schemes that take market and grid constraints

[18] Annual Fuel Poverty: Statistics report – Department Energy & Climate change (2016)

[19] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC – Accessed 11/12/2017 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.119.01.0001.01.ENG&toc=OJ:L:2016:119:TOC

[20] Virtual metering is a bill crediting system for community solar. The solar production is not used onsite but is installed at a distance, where there is a better yield or/and more area available. The solar energy is then shared amongst its subscribers. The subscribers receive credits on the electricity bill.
Collective self-consumption is the transfer of any production surplus, meaning that besides individual self-consumption, the surplus can be used in by members of the same legal entity, which includes various participants, energy producers and end users. An example is “Notre Soleil & Nous”, where joint-ownership associations, housing associations and other types of vertical housing croup produce and consumer their own electricity. Invalid source specified.

[21] In France, thanks to the installation of the Linky Smart Meter, prosumers don’t have to install two different set of meters anymore to measure consumption and production. One meter is sufficient..

into account, possibly lowering the cost of charging. It also can be used to charge more rapidly at home with a higher but non-firm connection capacity (combined with DSO real time control on this flexible capacity). In 2014, Itron (smart meter producer) and ClipperCreek (EV charging station producer) launched a project with Pepco, to test demand response and variable pricing programs for EV owners in Maryland service territory in the USA. [22] [8] Another interesting pilot project, launched in 2017, is the NB-IoT smart meter in partnership with JANZ CE and u-blox[23]. EDP Distribuição (Portugal) is using this smart meter for an electric vehicle pilot project as part of the UPGRID project[24] of the Horizon 2020 program of the European Commission [9]. This project includes demand response functionality in electric vehicles. [10]

§ Smart meters to facilitate smart charging of batteries: The smart meter could also be used to in the same way as the smart charging of electric vehicles, but for batteries. This can optimise the battery charging based on grid constraints, tariff prices or roof PV production. The Eco7, a company in the UK, is offering smart meter solutions that allows batteries to charge during off peak tariffs in case of for example lower solar production [25]. [11]

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[22] https://www.greentechmedia.com/articles/read/itron-and-clippercreek-launch-the-ev-charger-as-virtual-smart-meter - accessed 15/09/2017

[23] https://www.u-blox.com/en/press-release/portugal-presents-first-nb-iot-smart-meter - Accessed 15/09/2017

[24] https://ec.europa.eu/inea/en/horizon-2020/projects/H2020-Energy/Grids/UPGRID

[25] http://eco7smartcharge.co.uk/# - Accessed 06/12/2017

Concerns of consumers related to Smart metering roll-out

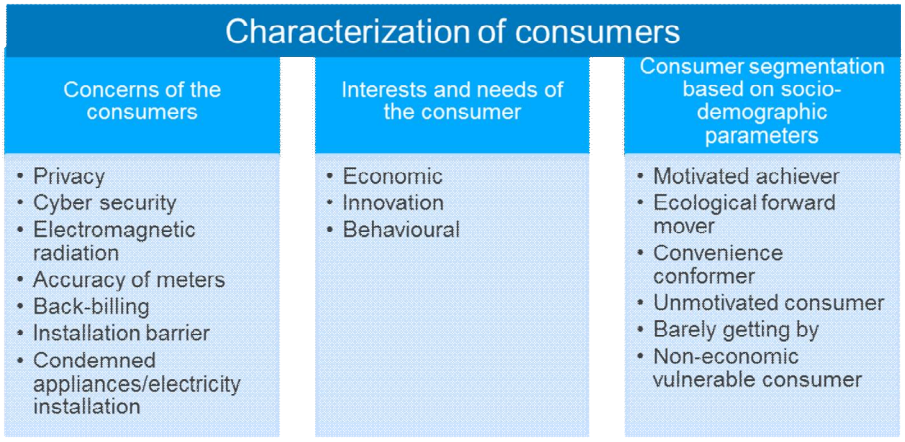

Figure 18: Overview of the context of chapter 2

This section discusses the concerns that some consumers have regarding the deployment of smart meters and might prevent certain Smart Meter benefits to materialize. These concerns are the perceptions of the consumers and therefore in general the Member States and regulators do not have these concerns regarding the smart meters. To have a successful deployment, Member States need to carefully consider and properly address related consumer concerns. How this is done in some cases can be found in the next chapter, see section 0, where regulatory framework examples are mentioned.

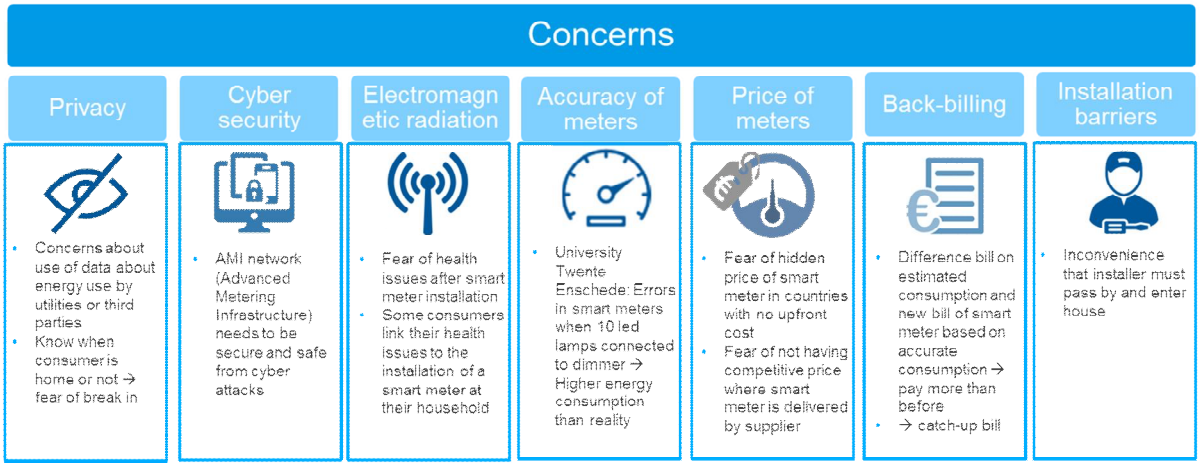

Figure 19: The concerns of the consumer regarding the smart meter

Privacy

Today, not all consumers are convinced of the advantages of the deployment of smart meters. An important perceived concern is the potential use of consumer data by energy companies and unwarranted access to the smart meter's two-way

communication. This gives rise to a fear that third parties could use their energy consumption data, for example to determine a good moment for a burglary.
In the Netherlands, a privacy assessment from the Tilburg Institute for Law and Technology (TILT) deemed that the legislative proposal constituted a violation of Article 8 of the European Convention on Human Rights which establishes the right to respect one's privacy and family life, home and correspondence. Following the publication of the report and the opposition of the public opinion to the proposal, the government withdrew it and put forward a proposal for voluntary roll-out of smart meters. [26] [12]

Cyber security

There are concerns that remote switching is open to cyber-attacks, increasing the vulnerability of the distribution grid. Also, the fear exists that smart meters can be hacked by consumers or third parties to increase or decrease the energy bill. Another aspect of cyber security is remote switching.
Today, typical protocols used by smart meters include ZigBee, which is used for communicating with smart appliances in the consumer's home, and GSM, which is used for communications between the meter and the electric utility. Both ZigBee and GSM have been known to contain vulnerabilities, and they have been poorly implemented in smart meters in the USA [27]. [13] Thus, addressing cybersecurity risk is a key priority for the successful implementation of smart meters.

Electromagnetic radiation

Some consumers (e.g. few examples in California) have voiced fears regarding the health impact of electromagnetic radiation of electronic meters.
There are several consumer websites in the UK, where consumers relate certain physical symptoms to the electromagnetic radiation of appliances, thus also from smart meters. Here they archive experiences of consumers, from headaches, dizziness to heart problems.[28] [14] .
There is still thus room for further reminding and reassuring consumers that legislation is already in place to ensure the safety all electronic equipment's put in the EC market.

Accuracy of meters

There are concerns from consumers on potential electromagnetic interference (EMI) that could affect the meter accuracy of the readings and thus results in bills that do not correspond to their actual electricity consumption. For example, one study carried out by University of Twente Enschede and the University of Applied Sciences Amsterdam found metering errors from smart meters in a lab, which were tested with Compact Fluorescent Lamps, 10 led lamps and other appliances that have electromagnetic radiation connected to a dimmer. In some of these cases, the three phase smart meters showed errors in the measured energy, between + 582% and minus 54%. Also, consumers have complained about a higher energy bill after a smart meter was installed on site[29]. [15].
These claims are not conclusive, however show the need for authorities to address these claims and reassure consumers.

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[26] Smart metering and privacy in Europe - Tilburg University 2012 - Cuijpers, Colette; Koops, Bert-Jaap

[27] http://www.securityweek.com/smart-meters-pose-security-risks-consumers-utilities-researcher - Accessed 18/09/2017

[28] http://www.es-uk.info/docs/front-02-ill-health-smart-meters.pdf - Accessed 18/09/2017

[29] Static Energy Meter Errors Caused by Conducted Electromagnetic Interference - IEEE Electromagnetic Compatibility Magazine Vol 5, Issue 4 – 2016 - Leferink, Frank; Keyer, Cees; Melentjev, Anton

Price of meters

Cost effectiveness of the smart meter deployment program is a point of concern for some consumers. In the UK, consumers have expressed concerns that there is a hidden price for the smart meters. Since there is no upfront cost of the smart meters, consumers fear that costs will be passed non-transparently onto them in the form of higher rates.[30] [16]

In Spain, consumers of Endesa (the largest electricity utility in Spain) have the right to choose between owning and hiring the smart meter. The consumers have expressed concerns that their regulated meter is not provided at a fair price, due to the fact that the metering installation is not open to competition.

In Germany, according to a survey launched by the vzbv-Verbraucherzentrale Bundesverband[31] two-thirds of German consumers expressed the fear that costs of smart meters will not result in a sufficient share of benefits for them. The vzbv has stated that only households with an annual consumption above 6,000 kWh would gain benefits from the smart meter roll-out with Time of Use tariffs due to the relative high cost of smart meters, which is around € 60 yearly [32] in Germany. [17] [33]

Back-billing

As a consequence of the deployment of smart meters, there may exist a difference between the bill based on estimated consumption and the new bill based on the accurate consumption enabled by the smart meter. This difference can be quite high, which has resulted in some bad surprises for some consumers when they suddenly had to pay much more than before. In some cases in the UK, the supplier sends a 'catch-up' bill, to recover the difference. This can result to large amounts of money being owned.[34] [18]

Installation barriers

For some consumers, the fact that an installer must pass by and enter their home is an inconvenience, and has led to cases where a consumer refuses the installation of the smart meter.

In some cases, the installation of a smart meter has been the occasion to identify homes with unsafe electricity installations. Even if this leads to the renovation of the electricity installation and thus higher security to the consumers, some consumers might perceive only the negative aspects, i.e. costs for the new installation, power cut-off during the works, and "blame" the smart metering installation for it.

Other concerns

There might be also other issues for some consumers that can cause them dissatisfaction or limit their engagement. These can be lack of interoperability resulting in loss of functionality when the consumer switches supplier or when systems are upgraded (e.g. return to traditional meters in the UK); complexity and/or lack of understanding about how to access/use information provided by smart meter; lack of trust with energy companies and poor installation experience (e.g. missed

[30] http://www.which.co.uk/consumer-rights/advice/do-i-have-to-accept-a-smart-meter#concerns-with-smart-meters – Accessed 26/07/2017

[31] vzbv-Verbraucherzentrale Bundesverband is an umbrella organisation for 40 consumer organisations across Germany. Vzbv is also a founding member of BEUC.

[32] https://discovergy.com/intelligente-stromzaehler

[33] Do's and Don'ts for Smart, Flexible Electricity Offers: Policy recommendations – BEUC: The European Consumer Organisation (2017)

[34] https://www.thinkmoney.co.uk/news-advice/ofgem-to-ban-energy-firms-from-back-billing-over-12-months-0-8642-0.htm - Accessed 11/12/2017

appointments, problems with communications to/from smart meters in difficult locations etc.).

Consumer motivations

An extensive literature review has been carried out to better understand needs and motivation of consumers with respect to the smart metering deployment. Relevant sources include "Consumer engagement in the energy market since the Retail Market Review" by Ofgem which identifies four segments based on socio-demographic parameters for the frequency of switching of suppliers [19], the "Energy poverty and vulnerable consumers in the energy sector across the EU: analysis of policies and measures" by Insight_E [35], which highlights the issues of vulnerable consumers and energy poverty and how Member States address them [20] and the study "Empowering consumers through smart metering" by BEUC (The European Consumer Organisation), where part of the study is the diversity of consumers and their motivations and capabilities.[36] [21].

The analysis aimed at identifying most relevant characteristics of consumers that can impact their ability to benefit from smart-meter enabled value propositions. For sake of clarity, in the following we provide an in-depth analysis of main relevant references.

The study "A typology of flexible user in a smart grid project (Belgium) - Centre for Studies on Sustainable Development"[37] [22] was carried out by the Centre for Studies on Sustainable Development (CEDD). They analysed the smart grid participants to create a typology of flexible users. The aim was to analyse the potential of flexibility in storing electricity with heat pumps and well insulated buildings. Important to note is that the participants to the study belong mainly to the upper-middle class and own their house. This means that the results are not representative of the whole population. They have identified six dimensions related to forms of flexibility, which are listed below:

- The environmental dimension: This dimension is ranked according to the intensity of the efforts of various actions on the environment.
- The dimension of economic calculation: This applies to the decisions needed to be made when acquiring new equipment and the importance of return on investment.
- The technical dimension: The interest of users in technologies and technical systems
- The approbation dimension: Ranks the type of intervention the heat pump has as settings to their intensity and frequency, which is of less importance for this study
- Electricity consumption management dimension: This is based on the actions users implement in their homes to reduce their electricity consumption
- Thermal flexibility dimension: By asking households what their minimum and maximum acceptable temperature is, the thermal flexibility of users is evaluated. This also is of less importance in this study.

[35] Energy poverty and vulnerable consumers in the energy sector across the EU: analysis of policies and measures – Insight E – 2015 - Pye, Steve; Dobbins, Audrey

[36] Empowering Consumers Through Smart Metering – BEUC – 2011 - Klopfert, Frédéric; Wallenbron, Grégoire

[37] A typology of flexible users in smart grid project - Centre of studies on sustainable development – 2015 - G., Gaye G. & Walleborn

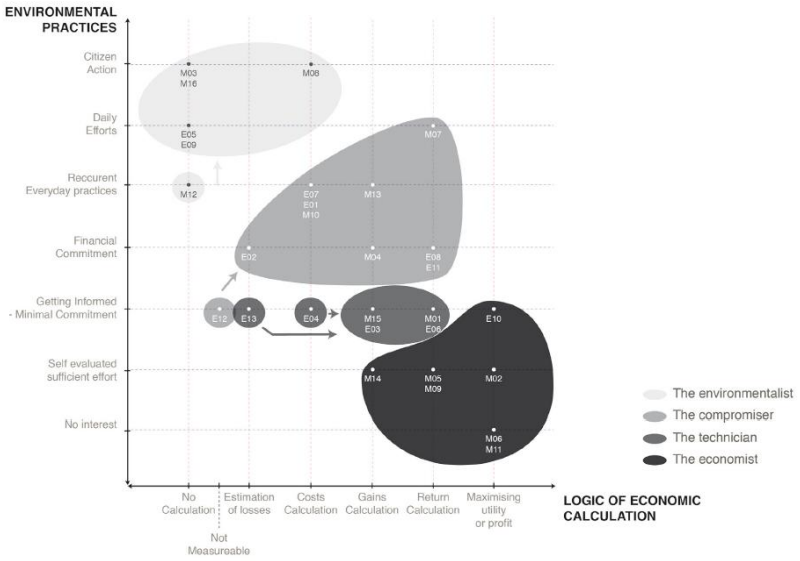

Figure 20: Environmental practices versus economic calculation and the defining of the segments. M stands for household, E for enterprises (G., 2015)

By crossing the economic and environmental dimension, following figure was created by the CEDD:

- The economist: the logic of economic calculations is predominant in the actions of the Economist.
- The environmentalist: An environmentalist relates his action to the conservation of the environment and solving ecological issues.
- The technician: Technicians are passionate about home technologies and want to keep control over their devices and their electricity consumption.
- The compromiser: They often seek for ways to combine financial effort with ecological choices, without going to extremes. They depend highly on what the rest of the society does.

"Energy Efficiency through Information and Communication Technology – Best Practice Examples and Guidance, EMPOWER DEMAND 2".[38] [23] discusses the segmentation classification developed by SEAS-NVE[39] that uses 'dream-reality dynamics' to find consumers segments. This approach distinguished the following consumer types:

- The dreamer: Dreamers are more likely to be woman and value the softer benefits of smart meters, such as environment.
- The reality consumer: This segment consists more of men and they value the harder benefits more such as energy-cost savings.
- The unique consumer: Likes to do things differently than the rest of the population.
- The standard consumer: Tends to follow the norm of the society.

[38] EMPOWER DEMAND 2: Energy Efficiency through Information and Communication Technology - Best Practice Examples and Guidance - VaasaETT Global Energy Think Tank – 2012 Lewis, Dr. Philip E.

[39] SEAS-NVE is a Danish energy company, which is the largest utility in Denmark that focusses on customers.

Based on these four types, the study identified four segments, being the critic (24%), the dreamer (16%), the local (16%) and the basic (40%), the percentage indicating the share of their consumer database. With these four profiles they created four different marketing packages for their smart meter roll-out. According to SEAS-NVE their segmentation has helped them to achieve high level of customer engagement, claiming that 84% of its customers have requested email newsletter and 45% has requested alarm messages.[40] [24]

Figure 21: SEAS-NVE Segmentation matrix (Lewis, 2012)

A third relevant report is the "European market segmentation report on consumer's needs, expectations and interests", written by UsmartConsumer Project.[41] [25] This study was carried out in seven European countries (Germany, Spain, United Kingdom, Austria, Finland, Italy and Poland) to find out the preferences, motivations and willingness of consumers to pay for a smart meter and related services. Statistical samples have been chosen to be representative of their country population, choosing relevant socio-demographic criteria. However, it is important to note that the respondents are not entirely representative of the average consumer, as it is likely that only those who showed some interest in smart meters will have filled in the survey. The majority of those who responded were between 40-59 years old, which affects the socio-demographic parameters of the segmentation. These are usually people that have more means to make changes, aware of the need to save energy and protect the environment. The participants have also an above-average educational level. This results in samples that do not represent socio-demographic levels completely, for example different age levels.
The segments chosen by the different countries have similarities and can be grouped together in following segments:

§ Target group: This group has a high interest for innovative technologies, good adaptation skills, good knowledge about smart meters and willingness to pay for it. They have low to no concerns about data privacy. Their socio-demographic

[40] Review of customer codes and procedures: A report to the Commission for Energy Regulation - Vaasa ETT – 2012 - Patten, Asheya
[41] European market segmentation report on consumer's needs, expectations and interests – UsmartConsumer - 2014

characteristics include higher education, professional success, and living in a household of 2 or more people.

- Potential needs to be activated: This segment has potential to benefit from smart meters but lack knowledge or do not have the willingness to pay for it. There are no specific socio-demographic characteristics for this segment. They need to be addressed with specific information campaigns depending on their values.
- Lowest potential: This group has the lowest potential for Smart Metering services and have in general low interest in technologies and no willingness to pay for a smart meter. Their socio-demographic characteristics are lower income and/or lower electricity consumption.

Consumers' motivation dimensions

On the ground of this extensive literature review, we identify three main dimensions that characterize interests and needs of consumers and that thus affect their interest in smart-meter enabled value propositions: economic, innovation and behavioural dimensions.

Economic dimension

The economic axis shows the importance to a consumer of reaping monetary benefits. A consumer, who finds the economic aspect important, will be willing to make changes to make savings. The further along on the axis, the more important this economic aspect becomes.
Two types of monetary gains can be identified:

1) Direct monetary benefits: This refers to economic gains reflected in the bill thanks to energy savings or a shift in energy demand. Another possible manner of making direct savings is by comparing different tariffs and/or suppliers.
2) Indirect savings: Indirect savings are savings made by the DSO since the DSO can run its network more efficiently. For example, the business case for the smart metering deployment in France relies on indirect economic benefits only. As a matter of fact, the business case that underlies Linky and Gazpar deployment is based solely on benefits for the distribution system operator. As such, the findings of the experience are mainly related to DSO deployment efficiency (installation time per consumer for instance) rather than the realization of consumer benefits. These savings are of limited interest to the consumers, since there are no immediate benefits. This is in line with the literature study, where DSO savings are never discussed as a benefit for consumers.

This economic dimension can also be found in the study from CEDD [22] (The dimension of economic calculation) and in the Empower demand 2 study [23] (reality consumers).

Innovation axis

The innovation axis shows the consumer willingness to use new innovative products and services. Data interoperability , portability and easy access from third parties for the smart meters is critical to fully benefit from the most innovative value propositions: IHD & applications on smart phones with real time display of energy consumption are the most innovative products & services existing in the market today Other innovative products are based on sub-metered consumer devices connected to the smart meter, to better track the energy consumption and allow for a more dynamic control of these

devices. For instance in the UK, this advanced functionality which will be included in the SMETS2 smart meter[42] standard.
The innovation axis is inspired by the 'Technical dimension' from the CEDD study, where these consumers are interested by technologies. Also the study from Usmartconsumer [25] finds consumers which have a high interest in innovative products.

Behavioural axis

The general attitude of a consumer also influences its motivation to install a smart meter in his house. The level to which consumers conform to society has a relation to what they will or will not buy. Comparison with peer consumers and level of diffusion of value propositions is an important dimension in motivating certain segments of customers.
The green aspect is important for consumers who consider the environment as a priority and are therefore more likely to choose suppliers providing "green" services. For example, it is possible in Finland to use a tariff which varies along with the availability of renewable energy sources.[43] [26] In the UK, there exist IHD on the market that shows the amount CO2 emissions from its domestic energy consumption. However, this is not a default requirement of the UK smart meter[44]. [27]
The behavioural axis is therefore useful to better understand consumer expectations. It covers both the Environmental dimension from the CEDD study [22] and the Standard consumer defined in the [23] study.

Consumer archetypes

Based on the literature review done in section 0, we have identified a number of socio-demographic parameters to segment consumers (see Figure 22). These parameters have been selected to determine the capability of the consumers to reap the benefits of the different value propositions. The basic parameters are based on the study from USmartConsumer [25] and the study from Ofgem [19]. However, additional parameters are added for the consumer segmentation for the definition of non-economic vulnerable consumer and the prosumer, who have additional benefits with the smart meter. (This analysis will then be further developed in the section "matching supply and demand".)

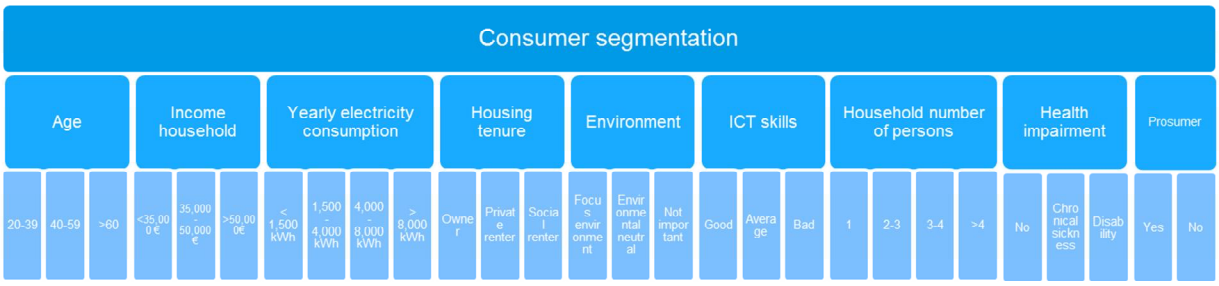

Figure 22: The socio-demographic parameters of consumer segmentation

[42] The SMETS2 are smart meter standard specifications from the UK, with more advanced specifications than the SMETS1. The SMETS2 for example will facilitate domestic renewables for peer-to-peer trading, has greater data security and interoperability to easily switch supplier.
[43] https://www.helen.fi/en/electricity/homes/electricity-products-and-prices/ - Accessed 25/07/2017
[44] http://www.energy-uk.org.uk/customers/about-smart-meters.html - Accessed 25/07/2017

- Age: This parameter is an indicator of the willingness of a consumer to adapt and learn innovative technologies. Usually, a younger person will be more adaptive to innovation. A person of middle age will have more means to invest in innovative technologies. An older person usually is quite settled and might be less motivated to make changes or less inclined to adopt innovative technologies.
- Household income: The income of a household influences the potential of a consumer to invest in smart appliances or in more energy efficient devices.
- Yearly electricity consumption: A household with a high electricity consumption typically has a higher potential to benefit from smart meter-related services (energy savings, demand response, etc.). The presence of electric heating will increase greatly the annual electricity consumption and will enhance the demand response value propositions. Therefore, each Member State should adapt the different levels of yearly electricity consumption to their own average. For example: in France, electric heating is widespread resulting in a high yearly average electricity consumption.
- Housing tenure: House ownership influences the extent to which consumers are willing to invest in their home. Private renters are less likely to be interested in buying a smart meter with an IHD. Home owners are generally more willing to invest.
- Environment: A consumer who is environmental friendly will be more willing to invest in green technologies, such as a smart meter which shows the CO2 emissions on the IHD. The consumer will also be more willing to make changes to make his lifestyle greener.
- ICT skills: ICT skills are often needed to benefit from the value propositions of smart meters. It relates to everyday use of technology in computer, tablets or mobile phones and data communication with these technologies.
- Number of persons in a household: This parameter influences other parameters in part, such as the income of a household and the electricity consumption. A high number of persons in a household causes higher monthly cost of energy and other household charges, such as food. This will be an incentive to try to make savings in the electricity bill to use this saved money in other domains of a household.
- Health impairment: Depending on national law, people with disabilities or chronical health issues may be entitled to health care benefits and social support. This may include a diverse range of measures including economic guidance and (lower) social retail tariffs. In the form of smart meters, these could be specific services which could help them benefit from smart meters, such as braille, high contrast display and safety features.
- Prosumer: If a consumer has solar panels on his/her roof will it impact the need of a smart meter. The smart meter is a benefit for a prosumer since it enhances the accurate metering data in both directions (injection and consumption grid). As a positive consequence from the Linky meter in France, consumers do not need two separate meters anymore if they have solar panels on their roof.

Selected consumers archetypes

On the ground of the socio-demographic parameters described above, we define five consumer archetypes to illustrate how different consumer types can reap the benefits of smart meter-related value propositions. It is worth stressing that these archetypes are not intended to represent exhaustively all consumers' types but represent a useful tool to communicate key factors that affect the capability of consumers to profit from smart metering value propositions.

- The motivated achievers are of average age, with an above average income. They are the owner of their homes. Their consumption is average or above average and they have a neutral attitude towards the environment. They have good ICT skills.
- The ecological forward movers are of average age, with an average income. Their consumption is average or a bit lower than average. Usually they are the owner of their homes. They find the environment very important and have good ICT skills.
- The convenience conformers can be found in all age categories and have an average income. Their yearly electricity consumption is average or a bit lower. The have a neutral attitude towards the environment and have average ICT skills.
- The unmotivated consumer are usually older and have a low income. Their energy consumption is average or below average and they are usually the owner of their houses. The environment is of little importance to them and they have bad ICT skills.
- The barely getting by consumers have a low income with a low to average energy consumption. The consumer of this arch is a social renter, not strongly interested in environmental impact and with average ICT literacy.
- Non-economic vulnerable consumers have health issues, such as disabilities or a chronic disease. Their income is generally lower than average. They are usually environmental neutral and have low to average ICT skills.

These archetypes are mainly inspired by three studies discussed in section 0, such as the economist, technician, environmentalist and compromiser from the CEDD study [22], the dreamer consumer, reality consumer and standard consumer from the Empower Demand 2 study [23] and finally the 'lowest potential' group from the [25] study.
Thus, with these studies in mind, 5 archetypes have initially been created: motivated achiever, ecological forward mover, convenience conformer, unmotivated consumer and barely getting. during the project, an additional archetype was suggested, that emphasize non-economic vulnerable consumer to cover those consumers with health issues or impairment that might need additional care.

		Motivated achievers	Ecological forward movers	Convenience conformers	Unmotivated consumers	Barely getting by	Non-economic vulnerable consumer
Age	20-39	✓	✓✓	✓	✓	✓	✓
	40-59	✓✓	✓	✓	✓	✓	✓
	>60			✓	✓✓	✓	✓
Income household	<35,000€				✓	✓	✓
	35,000-50,000€		✓	✓			✓
	>50,000€	✓					
Yearly electricity consumption	<1000 kWh					✓	✓
	1000-2500 kWh		✓	✓	✓	✓	✓
	2500-5000 kWh	✓	✓	✓	✓	✓	✓
	> 5000 kWh	✓✓					✓
Housing tenure	Owner	✓	✓	✓	✓		✓
	Private renter			✓			✓
	Social renter					✓	
Environment	Focus environment		✓				
	Environment neutral	✓		✓	✓		✓
	Not important				✓	✓	
ICT skills	Good	✓	✓	✓		✓	
	average			✓✓		✓✓	✓
	bad			✓	✓	✓	✓
#Persons household	1		✓		✓	✓	✓
	2		✓	✓	✓	✓	✓
	3	✓	✓	✓		✓	✓
	4	✓	✓	✓		✓	✓
	>5	✓		✓		✓	✓
Health impairment	No	✓	✓	✓	✓		
	Chronical sickness						✓
	Disability						✓

Figure 23: Consumer segmentation by socio-demographic parameters. The ticks represent the socio-demographic parameter domain in which the archetype most often belongs. The highlighted ticks represent the socio-demographic parameter that define the most that archetype.

Dimensions of consumers segmentation

In this section, we place the different consumer archetypes across the three axes defined in section 0. As explained before, the further along an axis a consumer is the more motivated and able the consumer is to change his habits, make efforts or invest in new technologies.

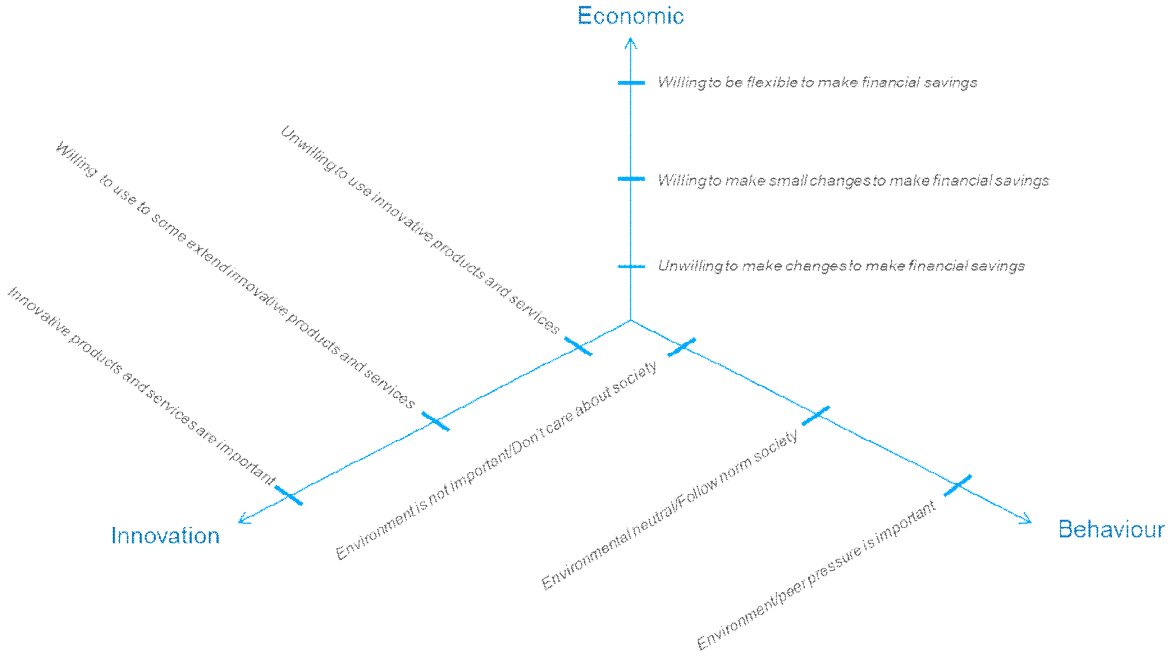

Figure 24: Three axis that motivate a consumer in the deployment of smart meters

The economic axis shows the willingness of a consumer to make changes to realize financial savings, from unwillingness to make changes up to willingness to make big changes. The environmental axis shows how important the environment is to the consumer. If the environment is very important to the consumer, the consumer will buy technologies specifically because it is a green technology. If the person is environmental neutral, one will not buy a technology merely because it is green. However, if there is supplementary green benefit of the technology, the consumer will see this as an additional benefit but not as the main driver for investment. Then there are consumers to whom the environment is not important and who do not see the additional benefit of a green service. The innovation axis is ranked from being very interested in innovative products and wanting to use and learn them down to being uninterested in them.

The archetypes have been placed as follows among these three axes:

1) Motivated achievers: Motivated achievers are very interested in innovation and are motivated to use the smart meter and benefit from its services to make financial savings. They are willing to pay for a smart meter,have high income &standard of living and are environmentally neutral.

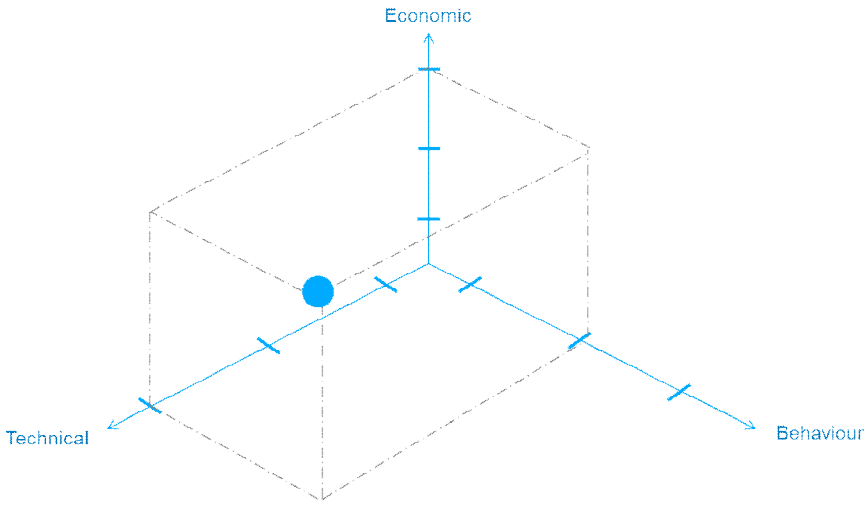

Figure 25: The dimensions of the motivated achiever

Barriers: Motivated achievers want to be certain that the technology they install will give them the expected results. This means that advertisement for smart meters should emphasise the high likeliness of financial benefits.

2) Ecological forward movers: This archetype wants to improve the environment and believes in sustainable development & social responsibility. They are very interested in innovation to achieve ecological benefits, such as CO_2 reductions.

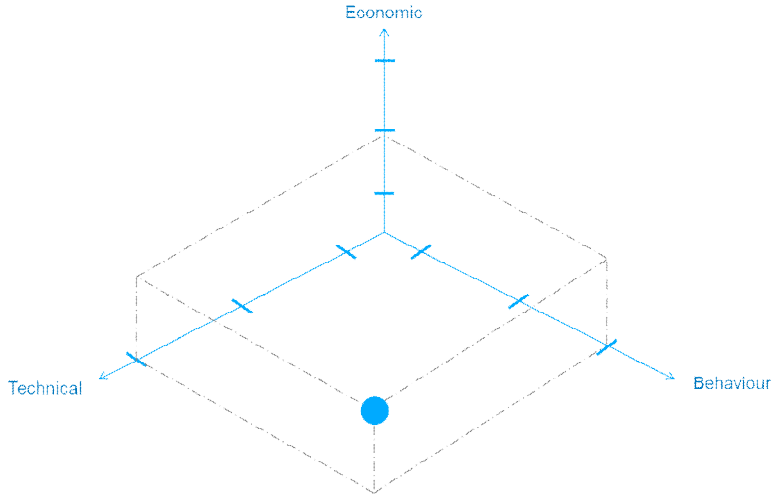

Figure 26: The dimensions of the ecological forward movers

Barriers: Same as for the motivated achievers, ecological forward movers want to have proof that the technology they install has proven benefits for the environment.

3) Convenience conformers: Convenience conformers only become interested in a certain product after it has become widely mainstreamed. They have an average income and are environmentally neutral. They are willing to make small changes that don't impact their lifestyle too much. Therefore, in all three dimensions they are willing to show interest but no extensive effort to obtain changes or benefits.

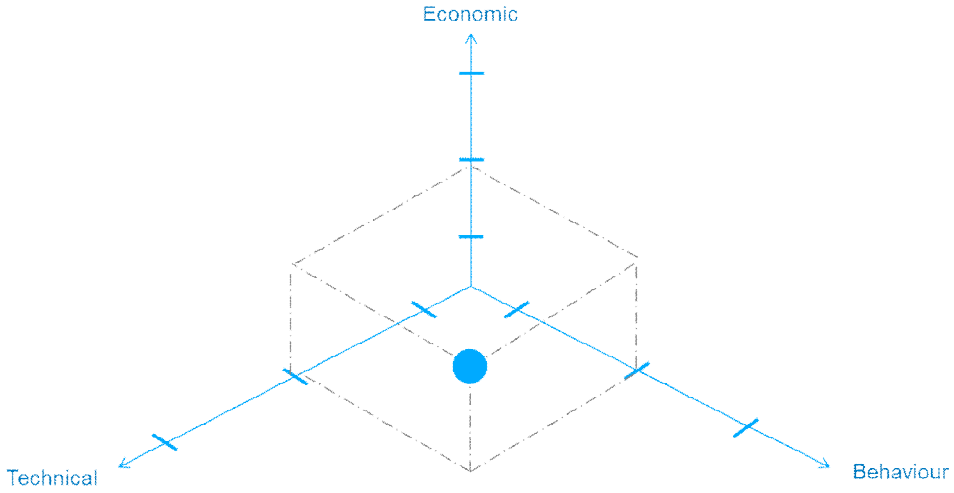

Figure 27: The dimensions of the convenience conformers

Barriers: Slow rate of smart meter deployment & lack of proven benefits are the main barriers for this archetype. Only after an innovative product has become widely spread are they interested in installing such a device. Afterwards they are only willing to do small changes in their routine in the three dimensions that won't influence their routine too much, such as buying a more energy efficient fridge or installing an application to understand better their electricity consumption.

4) Unmotivated consumers: This archetype consists of usually older consumers who are not excited about technology and find the environment less important. They have a retirement income and a small household with one or two persons. They have the lowest awareness of smart meters.

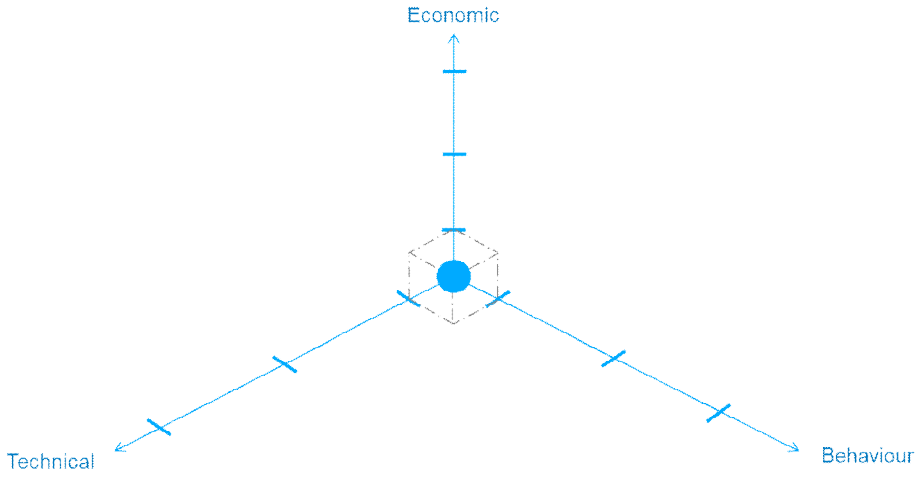

Figure 28: The dimensions of the unmotivated consumers

Barriers: The unmotivated consumer are, as the name suggests, unmotivated to make any changes. The barrier is thus to try to motivate them without them having to make any big changes. Their income is also low due to the fact that they have a retirement income; therefore, the services should cost little and be easy to understand since their ICT skills are limited.

5) Barely getting by: The consumers from this archetype have a low income and limited savings. They have no clear view of how their energy consumption impacts their bill and are not particularly interested in their environmental footprint. However, they have average technical skills and are willing to learn.

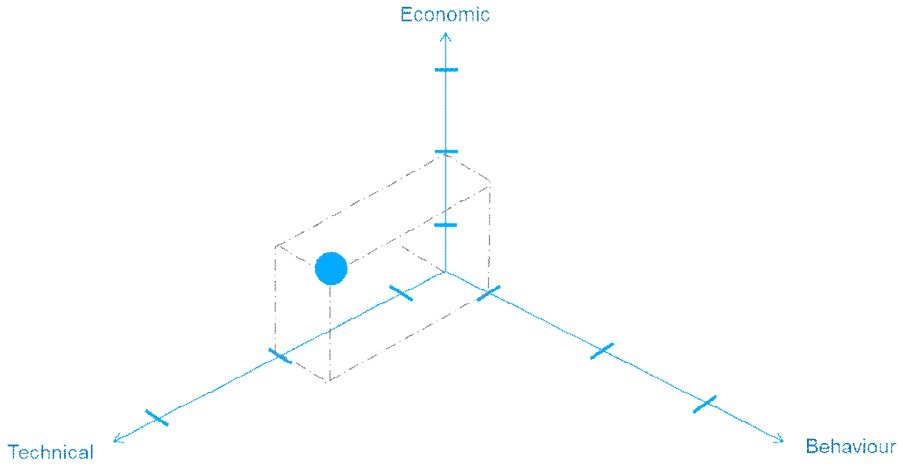

Figure 29: Dimensions of the archetype barely getting by

Barriers: The main barrier of barely getting by archetype is the fact that they cannot afford to buy technical efficient appliances and have less potential in changing their energy consumption profile.

6) Non-economic vulnerable consumer: This archetype consists of persons who have a health impairment, such as a disability or chronic disease. These people may be entitled to be recognized by administrative authorities in order to receive health care benefits but also access to specific protection from national health and social services. This can include economic guidance, (lower) social tariff and other forms of protection.

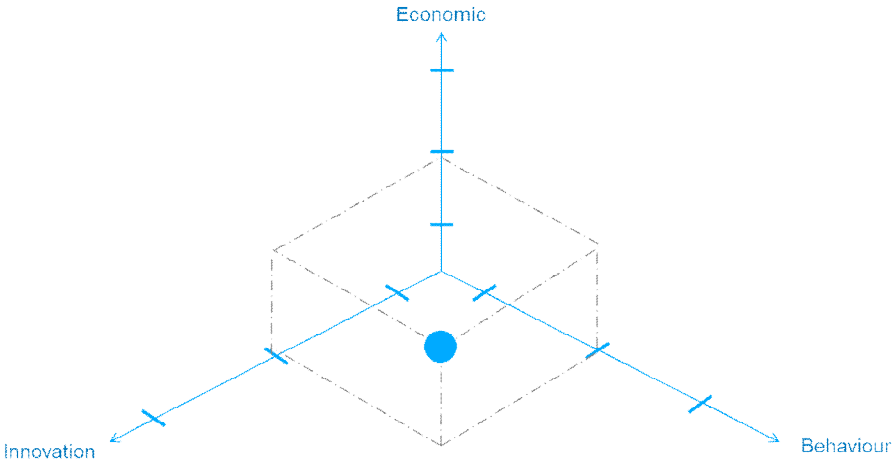

Figure 30: Dimensions of the archetype non-economic vulnerable consumer

Barriers: The main barrier for this archetype is their disability or health issue, such as visually impaired persons will need additional services, such as braille, to be able to benefit from the other value propositions.

Key Factors influencing Smart Metering Outcomes for Consumers

In this chapter, the analysis of the impact of smart meters on the different consumer archetypes, which are defined in the section 0 in chapter 0, is carried out. There will be a specific focus on the UK and in the Netherlands, since these two countries are in the two highest maturity levels, as described in chapter 0, and there are also value propositions already available. Therefore, some lessons learned and best practices from those both countries could be applicable for the other Member States.
First; the conditions for consumers to benefit from smart-meter enabled value propositions will be assessed. The analysis looks at two main dimensions: the context where the smart metering roll-out is taking place (e.g. the maturity of the market for smart home devices, storage, energy services etc.) and the characteristics of the consumers (e.g. age, IT literacy etc). Therefore, the focus lies on the matching of supply and demand to assess the conditions for consumers to benefit from the smart meter enabled value propositions.

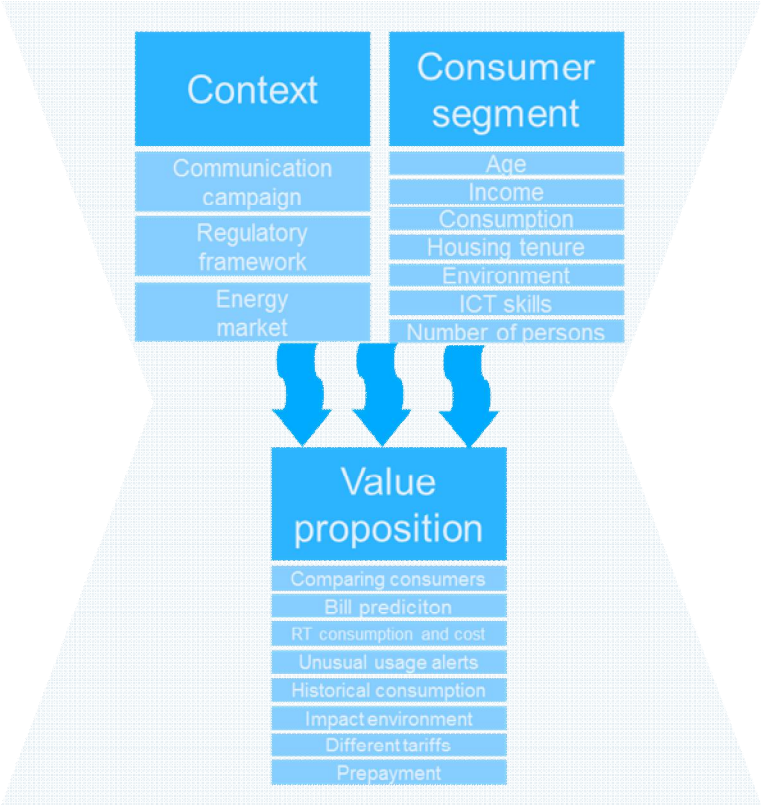

Figure 31: Characteristics of the context and of the consumers affect the ability of consumers to reap the benefits of smart meter-enabled value propositions

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Impact of context factors

The context factors influence the consumer's ability to benefit from smart meters. Consumers have little control in these context factors, these depend mainly on:

- the set-up of a suitable communication campaign to raise awareness about the potential value of smart meters for consumers;
- the existence of a suitable regulatory framework that can address consumers' concerns regarding smart meters (see previous chapter)
- the market conditions enabling market actors to develop value propositions. Relevant context factors include: the existing energy regulatory and market framework.

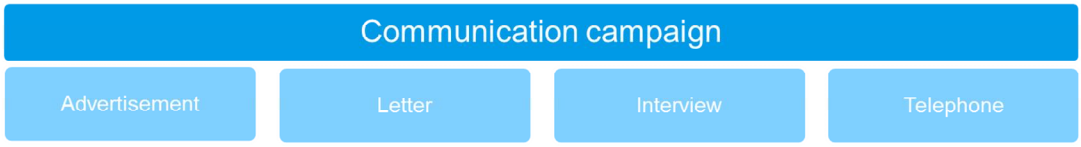


Figure 32: The communication channels countries have used to reach their consumers

Communication campaign on smart metering potential

The channel of communication is the way consumers will be informed about the installation and advantages of a smart meter. The consumers could also be reassured about their fears and concerns. It is recommended to adapt the communication campaign to the different stages of the roll-out of the smart meters in a country:

1. Initial communication campaign: This stage of communication provides the first information of the smart meters and its benefits, by advertisement and brochures, to the consumer.

   For example, SEAS-NVE, a Danish DSO/retailer, created different advertisements for their different consumer archetypes, see Figure 33. They prepared the roll-out of smart meters in 2005-2006 and performed a study of their customer base to better market their web portal and future smart meter roll-out.
   Additionally, information about the rights of the consumer concerning the privacy can be shared during this stage of communication. In the UK, the suppliers informed their customers about their possible control over the frequency of the meter readings their supplier can collect from their smart meter. This choice of the frequency varies between from daily to monthly. This information was provided with a letter or leaflet.[45] [28]
2. Pre-installation communication: A consumer should be informed of the smart meter installation before it takes place in order to prepare the consumer on what this entails. This stage of communication can be by letter, telephone or even text messages. A date needs to be arranged when both parties, the consumer and installer, can be present. The consumer needs to be informed on what to expect, how long it will take and if any preparations need to be made.
3. During installation: During the installation of the smart meter important information can be shared personally with the consumer. Therefore, it is important that the installer is also able to explain (or to refer to a website; to a publication etc.) to the consumer how the smart meter works and what key benefits it could bring. For example, in the UK, the installer explains how to use a smart meter, and hand out a guide addressing main questions.[46] [29]
4. Post-installation: After the installation, contacting the consumer to collect the feedback about the installation is useful to improve further installations at households in the future. Also for the consumer the post-installation communication stage is of importance to verify whether there are still questions unanswered or issues.

[45] Summary report on energy supplier's communication with consumers regarding smart meter data – Citizens Advice (2015)

[46] https://www.smartenergygb.org/en/how-to-get-a-smart-meter/the-installation-process - Accessed 10/10/2017

Figure 33: SEAS-NVE, advertisement for each segment (Lewis, 2012)

Additionally, an in-depth interview with vulnerable and/or disadvantaged consumers might be important in order that all consumers can benefit from the smart meter rollout. [28] This would provide extra advice, guidance and services for the vulnerable consumers. In the UK, the Citizens Advice have reached out to vulnerable consumers to hear their feedback about smart meters during interviews and gave this to the suppliers of smart meters.[47] [30]

Option	What we'll collect	How this helps you
Minimum	A meter reading once a month, with daily readings when necessary	• Your account can be managed effectively.
Standard (Your meter will be set at this option unless you tell us otherwise).	Monthly and daily readings	• You pay for what you actually use. • We give you relevant energy-saving advice. • We can develop products and services to suit you.
Optimum	Monthly and daily readings Half-hourly information	• You pay for what you actually use. • We give you even more energy-saving advice. • We can develop products and services that are even more suitable for you.

Figure 34: Information by letter about frequency of reading [28]

Right regulatory framework: addressing concerns of the consumers

This section discusses the regulatory steps a Member State has taken to handle the concerns of the consumers, explained in the previous chapter, see section 0. Also, the choices of the consumer regarding the smart meter and information set in place for them is analysed.

[47] Vulnerable consumers and the smart meter rollout - Analysis of information request – Citizens Advice - 2015

Privacy

In France, the deployment of the Linky and Gazpar smart meters are defined in the legal framework and their deployment is a legal duty of the DSO (Enedis for Electricity, GRDF for gas).
The following table illustrates the core decision of the French privacy agency, the 'Commission nationale de l'informatique et des libertés' CNIL, regarding the storage and transmission of detailed data. The default reading frequency is daily while the transmission of hourly data requires consumer explicit consent (opt in).

Privacy design features FRANCE	May the consumer refuse	How to exercise its right to refuse
Smart meter installation	No	-
Data storage	Yes	Explicit refusal (opt out)
Hourly Data to DSO	Yes	No consent (opt in)
Hourly Data to supplier and 3d parties	Yes	No consent (opt in)

In the United Kingdom, the supplier-led roll out is supported by a central market system – the Data & Communications Company in accordance with the smart energy regulation code.[48] [31]

Privacy design features UK	May the consumer refuse	How to exercise its right to refuse
Smart meter installation	?	-
Less than monthly Data to supplier	Yes	Explicit refusal (opt out)
Hourly Data to supplier	Yes	No consent (opt in)
Hourly Data to third party (through DCC)	Yes	No consent (opt in)

Moreover, DSOs only have the right to use aggregated data or otherwise treat the data in a way that it can no longer be associated with individual premises. For suppliers, exceptions are made for prepayment, as more regular readings are required to update consumer's credit, and pilot projects. Daily consumption information is also allowed upon suspicion of fraud or at a change event (tariff, tenant or supplier).
For all market players, the Data Privacy Impact Assessment DPIA is a key recommendation within the broader Smart metering implementation program [32]. [49]
The energy sector is the first sector that has translated the requirements from the General Data Protection Regulation GDPR [50] into a template; namely the DPIA. A test phase of the DPIA template for smart grids and smart metering systems is currently being completed aiming to analyse whether further refinement in the DPIA template is required.

[48] Smart Metering Implementation Programme - Data access and privacy: Government response to consultation - Department of Energy & Climate Change (Smart Metering Implementation Programme) - 2012
[49] Commission recommendation of 10 October 2014 on the Data Protection Impact Assessment Template for Smart Grid and Smart Metering Systems (2014/724/EU) – Official Journal of the European Union http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014H0724&from=EN
[50] Regulation EU 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and of the free movement of such data, and repealing Directive 95/46/EC (General Protection Regulation) – Official Journal of the European Union http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN

Cyber security

The utility needs to ensure the consumer that the AMI network (Advanced Metering Infrastructure) is secure and safe from cyber-attacks.
In the Netherlands, the DSOs gave a brochure to all consumers with information on their smart meter, explaining what changes after installation of a smart meter and their possible achievable benefits. In addition, the privacy issue explained above is included in this brochure. The security of data is also treated in this brochure, stating that the risk is very small. There are legal security demands that need to be complied with. In addition, the energy suppliers and network operators take extensive measures to protect their network and data traffic with the latest technologies. This is all closely monitored by two independent entities, namely the 'College Bescherming Persoonsgegevens' and the 'Autoriteit Consument en Markt'. ACM has concluded that the network operators have protected the smart meter against fraud, abuse and infringement of the smart meter.[51] [33]

Electromagnetic radiation

In France, some critics expressed concerns on the DSO communication regarding the potential impact of electromagnetic waves on human health. A parliament hearing regarding smart meters deployment showed that the criticisms could have been partly avoided by a commonly accepted methodology amongst experts before the deployment. Enedis only replied upon request of their consumers while 'Gaz Réseau Distribution France' GRDF issued a documented impact assessment. This could be the reason that the Linky meter (Enedis) is still under public scrutiny for this health issue, while the gas meter impact (GRDF) seems much more accepted in the public debate.
In the United Kingdom, The Public Health England (PHE) provides advice and information about several domestic appliances. They have stated that there is no evidence of health risk from exposure to smart meters, the exposure from smart meters is lower than other appliances, such as television and mobile phone.[52] [34]
Also, the European Commission has published a paper on the Potential health effects of exposure to electromagnetic fields where it is stated smart meters only make minor contributions to the total background of radiation level inside a home, which is very small compared to the accepted safety limits. These statements are based on several papers published regarding the exposure associated with smart meters. [53]
In any case, all measuring appliances in the European Union need to comply with the EU safety, health and environmental protection requirements. This means that the manufacturer is responsible to test and check the conformity of his product. The measuring instruments sector falls under the Directive 2014/32/EU. [54] This directive has

[51] De slimme meter: Informatie over uw energiemeter -- Ministerie van Economisch Zaken - 2015

[52] http://www.britishgas.co.uk/help-and-advice/Meters-meter-readings/Smart-Meters/whats-different-with-smart-meters/Are-smart-meters-safe.html - Accessed 26/07/2017

[53] Opinion on Potential health effects of exposure to electromagnetic fields (EMF) – Scientific Committee on Emerging and Newly Identified Health Risks – 27 January 2015 - - https://ec.europa.eu/health/sites/health/files/scientific_committees/emerging/docs/scenihr_o_041.pdf

[54] Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of measuring instruments http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0032

a specific class for electromagnetic environments, under which the smart meters are class E1, being "instruments used in locations with electromagnetic disturbances corresponding to those likely found in residential, commercial and light industrial buildings". Therefore, all smart meters with the CE marking on the market in Europe have no electromagnetic waves that will impact the health of the consumers and this should be communicated likewise to the consumers.

Accuracy of meter

As described in section 0, research conducted by University of Twente Enschede and the University of Applied Sciences Amsterdam found an error in accuracy from smart meters in a laboratory.
ESMIG, which is the European voice of smart energy solution providers, deemed that the test circumstances far exceed anything that is found in a normal household. At the tests done at the University of Twente, the electromagnetic disturbances exceeded the defined electromagnetic compatibility levels (EMC) for measuring instruments in households defined in the standards for smart meters, under the Directive for measuring instruments 2014/32/EU.[55] [35]
ANEC on the other hand is worried about the findings of this research, since it means that some consumers could be overcharged and thus consumers can lose their confidence in the smart meter deployment. ANEC would like to understand what could cause smart meters to record consumption inaccurately in real life situations. Therefore, they call for further independent research into this issue, and on electromagnetic interference in domestic environments and metering.[56] [36]

Price of meters

In the UK, there is no upfront cost for the smart meters for the consumers. The Department of Energy and Climate Change have carried out an impact assessment, where the cost of the entire roll-out is calculated to be £12.1 billion. [57]They claim however that the benefits will be £6.7 billion above the cost of the roll-out. The price of the smart meter roll-out is absorbed into the energy bills and results in an increase of the energy bill of about 6 pound per year.[58] [37] In Spain, the price of the smart meter is including the cost of the smart meter and other costs, such as installation cost and maintenance. Therefore, the price is higher than the purchase cost of the smart meter and the consumer should be made aware of this. Additionally, if the consumer in Spain chooses for a smart meter, these other costs are also included. By regulation, this is fully audited by the Competition Authority.

[55] ESMIG Position Paper: "Smart Meters are reliable; recent tests that caused meters to show failures were under abnormal circumstances and violating the European regulations" – ESMIG - 2017
[56] ANEC views on the research of the University of Twente on reading errors of static energy meters caused by conducted electromagnetic interference – ANEC - 2017
[57] http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/news/smart-meters-publication/ - Accessed 03/01/2018
[58] https://www.moneysupermarket.com/gas-and-electricity/smart-meters/ - Accessed 02/08/2017

Back-billing

Today, the policy in the UK is to limit back-billing to three years for electricity meters in case of micro-businesses and 12 months for domestic consumers.[59] [38] However, due to the roll-out of smart meters, Ofgem proposed new protection for the consumer regarding the back-billing and to limit the back-billing to 12 months for micro-businesses and domestic customers alike.[60] [39]

Installation barrier

In the UK, the installers will contact the consumer to arrange a date and time for installation. They will inform the consumer in what to expect and how long it will take. The installer is properly qualified to give all information needed and asked by the consumer. [40] However, in some countries, such as the Spain and Italy, the electricity meter is usually accessible from outside the house, limiting the importance of this barrier.
An additional installation barrier is the fact that some appliances might get condemned in a house, due to safety reasons. The possible prospect of this will increase the installation barriers for consumers living in older houses or with older equipment. If appliances are deemed unsafe by the installer, some suppliers will help repair or replace them. 84% of the suppliers in the UK [41] have plans to offer form of alternative heating, lighting or cooking facilities in case of condemnation but only 4 suppliers in the UK are currently offering such services. [61]

Energy market context

The existing energy market context regarding smart meters is of importance for the consumers. With a broad market context, consumers will have more choices regarding the different value propositions and therefore more different consumer archetypes will be able to benefit from the smart meter deployment.

In-home displays

In France today, there are almost no smart meter appliances. The IHD was supposed to be introduced in the year 2017 and free for vulnerable consumers. However, no information regarding the deployment of the IHD in France in 2017 was found.
In the Netherlands, the smart meter appliances are not regulated and are the responsibility of the market. Consequently, there exist several IHD, mobile smart phone applications and websites, with and without additional costs to the consumer. This means several value propositions are available, such as historic data of consumption, real time consumption, CO2 emissions and integration of PV information. These value propositions vary between the applications. Consumers can therefore choose themselves which value proposition is of value to them and how much they are willing to pay.
In the UK, suppliers are obliged to deliver an IHD along with the smart meter. Consumers can choose between different suppliers and thereby choose which information they want to see on their IHD. It is also possible to access web portals and install applications on the smart phone.

[59] http://www.energy-uk.org.uk/policy/microbusiness/back-billing.html - Accessed 12/12/2017
[60] https://www.ofgem.gov.uk/publications-and-updates/ofgem-proposes-new-protection-consumers-back-billing - Accessed 12/12/2017
[61] Smart Support: Support for vulnerable consumers in the smart meter roll-out – Citizens Advice 2017

In Finland, suppliers and market players have other smart meter based services, such as demand response and smart home products. Customers with electric heating can do demand response adjusting the heat production during the cheapest hours of the market. [4] Asela E Electricity saver is such a smart home application in Finland. The product exists of a touch screen display, adapters, switches, modules and sensors all connected to a central unit. This system will monitor real-time the consumer's electricity consumption and electricity costs with a smart meters and other sensors. The household appliances specific consumption can be monitored using the wireless switches and the connection can be controlled and programmed to react automatically to the electricity price.

Advanced Smart Metering Applications

The level of penetration of distributed energy resources (storage, heat pumps, EVs) contribute to the availability of market offers around new applications that can leverage the presence of a smart meter, such as smart charging; local energy community offers; demand response etc.
Different energy markets will affect the opportunities of different value propositions. For example, explicit demand response, with flexibility provision, has in most countries no interest from the consumers since there are not yet any aggregators. These energy markets need to be further developed in most Member States before consumers can consider if they wish to participate and reap benefits.
Additionally, implicit demand response with dynamic tariffs needs to be further developed in most Member States. Finland and Spain are two countries where such tariffs today are available, for example tariffs based on the RES availability in Finland or the PVPC[62] consumers in Spain. However, a large part of Member States does not yet have dynamic tariffs with implicit demand response.

Impact of consumer characteristics

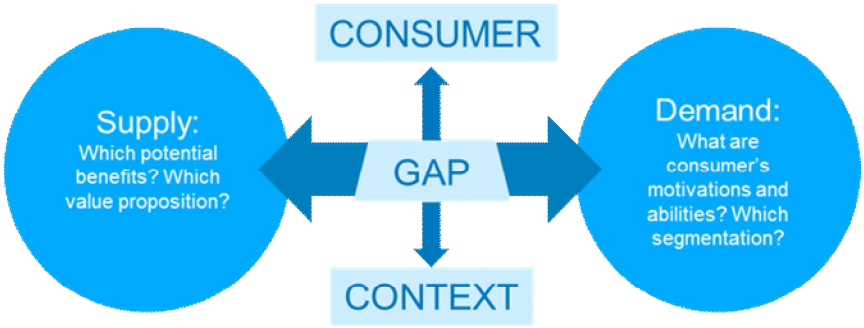


Figure 35: The gap existing between the supply side and demand side due to the context (market, regulations) and the socio-demographic parameters of the consumers

We have analysed in section 0 the impact of the supply side on the benefit realisation of the consumers. In this section the impact of the consumer archetypes and the characteristics impacting the benefit realisation will be assessed in the following way:

[62] PVPC is the 'Voluntary Price for Small Consumers", which is an hourly procing schedule for consumers with a capacity of less than 10 kW Invalid source specified.

- For each consumer archetype, first the gap existing for the consumer to benefit from different value propositions will be analysed. Possible gaps can be specific socio-demographic parameters, misalignment of expectations or simply that not enough information was received.
- Afterwards, possible mitigation factors for each archetype will be discussed.
- In case the consumers can overcome the gaps thanks to the mitigation factors, the most fitting value propositions for each consumer segment will be highlighted.
- Finally, the existing practices in the countries with the highest level of maturity will be highlighted with possible areas of improvement.

All these various aspects are summarized in the following *Table 3*.

Archetype	Gap	Mitigation factor	Most interesting value proposition	Example of Practice	Area of improvement
Motivated achievers	There is no socio-demographic gap.	General: The consumer should receive enough information and be made aware of the possible (financial) benefits. Example: In the Netherlands, a brochure has been given to all consumers to raise their awareness of the installation of smart meters. In here they explained that they were going to receive a bimonthly overview of their energy consumption and indication of the related costs. Also issues of privacy were communicated. [33]	* RT cost and consumption * Bill forecasting * Historical consumption * Implicit Demand Response (ToU, spot pricing) * Explicit Demand Response (Flexibility provision) * Energy sharing	In the Netherlands, the market of the smart meter appliances, such as IHD or energy manager apps, is free. Several value propositions today are available. Savings of 3-4% are achieved today in the Netherlands if their smart meter is supplemented by an IHD bought on the market. Without an IHD, savings of less than 1% are achieved. [63] [42]	In the UK, supplier switching for the SMETS1 smart meter has become more difficult. If the consumer switches of supplier, the meter will become a traditional meter. This has resulted in low consumer satisfaction.[64] [43]
Ecological forward movers	There is no socio-demographic gap.	General: The consumer should receive enough information and be made aware of the possible (environmental) benefits.	* RT consumption * RT carbon impact * Energy sharing * Implicit demand	In the UK, it is possible to view the CO2 production linked to the consumer's energy consumption.	Studies have shown that it is difficult to maintain the energy consumption reduction over time and therefore also

[63] De slimme meter, uitgelezen energie(k)? - Planbureau voor de Leefomgeving - 2016

[64] http://utilityweek.co.uk/news/smart-energy-gb%C2%AD%C2%AD-joins-age-uk-to-help-elderly-use-smart-meters/1269642#.WXg0XISGOpq – Accessed 26/07/2017

Archetype	Gap	Mitigation factor	Most interesting value proposition	Example of Practice	Area of improvement
		Example: In Denmark, SEAS-NVE has created advertisement for different consumer groups, and thus also a environmental advertisement focusing on the environmental benefits of the smart meter. [23]	response (tariff based on availability RES)		the CO2 reduction. [21]
Convenience conformers	There is no large socio-demographic gap. It is mostly the norm of the society that can form the gap in case that the smart meter hasn't widely spread.	General: Same as previous two archetypes, advertisement and brochures is of importance to convince this archetype.	* Relativity to other consumer * Bill forecasting * RT cost and consumption	In the UK, all consumers get automatically an IHD; therefore the IHD alongside the smart meter becomes the norm of the society.	The information made available to the consumers is of high importance to make them aware of all value propositions available to them. For the Netherlands, at the end of 2015, only 16% was well aware of the energy manager apps existing on the market. This resulted in lower than expected energy savings. [42]
Unmotivated consumers	ICT level: For most value propositions, the higher age of this group can be a gap since older people usually have more difficulties learning new and innovative services	General: Giving clear and widespread information will help this archetype. Example: Smart Energy GB works together with the charity Age UK to help people over 65 make use of their smart meters. They will provide information about the smart meters and services provided in the UK by brochures at retail shops, the charity's website, radio	Unusual usage alert	UK based company Intelesant has created a system which detects which appliances are in use. After a learning curve to learn the daily routines of the inhabitant, the system can send a notification to a nominated person if something might be wrong.[65] [44] This has been developed with EDF Energy.	In most countries, no specific action regarding the smart meter for elderly or unmotivated people has been put into action.

[65] https://www.howz.com/how-it-works/ - Accessed 4/08/2017

Archetype	Gap	Mitigation factor	Most interesting value proposition	Example of Practice	Area of improvement
		stations, newsletters. They will emphasise on the fact that the smart meter makes it easier to manage their budgets and understand their energy use. [43]			
Barely getting around	Income: Due to the lower income of this archetype, they have difficulties investing in efficient or smart appliances and smart meter services.	General: Smart meters can work in prepayment method or credit method. Prepayment customers can see their balance on their IHD and not unknowingly run out of credit. It is also possible to set to top up automatically, so that if the consumer runs out of credit in the night, the consumer isn't left without any power. [66] [45]	* RT cost * Bill forecasting * Prepayment * Fuel poverty detection	In the UK, prepayment can be used alongside IHD and smart meter. The smart meter makes the prepayment method easier, since for some suppliers, the consumer can top up online. Also the fact that the IHD is installed with the smart meter in the UK facilitates the checking of the remaining credit. Also in the Netherlands some apps exist that display the prepayment budget left	In the UK, additional measures are being investigated, such as extending the help credit and defining non-disconnection periods. Better and accessible information of energy efficiency is of high importance to make consumers understand their energy consumption and help them reduce it.[67] [46]
Non-economic vulnerable consumer	Due to the health impairment of this archetype, the consumers may have difficulties to benefit from the smart meter. The difficulties can be for example bad eyesight which hinders the use of an IHD or other app which can show the several value propositions.	General: Some mitigation factors could be high contrast screens, having a speaker instead of an IHD. Also given the correct information to the consumers and follow-up after installation is of importance.	* Unusual usage alert * RT consumption	EDF Energy in collaboration with Amazon Echo, which is a smart speaker from Amazon, established a voice user interface wherewith the consumer can check his/her account balance, ask when his/her next payment is due, check contract end date and submit a meter reading. This can help blind people. [68] [47]	More attention to this group must be given in the form of information and specific services customized for the specific needs.

Table 3: The various aspects having an impact on consumers regarding the context factors, socio-demographic parameters and existing gap and mitigation factors

[66] https://www.gov.uk/guidance/smart-meters-how-they-work - Accessed 25/07/2017

[67] https://www.smartenergygb.org/en/about-smart-meters/benefits-for-you/benefits-for-prepay - Accessed 09/08/2017

[68] https://www.edfenergy.com/for-home/self-service/amazon-alexa-skill - Accessed 31/07/2017

In order that Member States have a positive consumer impact with the smart meter deployment, the most pertinent key-takeaways are concluded:

- There is one general gap that can be applied to all consumer archetype, being the information received and the awareness of the consumer regarding the smart meter, its value propositions and the related benefits.
- Consequently, a mitigation factor applicable to all consumer archetype is that the information is given in a clear and straightforward way. This will help the consumer to understand how to benefit from the smart meter and its value propositions. Possible channels are advertisement, brochures, internet, social media and others.
- The most fitting value propositions for each consumer archetype depends on the objective of the consumers and therefore of his consumer archetype.
- Hence, a Member State should create a clear catalogue with all the available value propositions such that a consumer can personalize the services of the smart meter for himself with information easily found or given to him.

Monitoring Framework

In this final chapter, the assessment of the consumer's path to reap benefits from the value propositions of the smart meter will be carried out. To be able to do this in a systematic way, two different set of Key Performance Indicators KPIs will be defined: The Transition KPIs and Consumer KPIs.
The Transition KPIs assess if the right conditions are in place for consumer to be able to benefit from the smart meters. The Consumer KPIs will assess if the consumers are actually benefitting from the smart meter deployment. Therefore, Transition KPIs can typically be influenced by Member States, regulators and market actors, while the Consumer KPIs depend truly on the consumers' choice.

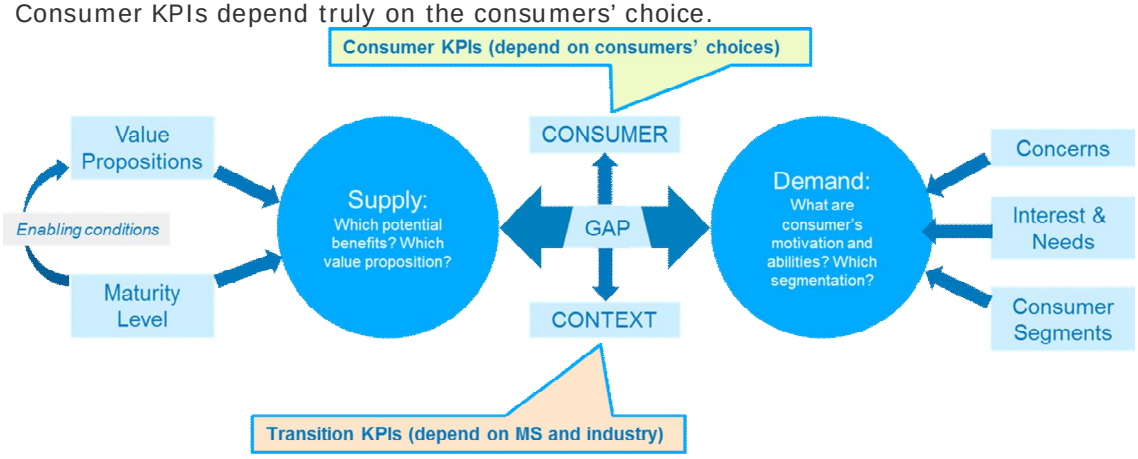


Figure 36: All the aspects influencing the consumers' path the benefit from the smart meter

Initial list of KPIs (ANEC)

The starting point from the KPIs proposed by Tractebel, are the KPIs proposed by the ANEC[69] to measure the consumers' impact of the smart metering roll-out. They are listed in the table below [3].

[69] ANEC is the European Consumer voice in standardisation, defends consumers interests in the process of standardisation and certification.

Consumer outcome	Lead indicators	Supporting indicators
Access to information	Proportion of bills based on actual meter readings Proportion of consumers with access to visualized historical consumption information Proportion of consumers provided with real time usage Number of privacy and security breaches	Proportion of smart meter readings collected and utilized for billing Provision of personalized historical consumption information including comparison to similar users Number of complaints about privacy issues Privacy by design and default of the entire smart meter system
Satisfaction	Overall satisfaction with installation of smart meter Overall satisfaction with ease of use of smart meters Number of remote cut-offs from grid Number of complaints related to metering, billing, … Protections/support provided for vulnerable groups	Satisfaction with: Information provided before and after installation on consumer rights, contact details, how to manage consumption and how to benefit from smart meter Ongoing personalized support, clarity of billing, improved complaint resolution Switching suppliers Savings achieved
Benefit realization	Reduction in consumption Financial savings from lower consumption Other benefits, such as remote health care, security systems, …	Bill increases/reductions due to costs of smart meter deployment or operational savings
Active engagement	Proportion of consumers switching suppliers Proportion of consumers on incentive/Time of Use tariffs	Proportion of consumers changing consumption pattern or reducing peak time usage Number of connections by consumer by year to access consumption data

Table 4: Proposed KPI by ANEC [3]

Our proposed framework: Transition and Consumer KPIs

The four domains defined by the ANEC for their value propositions are used as a starting point for the defining of the Transition and Consumer KPIs. In the table below the first lay-out for the framework of the KPIs has been set.

Position Paper: Monitoring the success of smart metering deployment from a consumer perspective – June 2015 – ANEC (Katrin Behnke)

	Domain	1. Transition KPI	2. Consumer KPI
1	Consumer awareness	Communication campaign level	§ Awareness of installation § Awareness of available value propositions
2	Consumer satisfaction	§ Response to consumer concerns § % bills based on actual meter readings	§ Ratio of complaints § Deactivation ratio
3	Active engagement	§ Maximal allowable switching time § Availability of detailed load curve	§ Switching rate § Number of consumers changing to different tariff
4	Benefit realisation	Available value propositions	§ Energy consumption reduction § Peak demand reduction

Table 5: Proposed Tractebel framework: Transition and Consumer KPIs

The four different levels can be compared with the pyramid of Maslow[70], which depicts the hierarchy of human needs and their motivation. Some needs take precedence over others, such as basic needs. This theory is translated in the needs of consumers regarding the Smart Meter deployment.

In a first time, the consumer needs to be made aware of the smart meter deployment, its value propositions and benefits (discussed in section 0). This can be achieved by having a good communication campaign (discussed in section 0), which is thus a Transition KPI.

Afterwards, the satisfaction of the consumer regarding the Smart Meter roll-out becomes of importance. The consumer may have concerns regarding his privacy, health and other, see section 0. It is therefore important that the responsible national authorities proactively inform and reassure their citizens of the regulations and measures in place to safeguard the privacy of their data and address their other concerns related to smart metering.

In a next stage, the active engagement of the consumer becomes important, where the consumer will participate to the market to find for example the best supplier for him. The consumer will feel empowered. Of course, for this to occur, the regulation and market need to be well developed with different suppliers that have different tariffs with the possibility to change easily and fast in tariffs and suppliers.

In a final stage, the consumer should be able to benefit from the smart meter thanks to the available value propositions, discussed in section 0.

The proposed KPIs are intended to provide guidance to Member States in monitoring the benefits of the Smart Meter roll-out for the consumers. In a first phase, Member States should be free to choose the Transition and Consumer KPIs and the computation mode. Progressively, a KPI convergence across all Member States would be of importance to facilitate the benchmarking of the outcomes of the Smart Meter deployment and to share the best practices. It is important to note that the proposed KPIs are non-exhaustive and in the first stages of the introduction of the framework could be adapted by each Member State.

[70] Maslow's hierarchy of needs is a theory in psychology proposed by Abraham Maslow in 1943 in his paper 'A Theory of Human Motivation'

The Transition and Consumer KPIs listed are mainly proposed by Tractebel with some KPIs proposed by Member States regulators and other stakeholders. For each KPI proposed, the feedback of Member States and other key actors will be given if given.

Consumer awareness

Consumer KPIs

Awareness of the installation

Description	The ratio of consumers aware of the smart meter installation at their home of all consumer who have a smart meter installed. This can be expressed in %.

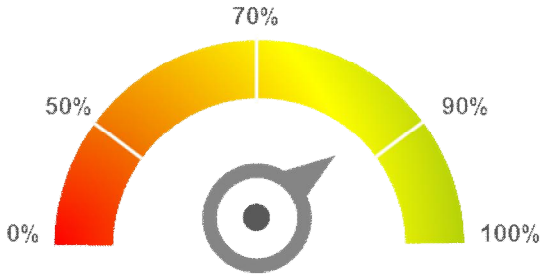


Figure 37: The Consumer KPI Awareness of installation score level

Relevance		*"A good communication is a key issue before the roll-out of the smart meters"*- stakeholder
Computability		"*It is a subjective activity and difficult to quantify*"- stakeholder
Comparability		"*Depending on consumers' behaviour in each Member State the same campaign could have different effects on the population*"- stakeholder
Example	In the Netherlands, 89% remembers the communication of the proposed smart meter installation at their home and was satisfied.[71] [48]	

Awareness of the available value propositions

Description	The ratio of consumers aware of the existing value propositions in their country, expressed in %.

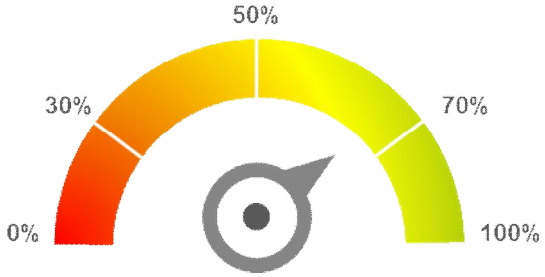


Figure 38: The Consumer KPI Awareness of value propositions score level

Relevance		Important that the consumers are aware of the value propositions to benefit from the smart meter across the different consumer archetypes.
Computability		Need of a survey.
Comparability		"*High comparability*"-stakeholder
Example	In the Netherlands, 59% of the consumers, with a recently installed smart meter, was aware that they were going to receive or already receiving a bi-	

[71] Marktbarometer Aanbieding Slimme Meters: Voortgangsrapportage 2016 - Rijksdienst voor Ondernemend Nederland -2017

	monthly letter regarding their consumption. This means that about 40% were not aware or considered the letter as spam. 6% feels well informed about the value propositions existing on the market. [48]. In the UK in 2017, 33% feels well informed about the value propositions. [72] [49].

Transition KPIs

Communication campaign level

Description

As mentioned several times in this report, the communication campaign is important to raise the consumer awareness about various aspects of the smart meter. A preliminary score system is set up, which can be adapted by the Member States.

1. Has an initial communication campaign been set in place, in the form of advertisement, brochures and/or social media?
   - ☐ Yes **à** 2 pts
   - ☐ No **à** 0 pts
2. Has the consumer been informed about the installation date and time at his house and other additional information about the installation (duration, …)
   - ☐ Yes **à** 1 pts
   - ☐ No **à** 0 pts
3. Is the installation performed by a certified installer who can answer question consumers have and explain how the consumer can benefit from the smart meter?
   - ☐ Yes **à** 2 pts
   - ☐ No **à** 0 pts
4. Did the consumer receive information about energy efficiency improvements?
   - ☐ Yes **à** 1 pts
   - ☐ No **à** 0 pts
5. Was the information tailored to the household?
   - ☐ Yes **à** 1 pts
   - ☐ No **à** 0 pts
6. Was there a follow-up of the consumer after the installation, such as a phone call to hear if there were any more question?
   - ☐ Yes **à** 1 pts
   - ☐ No **à** 0 pts
7. Was specific advice/support provided for vulnerable consumers?
   - ☐ Yes **à** 2 pts
   - ☐ No **à** 0 pts

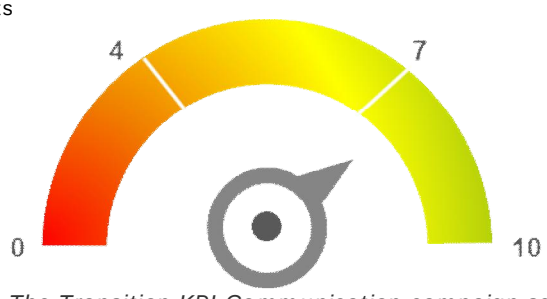


Figure 39: The Transition KPI Communication campaign score level

[72] Smart energy outlook – Smart Energy GB - 2017

Relevance		An effective communication campaign is key to have a positive consumer impact. *"Once the roll-out of smart meters has finished, the main activities to enhance the consumers depends on the suppliers and their undertakings. A key element for consumer engagement is the level of information that the companies give to consumers about the features and possibilities of smart meters."*- stakeholder
Computability		The computability can be complicated in case that the different levels of communication are handled by different actors.
Comparability		The difference in regulations and smart meter actors can entail some differences between different Member States. For example, in Spain and Italy, the smart meter is usually found outside the house. However, the installation is an opportunity to provide information to the consumer and how to use and benefit from the smart meter which will increase the consumer engagement.

Consumer Satisfaction

Consumer KPIs

Ratio of complaints

Description		The ratio of complaints to the number of households installed with a smart meter, can be calculated with the following formula $\theta = \frac{\#Complaints}{\#Households\ with\ a\ smart\ meter\ installed}$

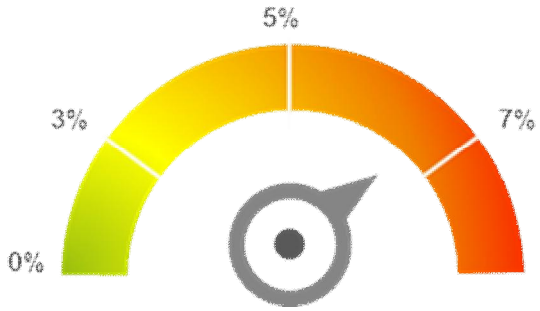


Figure 40: The Consumer KPI: Ratio of complaints score level

Relevance		"*It is important to know the number of complaints*"-stakeholder This indicates the level of satisfaction of the consumer with the Smart Meters. It can also be interesting to compare the number of complaints for consumer with a smart meter with the consumers without a smart meter.
Computability		The computability depends on how a Member State keeps track of the complaints (for example a databank or statistics).
Comparability		The difference in regulations and in the keeping track can complicate the comparability. Between the different Member States.

Deactivation ratio

Description	The amount of consumer who have turned their smart meter to traditional mode, in % $\theta = \frac{\#Deactivations}{\#Households\ with\ a\ smart\ meter\ installed}$

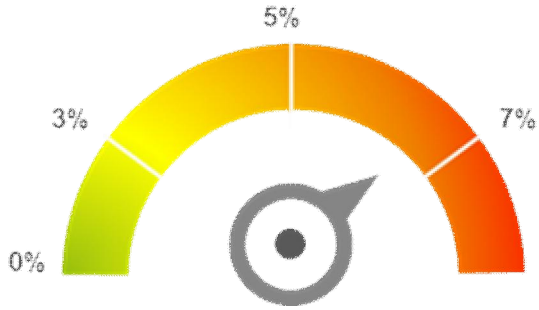


Figure 41: The Consumer KPI: Deactivation ratio score level

Relevance		The number of deactivations of Smart Meters show the dissatisfaction level. However, there might be other reasons than can justify that a smart meter is turned to the traditional mode (technical reasons).
Computability		Easy to measure. However, related to the previous comment, due care should be taken to exclude technical reasons that are not related to customer dissatisfaction when computing this KPI.
Comparability		Some Member States do not have the deactivation option, therefore this KPI should not be applied for them.
Example		In the UK, 8.6% of the smart meters have been turned conventional (correlated with switching issue)[73] [50]. In the Netherlands, 1.3% have been turned conventional[74] [51]. In Italy, the smart meter may not be turned traditional.

Transition KPIs

Response to consumers concerns

Description	Responding to the consumers regarding their concerns about privacy, cybersecurity or other is of high importance to gain their trust in the smart meter deployment. Following score system is one viable option of calculating this. 1. Which concerns have been expressed? ☐ Privacy ☐ Cybersecurity ☐ Electromagnetic radiation ☐ Accuracy meters ☐ Price meters ☐ Back-billing ☐ Installation barrier ☐ Condemned appliances/electricity installation 2. Has an adequate answer followed on these concerns, such as a communiqué of the regulations and/or safety systems put in place? ☐ For some **à** 3 pts ☐ Yes, for all **à** 5 pts ☐ No **à** 0 pts

[73] https://www.gov.uk/government/statistics/statistical-release-and-data-smart-meters-great-britain-quarter-1-2017 - Accessed 07/08/2017

[74] https://energiecijfers.info/hoofdstuk-6-cijfers-meetinstallaties/ - Accessed 07/08/2017

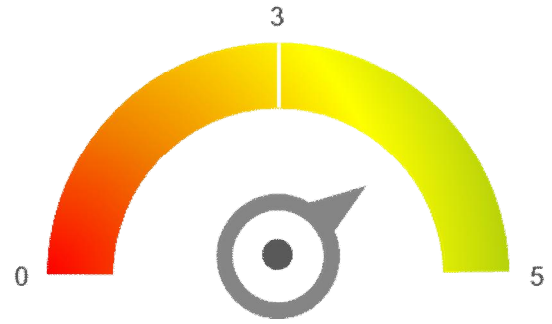


Figure 42: Transition KPI: Response to consumer score level

Relevance		The answer of Member States to the concerns of the consumers is of high importance for the consumer satisfaction
Computability		Easy to measure
Comparability		Easy to compare
Example		Some Member States have received less concerns of the consumers because of differences in the maturity levels defined in task 1

% of bills based on actual meter readings

Description	A fundamental expectation is that smart meters will provide all consumers with accurate bills, so we would expect to have a specific KPI on the % of bills which are issued based on actual meter readings. Ideally this would distinguish between bills where readings have not been received (e.g. because the meter is turned traditional or cannot communicate) and bills where readings have been collected but have not been used.

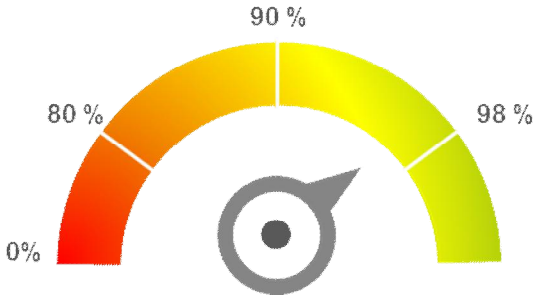


Figure 43: Transition KPI: %bills based on actual meter readings score level

Proposed by ANEC

Relevance		The accuracy is the main benefit from the smart meter and is therefore of high importance
Computability		Easy to measure
Comparability		Easy to measure

Active engagement

Consumer KPIs

Switching rate

Description	The number of consumers who have switched supplier in the last year. Expressed in %.	
Relevance		Switching can be enhanced by the Smart Meter and its value propositions, because the consumer will better understand the energy consumption and related cost in case that real-time information, historical consumption, bill forecasting or other value propositions are available. Therefore, motivated consumers will more easily change supplier. The availability of new, smarter, commercial offers can therefore trigger a contract change and the associated switching request. However, as one stakeholder mentioned, it is not always obvious to establish a cause and effect relationship between switching and smart meters. It would therefore be interesting to compare the number of switching consumers that have a smart meter compared to those with a traditional meter and analyse if a relevant correlation can be established.
Computability		Easy to measure
Comparability		Easy to compare.
Example	About 26% of the consumers of UK changed supplier in 2016.[75] [52]	

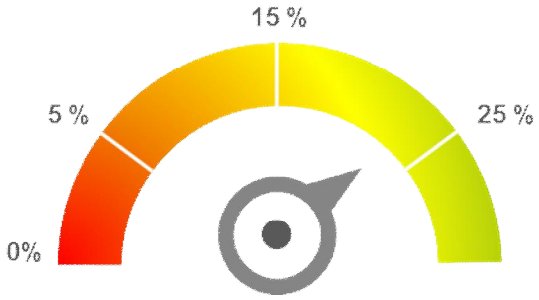


Figure 44: Consumer KPI: Switching rate score level

Number of consumers changing to different tariff

Description	How do consumers behave after the smart meter installation. It is possible that suppliers will convince consumer that another tariff might suit his consumption profile better. Expressed in %.

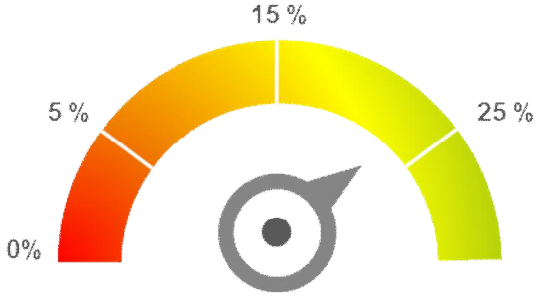


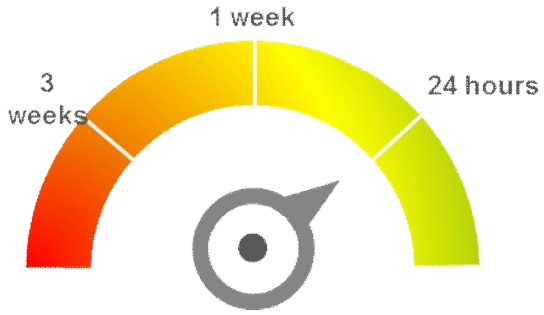
Figure 45: Consumer KPI: Ratio of number of consumers who change tariff with a smart meter rate score level

[75] https://www.theguardian.com/money/2017/feb/27/energy-bills-more-uk-customers-are-moving-supplier-figures-show - Accessed 12/12/2017

	Proposed by stakeholder and ANEC	
Relevance		Thanks to the smart meter, suppliers will have more detailed data of the consumption of the consumer and therefore could promote more dynamic tariffs to the consumer. "*It would be helpful to have another indicator of engagement in the market*"-ANEC "*Change of agreement or contract after the change to smart meters. How do consumers behave after installation smart meter?*"- stakeholder It would be interesting to compare also the number of consumers that change tariff that have a smart meter compared to those with a traditional meter in the first stages of the smart meter deployment.
Computability		Medium to low effort to measure : This KPI will depend on supplier's willingness to cooperate as this KPI targets an internal switching (not a change a supplier but a change of tariffs).
Comparability		Easy to compare.

Transition KPIs

Maximal allowable switching time

Description		A short supplier switching time is desirable for consumers because it encourages the consumer to search for better energy deals and to switch supplier. Therefore, a short supplier switching time enhances to consumer engagement. However, the cool-down period of a consumer must also be considered ('changing his mind').  *Figure 46: Transition KPI: Switching time score level*
Relevance		With the roll-out of smart meters and availability of different tariffs, the supplier switching simplicity will be improved. European Energy Regulators (CEER and ACER) have set a switching time target of 24 hours by 2025. The current European legislation has a maximal switching time of 3 weeks.
Computability		Easy to measure
Comparability		Easy to compare

Availability of detailed load curve

Description	The availability of a detailed load curve (per 15,30 or 60 minutes) to the consumer and supplier is important for the dynamic tariffs. This can be provided to the consumer with the real-time information or historical consumption value propositions, see chapter 4 section 0, on the IHD or application on the smart phone.

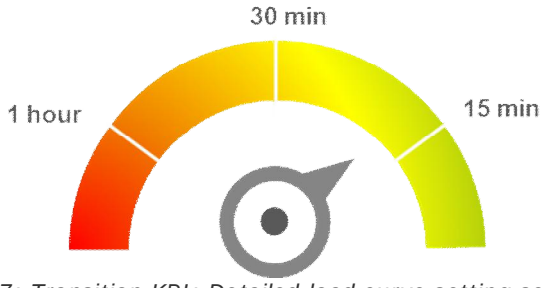


Figure 47: Transition KPI: Detailed load curve setting score level

Relevance		High relevance because it is of importance for multiple value propositions, one being the dynamic tariffs
Computability		Easy to measure
Comparability		Easy to compare

Benefit realisation

Consumer KPIs

Energy consumption reduction

Description	The average realised energy consumption reduction of households with a Smart Meter installed, in %.	
Relevance		One important benefit for the consumers is bill reduction. One possible way to obtain this is the energy consumption reduction, which is easily measurable. "*There are other ratios that can measure energy reduction*"-stakeholder
Computability		Easy to measure
Comparability		Easy to compare. It could also be interesting to compare this number to consumer without a smart meter in the first stages of the smart meter deployment to discount the changes due to other factors, such as a price increase, different weather patterns, …
Example	In the UK, they have realised between 2-3% of realised energy savings [4] and in the Netherlands less than 1% [42]. The difference lies in the fact that almost all households in the UK receive an IHD when the smart meter is installed, while in the Netherlands the consumers are less aware of the value propositions of the smart meter existing on the market.	

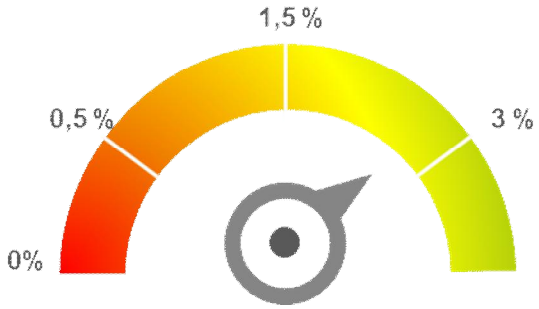


Figure 48: Consumer KPI: Energy consumption reduction score level

Peak demand reduction

Description	Benefits can also be achieved by shifting the peak demand and therefore reducing the peak demand. If done in parallel with a tariff who has higher prices at peak moments and low at non-peak

moments, peak shifting can also result in a bill reduction.

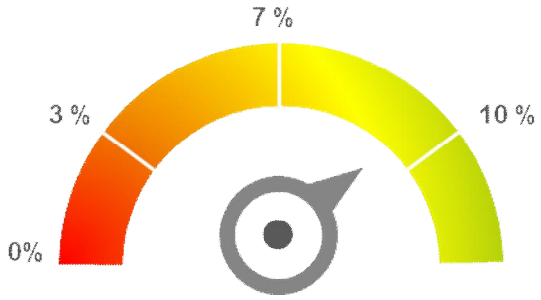


Figure 49: Consumer KPI: Peak demand reduction score level

This KPI is proposed by ANEC

Relevance		One important benefit for the consumers is bill reduction, which can be done with peak shifting
Computability		Easy to measure
Comparability		Easy to compare
Example	A study done in Ireland by CER has shown that with Smart Meters, Time of Use tariffs, accurate billing and giving richer information to consumers, an overall peak reduction of 8.8% can be achieved[76]. [53]	

Transition KPIs

Available Value Propositions

Description

A high number of value propositions will increase the number of different archetypes of consumers that will be able to benefit from the smart meter deployment.

1. Is real-time consumption/cost, historical consumption and dynamic tariffs (explicit DR) available? (all 3)
   - ☐ Yes, all of them **à** 4 pts
   - ☐ No **à** 0 pts
2. Are there Value Propositions available for economic vulnerable consumers? (prepayment, social tariffs)
   - ☐ Yes **à** 3 pts
   - ☐ No **à** 0 pts
3. Are there Value Propositions available for non-economic vulnerable consumers? (Unusual usage alert, fuel poverty detection, …)
   - ☐ Yes **à** 3 pts
   - ☐ No **à** 0 pts

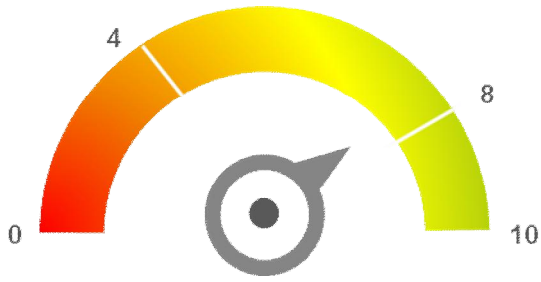


Figure 50: Transition KPI: Available Value Propositions Score level

[76] Electricity Smart Metering Technology Trials Findings Report – CER - 2012

Relevance		This has a high relevance in order that all consumer segments can benefit from the smart meter deployment.
Computability		Needs in some cases a market analysis
Comparability		Easy to compare

Feasibility

	Domain	1. Transition KPI	Rele-vance	Computability	Comparability	2. Consumer KPI	Rele-vance	Computability	Comparability
1	Consumer awareness	Communication campaign level				Awareness of installation			
						Awareness of available VP			
2	Consumer satisfaction	Response to consumer concerns				Ratio of complaints			
		% bills based on actual meter readings				Deactivation ratio			
3	Active engagement	Maximal allowable switching time				Switching rate			
		Availability of detailed load curve				Number of consumers changing tariffs			
4	Benefit realisation	Available value propositions				Energy consumption reduction			
						Peak demand reduction			

A table with a colour code for the KPIs is proposed to review easily the proposed framework. Some difficulties are:

- Some consumer KPIs need to be calculated with a survey. This will induce additional costs for the supplier, regulator or other.
- The comparability for some KPIs across the different Member States is lower due to the differences in regulations and market models, for example the difference in the handling of complaints.
- For the switching, it is not always clear if the cause is due to the introduction of the smart meter in a household. However, smart meters will enhance the consumer empowerment and therefore also the switching rate.

Smart meters should provide benefits to all consumers, thus to all archetypes. Therefore, it could be interesting to calculate all these KPIs for the different archetypes. However, the difficulty lies in the computability level, since there is the need of

extensive surveys with high participation level of consumers in all consumer archetypes defined in section 0.

For the different levels of KPIs, there is a timeframe. This means that some Member States will fulfil certain levels of KPIs (in other words reach high score levels). Therefore, they should afterwards not be calculated anymore, except if issues emerge in that specific level. The UK has stated that the KPI level Consumer Awareness was fulfilled and that therefore the need to calculate that KPI is eliminated.

For the further work related to the KPI framework, this study should be seen as a starting point that will help for the discussion in which the European Commission and the relevant stakeholders will engage in, in the near future. This will enable them to define a shared and comprehensive framework to monitor and compare the consumer impact of the smart metering roll-outs across all Member States.

The proposed monitoring framework could possibly serve regulators, such as ACER and CEER in tracing the consumer satisfaction with the smart metering deployment and finding the underlying key factors of influence. This could become part of their annual monitoring exercise they engage in.

Conclusions

The aim of this study was to carefully analyse the effect of smart metering on consumers in terms of context, demographics, including potential consumer vulnerabilities. To achieve this, we have first created the maturity model where the Member States were classified in different maturity levels according to the maturity of the Member States regarding the smart metering roll-out w.r.t the consumers. In a second phase, the focus was on the consumers. On one side, the value propositions from the smart meters existing for the consumers were listed and on the other side the concerns and motivations of the consumers for the smart meter roll-out. Based on these concerns and motivations and with an extensive literature study, six consumer archetypes were created that were characterized based on their abilities to collect smart meter benefits. Afterwards, key factors influencing the smart metering outcomes for consumers were assessed. These key factors are the communication campaign in a country, the regulatory framework and the energy market of the Member States that provides value propositions for the consumers. Finally, a monitoring framework was created where Transition KPIs, depending on the national context, and Consumer KPIs, depending on how consumers have been embracing the new smart energy system put at their disposal, were defined.

This study can be viewed as a contribution to the Energy Union Strategy “Clean Energy for All” with the broader perspective of delivering the new deal for consumers. We hope this study may guide Member States to timely design their own national monitoring scheme for assessing progress and effectiveness of smart metering deployment from a consumer perspective.

We recommend considering the KPIs defined in this report as a starting point in the discussion that the European Commission and the relevant stakeholders will engage in the near future towards defining a comprehensive framework to monitor and ultimately compare the consumer impact of smart metering roll-outs across Member States. The proposed monitoring framework could potentially serve the regulators (ACER/CEER) in tracing, as part of their annual monitoring exercise, consumer satisfaction with smart metering deployment and the underlying key factors of influence.

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Appendix

Annex A: Functional Requirements

In the table below, the functional requirements are listed.

	Segment	Functional requirements
A	Consumer	Provide readings directly to consumer and/or any 3rd party
B		Update reading frequently enough to use energy saving schemes
C	Metering operator	Allow remote reading by operator
D		Provide two-way communication for maintenance and control
E		Allow frequent enough readings for networking planning
F	Commercial aspects of supply	Support advanced tariff system
G		Remote ON/OFF control supply and/or flow or power limitation
H	Security – data protection	Provide secure data communications
I		Fraud prevention and detection

Table 6. Functional requirements

Annex B: Score of Member States in the Smart Meter Maturity Matrix

	1. CBA	2. Realization rate	3. Legal framework	4. Realization rate	5. Functionalities a, b and f	6. Research consumer benefits	7. Commercial offers	8. Implemented Commercial offer
United Kingdom - GB	x	x	x	x	x	x	x	x
Netherlands	x	x	x	x	x	x	x	
Luxembourg	x	x	x	x	x	x		
Estonia	x	x	x	x	x			
France	x	x	x	x	x			
Poland	x	x	x	x	x			
Romania	x	x	x	x	x			
Austria	x	x	x	x		x		
Sweden	x	x	x	x		x		
Denmark	x	x	x	x				
Finland	x	x	x	x				
Italy	x	x	x	x				
Spain	x	x	x	x				
Malta	x	x		x				
Ireland	x		x		x			
Belgium	x		x		x	x		
Czech Republic	x		x		x	x		
Germany	x		x		x	x		
Greece	x		x		x	x		
Lithuania	x		x		x	x		
Portugal	x	x	x	x				
Slovakia	x		x			x		
Cyprus	x				x			
Latvia	x	x		x		x		
Slovenia	x			x	x			
Croatia	x	x	x		x			
Hungary					x			
Bulgaria			x		x			

Annex C: Questionnaire

Throughout the duration of this study, we have sought the feedback of the most relevant stakeholders by using an online questionnaire and organizing a dedicated workshop. National regulatory authorities, consumers and industry representatives have expressed a strong support for our study and have delivered insightful comments and suggestions (see annexes), ensuring that the proposed monitoring framework will remain both relevant and easy to implement.
The questionnaire can be found back on the following link:
https://www.surveymonkey.com/r/smartmeter_consumer
Following Member States participated with the help of CEER

- Austria (E-Control)
- Portugal (ERSE)
- Luxembourg
- Germany (Bundesnetzagentur)
- Lithuania (National Commision for Energy Control and Prices NCC)
- Spain (National Commission on Markets and Competition)
- Malta (Regulator for Energy and Water)
- Croatia (Croatian Energy Regulation HERA)
- Ireland (Commission for Energy Regulation)
- France (Commission de Régulation de l'Energie CRE)
- Sweden (Ei)
- Denmark (The Danish Energy Regulatory Authority)
- United Kingdom
- Norway (NVE)
- Latvia (Public Utilities Commission)
- Italy (Retail Markets and Energy Consumer Protection Dept. AEEGSI)

The results of the questionnaire can be found back in the Workshop presentation, see Annex D.

Annex D: Workshop Presentation

Outline

9:45	Context and objectives of workshop
10:00	Maturity model & Member States Practices Value proposition for consumers & Consumer segments KPI & Monitoring framework
14:00	Summary finding from NRA questionnaire and discussion
16:00	Next steps

01

Context and objectives

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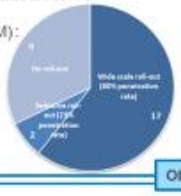
Scope of the project

Context

- Third Energy Package Electricity and Gas Directive
- Results on CBA of smart metering (SM):



Actual situation – consumer focus

- "Smart metering success should be monitored from a consumer outcomes perspective" (ANEC)
- Available consumer feedback and value propositions from Member States

Objective

Objective:

- **Design**, building on available best practices, **a comprehensive framework** with KPIs
- **Systematically** and **transparently monitor progress** and satisfaction from a **consumer perspective**
- Establish the success of **SM deployment in the EU**

Expectations:

1. Guide MS in anticipation to planned roll-outs, to design/refine their monitoring scheme for assessing progress and effectiveness SM deployment from consumer's perspective
2. Support regulators (ACER/CEER) in tracing consumer satisfaction

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Objective of the meeting

1. Maturity level
   - Highlight proposed maturity level model
   - Integrate feedback and revise maturity model
2. Consumers perspective
   - Discuss the defined value propositions for the consumers
   - Highlight the concerns and interests of consumers and the proposed consumer segmentation
3. Assessment framework
   - Present KPI types and selection
   - Discuss implementation & publication strategy

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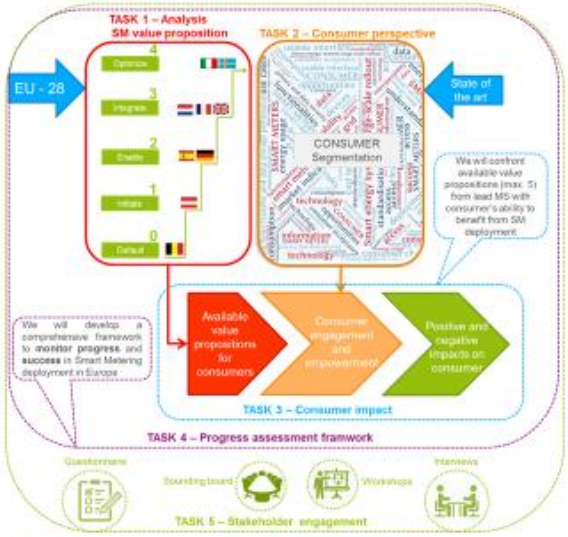

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02

Benchmarking Member States practices

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Task 1 – Benchmarking Member States practices

- To be able to define KPIS, we assigned Member States to different levels of smart metering deployment.
- Five maturity levels (and their associated criteria) were defined and applied to benchmark EU Member States
- In the more advanced Member States, we took a closer look at the benefits for consumers:
  - Main types of benefits included in the cost benefit analysis
  - Are there functionalities and services that provide **benefits directly** to the individual customer? In other words, what are the available **value propositions** for the consumer ?

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The Smart Meter Maturity Matrix is developed to divide Member States into different maturity levels

Maturity level	Default	Initiate	Enable	Integrate	Optimize
Criteria: Member state		1. Conducted a cost benefit analysis	3. Has an existing legal framework in place	5. Has its smart meter compliant with EC recommended functionalities a, b and f	7. Has commercial offers available
		Or	And	And	
Criteria: Member state		2. Realized a roll-out of > 1%	4. Realized a roll-out of > 10%	6. Did research on consumer benefits	
		MS that conducted a CBA show interest in **the potential value** of smart meters. MS that started without a CBA are also included	A legal framework is used for deployment and/or regulating specific matters. A **significant roll-out** is relevant to empirically assess the benefits that a smart meter brings.	Functionalities a, b and f are most critical to provide direct benefits to the consumers. Member States should also show interest in **consumer benefits**	The availability of commercial offers shows that both the market and the consumer are aware of the value of smart meters.

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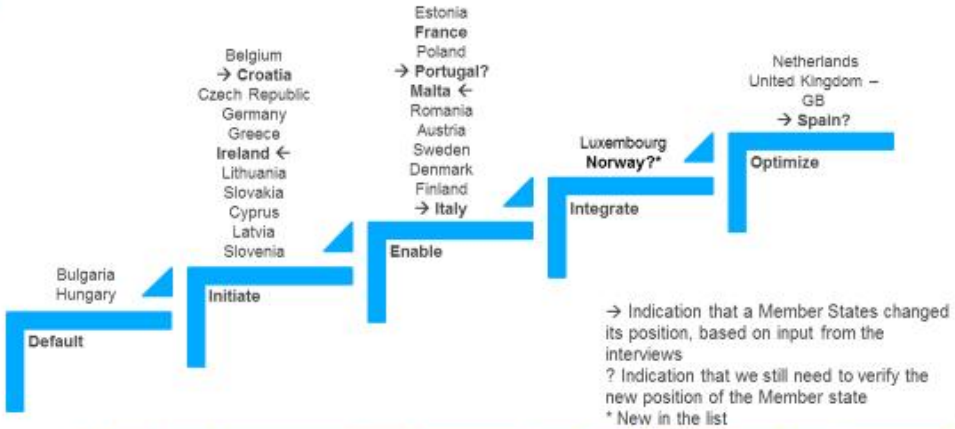
Based on the Maturity Model, the UK, Netherlands and Austria are considered to be the most mature countries



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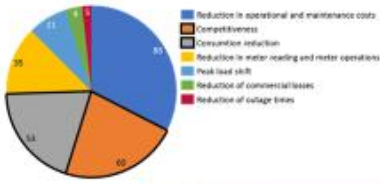
The most promising value proposition is 'consumption reduction'

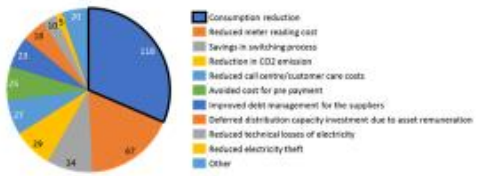
Of the most mature Member States the benefits are analysed. The expected share of the benefits can be found in the pictures below.

Consumption reduction provides direct benefits to the consumers (= value proposition).

Benefits of roll-out in United Kingdom - GB



Benefits of roll-out in the Netherlands



Changes compared to previous maturity model

- Member states that started with the out roll without a CBA can still move up to the next level
- Criteria that focus on consumer benefits moved up to a higher maturity level, such as the criteria on functional requirements
- Added the last, or seventh criteria, on available commercial offers

03

Consumer segments, abilities and motivations

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Introduction

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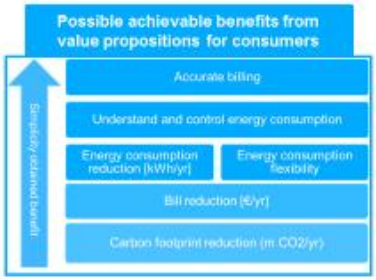
Supply side:
Description of value propositions for the consumers



A value proposition is a service providing direct benefits to the consumer:
- Monetary : bill reduction, accurate billing
- Non monetary: Reduced CO2 emissions, safety aspect

1. Standard value propositions
2. Advanced value propositions (Clean Energy Package)

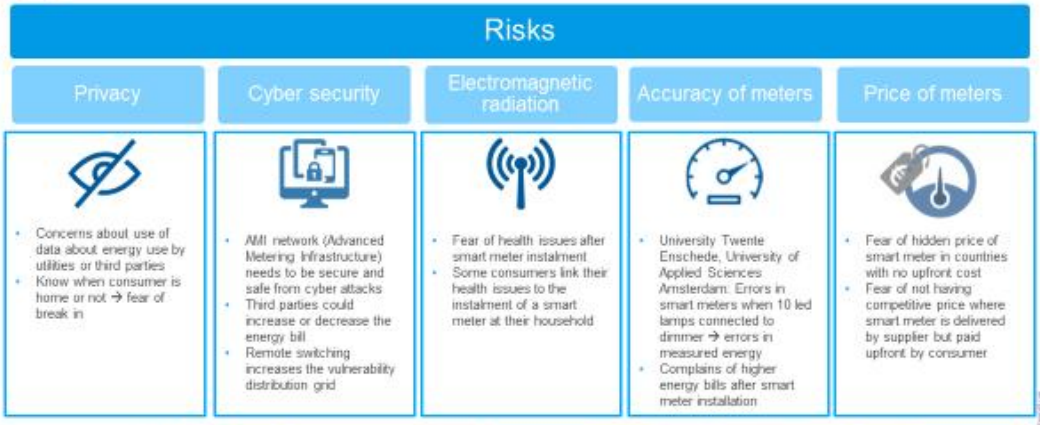
Supply side:
Traditional value propositions

		Achieved benefits						
		Bill reduction	Energy consumption reduction	Lower CO2 emissions	Accurate billing	Understand and control energy consumption	Safety	Example
Value propositions	Relativity to comparable consumers	✓	✓					Opower app (NL)
	Bill forecasting					✓		Website (NL)
	Real-time consumption	✓	✓			✓		IHD (UK)
	Real-time cost	✓				✓		IHD (UK)
	Unusual usage alerts		✓		✓		✓	Intelesant - notification company (UK)
	Historical consumption		✓			✓		Download (UK)
	Real-time carbon impact			✓				IHD (UK)
	Pre-payment					✓		IHD (UK)
	Implicit demand response (ToU)	✓						Peak & off-peak hours (FR)

Supply side: Advanced value propositions

		Achieved benefits						
		Bill reduction	Energy consumption reduction	Lower CO2 emissions	Accurate billing	Understand and control energy consumption	Safety	Examples
Value propositions	Implicit DR (spot pricing)	✓						Based on spot market, RES availability (FI)
	Flexibility provision (explicit DR)							Agency ORE (FR)
	Fuel poverty detection	✓			✓		✓	
	Energy sharing	✓	✓					
	Smart meter to integrate prosumers in the market	✓					✓	Only 1 SM needed (FR)
	Smart meter to ease charging of EV at home	✓						

Demand side (1/4): Concerns of the consumers



Demand side (2/4): Interests and needs of the consumer

Interests and needs of consumer

Economic

- **Direct savings**: By reducing your energy consumption or comparing tariffs and choosing the optimal one. The benefit of direct savings is often emphasised in brochures for smart meters.
- **Indirect savings**: Savings made by DSO since he can run his network more efficiently. In France, the economic success of the deployment only relies on indirect economical savings

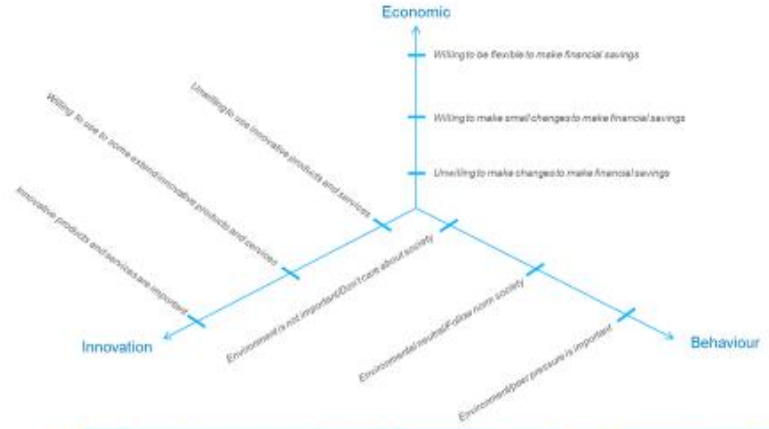
Behavioural

- **Conformity of society**: consumers like to do what rest of society is doing, the norm of the society
- **Green aspect**: consumers who value environment. Suppliers of smart meters can implement services which emphasise the green aspect of the meter
- **United Kingdom**: IHD shows the amount of CO2 emissions

Innovation

- Motivation and ability to learn, understand and use new products and services
- Importance of **interoperability** and portability of data and access to data from third parties

Demand side (3/4): Dimensions of consumer motivation



Demand side (4/4): Consumer segments and archetypes

		Motivated achievers	Ecological forward movers	Convenience conformers	Unmotivated seniors	Barely getting by	Non-economic vulnerable consumer
Age	20-39	✓	✓✓	✓		✓	✓
	40-64	✓✓	✓	✓		✓	✓
	>60			✓	✓	✓	✓
Income household	<10.000€				✓	✓	✓
	10.000-50.000€		✓	✓			✓
	>50.000€	✓					
Yearly electricity consumption	<1000 kWh					✓	✓
	1000-2000 kWh		✓	✓	✓	✓	✓
	2000-5000 kWh	✓	✓	✓	✓	✓	✓
	> 5000 kWh	✓✓					✓
Housing tenure	Owner	✓	✓	✓	✓		✓
	Private renter			✓			✓
	Social renter					✓	
Environment	Pure environmentalist		✓				
	Environmentalist	✓		✓	✓		✓
	Not important				✓	✓	
ICT skills	Good	✓	✓	✓		✓	
	average			✓✓		✓✓	✓
	bad			✓	✓	✓	✓
#Persons household	1		✓		✓	✓	✓
	2		✓	✓	✓	✓	✓
	3	✓	✓	✓		✓	✓
	4	✓	✓	✓		✓	✓
	>5	✓		✓		✓	✓
Health impairment	No	✓	✓	✓	✓		
	Chronical disease						✓
	Disability						✓

Matching supply and demand

Goal: finding the key factors of influence and the best practices in the different Member States

Context factors: Channel of communication

Context factors: Channel of communication

Context factors: The Energy Market

The energy market

Smart meter appliances


Application in the Netherlands


IHD in the UK

- **FRANCE**: IHD will be introduced in this year and will be free for vulnerable consumers
- **THE NETHERLANDS**: Smart meter appliances are the responsibility of the market. There exist several IHD, smart phone applications for free or for a fee
- **UNITED KINGDOM**: Suppliers obliged to deliver smart meter with an IHD.

Smart home appliances

- **FINLAND**: Asela E Electricity saver, with switches and sensors connected to a central unit. The connection of the appliances can be controlled and programmed to react automatically to the electricity price
- **SPAIN**: PVPC provides day ahead price signals

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04

KPIs and implementation strategy

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Proposed KPIs by ANEC

High level indicators

Consumer outcome	Lead indicators	Supporting indicators
Access to information	• Proportion of bills based on actual meter readings • Proportion of consumers with access to visualized historical consumption information • Proportion of consumers provided with real time usage • Number of privacy and security breaches	• Proportion of smart meter readings collected and utilised for billing • Provision of personalized historical consumption information including comparison to similar users • Number of complaints about privacy issues • Privacy by design and default of the entire smart meter system
Satisfaction	• Overall satisfaction with installation of smart meter • Overall satisfaction with ease of use of smart meters • Number of remote cut-offs from grid • Number of complaints related to metering, billing, ... • Protections/support provided for vulnerable groups	Satisfaction with: • Information provided before and after installation on consumer rights, contact details, how to manage consumption and how to benefit from smart meter • Ongoing personalized support, clarity of billing, improved complaint resolution • Switching suppliers • Savings achieved
Benefit realisation	• Reduction in consumption • Financial savings from lower consumption • Other benefits, such as remote health care, security systems, ...	• Bill increases/reductions due to costs of smart meter deployment or operational savings
Active engagement	• Proportion of consumers switching suppliers • Proportion of consumers on incentive/Time of Use tariffs	• Proportion of consumers changing consumption pattern or reducing peak time usage • Number of connections by consumer by year to access consumption data

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Assessing Transition KPI and Consumer KPI

Achieving consumer benefits through smart metering:

Domains consumer KPIs (depend on consumers choice):
- Concerns
- Satisfaction
- Awareness

Domains transition KPIs (depend on MS and industry)
- Communication campaign
- Regulatory framework (answer concerns)
- Energy market context

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KPI domains
Link between Consumer KPI and Transition KPI

	Domain	1. Consumer KPI	2. Transition KPI
1	Access to information	Awareness	Communication campaign
2	Satisfaction	Concerns of consumers	Proactive communication to answer public concerns
3	Active engagement	Empowerment/Market participation	Regulation/Market model
4	Benefit realisation	Benefits	Available value propositions

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1. Access to information:
Awareness ⇔ Communication campaign

1.1.1 Awareness of installation

The amount of consumers aware of the installation, in %

- In the Netherlands, 89% remembers the communication of the proposal of installation
- To be calculated with a survey

1.1.2 Awareness of value propositions

The amount of consumers aware of the value propositions available in their country, in %

- In the Netherlands, 6% feels well informed about the value propositions on the market (2015)
- In the UK, 33% feels well informed about the VP (2017)
- To be calculated with a survey

1.2.1 Communication campaign level

Information given to the consumer is of high importance to make the consumers aware of several aspects of the smart meter, such as the installation, the value propositions existing and the regulation framework in place

- Has the consumer received information before the installation? (letter/telephone/...)
  - Yes → 4 pts
  - No
- Has an advertisement campaign been set in place for the Smart Meter? (website/social media/newspaper/TV/brochures/...)
  - Yes → 3 pts
  - No
- Has an advertisement campaign been set in place for the Value Propositions? (website/social media/newspaper/TV/brochures/...)
  - Yes → 3 pts
  - No

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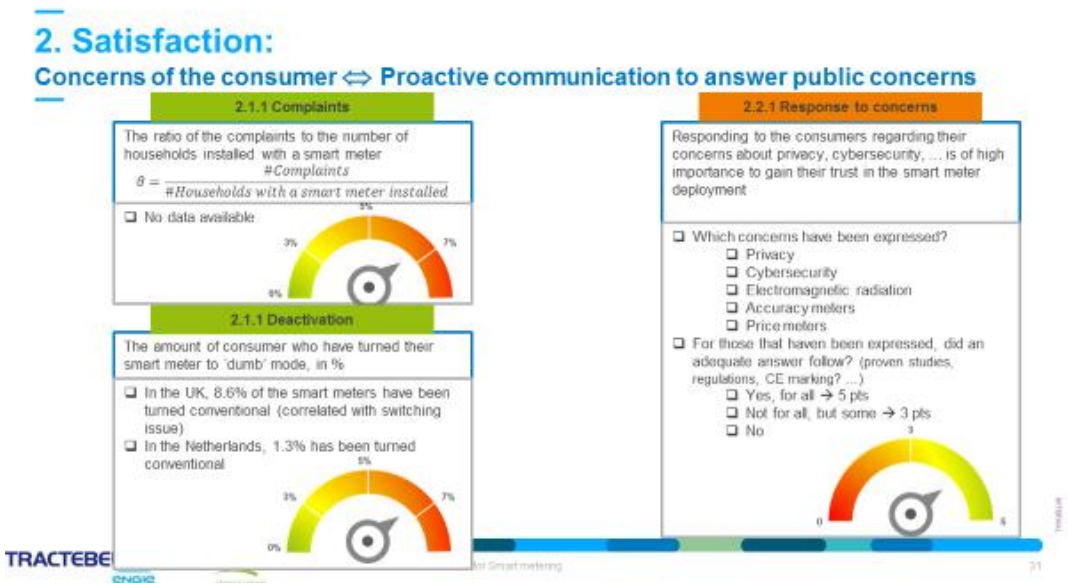
2. Satisfaction:
Concerns of the consumer ⇔ Proactive communication to answer public concerns
2.1.1 Complaints
The ratio of the complaints to the number of households installed with a smart meter
$\theta = \frac{\#Complaints}{\#Households\ with\ a\ smart\ meter\ installed}$
No data available
2.1.1 Deactivation
The amount of consumer who have turned their smart meter to 'dumb' mode, in %
In the UK, 8.6% of the smart meters have been turned conventional (correlated with switching issue)
In the Netherlands, 1.3% has been turned conventional
2.2.1 Response to concerns
Responding to the consumers regarding their concerns about privacy, cybersecurity, … is of high importance to gain their trust in the smart meter deployment
Which concerns have been expressed?
Privacy
Cybersecurity
Electromagnetic radiation
Accuracy meters
Price meters
For those that haven been expressed, did an adequate answer follow? (proven studies, regulations, CE marking? …)
Yes, for all → 5 pts
Not for all, but some → 3 pts
No
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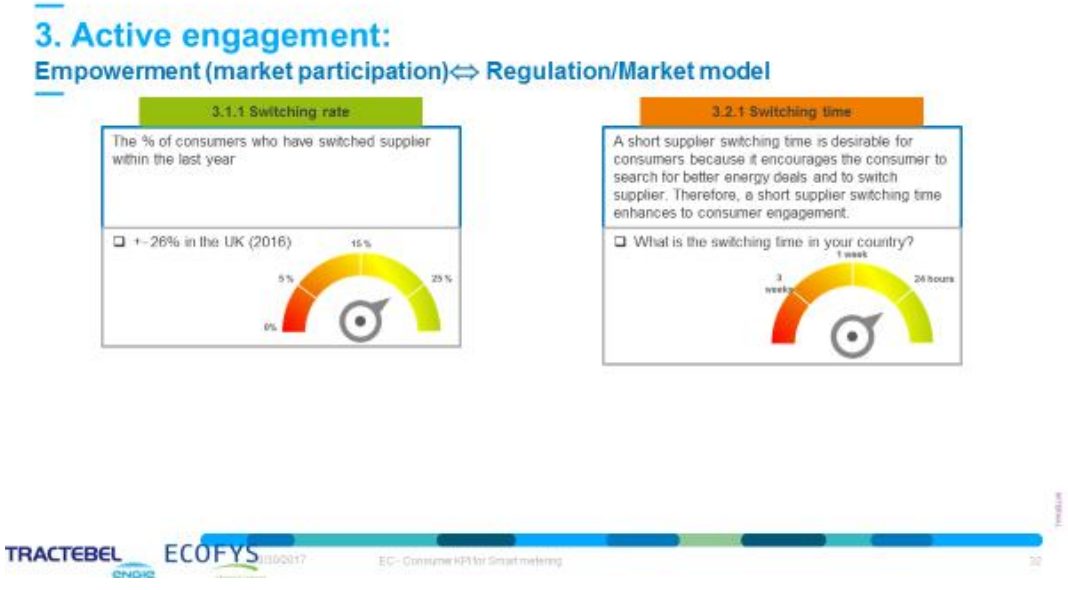
3. Active engagement:
Empowerment (market participation)⇔ Regulation/Market model
3.1.1 Switching rate
The % of consumers who have switched supplier within the last year
+- 26% in the UK (2016)
3.2.1 Switching time
A short supplier switching time is desirable for consumers because it encourages the consumer to search for better energy deals and to switch supplier. Therefore, a short supplier switching time enhances to consumer engagement.
What is the switching time in your country?
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4. Benefit realisation:

Benefits ⇔ Available value propositions

4.1.1 Achieved benefits

The ratio of the realized energy consumption reduction to expected energy consumption reduction of the consumers, in %

$$\theta = \frac{Realized\ energy\ consumption\ reduction}{Expected\ energy\ consumption\ reduction}$$

- In the UK, θ is between 70-110%
- In the Netherlands, $\theta < 31\%$

4.2.1 Available Value Propositions

A high number of value propositions will increase the number of different segments of consumers that will be able to benefit from the smart meter deployment

- Is Real time consumption/cost, historical consumption and dynamic tariffs (explicit DR) available? (all 3)
  - Yes → 4 pts
  - No
- Are there Value Propositions available for economic vulnerable consumers? (prepayment, social tariffs)
  - Yes → 4 pts
  - No
- Are there Value Propositions available for non-economic vulnerable consumers? (Unusual usage alert, fuel poverty detection, ...)
  - Yes → 2 pts
  - No

Implementing the KPI framework

Key success factors

KPI	Relevance	Computability	Comparability across Member States
1. Access to information			
1.1.1 Awareness of installation		Difficult, survey	If same survey spread to all MS
1.1.2 Awareness of value propositions			
1.2.1 Communication campaign level			
2. Satisfaction			
2.1.1 Complaints			
2.1.2 Deactivation			
2.2.1 Response to concerns			
3. Active engagement			
3.1.1 Switching rate			
3.2.1 Switching time			
4. Benefit realisation			
4.1.1 Achieved benefits			
4.2.1 Available value propositions			

05

Summary finding from NRA questionnaire and discussion

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Comments in the survey

Comments	Response
— There should be more focus on **market and consumer actions**	➢ Will be covered in the second part of the study
— Every Member State did **research on consumer benefits**, so this criteria doesn't add anything to the model	➢ Not all Member States did this research, in tot 7 Member States didn't include consumer benefits in their CBA
— Why are only functionalities a, b and f included in the **functionality criteria**?	➢ Functionalities were valued as most important for consumer benefits
— There were some comments on the **order of the criteria**	➢ The order is set up in a way that consumer benefits become more important for higher levels of maturity
— Comments on individual **ranking**	➢ Still need to verify the answers with the Member States

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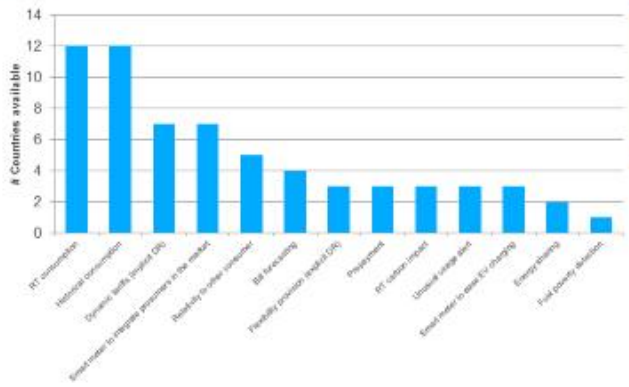
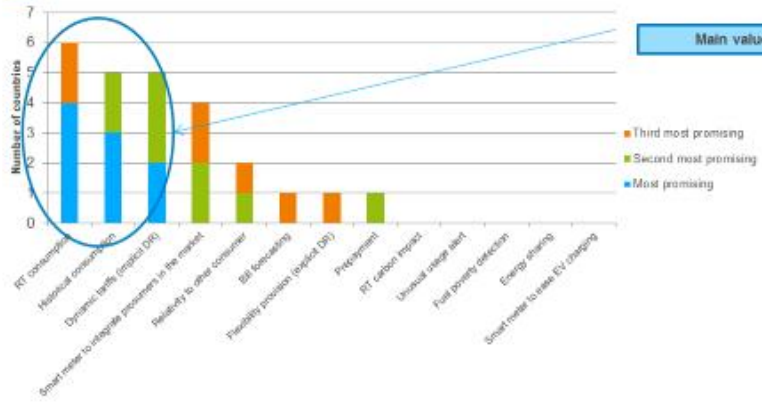
Value propositions feedback [1/2] (answer 14 NRAs)



Other VP proposed

- Incentive consumers to get a smart meter with a discounted tariff
- With SMETS2 deployment, third parties will be able to offer consumer access devices that connect to the smart meter
- Tool for bill verification (verify billing with consumption data and market values)
- Fraud detection
- Power quality monitoring

Value propositions feedback [2/2] (answer 7 NRAs)



Main value propositions

Examples value propositions
Real time information – Portugal, UK

- InovGrid - Portugal
  - Web services and applications
  - (130,000 consumers) → Reduction energy consumption between 3.9-6.6%
  - 6 million customers by 2020

- UK
  - Real-time information on IHD or application

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Examples value propositions
Historical consumption - France

- Access online to up to two years of consumption history online
- Consumers can set consumption targets

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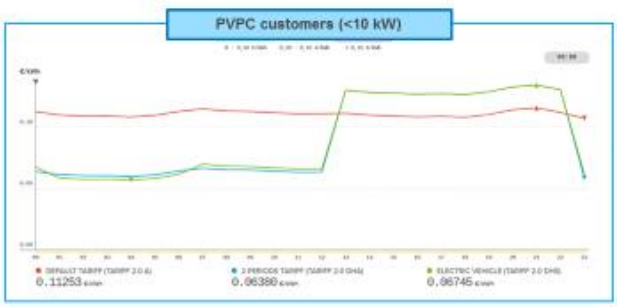
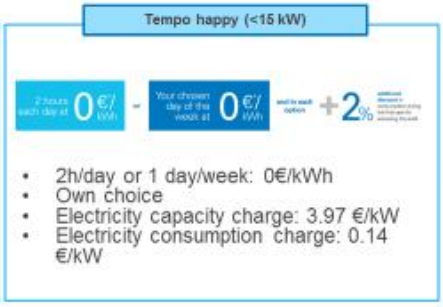
Examples value propositions answers survey
Dynamic tariffs – Spain – PVPC customers (<10 kW)





- 2h/day or 1 day/week: 0€/kWh
- Own choice
- Electricity capacity charge: 3.97 €/kW
- Electricity consumption charge: 0.14 €/kW

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Examples value propositions
Prepayment - UK

E-ON Energy
- Pay As You Go
- Balance alerts
- Top up anywhere (smartphone, app, computer)

British Gas
- Pay As You Go
- Shows how much energy you use in £
- Top up anywhere (smartphone, app, computer, phone, shop)

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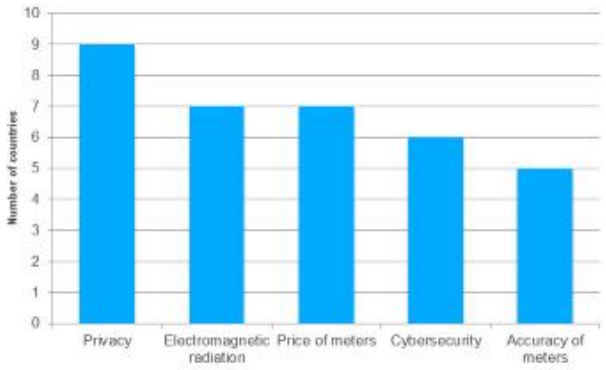
Consumer concerns (answer 12 NRAs)



Answers to concerns

- France: Proven studies
- UK:
  - Privacy: UK Data Protection Act & Suppliers must seek content from consumer
  - Electromagnetic radiation: Public Health England → Radio waves produced by SM low compared to ICNIRP guidelines (International Commission on Non-Ionizing Radiation Protection) and pose no health risk
  - Cybersecurity: State that various protections built in Smart Meters
  - Accuracy meters: Smart Metering Equipment Technical Specifications → minimum functional requirement Smart Meters. Possibility to independently test Smart Meter if consumer suspects an error
- Norway: Information on websites and newspapers
- Portugal: Concerns expressed to ERSE, answered accordingly
- Italy: 2G Smart Meters, state that 2G can not cost more than first generation Smart Meters

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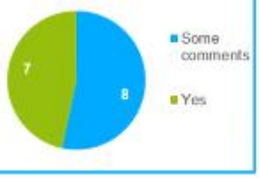
Consumer segmentation (answer 15 NRAs)

Parameters relevant and complete



Feedback segmentation

- DSO not related to consumer segmentation
- We miss energy poverty/vulnerable consumer → included in income/health impairment
- Add: Socio-professional category → Related to income / ICT skills
- Number of persons in household redundant → There is a link with the annual consumption, but for families living in financial stressful situations, this parameter can be of importance for vulnerable consumers
- Availability data problematic → Surveys, consumer segments can be seen as guideline for provision of value propositions
- Add payment method → Is seen as a value proposition (prepayment)
- Main heat source → Related to yearly electricity consumption, comment of importance of this parameter will be added in report
- Household with different age categories (ex young families living with parents) → Usually there is a main person in a household in charge of important decisions, base segmentation on that person

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Consumer survey – UK

Post-installation satisfaction survey

Participants = 2,015 smart meter customers

Margin of Error $MOE = \frac{1}{\sqrt{n}} = 2.2\%$

Age	Frequency	Percent
18-34	271	14%
35-44	235	12%
45-55	521	26%
55-64	243	12%
65-74	458	23%
75 and over	240	12%
Refused	44	2%

Payment type	Frequency	Percent
PPM	469	23%
Not PPM	1546	77%

Fuel type	Frequency	Percent
Electric	208	10%
Dual	1807	90%

Working status	Frequency	Percent
Working full time (30+ hours per week)	593	29%
Working part time (less than 30 hours a week)	296	15%
Retired/Not working with private pensions/means	449	22%
Unemployed	179	9%
Retired with state benefit/ pension only	332	16%
Not working with state benefit only	80	4%
Student	33	1%
Refused	68	3%

Total household income	Frequency	Percent
Less than £16,000 per year	631	31%
£16,000 - £30,000 a year	499	22%
£31,000 - £50,000 a year	301	15%
Above £50,000 a year	246	12%
Don't know	137	7%
Refused	271	13%

Gender	Frequency	Percent
Male	938	47%
Female	1072	53%
Unsure/Refused	5	*

Information viewed on IHD	All (1,763)	PPM (391)	Non-PPM (1,372)
Electricity use at that point in time	63%	58%	64%
Electricity used over the last week or month	57%	60%	57%
Traffic lights	55%	48%	56%
Carbon you have emitted	15%	17%	15%
Remaining credit balance	N/A	57%	N/A
Low credit alerts	N/A	36%	N/A
Debt balance	N/A	26%	N/A

Applied uses of IHD	All (1,763)	PPM (391)	Non-PPM (1,372)
Set a baseline	25%	30%	22%
Set a budget	10%	15%	9%
Check nothing is left on when you go out or go to sleep	23%	25%	22%
Encourage others in household to reduce their energy use	40%	42%	39%

Satisfaction with key elements of the smart meter installation visit:

Reasons for getting the installation (multiple choice)

Pre-payment customers	Non-PPM customers
Being able to top up in different ways (33%)	Being able to see how much energy I'm using (34%)
Being able to see how much energy I'm using (26%)	Not having to submit meter readings/ more convenient (31%)
It's more convenient (14%)	Accurate bills (17%)
Save money on energy (12%)	I was told/ thought I had to (14%)
Seeing my energy account balance (11%)	Necessary/ part of a general upgrade (13%)

Base: 2,015 smart meter customers / 469 PPM / 1,546 non-PPM

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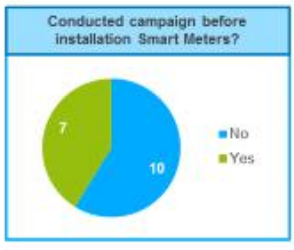
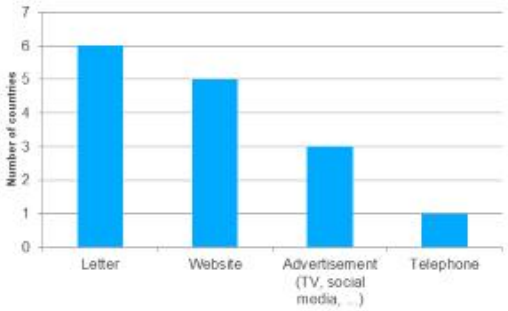
Communication campaign (answer 16 NRAs)





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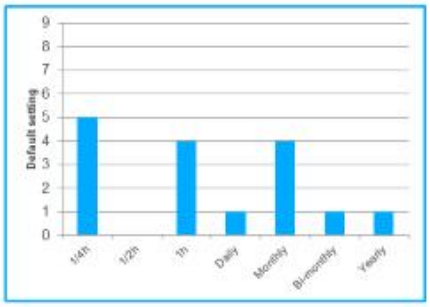
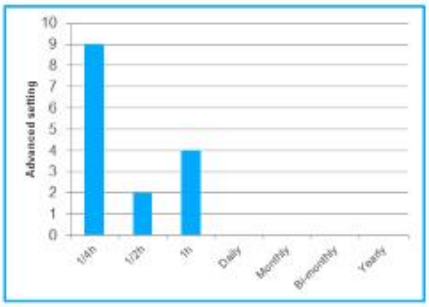
Reading meters (answer 14 NRAs)





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Privacy design features – May the consumer refuse?

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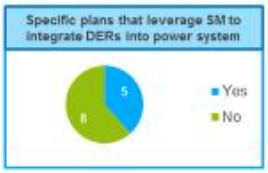
Other results survey



Research consumer benefits - Ireland

- CER
- Consumer behaviour trials with 5,000 participants for gas and electricity Smart Meters
- ToU tariffs, accurate billing and richer information → 3% overall usage reduction and peak reduction of 8.8%
- IHD important for achieving peak reduction and night rates

	Day Rate	Peak Rate	Day Rate	Night Rate
Timeband	8am – 5pm	5pm – 7pm	7pm – 11pm	11pm – 8am
Unit Rate (excl. VAT)				

Tariff Groups A-D by DSM Stimulus

Usage	All Tariff Groups and DSM Stimuli	Bi-monthly Bill and energy usage statement (Stimulus 1) %	Monthly Bill and energy usage statement (Stimulus 2) %	Bi-monthly Bill, energy usage statement and electricity monitor (Stimulus 3) %	Bi-monthly Bill, energy usage statement and OLR incentive (Stimulus 4) %
Overall	-2.5*	-1.1	-2.7*	-3.2*	-2.9*
Peak	-8.8*	-6.9*	-8.4*	-11.3*	-8.3*

* denotes results statistically significantly different from control group using a 90% confidence level.

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