Study on cost benefit analysis of

Smart Metering Systems in EU Member States

FINAL REPORT

Institute of Communication & Computer Systems of the National Technical University of Athens ICCS-NTUA

AF-MERCADOS EMI

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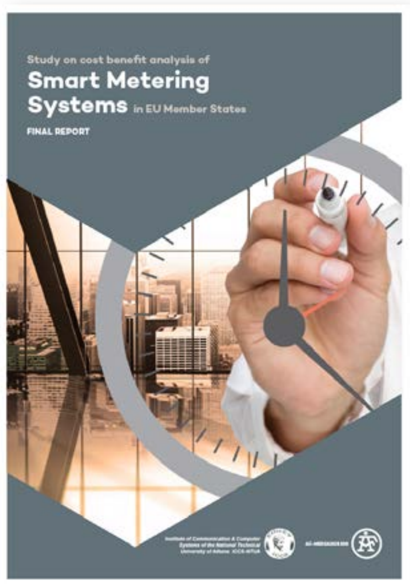

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Content

Enclosures

Executive Summary

This report presents findings of a review of the cost benefit analyses (CBA) of a widespread roll out of smart metering systems performed in various Member States (MS).

As a first step, and to provide context to the study, high level benchmarking was undertaken of the data in the CBAs, resulting in the following key findings on reported costs and benefits:

- The predominant cost driver is the meter and associated installation costs. Meter-related costs vary significantly across the CBAs, in part reflecting wide divergence in estimates of the type and cost of the smart meter, differences in labour costs (installation), and complementary investment identified in some cases (for example, meter boards and wiring). In practice, experience from large-scale rollouts supports costs towards the lower end of the range identified in the CBAs.
- There is a wide range in communications technologies and associated costs across MS. In particular, overall costs are highly sensitive to the extent to which GPRS and UMTS are adopted. While the appropriate choice of communications technology is location specific, advances in the cheaper PLC technology increasingly support its widespread use for data transfer where feasible.
- The key driver of benefits in most cases is the electricity efficiency and shifting benefits (electricity cost savings) available to customers, with important benefits also obtained by the DSO from savings in meter reading and operations costs and reduction in commercial losses. The CBAs suggest that relatively basic functionality can facilitate significant savings in meter reading costs and commercial losses. However, to obtain full benefits, particularly consumption-related ones, greater meter functionality is required. Notably, the CBAs show no link between cost and functionality.

A review of CBAs in a small sample of MS with positive results was carried out. This review showed that positive results for a wide spread roll out of smart metering have been achieved in a range of operating conditions and jurisdictional arrangements, including the supplier led roll out in Great Britain using a data communications hub, and distributor led models in the other jurisdictions. The CBAs in Great Britain, Netherlands and Romania have all considered electricity and gas, with joint provision of infrastructure proposed in Great Britain and the Netherlands. Where common infrastructure exists and/or benefits arise that can be spread across the two services the results of the CBA appear more robust including gas than if an electricity-only net benefit is estimated.

For the MS reporting negative or inconclusive results a two-stage process was adopted, in which the first stage involved a review of the MS CBAs. Key findings from this analysis include that:

- A number of these studies report high cost solutions, with in some cases this also being accompanied by high benefits. In some cases, key drivers are high cost metering and communications systems, which differ significantly from those reported in the CBAs with positive results.

- Many MS report country-specific features. For example: due to commonality in gas and electricity supply in the Belgian jurisdictions a dual fuel CBA is provided; the Czech Republic reports that due to its ripple control system of load control potential benefits from smart metering are low; while Lithuania states that low energy prices and relatively shallow peaks in electricity consumption limit potential benefits. None of these factors supports increased costs of smart metering per se, though the impact on the ability to obtain consumption-related benefits, including load shifting in the Czech Republic and Lithuania is important.
- The negative or inconclusive results are highly sensitive in some cases to key variables. The results in Germany can change dramatically based on the assumed consumption impact, while the CBAs in Portugal and the Slovak Republic can be interpreted as a positive rather than inconclusive or negative result.

In the second stage, the CBAs of the MS with negative or inconclusive results were recreated to the best extent possible using the MS data to better understand the key dynamics of the CBA. Based on this assessment a number of common issues have been identified:

- A consistent approach to meter replacement is not always adopted. In some cases, meter replacement is included in the CBA as an additional cost but commensurate benefits are not included, either explicitly or through the use of a terminal value. A simpler approach of aligning the modelling period to the asset life is recommended.
- There is not a consistent approach to cost allocation, or the attribution of benefits that may apply to services outside smart metering. At times infrastructure is introduced simultaneously with the smart meters – for example, wiring, new meter boxes that potentially provides general benefits to the distribution system as well as facilitating smart meter implementation. In other cases, the introduction of communications technology may provide the potential to sell non-meter related services, include smart grid services that are not reflected in the CBA.
- The avoided cost of standard meters is not included in all CBAs either directly or indirectly through adjustment to the smart meter cost. This benefit (or negative cost) should be incorporated in all analyses.
- Some MS note that local regulations necessitate meter certification in periods that are less than the economic life of smart meters. Where this is the case, the potential to receive the full benefits of the smart meters may be jeopardised as meters will need to be replaced or removed while still providing strong benefits.
- A consistent approach to key issues of the modelling period, including meter replacement, cost allocation and functionality, would promote comparability, and will potentially produce positive results in several cases without the need to alter key input data.

Other key findings include:

- There is not a common approach to the dissemination of results. Some CBAs are not in the public domain, while others are not readily accessible. Effective dissemination of results is an important step towards customer and broader stakeholder engagement.
- Due to technological change and experience from rollouts, there is a need for regular revision of costs and benefits. The revision is particular important in cases where roll out has been initiated to better understand key cost and benefit drivers, to inform the public of the accrued benefits, and to adjust the programme where necessary.
- Data privacy has been raised as an increasingly important issue in some MS. The response to these issues has the potential to raise costs and/or reduce benefits without appropriate regulatory or policy measures that link privacy and security to functionality in particular.

Recommendations

The following table set out the key recommendations, which are set out under four related categories – CBA methodology and functionality, cost-related issues, benefit-related issues and communications.

TABLE 1

KEY RECOMMENDATIONS

Category	Finding	Recommendation	Addressed Parties
A. METHODOLOGY AND FUNCTIONALITY			
Harmonization of methodology	Wide range of approaches to CBA adopted makes comparison difficult	Review of Recommendation 2012/148/EU should be undertaken to establish a base case for the CBAs of all MS, harmonizing critical values (modelling period, cost allocation, meter replacement, functionality)	**European Commission**
Functionality to be incorporated in the core CBA scenario	Positive link between functionalities and net benefits apparent in some cases	MS should review the functionality built into the CBA scenarios, particularly those that allow for effective demand response and in turn cost reductions for consumers and avoided network/generation costs	**Member States**
		The positive impacts of having the full set of functionalities available for all consumers should be further analysed.	**European Commission**

Category	Finding	Recommendation	Addressed Parties
Cyber-security	MS concerns over cyber-security are increasing, which is affecting proposed functionalities in some cases. One example is the decision in the Netherlands to remove the option of remote switch on/off.	The work of the Commission's Expert Group 2, which is currently mapping cyber-security issues by functionality, is critical. The group is tasked to consider mitigation measures based on best available techniques, including mitigation measures for cyber-attacks. A reference document is to be produced by the end of 2016. The EC is encouraged to follow up on cyber-security aspects in order to produce standard recommendations for all MS	**European Commission**
Data privacy and security issues related to implementation	Data privacy is of growing concerns in some MS, leading to the adoption of different solutions and technologies. One example is the communications gateway system adopted in Germany	Implementation of Commission recommendation 2014/724/EU on the Data Protection Impact Assessment (DPIA) template for Smart Grid and Smart Metering systems is critical to ensure no security or privacy issue arises when implementing smart metering systems.	**Member States**
Treatment of visual displays	Wide range of approaches to visual displays permitted, but consistent approach not always applied in CBAs	Due to fast pace of technological developments CBAs should consider most cost effective option, particularly in developing pilot projects.	**Member States**
Discount rate	General consistency in approach to the discount rate adopted but with PT an outlier	Divergences from core values across the EU (currently 4-6%) should be clearly justified	**Member States (specifically PT)**
Meter certification/life	In some MS local regulations require meter certification for periods shorter than the economic life of the meter	Review of local legislation and regulations essential to not impede an economically justified widespread roll out	**Member States (particularly CZ, HU)**
Technical architecture	Impediments to roll-out of smart meters identified in some MS (e.g., circuit breakers upstream of the meter may not be of use if smart meters are operational)	The EC is encouraged to work closely with the MS to assess whether existing regulations should be reviewed to adapt these to the Smart Grid environment	**European Commission**

Category	Finding	Recommendation	Addressed Parties
Potential for opt-in approaches	In cases where a large-scale rollout is not proposed, particular customers may benefit from the installation of smart metering systems.	Customers should have the right to request the installation of a smart metering system at a fair price. One way to facilitate this would be allow the retailers to install a smart meter (in parallel or replacing the existing one). Since the electricity network is not property of the retailer, the communications solutions must be either independent (GPRS, ADSL, etc.) or negotiated with the utility (PLC).	**Member States**
B. COST RELATED ISSUES			
Dispersion in meter costs	There is a wide range in meter costs that reflect divergences in the estimates of the type of meter, the cost of the meter, installation and associated works. The variation is greater than would be expected considering interoperability requirements.	There is a need to consider standardized metering solutions in CBAs as opposed to tailored solutions used in pilots or specific requests to manufacturers	**Member States**
		The MS need to ensure compliance with interoperability requirements in the 3rd Package as they relate to metering technology. Interoperability should necessarily lead to greater standardization of metering solutions and hence cost reductions due to economies of scale.	**Member States**
Treatment of meter replacement	There is a potential overstatement of cost in some CBAs due to inclusion of costs of meter replacement without full associated benefits	Equivalent treatment of costs and benefits required in the case of meter replacement. Simplest approach is to align modelling period with the asset life without replacement.	**Member States (specifically BE-BR and DE in relation to meter replacement)**
Cost allocation between metering and other services	A number of costs/ services that are not directly meter-related are included in some CBAs	Apportionment of common costs to metering services when the infrastructure provides additional benefits that are not included in the CBA should be clearly justified (e.g., smart grid, distribution enhancement, and other utility services).	**Member States**
Communications technology and cost	There are a wide range in communications technologies and costs that significantly affect overall CBA result	MS should review communication technology, particularly where widespread use of GPRS or UMTS is proposed in the light of developments with PLC	**Member States**

Category	Finding	Recommendation	Addressed Parties
C. BENEFIT RELATED ISSUES			
Avoided cost of standard metering	The avoided cost of standard metering is not included, or is unclear in some CBAs	The avoided cost of standard metering is a key benefit that should be included in all CBAs	**Member States (treatment in NL, BE-WA, HU, SK unclear)**
Approach to peak load transfer	The approach to peak load transfer is not fully coherent in many cases	The relationship between dynamic pricing and peak load deferral and between technical losses and peak load deferral should be investigated further. Experience shows that peak load reduction, at a minimum, reduces technical losses.	**Member States**
D. COMMUNICATIONS			
Public dissemination of results	Some CBAs are not in the public domain or easily accessible	Public reporting of CBA findings is essential to engage key stakeholders, including the public, prior to a widespread roll out.	**Member States**
Updates to CBA reports	Technological change and experience from roll-out provides important new data for the MS in question	Regular revision in CBAs for changes in costs and findings of pilot projects and experience in widespread rollout is supported.	**Member States**
	Change in circumstances of MS provides important EU-wide information	The Commission's benchmarking report should be updated consistent with amendments/updates in MS CBAs.	**European Commission**

1. Introduction

This report reflects the final deliverable in the assessment of the cost benefit analysis (CBA) of a widespread roll out of smart metering systems in Member States (MS). It considers the context to the project, and findings related to the projects key tasks, including:

- Evaluation of cases where the CBA for the roll out of smart meters is positive (Task 1), which involves assessment of the extent to which the methodology employed in a sample of countries reporting a positive result in their CBA is consistent with the Commission's methodology. In the case of divergences with the methodology, sensitivity analysis is to be conducted in order to assess if the following the recommended methodology would give a different result, with lessons learnt highlighted.
- Evaluation of cases where the CBA for the roll out of smart meters is negative or inconclusive (Task 2), which involves assessment of the methodology used, and assumptions adopted, in countries where a roll out of smart meters is assessed as negative or inconclusive. In particular, this task will assess the extent to which the methodology employed in these countries is consistent with the Commission's methodology.
- Carry out a cost benefit assessment applying the recommended methodology, and in the light of lessons learned from the first step, in all cases where there was a negative/inconclusive outcome in the national CBA for large-scale deployment of smart metering by 2020 (Task 3).
- Formulate country-specific recommendations to the Commission based on findings (Task 4).
- Analyse and develop a set of regulatory and non-regulatory options at EU level for the successful rollout of smart metering (Task 5).

1.1. Relation with Commission's Benchmarking Report

This project is designed to complement and extend the analysis undertaken by the Commission in its Benchmarking Smart Metering Deployment study of June 2014 (COM(2014)356).[1] This report includes assessment of the CBAs in those countries where the result was reported in the Commission's Report COM(2014)356 as negative or inconclusive, and considers a subset or sample of those CBAs with positive results. The phase of re-running the CBAs in a harmonised way and based on the methodology in the Commission's Recommendation 2012/148/EU, in particular, is designed to extend the Commission's analysis and better understand the key drivers of the results in those MS reporting a negative or inconclusive finding.

1 *European Commission, Report: Benchmarking smart metering deployment in the EU-27 with a focus on Electricity, COM(2014) 356, Brussels, 17 June 2014; European Commission, DG-Energy, Cost-benefit analyses & state of play of smart metering deployment in the EU-27, Staff Working Document (2014) 189, Brussels, 17 June 2014; and European Commission, DG-Energy, country fiches for electricity smart metering, Staff Working Document (2014) 188, Brussels, 17 June 2014.*

In several cases, the numbers reported in this document differ from those in the benchmarking report: in general, the changes reflect either new information or different means of calculations adopted in this report – for example, the estimation of costs and benefits of a joint electricity and gas CBA that can be attributed to electricity. These differences are summarised in section 3.1

1.2. Data requirements

In developing this report, principal reliance has been placed to date on publicly available information, supplemented by requests to, and discussions with various MS. The following table outlines the publicly available CBA reports reviewed:

TABLE 2

KEY DATA SOURCES FOR CBA

Country	Key sources for CBA analysis
Great Britain	• “Smart meter roll-out for the domestic and small and medium non-domestic sectors (GB): Impact Assessment” Department of Environment and Climate Change, January 2014
Netherlands	• “Smart meters in the Netherlands: Revised financial analysis and policy advice”, KEMA, July 2010 • “Implementing smart metering infrastructure at small-scale customers”, SenterNovem, October 2005
Romania	“Smart metering in Romania”, AT Kearney, September 2012
Belgium – Brussels	• “Opportunité du comptage intelligent en Région de Bruxelles”, PWC, February 2012 • “Potentiële functionaliteiten van Intelligente Tellers in de Brusselse (energie) distributie markt - Studie in opdracht van Brugel” Capgemini consulting, May 2011 • “Fonctionnalités potentielles des compteurs intelligents pour le marché de distribution de l’énergie bruxellois: Etude réalisée pour le compte de Brugel”, Capgemini consulting, May 2011
Belgium – Flanders	• “Rapport van de Vlaamse Regulator van de Elektriciteits- en Gasmarktvan 14 maart 2014 met betrekking tot de actualisatie van de kosten-batenanalyse slimme meters” RAPP-2014-02 • “Financiële haalbaarheid slimme energiemeters in Vlaanderen: Een kosten-batenanalyse in maatschappelijk perspectief”, KEMA, January 2012
Belgium – Wallonia	• “Etude portant sur la mise en oeuvre des compteurs intelligents, leurs fonctionnalités ainsi que leurs coûts et bénéfices en Wallonie pour les acteurs du marché de l’énergie et la société”, Capgemini Consulting June 2012
Czech Republic	• “Ekonomické posouzení všech dlouhodobých přínosů a nákladů pro trh a jednotlivé zákazníky při zavedení inteligentních měřicích systémů v elektroenergetice ČR” Ministerstvo Průmyslu A Obchodu (including unofficial translation into English)
Germany	• “Kosten-Nutzen-Analyse für einen flächendeckenden Einsatz intelligenter Zähler”, Ernst & Young, 2013 • “Cost-benefit analysis for the comprehensive use of smart metering. On behalf of the Federal Ministry of Economics and Technology”, Ernst & Young, 2013

Country	Key sources for CBA analysis
Lithuania	• "Cost-benefit analysis of the roll-out of smart electricity metering grid in Lithuania: Cost-benefit analysis of the smart metering roll-out Scenarios", Ernst & Young, September 2012
Portugal	• "Estudo sobre contadores inteligentes de electricidade e de gás natural • Relatório 3E/G: Análise Custo-Benefício para os sectores da electricidade e do gás natural", KEMA, May 2012
Slovak Republic	• "Economic Assessment of the Long-term Costs and Benefits of Smart Metering Implementation in the Electricity Sector". Regulatory Office for Network Industries, August 2012

In the case of Latvia a CBA was not provided prior to developing this report. A CBA has been received from Hungary, and is reviewed in this report, but this is not publicly available. Note that the reports used for Flanders and Great Britain have been updated since the publication of the Commission's Smart Metering Benchmarking Report (COM (2014)356).

Requests for additional information and/or meetings were sent to the majority of countries considered in the study. In addition to email correspondence, conversations were held with members of the following entities in the early part of the study:

- Great Britain: DECC
- Italy: Enel
- Belgium – Flanders: VREG
- Czech Republic: Ministry of Industry and Trade
- Germany: Federal Ministry for Economic Affairs and Energy

Moreover, stakeholder feedback was received at, and subsequent to, the following two workshops:

- The first, held on 3 February 2015 with relevant MS to discuss the findings of the Interim Report, which focused on Tasks 1 and 2 of this project.
- The second, held on 26 March 2015 and open to all MS, to discuss the findings of the Draft Final Report.

1.3. Structure of the report

The remainder of this report is structured as follows:

- Section 2 provides context to the study.
- Section 3 outlines general findings of high level benchmarking and recent studies.
- Section 4 sets out draft findings in the sample of countries where the roll out is assessed as providing positive results.

- Section 5 considers countries where the CBA has negative or inconclusive results.
- Section 6 sets out draft findings of more detailed analysis of country CBAs.
- Section 7 considers regulatory and non-regulatory elements necessary for successful implementation.
- Section 8 includes key findings and recommendations.
- Section 9 set out key references.

In addition, a separate annex is provided, which sets out more detailed analysis regarding the Task 1 and Task 2 reviews of MS CBAs, the key findings of which are considered in sections 4 and 5.

2. Context to the study

Commission Directive 2009/72/EC requires that MS undertake a CBA regarding the widespread roll out of smart meters. Annex 1 (2) specifies the following:

"Member States shall ensure the implementation of intelligent metering systems that shall assist the active participation of consumers in the electricity supply market. The implementation of those metering systems may be subject to an economic assessment of all the long-term costs and benefits to the market and the individual consumer or which form of intelligent metering is economically reasonable and cost-effective and which timeframe is feasible for their distribution.

Such assessment shall take place by 3 September 2012.

Subject to that assessment, Member States or any competent authority they designate shall prepare a timetable with a target of up to 10 years for the implementation of intelligent metering systems. Where roll-out of smart meters is assessed positively, at least 80 % of consumers shall be equipped with intelligent metering systems by 2020.

The Member States, or any competent authority they designate, shall ensure the interoperability of those metering systems to be implemented within their territories and shall have due regard to the use of appropriate standards and best practice and the importance of the development of the internal market in electricity."

The recommended methodological approach to developing a CBA is set out in the Commission's Recommendation 2012/148/EU.[2] Key aspects to this methodology include:

- The specified approach to carrying out a CBA
- Minimum functionality of the smart metering system
- Costs to be considered in the CBA
- Benefits to be considered in the CBA

2.1. Approach to carrying out a CBA

Recommendation 2012/148/EU provides a framework for conducting a consistent, credible and transparent economic assessment of the long-term costs and benefits of the roll out of smart metering.

The key components of this approach are:

- Tailoring to local conditions –including the incorporation of the results of pilot projects, field performance and other pertinent "real life" experience.
- Conducting a CBA, incorporating the following seven key steps:
    - Review and describe technologies, elements and goals
    - Map assets into functionalities

2 *Commission Recommendation 2012/148/EU of 9 March 2012 on preparations for the rollout of smart metering systems (OJ L 73, 13.3.2012, p.9).*

  - Map functionalities into benefits
  - Establish the baseline
  - Monetise benefits and identify beneficiaries
  - Identify and quantify costs
  - Compare costs and benefits

- Carry out sensitivity analysis, including the reporting of the magnitude of variable range.
- Assess externalities (such as the environment and health), the impact of public policy measures and social benefits expected from the roll out of smart metering systems.

As the methodology set out in Recommendation 2012/148/EU is not obligatory, in some cases there is significant divergence in approach to developing the CBA. In addition, it should be noted that some MS undertook their CBA prior to the release of Recommendation 2012/148/EU. However, the framework set out in Recommendation 2012/148/EU forms the logical benchmark for this exercise, with any subsequent methodological departures, including the inclusion of additional costs and benefits, or removal of specified costs and benefits, to be evaluated based on country specific factors and more general experience gained since the release of the Commission's methodology.

In the implementation of this methodological approach, various factors need to be considered, including:

- The distinction between economic and private costs and benefits. The principal purpose of the CBA is to determine if a widespread rollout of smart meters is economic for the country as a whole. In practice, certain participants may bear a disproportionate share of the costs, which by itself does not provide grounds for overturning the results. However, distribution issues are critical at the implementation stage, and in particular in the development of policy recommendations.
- The period of analysis, including whether replacement of "new" assets (smart meters/communications equipment) is to be considered, and in any case, the terminal value of these assets at the end of the modelling period, where a residual value of assets will be present.
- The time profile of costs and benefits, in particular in the period of the roll out.
- The discount rate to be applied.

2.2. Minimum functionality

Recommendation 2012/148/EU also sets out common minimum functionality requirements for smart metering systems for electricity. Understanding these requirements is critical for ensuring comparability in the CBA, and in particular, to be able to make comparisons where countries are proposing different technical solutions and have different overall objectives for the CBA. The minimum functionality requirements cover the needs of customers, meter operators, commercial aspects of supply, security and data protection and distributed generation, and are summarised below:

TABLE 3

RECOMMENDED MINIMUM FUNCTIONALITIES

Party		Functionality	Additional information on key features and requirements
Customer	**A**	Provide readings directly to the customer and any third party designated by the consumer	Provision of standardised interfaces to enable energy management solutions in 'real time', such as home automation. Accurate, user-friendly and timely readings provided directly from the interface of customer's choice to the customer and any third party designated by the consumer
	B	Update the readings referred to in point (a) frequently enough to allow the information to be used to achieve energy savings	Meet the necessity for the customer to see the information responding to their action, with update of at least every 15 minutes required. Includes data storage within the meter
Metering operator	**C**	Allow remote reading of meters by the operator	Relates to the supply side (meter operators)
	D	Provide two-way communication between the smart metering system and external networks	Includes need to remove manual intervention, time synchronisation and ability to upload new tariffs
	E	Allow readings to be taken frequently enough for the information to be used for network planning	Frequency of data will depend on whether micro (local) or macro (substation) control facilitated
Commercial aspects of metering supply	**F**	Support advanced tariff systems	Smart meter systems should include advanced tariff structures, time of use registers and remote tariff control. System should allow automatic transfer of information about advanced tariff options to the final customer
	G	Allow remote on/off control of the supply and/or flow or power limitation	Should allow for gradings in the limitations – for example in moving home or grid emergencies
Security and data protection	**H**	Provide secure data communications	Key aspects are: privacy, which is the restriction of information to the customer and those authorised by the customer to have access to it; and security, which is the prevention of access to information by unauthorised 3rd parties
	I	Fraud prevention and detection	Includes security and safety in the case of access
Distributed generation	**J**	Provide import/export and reactive metering	Smart metering systems should allow renewable and local micro-generation

An important part of promoting comparability is to evaluate not just absolute but also relative compliance with the minimum requirements, as there is no reason to presuppose that the relationship between functionality, costs and benefits is linear. For example, it is possible that both the following situations may apply depending on the context:

- Highly engineered technical solutions that significantly increase cost but provide minimal benefits.
- Additional functionality due to software modifications that provide significant benefits with a limited impact on costs.

In this regard, recent comments by Meter-ON concerning the relationship between functionality, costs and benefits in a small sample of pilot projects implemented by DSOs are particularly pertinent:(3)

"Five out of the eight roll-out projects participating in Meter-ON provided details of the functionalities they have applied. The results of the analysis were not sufficient to establish a direct link between the project cost per metering point for the DSO and the number of functionalities.

However, the analysis showed a direct link between the number of functionalities and savings per consumer, where a higher number of functionalities translates into higher savings per consumer."

The comments of Meter-ON are also consistent with the findings of the Benchmarking Study of DG-Energy:(4)

"Available data do not indicate a direct link between the range of common minimum functionalities considered for the smart metering systems and their overall cost. As we have noted, total investment appears to be influenced far more by other parameters such as local conditions, additional features beyond the minimum set of functionalities, and the discount rates and appraisal periods considered in the CBAs."

In general, to the extent that expanded functionality is a result of enhancements to software rather increased use of hardware there is a greater expectation that the costs will be relatively low in relation to the benefits provided.

3 *Meter-ON (2014), Steering the implementation of smart metering solutions throughout Europe: Final Report, autumn 2014, p.9.*

4 *European Commission, DG-Energy, Cost-benefit analyses & state of play of smart metering deployment in the EU-27, Staff Working Document (2014) 189, Brussels, 17 June 2014, p.69.*

2.3. Costs to be considered in the CBA

Recommendation 2012/148/EU sets out the following list of non-exhaustive costs to be taken into account in the CBA.

TABLE 4

LIST OF NON-EXHAUSTIVE COSTS TO BE INCLUDED IN THE CBA

General category	Type of cost to be tracked for roll-out and to be estimated for the baseline
CAPEX	Investment in the smart metering systems
	Investment in IT
	Investment in communications
	Investment in in-home displays (if applicable)
	Generation
	Transmission
	Distribution
	Avoided investment in conventional meters (negative cost to be added to the list of benefits)
OPEX	IT maintenance costs
	Network management and front-end costs
	Communication/data transfer costs (inc GPRS, radio communications)
	Scenario management costs
	Replacement/failure of smart metering systems
	Revenue reductions (e.g. through more efficient consumption)
	Generation
	Distribution
	Transmission
	Meter reading
	Call centre/customer care
	Training costs (e.g., customer care personnel and installation personnel)
Reliability	Restoration costs
Environmental	Emission costs (CO_2 control equipment, operations and emissions permit)
Energy Security	Costs of fossil fuels consumed to generate power
	Costs of fossil fuels for transportation and operation
Other	Cost of consumer engagement programmes
	Sunk cost of previously installed (traditional) meters, including recycling costs of old meters

Source: Recommendation 2012/148/EU, Annex, section 4.

Some of the key factors that affect the comparability of costs between countries include:

- Choice of metering equipment
- Communications and IT technology
- Local labour costs

High level benchmarking is undertaken in this report to shed light on these particular issues.

The list of costs above includes items that may also be considered as a benefit – for example, revenue reduction, change in fossil fuel costs and emissions costs. In practice the exact approach adopted (negative costs, or positive benefits) is less significant than ensuring a common approach is applied for the particular items in question.

2.4. Benefits to be considered in the CBA

Recommendation 2012/148/EU sets out formulae for the calculation of the following list of non-exhaustive benefits to be taken into account in the CBA.

TABLE 5

NON-EXHAUSTIVE LIST OF BENEFITS TO BE INCLUDED IN THE CBA

Benefit	Sub-benefit
Reduction in meter reading and operations cost	Reduced meter operations costs
	Reduced meter reading costs
	Reduced billing costs
	Reduced call centre/customer care costs
Reduction in operational and maintenance costs	Reduced maintenance costs of assets
	Reduced costs of equipment breakdowns
Deferred/avoided distribution capacity investments	Deferred distribution capacity investments due to asset remuneration
	Deferred distribution capacity investments due to asset amortisation
Deferred/avoided transmission capacity investments	Deferred transmission capacity investments due to asset remuneration
	Deferred transmission capacity investments due to asset amortisation
Deferred/avoided generation capacity investments	Deferred generation investments for peak load plants
	Deferred generation investments for spinning reserves
Reduction in technical losses of electricity	Reduced technical losses of electricity
Electricity cost savings	Consumption reduction
	Peak load transfer

Benefit	Sub-benefit
Reduction in commercial losses	Reduced electricity theft
	Recovered revenue relating to 'contracted power' fraud
	Recovered revenue relating to incremental 'contracted power'
Reduction of outage times	Value of service
	Reduced cost of client indemnification
Reduction of CO_2 emissions	Reduced CO_2 emissions due to reduced line losses
	Reduced CO_2 emissions due to wider spread of low carbon generation sources
	Reduced CO_2 emissions due to truck rolls of field personnel
Reduction of air pollution	Reduced fuel usage due to truck rolls of field personnel
	Reduced air pollutants emissions due to reduced line losses
	Reduced air pollutants emissions due to wider diffusion of low carbon generation sources
	Reduced air pollutants emissions due to truck rolls of field personnel

Source: Recommendation 2012/148/EU, Annex, section 5.

The exact formulae proposed are set out in the annexes to Recommendation 2012/148/EU.

The benefits of a smart meter rollout will not be uniform across MS and will be highly influenced by the starting conditions of the country. For example, smart meters have been shown to provide significant benefits to the DSO in countries with high levels of theft and commercial losses. However, in countries where commercial losses are already relatively low, the impact of smart meters may be more apparent in other areas – particularly the willingness of the customer to adjust consumption behaviour in response to having the smart meter and receiving new price signals.

Similarly, the scope to defer peak investment, reduce technical losses and reduce the time of outages will depend on the starting position of the country, while the scope to reduce meter reading costs will depend on the existing regulatory requirements regarding meter reading and the local labour costs.

3. Preliminary findings

3.1. Benchmarking key data in the studies considered

As empirical context to the study, high level benchmarking has been undertaken of key costs and benefits reported in the various CBA studies. While these studies ultimately follow ‘in-spirit’ the recommendations provide by the EU, the existence of different frameworks and approaches means that judgement has to be made and assumptions applied in drawing comparisons.

In this regard, the following approach has been undertaken to prepare a more comparable set of data:

- Review of the studies
- Allocation of data according to the categories included in Recommendation 2012/148/EU
- Detection of uneven values
- Discussion with countries about their results
- Harmonization of the values
- Preliminary conclusions

The present section aims to show the costs and benefits of the different studies provided by the MS under the same structure as per Recommendation 2012/148/EU. It is important to note that the evaluation of data and conversion into standard categories has not been easy in all the cases. In some counties, a combination of categories has been necessary as the information provided (both written and oral) has been insufficient for the disaggregation.

Costs have been grouped in 12 categories as per the Recommendation including the capital expenditure (capex) and the operating expenditure (opex) for the modelling period.

Evaluating the capex and opex by the different MS provides a significant challenge. On one hand, not all CBAs distinguish between capital and operating expenditure. On the other hand, very different modelling periods are applied in the different studies – for example, the study in Lithuania is based on a 14-year period, while that of the Netherlands involves 50 years of analysis. In order to provide comparable values, the modelling period for the opex has been harmonized to 15 years for analytical purposes. This exercise has not always been easy as not all the studies disclose the data with the necessary details (particularly in the case of communications and IT where the costs of data servers, hardware, software, related staff and those of the data transfer are not always clearly distinguished). In the particular cases of Netherlands and Portugal, it is assumed that the annual operating expenditure for Communications equals 1.5% of the total capital expenditure for that category, and likewise 5% for IT. The estimated values have been extrapolated from data of other MS in the sample.

In addition, certain countries provide costs and benefits for a combined electricity and gas roll out of smart metering systems. Due to the focus on electricity in this report, it has been necessary to undertake a separate exercise to evaluate the costs for the sole implementation of smart metering systems in the electricity sector. The data included for Great Britain, the Netherlands and the Belgian jurisdictions include adjustments to estimate the impact of removing gas-related costs and benefits.

The categorization of benefits has also followed the Recommendations and other benefits not included have been categorized as extra. It is important to note that most countries have considered the (negative) cost of avoided investment in standard meters as a benefit, which is adopted here, though in some cases this is not possible – for example, in Great Britain where new meter costs are reported net of avoided standard meter costs.

With regard to the harmonization, all benefits have been harmonized to 15 years but the avoided investment in standard meters has been kept as the original, consistent with the capital cost of the smart meter, which is also considered invariant to the modelling period.

This approach, which involves simple adjustments has limitations as for example, the original path for benefits (and operating expenditure) will incorporate a ramp up as the rollout proceeds, while future benefits and costs will be subject to heavy discounting. As a result, the following analysis should be considered as indicative and designed to capture key outliers and trends that may be useful in the subsequent phase of revising the CBAs for some countries.

Note the figures reported in the subsequent sub-sections are similar but not always identical to those in the Commissions benchmarking report COM(2014)356.[5]

3.1.1. Costs

The following table below shows the (raw) total costs of each of the countries as per the information collected, adjusted to best reflect electricity-specific activities where the CBA is based on a joint electricity and gas roll-out (Great Britain, Netherlands, Belgium). The adjustments made are relatively high-level in nature, and are explained in greater detail in the country sections and respective annexes.

5 The numbers differ from those in the Commission's Benchmarking report (COM(2014)356) in several respects: Updated CBA reports are used for BE-FL and GB, with the results in both cases adjusted for gas; adjustments for gas are applied in BE-BR and BE-WL; a different roll-out methodology is reported for DE (EU vs Roll-out plus); data is not included in COM(2014)356 for HU; a longer modelling period is shown for SK; the same cost/metering point for RO is applied, though totals differ; while a slightly different approach is applied for NL, with the cost and benefit breakdown in 2005 adjusted for changes in key assumptions in the 2010 report. The figures for Portugal and the Czech Republic have been developed from more disaggregated data in the respective CBA reports. Note that since the production of the CBA Romania has revised its estimates of costs. However, this table is based on the figures in the national CBA.

TABLE 6

TOTAL COSTS PER CATEGORIES AS PRESENTED BY THE COUNTRIES' STUDIES (€ MILLION, NPV BASIS)

Cost type	GB	NL	RO	BE-BR	BE-FL	BE-WL	CZ	DE	HU	LT	PT	SK
Smart meters	4,851.3	549.4	648.2	166.5	1,278.7	1,245.3	1,417.5	7,328.0	510.1	161.1	364.0	55.4
Information Technology	992.5	38.7	13.0	49.2	275.0	232.7	628.5	3,324.1	46.7	18.9	51.0	13.7
Communications	2,967.5	786.9	157.8	89.6	75.0	172.9	349.0	6,589.2	220.5	52.1	217.0	34.3
In-home display	-	-	-	-	-	-	-	1,284.5	47.7	-	-	-
Generation	-	-	-	-	-	-	-	-	-	-	-	-
Transmission	-	-	-	-	-	-	-	-	-	-	-	-
Distribution	-	-	-	-	-	-	14.9	-	-	18.7	-	-
Training costs	-	-	-	4.0	-	10.1	-	420.7	-	0.2	-	-
Customer care and engagement programmes	466.3	234.9	-	17.5	200.0	68.8	14.7	-	117.8	3.2	121.0	-
Sunk costs	-	-	-	-	-	-	7.8	-	42.1	-	-	-
Security	-	-	-	-	-	-	22.9	-	-	-	-	-
Others not defined	-	-	-	-	50.0		38.8	-	0.1	-	-	-
TOTAL	**9,277.5**	**1,609.9**	**819.0**	**326.8**	**1,878.7**	**1,729.8**	**2,494.0**	**18,946.5**	**985.1**	**254.1**	**753.0**	**103.3**

The following table sets out the respective average cost per metering point based on the above data and number of smart meters to be installed:

TABLE 7

AVERAGE COSTS PER METERING POINT PER CATEGORIES BASED ON THE MODELLING PERIODS IN THE COUNTRIES' STUDIES (€/METERING POINT, NPV BASIS)

Cost type	GB	NL	RO	BE-BR	BE-FL	BE-WL	CZ	DE	HU	LT	PT	SK
Smart meters	147.28	81.99	77.35	268.94	387.49	493.74	248.13	190.34	125.55	103.57	56.32	91.72
Information Technology	30.13	5.78	1.55	79.47	83.33	92.26	110.03	86.34	11.49	12.14	7.89	22.61
Communications	90.09	117.45	18.83	144.75	22.73	68.54	61.09	171.15	54.27	33.48	33.58	56.81
In-home display	-	-	-	-	-	-	-	33.36	11.74	-	-	-
Generation	-	-	-	-	-	-	-	-	-	-	-	-
Transmission	-	-	-	-	-	-	-	-	-	-	-	-
Distribution	-	-	-	-	-	-	2.60	-	-	12.02	-	-
Training costs	-	-	-	6.48	-	4.01	-	10.93	0.01	0.12	-	-

Cost type	GB	NL	RO	BE-BR	BE-FL	BE-WL	CZ	DE	HU	LT	PT	SK
Customer care and engagement programmes	14.15	35.06	-	28.29	60.61	27.27	2.57	-	28.98	2.06	18.72	-
Sunk costs	-	-	-	-	-	-	1.36	-	10.36	-	-	-
Security	-	-	-	-	-	-	4.01	-	-	-	-	-
Others not defined	-	-	-	-	15.15	-	6.67	-	0.01	-	-	-
TOTAL	**281.65**	**240.28**	**97.73**	**527.92**	**569.30**	**685.82**	**436.46**	**492.12**	**242.42**	**163.37**	**116.51**	**171.15**

Note: same differences with COM(2014) 356 apply as per the previous table.

The subsequent table below provides the average costs per metering point with a harmonized modelling period of 15 years. The initial modelling periods by country (years) vary and are: Great Britain (18), Netherlands (50), Romania (20), Brussels (20), Flanders (30), Wallonia (30), Czech Republic (26*), Germany (18), Hungary (18), Lithuania (14), Portugal (40) and Slovak Republic (8). The conversion to a 15-year period is notional.

TABLE 8

AVERAGE COSTS PER METERING POINT PER CATEGORIES BASED ON A HARMONISED MODELLING PERIOD OF 15 YEARS (€/METERING POINT, NPV BASIS)

Cost type	GB	NL	RO	BE-BR	BE-FL	BE-WL	CZ	DE	HU	LT	PT	SK
Smart meters	140.17	81.99	77.35	250.24	330.03	303.92	243.74	189.20	104.62	103.64	56.32	91.72
Information Technology	27.88	2.89	1.16	70.79	60.08	60.91	96.23	84.17	9.58	12.73	5.18	27.34
Communications	87.70	82.22	14.12	108.56	11.36	42.43	57.43	149.27	45.22	34.85	29.59	75.40
In-home display	-	-	-	-	-	-	-	33.36	9.79	-	-	-
Generation	-	-	-	-	-	-	-	-	-	-	-	-
Transmission	-	-	-	-	-	-	-	-	-	-	-	-
Distribution	-	-	-	-	-	-	2.06	-	-	12.88	-	-
Training costs	-	-	-	4.86	-	-	-	9.11	0.01	0.12	-	-
Customer care and engagement programmes	14.15	10.52	-	24.89	30.30	17.65	2.03	-	24.15	2.06	7.02	-
Sunk costs	-	-	-	-	-	-	1.36	-	8.64	-	-	-
Security	-	-	-	-	-	-	4.01	-	-	-	-	-
Others not defined	-	-	-	-	7.58	-	6.67	-	0.01	-	-	-
TOTAL	**269.90**	**177.62**	**92.64**	**459.34**	**439.35**	**424.90**	**413.52**	**465.11**	**202.02**	**166.28**	**98.11**	**194.46**

Note that the Czech Republic CBA states a modelling period of 26 years, but in these calculations the 7-year preparatory period is excluded. In practice as the asset life is considered 12 years, the use of a 19-year period may understate costs against the national benchmark.

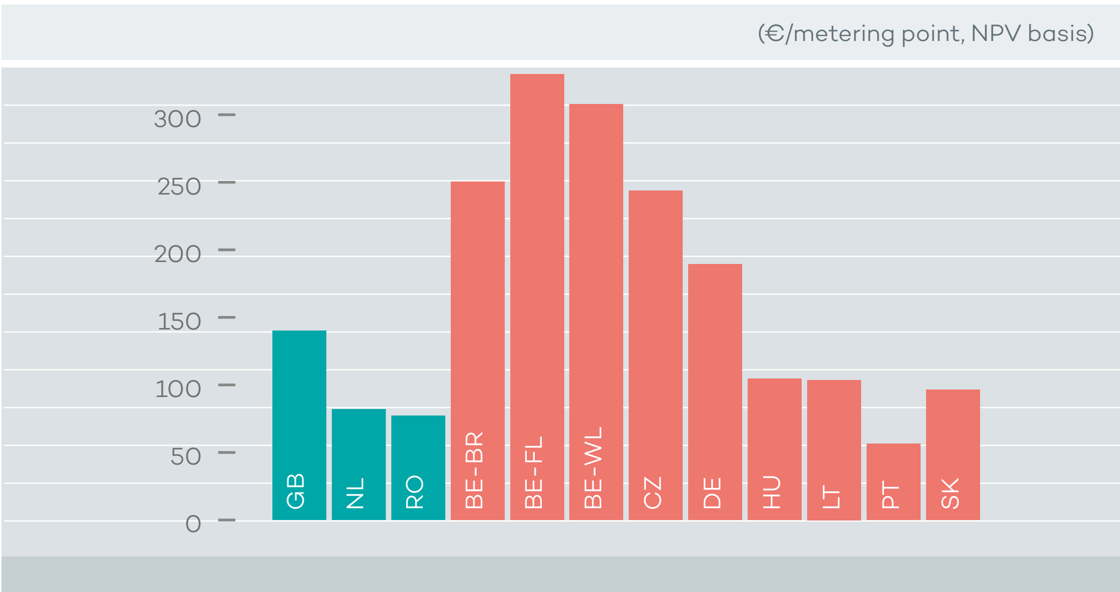
Note that one limiting factor in this simple comparison is the treatment of meter replacement in countries with long modelling periods. However, in practice due to the impact of discounting, costs incurred at the end of the asset life of new meters should have a much lower impact on the overall results.

The analysis of the most relevant items in the above table provides various findings:

Smart Meters

Though all studies stipulate that the meters are following the functionalities provided in the recommendation, the reality is that there are wide differences in the average costs estimated for each country, which range from €56 in Portugal to €330 in Flanders, suggesting that there is a wide difference in the characteristics of the meters. It is important to note that this cost includes installation, which means that labour costs in each country will affect the final costs. However, differences are very high to correspond to only the installation costs. In addition, the experience of Italy and Spain, which have actually purchased large quantities of smart meters, shows that the costs of the meters in tender situations are closer to the values provided by Portugal, Romania and Netherlands than those of the Belgian jurisdictions, Germany and the Czech Republic. If a comparison is made between the Netherlands and Belgium, any difference in cost is unlikely to be attributed to labour costs due to similar wages and conditions of employment applying in the two countries.

Figure 1 Smart Meter Unit Cost - 15 year modelling period

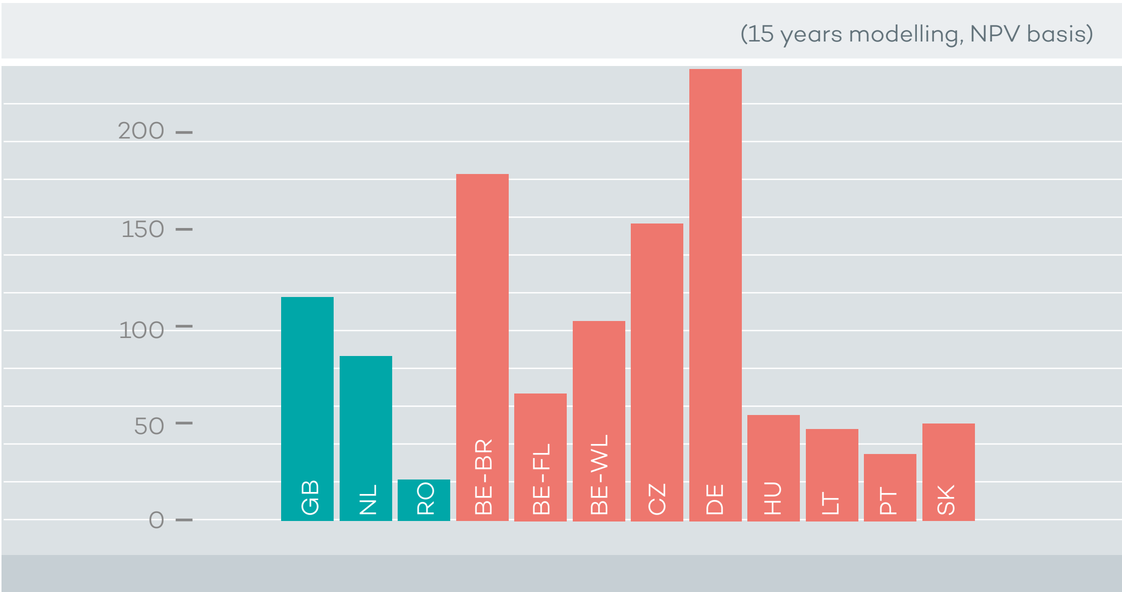


Moreover, there appears limited relationship if any, between cost and functionality. For example, in the MS with highest cost (Belgium, Czech Republic) the key feedback to customers is via indirect feedback, which is similar to that in MS with lower cost meters.

Information Technology and Communications

These two items are analysed in parallel as it is considered (based on the relative differences among the values for IT and Communications between the different countries) that there is no standard criteria for their cost allocation. In this regard, the graph below shows that the total cost of these two items is generally in a range between €50 and €100. While some countries exhibit values above this range – including Belgium-Wallonia and the Czech Republic – the most notable exceptions are Belgium-Brussels and Germany, where in the latter case the cost for the entire system is estimated at over €233/metering point.

Figure 2 IT plus Communication cost per metering point

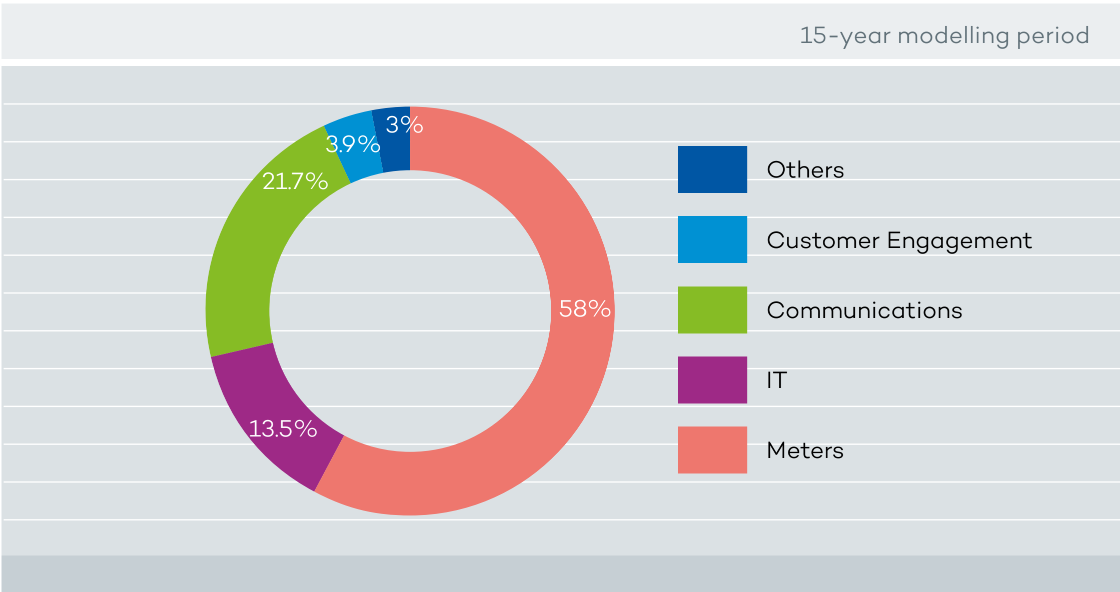


It is notable that in the MS with the highest reported cost, more expensive communications technologies are adopted: GPRS in Germany, UMTS in Brussels, with the costs in Czech Republic reflecting the costs of the proposed data centre and a significant use of GPRS. On the other hand, PLC is principally applied in the countries with lowest report cost, including Romania, Hungary, Lithuania and Portugal.

Key cost drivers

For the countries as a whole meters, IT and communications account for the vast majority of total costs. Based on a simple average of the country results, the following overall breakdown in the 15-year period is obtained, with more than half of total costs accounted for by the smart meter (including installation).

Figure 3 **Average cost breakdown by category – all MS (%)**



3.1.2. Benefits

The following table below shows the reported total benefits in the country analysis, adjusted to remove benefits that could be attributed to gas if an electricity-only roll out were to proceed:

TABLE 9

TOTAL BENEFITS INCLUDED IN THE COUNTRY ANALYSIS (€ MILLION, NPV BASIS)

	GB	NL	RO	BE-BR	BE-FL	BE-WL	CZ	DE	HU	LT	PT	SK
Benefits in Rec. 2012/148/EU												
Reduction in meter reading and operation	4,803	870	390	41	536	322	420	1,937	59.0	8	208	23
Reduction in O&M costs	-	-	90	10	200	8	-	-	-	-	-	6
Deferred distribution capacity investments	176	-	-	-	-	-	-	1,214	-	-	-	-
Deferred transmission capacity investments	-	-	-	-	-	-	-	355	-	-	-	-
Deferred generation capacity investments	1,004	-	-	-	-	-	-	2,892	-	-	-	-
Reduction in technical losses	384	-	96	5	10	-	-	-	18.1	14	34	8
Electricity cost savings	3,236	518	3	107	359	263	9	9,228	30.9	52	530	120
Reduction of comm. Losses	167	62	365	51	200	897	-	59	79.6	30	169	26
Reduction of outage times	118	32	-	3	75	-	-	16	-	-	7	-
Reduction of CO_2 emissions	225	-	-	16	-	-	-	-	-	2	-	2
Reduction of air pollution	61	-	-	-	-	-	-	-	-	-	-	-
Benefits not in Rec. 2012/148/EU												
Avoided investment in standard meters	-	-	140	9	314	-	728	2,966	-	22	147	-
Competitiveness and others	-	424	-	-	-	77	-	-	481.3	-	-	-
TOTAL BENEFITS	**10,174**	**1,906**	**1,084**	**242**	**1,694**	**1,567**	**1,156**	**18,667**	**668.9**	**128**	**1,095**	**186**

Note: same methodological or data source differences with COM(2014) 356 apply as per the cost tables.

The following table estimates average benefits per metering point based on the modelling period in the respective CBAs and the number of metering points:

TABLE 10

AVERAGE BENEFITS PER METERING POINT BASED ON DATA IN THE COUNTRY ANALYSIS (€/METERING POINT, NPV BASIS)

	GB	NL	RO	BE-BR	BE-FL	BE-WL	CZ	DE	HU	LT	PT	SK
Benefits in Rec. 2012/148/EU												
Reduction in meter reading and operation	145.8	129.9	46.6	66.9	162.4	127.9	73.5	50.3	14.5	5.3	32.2	38.5
Reduction in O&M costs	-	-	10.8	15.4	60.6	3.3	-	-	-	-	-	10.1
Deferred distribution capacity investments	5.4	-	-	-	-	-	-	31.5	-	-	-	-
Deferred transmission capacity investments	-	-	-	-	-	-	-	9.2	-	-	-	-
Deferred generation capacity investments	30.5	-	-	-	-	-	-	75.1	-	-	-	-
Reduction in technical losses	11.7	-	11.4	7.4	3.0	-	-	-	4.4	8.9	5.3	14.0
Electricity cost savings	98.2	80.2	0.3	173.3	108.8	104.1	1.5	239.7	7.6	33.5	82.0	198.5
Reduction of comm. Losses	5.1	9.3	43.6	82.4	60.6	379.9	-	1.5	19.6	19.2	26.2	42.7
Reduction of outage times	3.6	4.8	-	4.9	22.7	-	-	0.4	-	-	1.1	-
Reduction of CO_2 emissions	6.8	-	-	25.2	-	-	-	-	-	1.1	-	3.4
Reduction of air pollution	1.9	-	-	-	-	-	-	-	-	-	-	-
Benefits not in Rec. 2012/148/EU												
Avoided investment in standard meters	-	-	16.8	15.0	95.2	-	127.5	77.0	-	14.3	22.7	-
Competitiveness	-	63.2	-	-	-	30.6	-	-	118.5	-	-	-
TOTAL BENEFITS	**308.9**	**287.3**	**129.4**	**390.3**	**513.3**	**645.8**	**202.4**	**484.9**	**164.6**	**82.3**	**169.4**	**307.3**

Note: same methodological or data source differences with COM(2014) 356 apply as per the cost tables.

The table below estimates benefits per metering point based on a modelling period of 15 years. Note that these calculations are extremely high level as the benefits have been adjusted lineally by the number of years of analysis without incorporating the ramp up of benefits as meters are installed, or the impact of discounting in the countries with long modelling periods.

TABLE 11

AVERAGE BENEFITS PER METERING POINT BASED ON MODELLING PERIOD OF 15 YEARS (€/METERING POINT, NPV BASIS)

	GB	NL	RO	BE-BR	BE-FL	BE-WL	CZ	DE	HU	LT	PT	SK
Benefits in Rec. 2012/148/EU												
Reduction in meter reading and operation	121.5	39.0	43.0	50.1	111.5	63.9	58.0	41.9	12.1	5.7	12.1	28.9
Reduction in O&M costs	-	-	-	11.5	30.3	1.6	-	-	-	-	-	7.6
Deferred distribution capacity investments	4.5	-	-	-	-	-	-	26.3	-	-	-	-
Deferred transmission capacity investments	-	-	-	-	-	-	-	7.7	-	-	-	-
Deferred generation capacity investments	25.4	-	-	-	-	-	-	62.6	-	-	-	-
Reduction in technical losses	9.7	-	8.6	5.5	1.5	-	-	-	3.7	9.6	2.0	10.5
Electricity cost savings	81.9	24.1	0.3	130.0	54.4	52.1	1.2	199.7	6.3	35.9	30.8	148.9
Reduction of comm. Losses	4.2	2.8	32.7	61.8	30.3	190.0	-	1.3	16.3	20.5	9.8	32.0
Reduction of outage times	3.0	1.4	-	3.6	11.4	-	-	0.4	-	-	0.4	-
Reduction of CO_2 emissions	5.7	-	-	18.9	-	-	-	-	-	1.2	-	2.6
Reduction of air pollution	1.6	-	-	-	-	-	-	-	-	-	-	-
Benefits not in Rec. 2012/148/EU												
Avoided investment in standard meters	-	-	16.8	15.0	95.2	-	127.5	77.0	-	14.3	22.7	-
Competitiveness and others	-	19.0	-	-	-	15.3	-	-	98.7	-	-	-
TOTAL BENEFITS	**257.4**	**86.2**	**101.3**	**296.5**	**334.5**	**322.9**	**186.7**	**416.9**	**137.2**	**87.1**	**77.7**	**258.2**

The following observations are made from the analysis in the above tables:

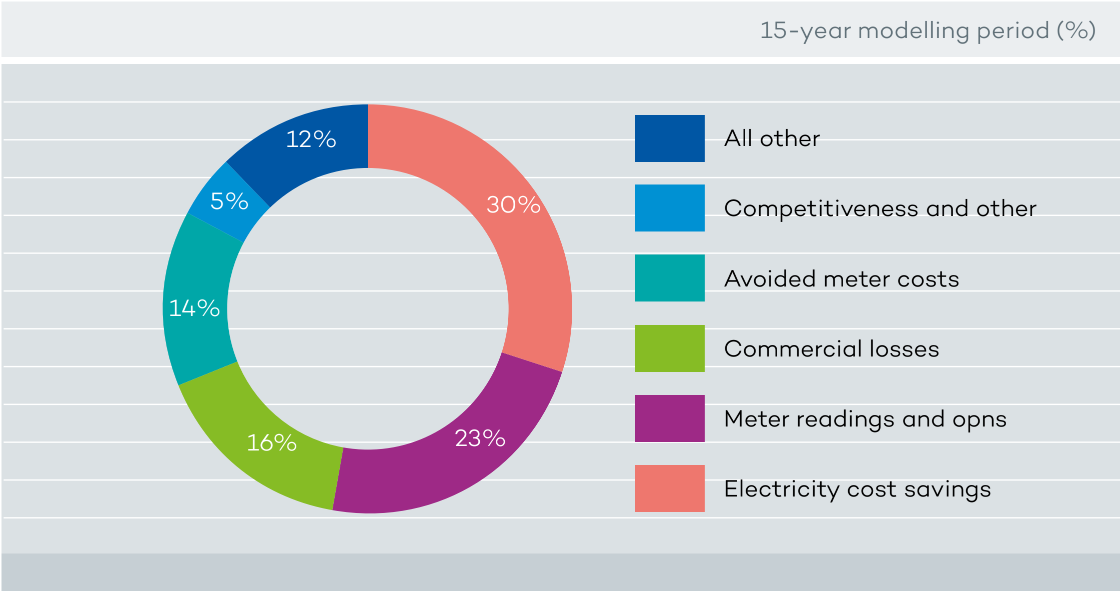
- Reduction in meter reading and meter operation: all analysed countries provide values for this item, though there is a substantial range of reported benefits, from 5.7 to 121.5c/metering point. The following factors may explain some of these differences: a) divergent regulatory and operational arrangements with regard to the billing cycle, management of meters and the treatment of incidences; b) differences in labour costs; and, c) the expected final operational process.

The MS studies mostly assume that the introduction of smart metering systems will reduce significantly the need for manual or semi-manual activities.

- Reduction in operational and maintenance costs: In many cases, the studies do not report any benefit under this item as they consider the entire operational benefit in the previous category.
- Deferred/avoided distribution/transmission/generation capacity investments: only Great Britain and Germany have included benefits under these categories.
- Reduction in technical losses of electricity: most countries have provided values, though in general it is not a notable source of benefits. In some cases (for example, the Netherlands and Czech Republic), the MS claims that the losses are currently so low that there is no room for improvement.
- Electricity cost savings: this is a critically important component, with a wide divergence in the values shown, including some – for example the Czech Republic and Romania – with extremely low values. The reasons are not uniform - in the case of the Czech Republic, it is assumed that all benefits from optimising consumption profiles are captured by the HDO system (power supply with ripple control) with customers unwilling to reduce consumption more generally, while in Romania consumption reduction is principally linked to theft reduction.
- Reduction of commercial losses: a high potential to reduce commercial losses is reported in a number of cases, notably Belgium, Slovak Republic, Romania and Hungary.
- Reduction of outage times: values provided by each country are low. In general, due to the high level of automation in European distribution network, outages are not producing high periods of disconnection so the potential for improvement is low. However, there is an additional component that relates to the number of unexpectedly broken distribution transformers. This situation is producing outages regardless of the automation and meshing level. Though companies perform their own analysis and have information about the situation of transformers, it is important to clarify the annual incidences, which shall be eliminated with the Smart Metering system.
- Reduction of CO_2 emissions and pollution: relatively few countries provide values under this category.
- Avoided investment in standard meters: though in the methodology this is considered a (negative) cost, the majority of the countries' studies are considering them as a benefit.
- Amongst additional items –or externalities– some countries consider increased competitiveness as a key benefit, most notably the Netherlands, Wallonia and Hungary.

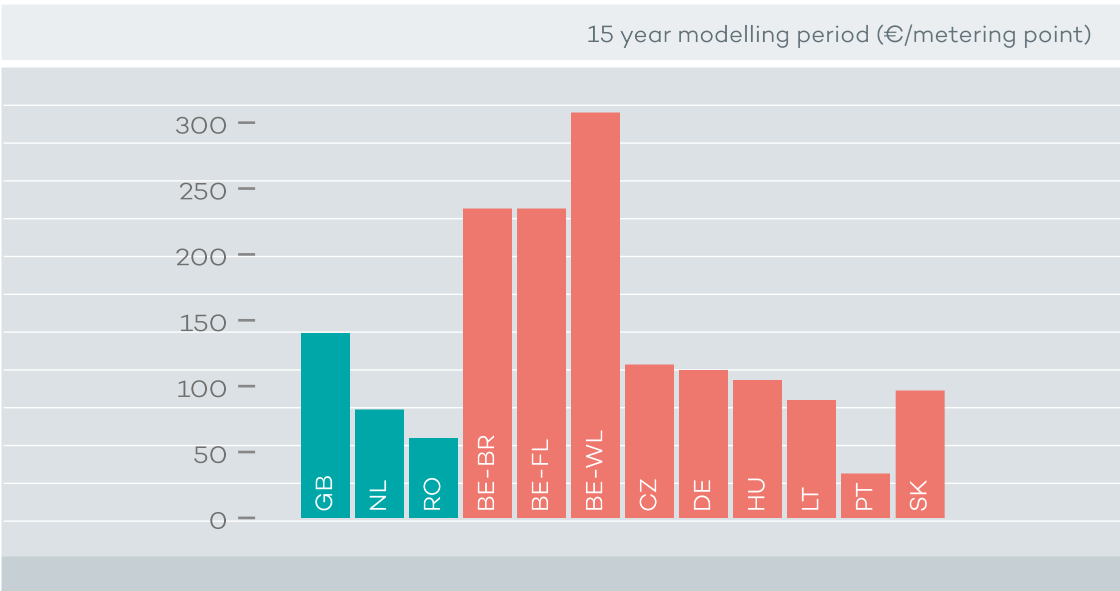
A high-level average breakdown of benefits by key categories is set out below. This shows that the key driver of benefits is the electricity cost savings (30%) followed by meter reading and operations (23%) and commercial losses (16%).

Figure 4 High-level breakdown of key benefits, total sample



The fourth largest category of benefits is the avoided cost of standard meters. If this value is subtracted from the smart metering cost estimated in the previous section the following net cost is produced. This graph indicates greater commonality across countries than in the cost-only graph, and that the average reported smart meter costs in Belgium are well above those in other jurisdictions.

Figure 5 Cost of smart meters less avoided cost of standard meters



3.2. Findings of recent related studies

Findings of some recent studies provide additional insight into the issues considered in the CBA.

The **Netherlands Enterprise Agency (RVO)**, in its March 2014 report on Dutch Energy Savings Monitor for the Smart Meter(6) concluded that smart metering in combination with direct feedback, in particular, can lead to a considerable reduction in household energy usage. It notes two trials:

- Scientific pilot research by network operator Liander, with a real-time energy management app for smart phones amongst homeowners, showed average savings of 3 % for electricity and 4 % for gas.
- Another trial by network operator Stedin, housing corporation Woonbron and the City of Rotterdam, testing the consumption change effects of a real-time in-home energy dashboard amongst households in the low rental segment, delivered average savings of 5.6 % for electricity and 6.9 % for gas

However, a key conclusion of RVO is that the initial achieved savings are only persistent if the feedback medium matches the user's practical preference, and if the functionality and data presentation are tailored to the consumer's interests and capability for reinforcement and habit formation with the feedback system. In this regard, they state, "sophisticated real-time web services on PC, tablet and smart phone are potentially powerful to help reduce energy demand, but more so with already committed and technology minded subsets of the population, who are actively looking to further reduce their energy consumption".(7) For other subsets of the population RVO stresses the need for in-home devices to activate consumer interest and engagement, with these complemented by direct feedback to promote longer-term energy efficiency savings.

The **Meter-ON** consortium, which was led by the DSOs, concluded in its final report of autumn 2014(8) that in most cases a smart metering roll out was not self-financing for the perspective of the DSO alone. In relation to some of the regions in this study, it included the following observations:

- **Belgium-Flanders:** Eandis CVBA, has carried out a pilot project involving 40,000 meters in the Flemish region with the potential to become a major rollout involving 2.5 million smart meters. A CBA was carried out, which resulted in a positive business case (net value of €144 million). The main benefits are related to energy savings through monthly feedback of energy consumption data, savings on physical meter readings and the savings resulting from reducing non-billable usage.
- **Latvia:** The NRA has performed the CBA and considered six various smart metering rollout scenarios with different volumes of metering. Only one of the scenarios has resulted in a positive economically justifiable result. This scenario

6 RVO (2014), "Dutch Energy Savings Monitor for the Smart Meter", Final Report, March 2014.

7 Ibid, p.6.

8 Meter-ON (2014), "Steering the implementation of smart metering solutions throughout Europe: Final Report", autumn 2014.

assumes installation of 250,500 smart meters (approximately 25% of all consumers of Latvenergo & Sadeles tikls) by 2017. However, the final decision has not been taken and CBA information is not yet public.

- **Portugal:** EDP Distribuçao affirms that the net present value is clearly positive, where consumers capture the highest share of benefits mainly due to energy savings, but all other players are negatively impacted (retailers, DSOs, TSOs).

The Meter-ON Final report makes the following recommendation regarding the development of CBAs that consider benefits and costs solely from the DSO perspective:

- The rate of return should equal the weighted average cost of capital (WACC)
- Future benefits and opportunities related to advanced functionalities should be included
- A one-size-fits-all CBA model is not sufficient, although guidelines should be provided (to ensure better comparison among results across countries), taking into account local conditions
- The most relevant parameters for making smart metering projects feasible are the project cost per consumer and additional / regulatory cost coverage

Note that the perspective of Meter-ON is principally that of the DSO, from whose perspective it developed a simplified CBA template to estimate the rate of return of a smart metering project and the necessary regulatory payment per meter to ensure project viability. However, the DSO material does not represent a full cost benefit analysis of smart metering rollout.

The Meter-ON report is generally supportive of enhanced functionality with its recommendation N° 5 supporting the actual implementation of functionalities that contribute to positive CBA outcomes. This is consistent with its observation, noted in section 2 that there is generally a link between enhanced functionality and benefits, though not necessarily with cost.

A recent report by **Beama/vaasaETT** (April 2014)[9] considered the impact of the use of in-home displays (IHDs) on customer consumption behaviour. This report claims that in Great Britain the use of IHDs provides electricity savings of over 9% per year, and that the results of some pilots have been shown to provide savings of up to 11-18%. It also notes that savings have generally been 81% higher in cases than in pilots where IHDs have not been used.

A key conclusion of this study is that "reductions persist, and are not short-term gains only. Savings after more than two years are even better than in the first year, but education and awareness prior to IHD installation is essential for high and sustained savings. It is also essential that service providers take the customer through the savings journey by providing ever new and extended ways to save".

9 *Lewis, P., Bogacka, A., Grigoriou, R., XuBeama, S (Beama/Vaasa ETT) (2014), "Assessing the use and value of energy monitors in Great Britain", 3 April 2014.*

However, it needs to be noted that Beama is the trade association for manufacturers of smart metering devices, including IHD. In addition, there is limited detail provided on the studies included in the report. More generally, results of pilot projects need to be taken with a degree of caution as these projects are run with a limited number of voluntary customers and the same reaction cannot be expected when moving from the pilot to the deployment stage.

4. Countries where the CBA produced a positive result for a widespread roll-out

This section considers the CBAs conducted in the following jurisdictions:

- Great Britain
- Netherlands
- Romania

In addition, this experience is supplemented with ex-post findings of the large-scale rollout undertaken in Italy between 2001 and 2010.

4.1. Summary findings

Based on the three CBA studies considered and the experience of Italy a number of key findings arise:

- Positive results for a wide spread roll out of smart metering have been achieved in a range of operating conditions and jurisdictional arrangements, including the supplier led roll out and use of DCC model in Great Britain, and distributor led models in the other jurisdictions.
- Reflecting the different environment in the various MS considered, the key drivers of the results vary by country, particularly in the case of the benefits. For example, in Great Britain a critical factor in producing the positive outcome is the reduction in consumption following introduction of the smart meters, whereas in Romania no direct consumption effect is included, with a key driver of the result being the significant reduction in commercial losses and theft facilitated by the smart meters.
- In all four countries relatively low to moderate cost technological solutions have been introduced or proposed, most notably in Italy and Romania. However, in general the overall results can change significantly if high cost technologies are required; for example, increased use of GPRS as a means of communications.
- The CBAs in Great Britain, Netherlands and Romania have all considered electricity and gas, with joint provision of infrastructure proposed in Great Britain and the Netherlands. Where common infrastructure and/or benefits arise that can be spread across the two services the results of the CBA appear more robust including gas than if an electricity-only net benefit is estimated.
- The technology proposed in the CBAs is consistent with the minimum functionalities of Recommendation 2012/148/EU. However, in some cases the core CBA scenario does not incorporate all potential functionalities – most particularly in the Netherlands and Romania - where customers do not receive real time information on their usage. While this approach is consistent with the approach actually adopted in Italy, a fuller consideration of the possible net benefits of smart meters are most

evident in scenarios that reflect the use of additional functionality, including direct feedback to customers. In the case of the Netherlands scenarios are included that show a greater consumption impact in the case of direct feedback and a higher NPV, indicating a positive relationship between functionality and net benefits.

- Some additional potential costs are highlighted in the reports that may have a broader application, including: greater inefficiency in manual meter reading during the transition to full roll out of smart meters; and the incremental energy usage of smart meters.
- Additional benefits that can be considered in other circumstances include: economies of scope and scale where smart metering data systems can be combined with those used for customer switching; additional operational savings for customers with pre-payment meters; and debt management benefits for suppliers (including working capital benefits).
- Explicit costs for distribution activities, transmission and generation are generally not considered significant in the assessment.

4.2. Great Britain

The CBA considered for Great Britain is that issued by DECC in January 2014. The key roll out scenario considered in this report refers to the domestic sector IA.

4.2.1. Recommended methodology

The Great Britain CBA is broadly consistent with the recommended methodology, although it does not follow the same formulaic approach for benefits as in the annexes of Recommendation 2012/148/EU for benefits. In relation to the various components:

- Capital expenditure is consistent with the methodology in the key areas of metering, installation, communications, IT and IHD. No explicit allowance is included for distribution, transmission and generation – except for investment in distribution system IT - though it should be noted that the model in place in Great Britain is supplier led.
- Key operating expenditure components are included and individually specified. As in most other analyses no allowance for incremental transmission and generation costs are included.
- Functionalities are broadly in excess of minimum requirements – particularly in relation to the information provided to customers, data storage and the information available for use in network operational decisions (outages etc.), but as the divergences are largely software-driven the cost impact is likely to be limited.

While all the costs and benefits can largely be grouped under the headings proposed by the Commission there are several key costs and benefits that are not explicitly foreshadowed in Recommendation 2012/148/EU:

- The incremental electricity usage of smart metering and communications devices

- Switching benefits, which are largely driven by being able to incorporate existing switching functions into the Data Communications Company (DCC) model used for smart metering
- Benefits in the cost of supply to pre-payment customers, which is a segment particularly prevalent in Great Britain
- Better capacity for the suppliers to manage debt due to the enhanced information provided by smart meters
- Increased inefficiency in manual meter reading in the transition to a full roll out

A notable feature of the approach in Great Britain is that smart metering costs are specified net of the existing metering costs, rather than separately identifying the costs of new meters and the avoided costs of traditional meters. While this methodological approach does not affect the results, it is less easy to identify the cost of smart metering assumed in the analysis.

4.2.2. Sensitivity/volatility analysis

The core CBA, which includes gas, is relatively stable to changes in key assumptions due to the high benefits estimated. DECC itself has undertaken sensitivity analysis on key components of customer, supplier, network and generation benefits and found the results of the analysis to be robust.

A key feature of the CBA in Great Britain is that is foreshadows a dual fuel electricity and gas smart meter roll out. A CBA of this nature reflects the fact that the metering market is de-regulated and that many customers use the same provider for gas and electricity supplies, and hence in the British supplier-led model there will be strong incentives to replace both electricity and gas meters with smart meters at the same time. This dynamic will not be applicable in all other countries.

To facilitate analytical comparison with the results of electricity-only CBAs, high-level sensitivity analysis is run on the costs and benefits to separate out the impact of gas. Under the assumptions adopted, the results are still positive, though costs per metering point are higher and benefits per-meter lower in an electricity-only model.

The key results are summarised below. Further detail is provided in the Annex.

TABLE 12

SENSITIVITY ANALYSIS - ESTIMATE OF ELECTRICITY-ONLY COSTS AND BENEFITS, NPV BASIS

	Dual fuel		Electricity only	
	(€ million)	(€/metering point)	(€ million)	(€/metering point)
Total Costs	13,088	219.70	9,278	281.65
Total Benefits	18,513	310.77	10,200	309.68
NET BENEFIT	**5,425**	**91.07**	**923**	**28.02**

Note that only the domestic customer costs and benefits are considered from the DECC report.

The assumptions adopted in producing these results are conservative in nature in some respects, notably:

- All capital and operating costs related to the DCC, the IT costs of suppliers, network operators and aggregators are assumed constant under an electricity-only model
- Costs related to customer information and engagement are assumed unchanged

A saving of 33% in meter reading costs is adopted, as it is assumed that some gas and electricity meters are currently read concurrently, and hence the introduction of smart meters only for electricity would not change meter-reading requirements in all cases. The appropriate value will not be zero as not all customers have the same supplier for gas and electricity, and even in these cases joint meter reading is not necessarily undertaken.

4.2.3. Lessons learnt

Key lessons that can be learnt from the Great Britain analysis include:

- The importance of context – in practice, due to the similarities in regulatory and commercial approach applied to gas and electricity metering and supply, it is difficult to undertake a simple electricity-only cost-benefit analysis.
- Various additional costs may be included that are not necessarily foreshadowed in Recommendation 2012/148/EU, and especially in other CBAs, including:
    - Incremental energy usage of smart meters
    - Meter reading inefficiency of existing meters during the transition to a widespread smart metering rollout
    - Costs of industry participants to prepare for a wide spread roll out
- Several additional benefits may be possible under a widespread roll out, including:
    - Savings in institutional costs where there are economies of scale or scope between the information required for smart metering systems and that for customer transfer functions
    - Potential improvements to the debt management position of the suppliers with the enhanced information received from smart meters
- The scope to gain commercial benefits may vary depending on the industry structure and maturity of the market. In the case of Great Britain reported commercial loss savings/theft are low, but significant benefits are obtained for customers on pre-payment meters, who would otherwise be higher risk customers.
- A more flexible approach to valuing environmental benefits to that in the Annex to Recommendation 2012/148/EU may be justified in cases where the MS has undertaken its own modelling in areas of CO2 emissions and air quality.

A notable feature of the model applied in Great Britain is the use of a 'Central Hub' entity – in this case the DCC- to route and deliver data to energy suppliers, DSOs and other third parties with appropriate access permissions. This model is relatively uncommon, with only Slovakia and the Czech Republic of the countries in this study proposing arrangements with similar features.[10] The use of a Central Hub requires additional costs in developing the entity and systems involved. However, the analysis undertaken in Great Britain suggest that additional benefits do arise in data processing and transfer, and that economies of scope may be possible where the Central Hub is also responsible for related activities in the electricity sector, for example, managing customer transfer.

4.3. Netherlands

For the analysis, primary reliance is placed on the CBA of smart metering produced by KEMA in 2010, supplemented by earlier analysis summarised in a report issued in 2005 by SenterNovem. The consideration of the two documents reflects a more detailed breakdown of costs and benefits reported in the 2005 report, which forms the basis for the 2010 update.

4.3.1. Recommended methodology

The KEMA report was issued in advance of the publication of Recommendation 2012/148/EU. Its findings are premised on a dual electricity and gas roll out of smart metering systems, with the analysis rolling forward and adapting earlier analysis in 2005, which contains a detailed breakdown of costs and benefits. Based on the more detailed breakdown of the 2005 report, combined with changes reported in 2010, is estimated that a CBA conducted solely for electricity would be positive.

The metering, communications and IT approach proposed for the Netherlands is compliant with Recommendation 2012/148/EU. However, the Netherlands situation raises two general issues: first, the core scenario for the CBA doesn't invoke all the available functionality; and second, the local legislation permits smart meters to be installed and operated in a manner that also does not activate all potential functionality ("administrative off").

The core situation proposed in the CBA of the Netherlands does not include direct feedback. Instead, bi-monthly readings are provided to customers, with this supplemented by additional information on usage. However, for the purpose of the CBA this approach is likely to be conservative as the full system costs are likely to still be incurred, but with benefits proportionally reduced due to the non-activation of full functionality. Scenarios included in the CBA support this hypothesis: the net benefits of the project increase with 20% penetration of IHD, and with detailed meter reading for 20% of customers.

Since the production of the CBAs, the Netherlands has announced that the remote shut off functionality will be removed from smart meter rollout due to security issues. This will affect full compliance with functionality (g) relating to remote on/off control of supply and/or flow or power limitation.

10 *European Commission, DG-Energy, Cost-benefit analyses & state of play of smart metering deployment in the EU-27, Staff Working Document (2014) 189, Brussels, 17 June 2014, p.22.*

In addition, due to legislative requirements, the CBA considers the option to have the meters set to "administrative-off mode". This mode grants the consumers with the guarantee that no information has been exchanged with the DSO or any third party; however the consumer himself can still have access to his metering data (via the consumer port).[11] The option for administrative-off was included to minimise the number of consumers rejecting the installation of the smart meter. While the take up of "administrative-off" reduces net benefits, in practice few customers have actively requested this option to date.

On the cost side, the CBA includes most key items, without any explicit allowance for distribution, transmission and generation. Additional allowance is provided for billing costs due to the assumption that customers will receive additional feedback on their usage through more regular billing. The communications costs are relatively high, half of which can be accounted for by the use of GPRS, as the CBA assumes the use of 80% PLC and 20% GPRS for data transfer.

Several benefits in Recommendation 2012/148/EU are not explicitly addressed in the assessment, including deferred investment, technical losses, CO2 emissions and air pollution. However, an important additional consideration is an allowance for increased competitiveness resulting from the installation of the smart meters, which is assumed to arise due to the ability for competitors to develop new market niches in a market with a full roll out of smart meters.

4.3.2. Sensitivity/volatility analysis

A key sensitive item in the CBA is the treatment of competitiveness, the removal of which under plausible assumptions is sufficient to produce negative net benefits (of €127 million or approximately €19 per metering point) for an electricity only assessment.

However, in other cases the CBA analysis undertaken is relatively conservative in nature. For example, communications costs are relatively high by the incorporation of 20% use of GPRS, and the assumption for consumption reduction of 3.2% under the indirect feedback included in the CBA is lower than the findings reported in the 2010 report that reductions of 6.4% are anticipated with direct feedback. Moreover, the results of the pilot studies reported by RVO that consumption impact of up to 5.6% has been reported for direct feedback. In this regard, it should be noted that a sensitivity is included in the CBA based on 20% direct feedback via an IHD, for which the NPV of the programme increases from €770 million (electricity and gas) to €860 million (electricity and gas).

On the other hand, the report estimates that the NPV will become negative if 20% of customers opt for "administrative off" or be slightly positive if there is 20% installation of traditional meters. Moreover, removing the ability for remote disconnection and connection is an additional factor that may reduce the expected benefits. These factors

11 *Ibid*, p.21.

suggest that the overall net benefits of the programme are sensitive to functionality. Put another way the CBA findings show that greater functionality increases the robustness of the results.

However, in general the results presented in the reports appear reasonably robust as the costs do not appear to be understated, while there are many omitted potential benefits, including investment deferral, emissions reduction and reductions in technical losses.

4.3.3. Lessons learnt

The lessons that can be learnt from the Netherlands analysis include:

- The importance of policy clarity over conditions where customers may be allowed to opt out of having key features of the smart meter activated, due to the benefits being sensitive to functionality
- The importance of developing an appropriate base case and the increasing value of enhancing functionality
- The need to accurately estimate the proportion of PLC/GPRS in the communications mix due to the sensitivity of the results to the technology adopted
- The need to manage privacy concerns, given that the option for remote disconnection and connection has been removed as a functionality in the Netherlands

4.4. Romania

The CBA considered is that undertaken by AT Kearney in September 2012 for the European Bank of Reconstruction and Development (EBRD).

4.4.1. Recommended methodology

The evaluated model in Romania is designed with a “middleware layer”, consisting of data concentrators and balancing meters placed on each substation, with data communication occurring through PLC wiring from the meters to the concentrators and through various communication channels from concentrators to the central application.

In general, the model analysed in the CBA is stated as fully consistent with minimum functionalities. However, it appears that the CBA is run assuming indirect feedback to customers (i.e., not real time feedback); though at the same time no consumption impact is included in the benefits. Similarly, it is unclear whether the metering arrangements are designed to support enhanced tariff structures. The report also states the need for various additional functionalities to be included in a smart metering system, though it is not specified if these are all activated under the metering and communications infrastructure proposed in the scenario presented in the CBA.

The CBA considers gas and electricity separately, and hence there are no common costs to attribute to each activity.

The overall unit costs of the proposed system are low, with the average expenditure per metering point estimated at just under €100. The report includes total costs and unit costs of meters, data concentrators and balancing meters, though the total costs are not broken down into capital and operating expenditures. Subsequent to the CBA a breakdown of the total cost has been provided, in which the MS has advised that it now considers the average cost per metering point to have risen to €122 based on analysis on recent pilot projects. A key difference is the inclusion of a €25/metering point cost of distribution investment.

Almost 70% of the overall benefits of the project are accounted for by two variables – reduced manual meter reading costs, which is based on a saving of 4 manual reads per meter per year; and reduced commercial losses. In the core scenario, it is assumed that commercial losses – estimated at 7% - will be reduced by 60% of this amount. The only consumption impact included under the benefits is indirectly related to the commercial losses, as it is assumed that 50% of the reduction in commercial losses will be subsequently invoiced to customers, and 50% manifest in reduction in consumption.

Several benefits included in Recommendation 2012/148/EU are not directly included in the CBA, including:

- Call centre costs
- Consumption impact (apart from via commercial losses)
- CO_2 costs (though these are considered separately)
- Deferral of network investment

4.4.2. Sensitivity/volatility analysis

The report considers the sensitivity of the results to changes in the discount rate and the available reduction in commercial losses. Including in the case of a "pessimistic" scenario with 30% commercial loss reduction and a higher discount rate of 9% the project has a positive NPV.

In practice, the results will be sensitive to significant increases in costs. However, both costs and benefits may be understated in this analysis:

- The costs appear to almost exclusively refer to metering, communications and IT, with limited additional investment at the customer premises or in other areas of the supply chain (training, customer programmes etc.). Similarly, assuming that PLC can be used for 99% of customers may be optimistic.
- Several benefits are not included in the analysis (as listed above), while the CBA scenario does not anticipate benefits related to real time provision of information to customers.

The report itself notes that over time a consumption reduction of over 3.8% may be possible based on international experience as the smart meters are progressively installed, but to obtain these benefits, investment in the smart metering system will need to be combined with other measures such as investment in IHD.

Overall, the results are sufficiently positive that even allowing for some additional costs a positive CBA is supported. Over time, it would be expected that once commercial losses are reduced, customers might start to adjust their consumption in a manner stated by the report, and consistent with experience in other jurisdictions. However, to achieve these benefits greater functionality may need to be activated into the smart metering system.

4.4.3. Lessons learnt

Some key lessons from the Romanian analysis are that:

- Where commercial losses are high relatively low cost forms of smart metering solutions can provide strong net benefit.
- To undertake an analysis most consistent with the methodological requirements of Recommendation 2012/148/EU, including minimum functionality, costs reflecting this functionality should be included the analysis. In the case of Romania, while the analysis is logically coherent by neither including the costs of providing customer feedback nor any respective benefits, a more comprehensive result may be obtained by including all impacts.

4.5. Italy

A copy of the CBA for Italy was not provided. However, any CBA for Italy will be extremely dated, as we understand that the only CBA conducted was that undertaken by Enel for its own purpose before embarking on the introduction of smart meters, the widespread rollout of which was later mandated by the Regulator. Over the period 2001-2010 approximately 37 million smart meters were installed and managed by Enel under its Telegestore automated meter management (AMM) system. As a forerunner in the implementation of smart metering technology, of greater interest for this study are the findings of the widespread rollout exercise under Telegstore.

The project can be seen to have two phases, the first being the full roll out of the AMM system, with the second being its extension to provide ancillary (in-home) services to customers through the available infrastructure.

The key components of the Telegestore system are:[12]

- The electronic meter, for energy reading, remote reading and remote management
- The data concentrator, installed in every medium voltage and low voltage station of ENEL Distribuzione, to collect the data registered by the meters connected to it
- The central system, to manage the system, by collecting and sending data from and to concentrators
- The operative centre, which manages the acquisition of measurement data and the contractual operations

12 European Commission, Enterprise and Industry, The Sectoral e-business watch, Case Study: Telegestore ENEL, December 2009.

The data is transmitted from the meters to the concentrator on the low voltage network, while the communication between the concentrator and the central system is established through a public GSM network.

Enel estimates that the total cost of the roll out was €2.1 billion, with the costs broken down as follows:(13)

- Smart meters and data concentrators – 71%
- Installation – 22%
- Systems-IT – 7%

For an estimated 37 million meters installed the average cost works out at only €57/meter (note Enel reports capital expenditure of €70/meter). However, functionality does not meet the minimum recommended requirements in the following areas:

- Meters are read only once a month, with consumption data not stored
- Customers are not able to monitor their usage and receive no real time signals

Various benefits have been realised in Italy from the introduction of smart meters. The most direct benefits have been achieved in the following areas:

- Reduction in the number of manual meter readings, where there was an obligation for a physical meter read once a year
- Removal of the need to change the meter when a customer changes its power contract
- Removal of the need to change the meter and undertake a manual meter read when a customer changes its supplier
- Reduction in non-technical losses

Savings in operational expenditure are estimated at €16/meter/year.

In addition, Enel reports benefits in the following areas, which it attributes to a combination of the introduction of smart metering and greater automation in secondary substations:

- Reduction in technical losses
- Reduction in outage duration (SAIDI) – from 128 minutes in 2001 to 42 minutes in 2011

Key customer benefits include the facilitation of switching and the enabling of time of use tariffs.

Currently meters are only read once a month, billing is carried out every two months, with customers receiving no direct information on their usage, there is little evidence to suggest that customers have adjusted their consumption in response to the introduction of smart metering. However, as a second phase to the Telegestore project, Enel has developed a product, known as Enel Smart Meter Info ®. Under this system

13 *Presentation by Claudio Zito, ENEL Distribuzione, "Smart Technologies Developed by Enel for Grid Management – Enel AMY system".*

a device is plugged into the customers home, which communicates with the meter via PLC and provides information to a portable device (PC) via Wifi on real time usage, with information also provided on usage compared with other customers (above or below average etc.,). This device is currently the subject of a large-scale trial for 5,000 customers with basement meters. While results of the trial are not publicly available Enel advises that a significant consumption impact is evident including 2-3 years after the start of this pilot programme, which is consistent with the findings of the vaasaETT study reported in section 3.2 .

For the smart meters installed Enel reports:

- Meter failure rate below 1%
- Assumed asset life of 15-20 years, but many meters now are 14 years old with no sign of deterioration

Enel estimates that from a €2.1 billion investment it recoups savings of around €450 million/year resulting in a short payback period based on private benefits only.

4.5.1. Key lessons learnt

Key lessons learnt from the Italian experience of relevance for the CBA include:

- Relatively low cost technology can be applied and ensure the majority of benefits can be reaped
- Savings from reductions in theft can be significant
- Operating cost savings, particularly meter-related ones have been critical to the success of the project
- An asset life of at least 15 years appears justified based on real life experience
- The extent of network related benefits (outages, supply restoration, etc.) need to be considered in the context of other related investments at the same time

A current challenge for the Telegestore system is to demonstrate that consumption, or in-home, benefits can also be achieved in a low cost manner. The preliminary results of the pilot project using the Enel Smart Meter Info ® device provide early indications that this is also possible in a way that provides the customer benefit without incurring significant additional communications costs.

5. Countries where the CBA produced an inconclusive or negative result for a widespread roll-out

5.1. Summary findings

The following summary findings arise from the review of the CBAs reporting an inconclusive or negative result:

- A number of these studies report high cost solutions, with in some cases this also being accompanied by high benefits. In some cases, key drivers are high cost metering and communications systems, which differ significant from those reported in the CBAs with positive results.
- Context is an important issue in the development of the CBA in particular countries. For example: due to commonality in gas and electricity supply in the Belgian jurisdictions a dual fuel CBA is proposed; the impact of ripple control systems in the Czech Republic affects the potential benefits from smart metering, while in Lithuania low energy prices and relatively shallow peaks in electricity consumption are reported. In addition, in Germany privacy is reported as a key concern.
- The negative or inconclusive results are sensitive in some cases to key variables. The results in Germany can change dramatically based on the assumed consumption impact, while the CBAs in Portugal and the Slovak Republic as they currently stands can be interpreted as a positive rather than inconclusive or negative result.
- In some cases, the results appear more robust where additional functionality is built into the metering system and associated infrastructure. A notable example is that of Hungary.
- Many potential benefits and costs are not always considered in the CBA.

5.2. Belgium – Brussels

In Belgium-Brussels Capgemini Consulting for Brugel undertook a CBA in May 2011. The CBA is based on a joint roll out of electricity and gas smart meters. Four distinct roll out options are considered: basic, moderate, advanced, and full. The third, “advanced” option is considered the one that most closely representing the Commission’s requirements, and is considered in this section.

5.2.1. Assumptions made

Key assumptions made in developing the CBA are set out below:

TABLE 13

KEY ASSUMPTIONS BRUSSELS CBA

Key assumption	Unit	Value
Roll out period	Years	2015-2019
Proportion of metering points covered	%	100% by 2019
Modelling period	Years	2011-2030
Discount rate	%	6.5%
Asset life of meters	Years	15
Reduction in call centre costs	%	50%
Reduction in consumption	%	Between 1% (basic) and 4.6% (full) depending on functionality – 75% of full benefits apply in the advanced scenario
Reduction in non-supplied energy	%	10%
Reduction in theft	%	75%

The costs and benefits are reported for electricity and gas combined. A high-level estimate has been made of those costs relating solely to electricity by assuming that around 60% of the smart meter costs (including installation) are attributed to electricity, while 20% of communications costs could be avoided with an electricity only roll out. In the case of benefits, it is assumed that the following categories are reduced by the proportion of gas meters: meter reading and operational cost, electricity cost, and commercial losses. Other benefits are assumed to apply solely to electricity.

The resulting key costs and benefits are summarised in the following table:

TABLE 14

KEY COSTS AND BENEFITS, ELECTRICITY-ONLY, BRUSSELS CBA, NPV BASIS

Item	Value (€/metering point)
Costs	
Average cost of smart meters	268.94
Average cost of IT	79.47
Average cost of communications	144.75
Average training costs	6.48
Customer engagement programmes and other	28.29
TOTAL COSTS	**527.92**
Benefits	
Reduction in meter reading and operations	66.85
Reduction in O&M costs	15.37
Reduction in technical losses	7.36
Electricity cost savings	173.27
Reduction in commercial losses	82.36
Reduction in outage times	4.85
Reduction in CO2 emissions	25.21
Avoided investment in standard meters	15.04
TOTAL BENEFITS	**390.33**
NET BENEFIT	**-137.59**

Note that the smart meter cost is the installation plus replacement of defects (Brussels CBA, p.24 multiplied by the assumed proportion of electricity costs (60%).

The results are strongly negative. However, what is notable is that high benefits are foreseen in electricity consumption, commercial losses and meter reading and operations.

5.2.2. Adequacy of the approach

The CBA study in Brussels was developed before the issuance of Recommendation 2012/148/EU and hence has not been developed along these lines. However, the majority of benefits specified in this Recommendation are captured in the analysis. A notable finding is that the net benefits increase in moving from the “basic” to the “moderate” and subsequently to the “advanced” scenario. This progression supports the hypothesis that the benefits of additional functionality generally outweigh the costs. However, the report does contain a fourth scenario, namely "full" that shows a much lower net benefit than the other scenarios. A key reason for this finding is the assumption that the unit cost of the meter itself will almost double from €83 to €160. The report notes that an IHD would be included under this scenario. However, the difference in unit cost (€77) is significantly higher than the cost of IHDs in other jurisdictions.

5.3. Belgium – Flanders

A CBA was conducted for Belgium-Flanders in 2012 by KEMA, which was updated in 2014, the results of which are summarised in a document issued by the Regulator, VREG.

Two key roll out options are considered – a uniform rollout over 5 years or a segmented roll out over 6 years, which starts with larger commercial customers, moving over time to residential customers. The former is considered in this section as most closely approximating the expectations of Recommendation 2012/148/EU.

A notable feature of the CBA for Flanders is that it is based on a joint rollout of gas and electricity smart meters, which is considered the most feasible policy decision due to the vast majority of customers obtaining gas and electricity from the same supplier. The result of the 2012 CBA covering both electricity and gas showed a small net benefit of €144 million, the updated analysis shows a net cost of €157 million.

5.3.1. Assumptions made

Key assumptions made in developing the CBA are set out below:

TABLE 15

KEY ASSUMPTIONS FLANDERS CBA

Key assumption	Unit	Value
Roll out period	Years	2015-2020
Proportion of metering points covered	%	96% by 2020
Modelling period	Years	2015-2045
Discount rate	%	5.5%
Asset life of meters	Years	15
Number of avoided meter readings	N°/meter	2
Reduction in consumption	%	3.4% electricity, 0% gas
Peak load transfer	%	15% for 20% of customers

Currently meters are only manually read once per year. However, the CBA assumes that the reading of manual meters will increase to twice per year under the counterfactual to best comply with the requirements of Directive 2012/27/EU on energy efficiency. A notable change from the 2012 analysis is that it is assumed that the reduction in electricity consumption upon installation of a smart meter increases from 1% to 3.4%, while that for gas reduces from 2% to zero. At the same time there has been:

- A significant increase in the assumed capital cost of meters, and installation costs, offset somewhat by lower communications costs as a result of these being embedded in the meter
- Increase in the avoided cost of traditional meters

The net impact of these factors is to produce a negative result. For the purpose of considering the impact of electricity in driving the results, high level estimates of the costs and benefits that can be attributed solely to electricity have been made. In doing so, a breakdown of gas and electricity specific costs and benefits has been made for 2012, with these values adjusted by overall changes in the category results between 2012 and 2014. Key assumptions adopted in estimating electricity costs and benefits include that:

- Around 78% of the smart meter costs (including installation) are attributed to electricity
- 20% of communications costs could be avoided with an electricity only roll out
- The majority of benefits are electricity-specific benefits, with the exception of meter reading and operations, commercial losses and avoided costs of standard meters, where the apportionment between gas and electricity depends on the proportion of meters and respective costs

With these assumptions the key findings are that the overall net benefit:

- In 2012 becomes slightly more positive for electricity-only (€20 million greater)
- In 2014 is slightly more negative than the overall combined result at -€185 million

The resulting key costs and benefits, adjusting for gas, reported on a per-metering point basis, are summarised in the following table:

TABLE 16

KEY COSTS AND BENEFITS, FLANDERS CBA, ELECTRICITY-ONLY (2014), NPV BASIS

Item	Value (€/metering point)
Costs	
Average cost of smart meters	387.49
Average cost of IT	83.33
Average cost of communications	22.73
Additional roll out and other costs	75.76
TOTAL COSTS	**569.30**
Benefits	
Reduction in meter reading and operations	162.42
Reduction in O&M costs	60.61
Reduction in technical losses	3.03
Electricity cost savings	108.79
Reduction in commercial losses	60.61
Reduction in outage times	22.73
Avoided investment in standard meters	95.01
TOTAL BENEFITS	**513.33**
NET BENEFIT	**-55.97**

5.3.2. Adequacy of the approach

For the purpose of the MS, undertaking a CBA based on a joint roll out appears appropriate. The chosen technology choice presupposes that a joint roll out will be mutually beneficial with the electricity meter as a conduit for information from the gas meter. While it is unclear if currently the same personnel read electricity and gas meters significant efficiency benefits should theoretically be available for a joint roll out that are not present in a single electricity-only roll out. High level estimates of costs and benefits that would only arise in the case of an electricity-only rollout do not indicate the presence of strong efficiency gains. However, it should be noted these assumptions have not been subject to detailed review by the MS.

Not all costs and benefits included in Recommendation 2012/148/EU are included in the CBA. However, it is notable that the costs and benefits are both extremely high on a per-metering point basis. In particular, the technology choice, the unit costs of metering equipment and associated installation costs are high, and well above the levels in some other countries. These values are considered further in the following section.

5.4. Belgium – Wallonia

The CBA considered is that prepared by Capgemini consulting in June 2012 for CWAPE, the Commission Wallonne pour l'Energie.

Two key roll out options are considered:

- A "Full Roll-out" scenario, with 80% of customers fitted with electricity and gas meters by 2020.
- A "Smart-meter friendly" scenario, with a selective roll-out to particular customer segments, including those with a bad payment record, new installations, replacements, and those customers requesting a smart meter and paying for the installation.

The CBA is based on a joint roll out of gas and electricity smart meters, which is considered most feasible due to the majority of customers receiving gas and electricity from the same supplier.

5.4.1. Assumptions made

Key assumptions in developing the CBA are set out below:

TABLE 17

KEY ASSUMPTIONS FLANDERS CBA

Key assumption	Unit	Value
Roll out period	Years	2015-2020
Proportion of metering points covered	%	80% by 2020
Modelling period	Years	2015-2045
Discount rate	%	5.5%
Asset life of meters	Years	15
Reduction in consumption	%	0% (electricity and gas)
Peak load transfer	%	12% (electricity)

The resulting costs and benefits are set out in the following table, which includes adjustment for costs that are estimated as directly attributed to gas in the joint gas-electricity roll out. The key assumptions adopted in estimating electricity costs is that around 73% of the smart meter costs (including installation) are attributed to electricity, while 20% of communications costs could be avoided with an electricity only roll out.

TABLE 18

KEY COSTS AND BENEFITS, WALLONIA CBA, ELECTRICITY-ONLY, NPV BASIS

Item	Value (€/metering point)
Costs	
Average cost of smart meters	493.74
Average cost of IT	92.26
Average cost of communications	68.54
Additional roll out and other costs	31.28
TOTAL COSTS	**685.82**
Benefits	
Reduction in meter reading and operations	127.86
Reduction in O&M costs	3.25
Electricity cost savings	104.11
Reduction in commercial losses	379.93
Competitiveness	30.65
TOTAL BENEFITS	**645.80**
NET BENEFIT	**-40.02**

A notable feature of the Wallonia CBA is high average costs and benefits. This is to a large part driven by the modelling period, which includes replacement of still to-be-installed smart meters. A notable feature of this CBA is the predominant role of commercial loss reductions in driving overall project benefits, which is attributed to the large number of customers on pre-payment meters. The MS advises that detailed regulation for pre-payment meters is specified in Wallonia and only one provider is able to provide the necessary budget meter that meets these requirements. As the budget meter is costly, replacement of this system by smart meters will provide significant benefits. It is notable that a zero direct consumption impact is forecast, due to the interface considered insufficient to provide the necessary incentives to customers, with electricity cost savings arising due to peak load shifting. The MS noted that third parties could potentially provide enhanced interfaces (applications etc.,) and thereby produce consumption savings, but this was considered outside the scope of the CBA.

In the case of Wallonia, the result is still negative using the MS results incorporating fully the costs of gas metering and its benefits. Notably the “Smart Meter Friendly” scenario is strongly positive. However, this scenario only results in a 15% penetration of smart meters by 2020.

5.4.2. Adequacy of the approach

Similar considerations apply as in the case of the other Belgian jurisdictions regarding the applicability of a joint rollout of electricity and gas smart meters, with the technology choice presupposing that a joint rollout will be beneficial due to the use of the electricity meter as a conduit or gateway for the gas meter.

Not all costs and benefits included in Recommendation 2012/148/EU are included in the CBA. Notably no consumption impact is forecast, which suggests the proposed interface with customers should be evaluated. On the other hand the high savings in fraud detection and non-payment may suggest that the immediate necessity for a roll out is to reduce losses, which may permit a greater customer demand response over time.

The treatment of avoided investment in standard meters is unclear from the analysis.

5.5. Czech Republic

The Ministry of Industry and Trade performed the CBA considered. The CBA evaluates costs and benefits under two scenarios, a “blanket” scenario involving the introduction of smart metering, and a “basic” scenario that is a variant of the status quo. The blanket scenario is that which most closely represents the EU requirements and is considered in this report.

5.5.1. Assumptions made

Some key assumptions made in developing the CBA are set out below:

TABLE 19

KEY ASSUMPTIONS CZECH REPUBLIC CBA

Key assumption	Unit	Value
Roll out period	Years	2019-26
Proportion of metering points covered	%	100% by 2026
Modelling period	Years	2012-2038
Discount rate	%	6.1%
Asset life of meters	Years	12
Reduction in consumption	%	0%
Reduction in non-supplied energy	%	0%
Reduction in commercial losses	%	0%

The Ministry notes that due to the district ripple control (HDO) system in place in the Czech Republic, there is limited potential for additional demand management and load control, and hence no assumption on investment deferral is included. The HDO system is used for direct remote control of groups of appliances according to the time schedules set, and reflecting the electricity network load conditions. In this way, the distribution system operators are able to optimise daily load profiles.(14) A two-tier electricity pricing system is in place (high/low) in which the use of heating appliances is strictly linked with the tariff system so that customers are compensated for the use of load control through lower tariffs. For the use of other appliances, customers are also to differentiate between the high and low electricity price level.

In addition, the CBA foresees no reduction in consumption, concluding that pilot programmes demonstrate that customers are "reluctant to reduce comfort or change their consumption patterns even when offered motivational tools".(15)

Key costs and benefits are summarised in the following table:

TABLE 20

KEY COSTS AND BENEFITS, CZECH REPUBLIC CBA, NPV BASIS

Item	Value (€/metering point)
Costs	
Average cost of smart meters	248.13
Average cost of IT	110.03
Average cost of communications	61.09
Average cost of distribution	2.60
Customer engagement programmes	2.57
Sunk costs	1.36
Security	4.01
Others not defined	6.67
TOTAL COSTS	**436.46**
Benefits	
Reduction in meter reading and operations	30.67
Reduction in O&M costs	44.27
Electricity cost savings	1.49
Avoided investment in standard meters	127.49
TOTAL BENEFITS	**202.43**
NET BENEFIT	**-234.03**

14 *European Commission, DG-Energy, country fiches for electricity smart metering, Staff Working Document (2014) 188, Brussels, 17 June 2014, p.24.*

15 *Ministerstvo Průmyslu A Obchodu, "Economic assessment of all the long-term costs and benefits for the market and the individual costumer through application of smart metering systems in the Czech Republic power sector" (unofficial translation), p.7.*

Note that the above costs of smart meters include costs of €64.47 per metering point for the replacement of wiring at the same time as the meters are installed. The net cost of the smart meters adjusting for this factor is therefore €183.66.

The net benefit produced in the CBA is highly negative. The MS notes several additional features of the Czech system – over and above the HDO system - that produce this result, including: existing standardisation of metering devices and switchboards, low losses, no pre-payment meters, and existing high quality of services. However, a number of other factors suggest that net benefits may be understated:

- The capital costs of the metering equipment, IT and communications infrastructure are extremely high. The Ministry based its CBA on prices received metering companies upon request for quotes for technology compliant with the functionality in Recommendation 2012/148/EU. However, experience in other MS suggests that much lower cost solutions are available. Reflecting this observation the CBA notes that significant decreases in the prices of the technological components would be expected prior to a large scale roll out.
- No direct consumption impact is included for the smart metering roll out. Even if the direct control of some heating appliances is a critical feature of the Czech electricity sector, there is a significant proportion of consumption that falls outside this mechanism.
- The conclusion that customers are reluctant to alter consumption even when faced with motivational tools is not in line with that in many other countries.

5.5.2. Adequacy of the approach

The approach adopted is generally consistent with the requirements of Recommendation 2012/148/EU. Indeed, the Ministry references the Commission's Recommendations in various places, and even shows how each benefit and subcomponent has been addressed in the report. Due to the long rollout timeframe proposed with a 7-year preparatory phase, there is not 80% coverage of smart meters by 2020.

While the breakdown of benefits is not obvious from the analysis, a more fundamental issue in the report is the empirical assumptions adopted. For example, the high capital costs combined with a lack of consumption impact are not conducive to obtaining a positive result.

In the Czech Republic a 12-year asset life is noted due to existing meter certification requirements. However, where the meters have a useful life longer than the certification period the local regulations may need to be reviewed.

5.6. Germany

The CBA considered for Germany is that undertaken by Ernst and Young for the Federal Ministry of Economics and Technology in 2013 (English and German versions). The CBA considers various scenarios for smart meter roll out.

Focus is placed on the "EU scenario" as it is most consistent with the requirement for an 80% roll out of smart metering by 2022.

5.6.1. Assumptions made

Some key assumptions made in developing the CBA are set out below:

TABLE 21

KEY ASSUMPTIONS GERMANY CBA

Key assumption	Unit	Value
Roll out period	Years	2012-22
Proportion of metering points covered	%	80% by 2022
Modelling period	Years	2012-2032
Discount rate	%	5% commercial, 3.1% residential and company
Asset life of meters	Years	13
Number of avoided meter readings	N°/meter	1
Reduction in consumption	%	Between 0.5% and 2.5% (average 1.8%)
Peak load transfer	GW	6.1
Reduction in non-supplied energy	%	1%
Reduction in theft	%	20%

The CBA does not provide a full breakdown of costs and benefits of the EU roll out scenario, though it has been possible to approximate these from the unit costs and volumes reported in the CBA. The resulting estimated costs and benefits for the period up to 2032 are set out below:

TABLE 22

KEY COSTS AND BENEFITS, GERMANY CBA, NPV BASIS

Item	Value (€/metering point)
Costs	
Average cost of smart meters	190.34
Average cost of IT	86.34
Average cost of communications	171.15
Average cost of in-home displays	33.36
Training	10.93
TOTAL COSTS	**492.12**

Item	Value (€/metering point)
Benefits	
Reduction in meter reading and operations	50.32
Avoided distribution capacity investment	31.53
Avoided transmission capacity investment	9.22
Electricity cost savings	239.69
Reduction in commercial losses	1.52
Reduction in outage time	0.43
Avoided investment in standard meters	77.04
TOTAL BENEFITS	**484.90**
NET BENEFIT	**-7.22**

The technological choice adopted in Germany is that of a gateway located in the consumer premises that manages the transfer of data to necessary parties, thereby providing high levels of data protection –both privacy and security– to the customer. The gateway configuration involves higher costs than other approaches, though it has the benefit of allowing the connection of other utility services to the same infrastructure (for example, gas and heating). In addition, to meet the required functionality, the CBA assumes a 110% communications coverage, involving 80% use of GPRS and 20% use of PLC. The high proportion of GPRS is a key driver of overall communications costs.

Despite the high cost of the system, the CBA reports high benefits. The core EU scenario reports a negative net benefit of only -€0.1 billion. In addition, the report by the consultant undertakes sensitivity analysis, reporting the following findings.

- NPV of -€5.9 billion for zero consumption impact
- NPV of +€6.1 billion for a 3.6% consumption reduction

These findings imply significant volatility in the results depending on the consumption impact, which appears part of the reason for which the consultant does not support the widespread roll out.

At the same time, the consultant undertakes sensitivity analysis on the number of meter operators. This analysis shows a positive NPV if the current 900 meter providers are amalgamated into 70 (+€0.6 billion), with the benefit rising to €1.1 billion in the case of there being 10 meter operators. The finding suggests significant economies of scale in the development costs of IT infrastructure.

5.6.2. Adequacy of the approach

In general, the assessment provided by the consultant is consistent with the methodology set out in Recommendation 2012/148/EU. However, the German analysis raises a number of issues that require further evaluation. These include:

- The relationship between the costs and benefits of the proposed gateway system, and the associated use of GPRS. The approach results in high communications costs, but may have other offsetting benefits, including the potential to incorporate other utility services (other than gas). For example, the MS advises that in many cases heating bills are of greater concern to customers than electricity bills. The average reading/billing costs for heating is estimated to be around €80/year, which could offset significantly any additional gateway costs.
- The potential role of intelligent meters, which are effectively smart meters without the communication functionality. Due to their low cost, these could be installed in cases of meter replacement, though data security issues may limit the extent to which price signals can be provided to customers.

5.7. Hungary

The CBA considered for Hungary is that produced by Energlobe Service Kft for the Ministry of National Development in June 2013. The detailed roll out scenario considered is labelled as "Scenario 1", which involves a distributor-based roll out of smart meters resulting in 80% coverage by 2021.

5.7.1. Assumptions made

Key assumptions made in developing the CBA are set out below:

TABLE 23

KEY ASSUMPTIONS HUNGARY CBA

Key assumption	Unit	Value
Roll out period	Years	2015-23
Proportion of metering points covered	%	80% by 2023
Modelling period	Years	2015-2033
Discount rate	%	Cash flow discount rate of 10.3% reported
Asset life of meters	Years	15
Number of avoided meter readings	N°/meter	1
Reduction in consumption	%	1.5%
Reduction in theft	%	50%
Reduction in technical losses	%	1.5% reduction in scenario considered (rising to 10% in other scenarios)

The report considers various alternative roll out scenarios:

- "Scenario 2", a joint roll out by all DSOs, in which the companies concerned jointly develop the system that process and store the data provided by smart meters, and make them available to the utilities and authorities for further use. Under this scenario, there is a necessity to create a new entity known as the Smart Meter Operator responsible for data collation and transfer.
- "Scenario 3", a variation of scenario 2, with MAVIR the Transmission System Operator taking over the functions of the Smart Meter Operator.
- "Scenario 4", a variation of scenario 3 in which demand management functions are included in the smart meter set up (remote operations etc.).

Key costs and benefits for the scenario considered (Scenario 1) are summarised in the following table:

TABLE 24

KEY COSTS AND BENEFITS, HUNGARY CBA, NPV BASIS

Item	Value (€/metering point)
Costs	
Average cost of smart meters	125.55
Average cost of IT	11.49
Average cost of communications	54.27
Average cost of in-home displays	11.74
Average cost of customer engagement programmes	28.98
Sunk costs	10.36
Other costs	0.02
TOTAL COSTS	**242.42**
Benefits	
Reduction in meter reading and operations	14.52
Reduction in technical losses	4.45
Electricity cost savings	7.61
Reduction in commercial losses	19.59
Competitiveness (retail price)	49.79
Generation efficiency (wholesale price)	68.66
TOTAL BENEFITS	**164.62**
NET BENEFIT	**-78.20**

While the overall result is negative, it needs to be noted that the other scenarios result in either a lower negative result (scenarios 2 and 3) or a positive result (scenario 4). In the case of scenario 4, the following benefits are reported:

- A 10% reduction in network losses
- A 75% reduction in customer switchover costs
- A 16% decrease in balancing power demand
- A 6% decrease in wholesale prices, relating to a 2% in end-user prices due to more intense competition

5.7.2. Adequacy of the approach

The approach adopted is generally consistent with the requirements of Recommendation 2012/148/EU though the proposed 80% roll out is not in place until 2023. In addition, the vast majority of benefits relate to activities – wholesale and retail price reductions – that are not foreshadowed in the Commission's methodology. Some benefits, including emissions-related and peak shifting are not included, with others only included in the final scenario. It is only in the final scenario where the full capabilities of smart meters appear to be present. This raises the question of whether it is possible to achieve the full benefits under a lower-cost solution, or if Scenario 4 should be considered the core scenario.

5.8. Latvia

A national CBA was not received from Latvia. However, we understand that analysis has been undertaken and that a decision to proceed with a roll out has been made.

The Meter-ON report states that a CBA was performed in Latvia, which considered six various smart metering rollout scenarios with different volumes of metering. Only one of the scenarios has resulted in a positive economically justifiable result. This scenario assumes installation of 250,500 smart meters (approximately 25% of all consumers of Latvenergo & Sadales tikls) by 2017. The predominant DSO, Sadales tikls has stated that based on the results it decided to implement the 25% rollout. However, after receiving bids for meters significantly lower than assumed in the CBA, it took a business decision to proceed to a full rollout. This will cover 1.1 million customers by 2023 and reach 80% by 2020.

The CBA information is not yet public.

5.9. Lithuania

Ernst & Young wrote the CBA considered for Lithuania in September 2012. The CBA considers a smart meter roll out three different scenarios: base case, advanced functionality and multi-metering. For the Base case scenario, the meter functionalities were chosen with compliance to the Commission's recommendations, and thus is the scenario analysed.

5.9.1. Assumptions made

Key assumptions made in developing the CBA are set out below:

TABLE 25

KEY ASSUMPTIONS LITHUANIA CBA

Key assumption	Unit	Value
Roll out period	Years	2016-20
Proportion of metering points covered	%	80% by 2020
Modelling period	Years	2015-2029
Discount rate	%	5% financial, 5.5% economic
Asset life of meters	Years	15
Number of avoided meter readings	N°/meter	1.3
Reduction in consumption	%	2.3% (households without in-home display)
Peak load transfer	%	Up to 4.5%
Reduction in commercial losses	%	50% reduction from current level of 8%

The resulting key costs and benefits are summarised in the following table:

TABLE 26

KEY COSTS AND BENEFITS, LITHUANIA CBA, NPV BASIS

Item	Value (€/metering point)
Costs	
Average cost of smart meters	103.57
Average cost of IT	12.14
Average cost of communications	33.48
Average cost of distribution	12.02
Average cost of training	0.12
Average cost of customer engagement	2.06
TOTAL COSTS	**163.37**

Item	Value (€/metering point)
Benefits	
Reduction in meter reading and operations	5.28
Reduction in technical losses	8.94
Electricity cost savings	33.52
Reduction in commercial losses	19.18
Reduction in CO_2 emissions	1.08
Avoided investment in standard meters	14.30
TOTAL BENEFITS	**82.29**
NET BENEFIT	**-81.08**

The CBA for Lithuania breaks down costs between capital and operating costs, with capital expenditure averaging at €120.71/meter and operating expenditure €41.79/meter. The overall result is highly negative. However, it should be noted that:

- Reduction in meter readings and O&M costs are extremely low
- The average cost of smart meters is higher than in some other comparable jurisdictions

5.9.2. Adequacy of the approach

The CBA for Lithuania includes more information than many of its counterparts, including capital and operating expenditure and meter roll out profiles over time. While it excludes some benefits included in Recommendation 2012/148/EU, it appears to have been prepared with this methodology in mind. A key issue in reviewing the CBA in detail are the key underpinning assumptions. In this regard, the sensitivity analysis performed by the consultant highlights the following key parameters:

- Demand growth
- Consumption efficiency
- Smart metering equipment prices
- Price of electricity

It is noted that a negative result applies for each of the sensitivities run.

5.10. Portugal

The CBA considered for Portugal is that undertaken by KEMA for the Entidade Reguladora Dos Serviços Energéticos (ERSE) in 2012.

5.10.1. Assumptions made

Key assumptions made in developing the CBA are set out below:

TABLE 27

KEY ASSUMPTIONS PORTUGAL CBA

Key assumption	Unit	Value
Roll out period	Years	2014-22
Proportion of metering points covered	%	80% by 2020, 100% by 2022
Modelling period	Years	2014-2060
Discount rate	%	10%
Asset life of meters	Years	15
Number of avoided meter readings	N°/meter	4
Reduction in consumption	%	2%
Peak load transfer	%	2%
Reduction in non-supplied energy	%	8%
Reduction in theft	%	90%

A long modelling period is applied, though with a high discount rate of 10%.

The resulting key costs and benefits are summarised in the following table:

TABLE 28

KEY COSTS AND BENEFITS, PORTUGAL CBA, NPV BASIS

Item	Value (€/metering point)
Costs	
Average cost of smart meters	56.31
Average cost of IT	7.89
Average cost of communications	33.57
Additional costs of billing	18.72
TOTAL COSTS	**116.50**

Item	Value (€/metering point)
Benefits	
Reduction in meter reading and operations	32.18
Reduction in technical losses	5.26
Electricity cost savings	82.00
Reduction in commercial losses	26.15
Reduction in outage times	1.08
Avoided investment in standard meters	22.74
TOTAL BENEFITS	**169.42**
NET BENEFIT	**52.92**

5.10.2. Adequacy of the approach

The approach taken to the CBA in Portugal is broadly consistent with Recommendation 2012/148/EU. It envisages an 80% roll out of smart meters by 2020 under a rollout period from 2014-22. Furthermore, the proposed system complies with minimum functionalities, although the CBA is based on the assumption that customers do not receive real time data, but indirect feedback through monthly billing.

Key cost and benefit categories correspond to those in the methodology. Overall, average costs are low and these include additional billing costs, due to the assumption in the analysis that customers will physically receive monthly bills upon the installation of smart meters in place of bi-monthly bills. The majority of key benefits of Recommendation 2012/148/EU are included in the analysis. The assessment includes CO2 costs as part of the overall electricity cost savings.

The results of the CBA show significant net benefits. In the assessment, sensitivity analysis is also included on various factors including the discount rate, consumption reduction, meter costs and avoided meter reading costs, each of which report a positive value. Based on a preliminary evaluation of the data the inconclusive finding is not supported solely by consideration of the analysis undertaken. However, a key issue in Portugal is that the DSO does not receive overall net benefits in the proposed roll-out scenario, which is a key constraint in implementation, and a factor to be considered in developing policy recommendations.

5.11. Slovak Republic

The CBA considered was prepared by the Regulatory Office for Network Industries (URSO) in August 2012.

The CBA is premised on a roll-out of smart meters covering only 23% of low voltage supply points by 2020. This would cover all customers with annual consumption of over 4 MWh. The total number of the supply points with installed smart meters will reach 603,750 by 2020, accounting for approximately 53% of total annual LV electricity consumption.

5.11.1. Assumptions made

Some of the key assumptions in developing the CBA are set out below:

TABLE 29

KEY ASSUMPTIONS SLOVAK REPUBLIC CBA

Key assumption	Unit	Value
Roll out period	Years	2013-20
Proportion of metering points covered	%	23% by 2020
Modelling period	Years	20 years
Discount rate	%	6.04%
Asset life of meters	Years	15
Reduction in consumption	%	1%
Peak load transfer	%	2%

Within the 23% cap on total meters the CBA considers the following two options:

- A "Progressive" option in which 70% of the smart meters covered will be installed during the first 4 years and 100% of the planned target will be fitted with smart meters after 8 years, in 2020
- A "Linear" approach with an even implementation profile for smart meters over the period to 2020

In its report capital costs, operating costs and benefits are projected on an annual basis up to 2020. The impact of the full 20-year period has been evaluated by projecting forward the operating expenditure and benefits over the relevant period. The resulting discounted costs and benefits for the period 2013-32 are set out in the following table:

TABLE 30

KEY COSTS AND BENEFITS, SLOVAK REPUBLIC CBA, NPV BASIS

Item	Value (€/metering point)
Costs	
Average cost of smart meters	91.72
Average cost of IT	22.61
Average cost of communications	56.81
TOTAL COSTS	**171.15**
Benefits	
Reduction in meter reading and operations	38.48
Reduction in O&M costs	10.10
Reduction in technical losses	14.02
Electricity cost savings	198.52
Reduction in commercial losses	42.71
TOTAL BENEFITS	**307.27**
NET BENEFIT	**+136.12**

Note: In the case of capital costs, estimates have been made from the unit costs included in the report. This produces a larger value than those stated in the CBA.

The above results imply that the project has an extremely short payback period and that a much broader meter installation programme can be proposed even using the assumptions of URSO's CBA.

5.11.2 Adequacy of the approach

The approach followed in the CBA is broadly consistent with the requirements of Recommendation 2012/148/EU. A number of benefits are not included in the assessment, including maintenance costs, outage reduction and equipment breakdown. Despite a consumption benefit from peak load transfer, no network benefit is assumed. In addition, not all benefits are clearly identified in the CBA, including the avoided cost of standard meters. In general, however, a key required development would be to develop a rollout scenario covering 80% of customers by 2020.

6. More detailed review of the Cost Benefit Analysis

6.1. Introduction and Methodology

This section sets out findings from undertaking more detailed investigation into the cost benefit assessment of the large-scale deployment of smart metering in Member States where there was a negative or inconclusive outcome in the national CBA.

The aim of the analysis in this section is to replicate, in a relatively standard format, the key dynamics of the CBAs of the respective MS, and in doing so:

- Provide a crosscheck on the existing CBAs
- Permit further harmonisation of the results and better understand key drivers of costs and benefits
- Facilitate additional analysis of key sensitivities and the impact of country-specific factors
- Allow greater understanding of key constraints to a widespread implementation of smart metering systems in specific MS

A key requirement for this analysis has been to develop annual paths for costs and benefits. Consistent with this requirement, two key broad analytical approaches have been adopted in recreating the dynamics of the CBAs in question.

In some cases a **bottom up** approach to estimating annual costs and benefits has been undertaken based on unit costs and benefits stated in the report (meters, communications, cost and energy savings per meter etc.,) and the identified roll out profile. This approach has been that principally adopted in Germany, Hungary, Lithuania, Portugal and the Slovak Republic.

In other cases, in particular where total costs are primarily reported, a **top down** approach to estimating key cost and benefit categories per metering point has been adopted, where the costs and benefits per category and by year have been estimated from aggregated figures, the roll out profile and other key parameters (discount rate, modelling period etc.,). This approach has been adopted in the Belgian jurisdictions and the Czech Republic.

The analysis has also taken into account various other factors:

- In the case of CBAs with joint gas and electricity roll-outs and with common costs that are not directly allocated to each service, the approach to estimating electricity-only costs and benefits follows the approach adopted in the earlier analysis set out in section 3 This is particularly relevant in the case of Belgium.
- Where practical the key formulas in Recommendation 2012/148/EU are applied in this exercise, particularly in the calculation of benefits – both for top down and bottom up approaches– and in the calculation of key parameters from aggregated data.

- Harmonisation of the results to common modelling periods is applied, in which 15 year and 20-year analytical periods (including the roll out) have been considered. In doing so a more accurate estimate of changes to the results in changing the modelling period is possible than in section 3 due to the development of a year-by-year profile of costs and benefits, which take into account the relevant discount rate. The longer period is designed to reflect the potential impact of a longer metering life without the need for meter replacement. However, it should be noted that the modelling periods include roll out, so for example, in the case of a 15 year modelling period with a 5 year uniform roll out, the effective average life of the smart meters over the life of the project would be around 12.5 years, whereas in the similar analysis with a 20 year period, the effective average life would be 17.5 years.

The above analysis is not intended to act as a new CBA per se for various reasons:

- Key assumptions applied by each MS in its CBAs are maintained in the first instance. For example, there is no attempt to over-write key parameters and assumptions given the absence of detailed information in the study
- The assessment does not involve the inclusion and/or removal of various costs and benefits
- While the analysis involves greater standardisation of the methodology to that in Recommendation 2012/148/EU, it does not involve filling in data for each specified item

The analysis set out in the following sub-sections and reported for the original modelling period aims to best reconcile the original data. In not all cases has full reconciliation been possible, though key dynamics of the CBAs should be evident.

6.2. Belgium – Brussels

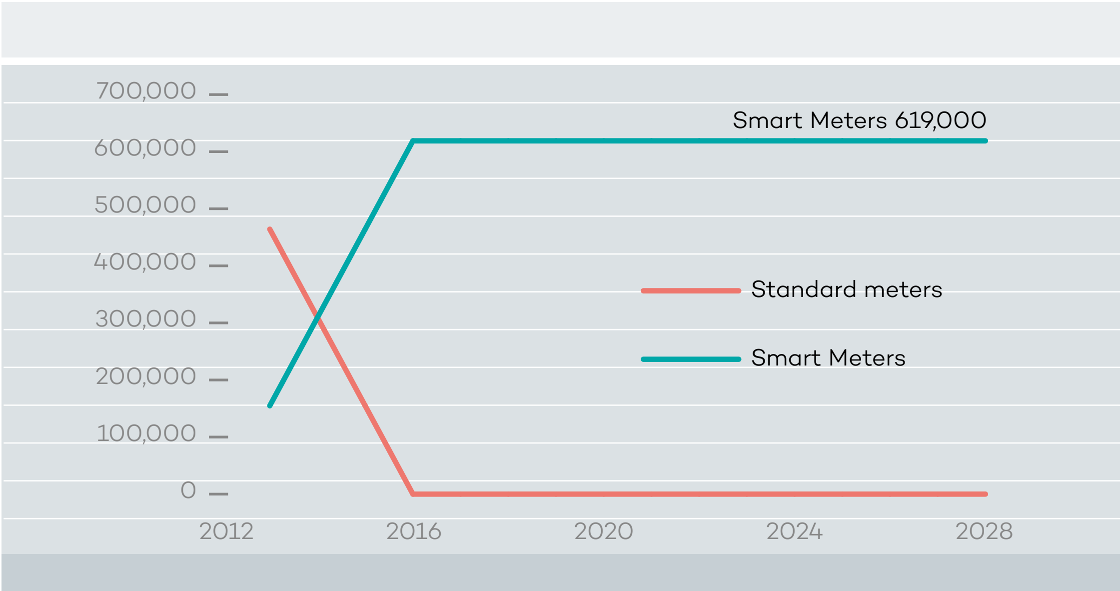
6.2.1. Key methodological assumptions

The approach adopted in recreating the dynamics of the Brussels CBA is top-down in nature given the MS reports principally aggregated costs and benefits on a net present value basis. The key dynamics of the CBA have been recreated by estimating annual profiles for costs and benefits taking into account:

- The smart meter roll out profile
- The estimated breakdown between capital and operating costs developed for the analysis in sections 3.1 and 5.2
- Key benefits included in the CBA and their controlling parameters

A four year roll out is proposed in the CBA. It is assumed that the 619,000 electricity smart meters are installed on a proportional basis as follows (dates from original CBA).

Figure 6 Cumulative profile of smart meters and standard meters, Brussels



For the costs, the total discounted value reflects the amount determined in the previous section after adjusting for gas and less avoided standard metering costs (negative cost). In the case of particular cost categories:

- Meter related capital costs (meter plus installation) are assumed directly proportional to the annual number of meters installed. The key control variable is the per-metering point investment cost, whose value is estimated so that the total cost, after multiplying by the number of meters installed, equals the total estimated capital cost of meters using the discount rate in the CBA (6.5%).
- All capital investment in information technology (€29.4 million) is assumed to take place in the first year.
- Customer engagement costs (€9.1 million) are spread equally over the first four years of analysis.
- Operating costs for each respective cost category are assumed proportional to the number of smart meters installed, and become constant once full rollout is in place. The value of key control parameters are adjusted to obtain the same NPV of costs as in the earlier analysis. The key parameters (all €/metering point/year) are: IT maintenance costs; network management costs; communications/data transfer costs; costs of replacement/failure of smart meters; and training costs.

A similar approach to operating expenditure is applied to estimate the annual profile of key benefits. Key control parameters (€/metering point/year) are: reduction in meter reading and operational cost, reduction in O&M costs, reduction in technical losses, electricity cost savings, reduction in commercial losses and reduction in CO_2 emissions.

6.2.2. Key findings

The reported results for a joint gas and electricity roll-out based on the original modelling period, and estimated periods of 15 and 20 years (both from the start of the roll-out period) are set out in the following table.

TABLE 31

SUMMARY RESULTS: BRUSSELS, GAS AND ELECTRICITY - ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (20 years)	15 years	20 years
Costs	445.12	375.01	445.12
Benefits	365.50	309.67	365.50
NET BENEFITS	**- 79.62**	**- 65.34**	**- 79.62**
Results	Negative	Negative	Negative

In practice as a 20-year period is applied in the original CBA, the first and third columns are identical. The estimated results for an electricity-only roll out are summarised below. Note that different total costs and benefits are reported than in the earlier as avoided standard metering costs are treated as a negative cost as opposed to a positive benefit.

TABLE 32

SUMMARY RESULTS: BRUSSELS, ELECTRICITY ONLY - ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (20 years)	15 years	20 years
Costs	317.46	266.17	317.46
Benefits	232.30	196.82	232.30
NET BENEFITS	**-85.16**	**-69.36**	**-85.16**
Results	Negative	Negative	Negative

The overall results are slightly more negative considering electricity only rather than electricity and gas combined, suggesting some small economies from a joint rollout. It should be noted:

- On the cost side there are various fixed capital costs related to systems (communications in particular) that are unlikely to change significantly if gas is removed from the CBA. The analysis assumes only a 20% reduction in these costs for an electricity only roll out.

- There is a disproportionate share of benefits that are only allocated to electricity services. However, this is not quite as high as for the costs. For example, commercial losses, meter reading costs and electricity consumption savings are assumed to vary by metering point.

For the electricity-based analysis, a breakdown of key cost and benefit items is set out below:

TABLE 33

KEY COST AND BENEFIT ITEMS, BRUSSELS CBA, €MILLION, NPV BASIS

	Original (20 years)	15 years	20 years
CAPEX			
Investment in smart meters	120.18	95.76	120.18
Investment in Information Technology	27.71	27.71	27.71
Avoided investment in standard meters	-9.31	-6.86	-9.31
TOTAL CAPEX	**138.58**	**116.60**	**138.58**
OPEX			
IT maintenance costs	21.48	17.75	21.48
Network management and front end costs	8.42	6.96	8.42
Communications/data transfer costs	89.60	74.05	89.60
Replacement/failure of smart meter systems	46.29	38.25	46.29
Training costs	4.01	3.48	4.01
TOTAL OPEX	**169.79**	**140.48**	**169.79**
Other costs not defined	9.09	9.09	9.09
TOTAL COSTS	**317.46**	**266.17**	**317.46**
BENEFITS			
Reduction in meter reading and operations costs	41.38	35.06	41.38
Reduction in operational and maintenance costs	9.51	8.06	9.51
Reduction in technical losses of electricity	4.56	3.86	4.56
Electricity cost savings	107.26	90.87	107.26
Reduction of commercial losses	50.98	43.20	50.98
Reduction of outage times	3.01	2.55	3.01
Reduction of CO_2 emissions	15.61	13.22	15.61
TOTAL BENEFITS	**232.30**	**196.82**	**232.30**
NET BENEFIT	**-85.16**	**-69.36**	**-85.16**

The same data is represented below on a per-metering point basis:

TABLE 34

KEY COST AND BENEFIT ITEMS, BRUSSELS CBA, €/METERING POINT, NPV BASIS

	Original	15 years	20 years
CAPEX			
Investment in smart meters	194.15	154.69	194.15
Investment in Information Technology	44.77	44.77	44.77
Avoided investment in standard meters	-15.04	-11.09	-15.04
TOTAL CAPEX	**223.87**	**188.37**	**223.87**
OPEX			
IT maintenance costs	34.69	28.67	34.69
Network management and front end costs	13.60	11.24	13.60
Communications/data transfer costs	144.75	119.63	144.75
Replacement/failure of smart meter systems	74.78	61.80	74.78
Training costs	6.48	5.61	6.48
TOTAL OPEX	**274.30**	**226.95**	**274.30**
Other costs not defined	14.69	14.69	14.69
TOTAL COSTS	**512.86**	**430.01**	**512.86**
BENEFITS			
Reduction in meter reading and meter operations costs	66.85	56.64	66.85
Reduction in operational and maintenance costs	15.37	13.02	15.37
Reduction in technical losses of electricity	7.36	6.24	7.36
Electricity cost savings	173.27	146.81	173.27
Reduction of commercial losses	82.36	69.78	82.36
Reduction of outage times	4.85	4.11	4.85
Reduction of CO_2 emissions	25.21	21.36	25.21
TOTAL BENEFITS	**375.28**	**317.96**	**375.28**
NET BENEFIT	**-137.57**	**-112.04**	**-137.57**

6.2.3. Observations

Key notable features of the above analysis and the assessment of the proposed specification of the Brussels system include the following:

- The CBA includes meter replacement at the end of the 20-year modelling period, without including a corresponding terminal value to reflect the potential benefits of the metering assets beyond the modelling period. Specifically, based on our understanding of the CBA, each smart meter is replaced once it has been in service for 15 years at its full cost.

- Communications costs are high as the proposed solution involves the use of UMTS, which is significantly more expensive than PLC, and typically more so than GPRS.
- Investment costs in smart meters include the replacement of the meter box and circuit breakers (and associated installation costs) for some customers at the same time as the smart meter is replaced.

The impact of each of these items is significant.

The analysis has been re-run without meter replacement, with the results reproduced below:

TABLE 35

SUMMARY RESULTS: BRUSSELS, ELECTRICITY ONLY – REMOVING METER REPLACEMENT (€ MILLION, NPV BASIS)

	Original (20 years)	15 years	20 years
Costs	287.18	257.88	285.94
Benefits	232.30	196.82	241.47
NET BENEFITS	**- 54.88**	**- 61.06**	**- 44.47**
Previous net benefit	-85.16	-69.36	-85.16

With a 20-year analytical period, the net benefit increases by just over €30 million; and by around €8 million in the 15-year period. The value for 20-years is equivalent to around €49 per metering point: more than one-third of the absolute value of the negative net benefit.

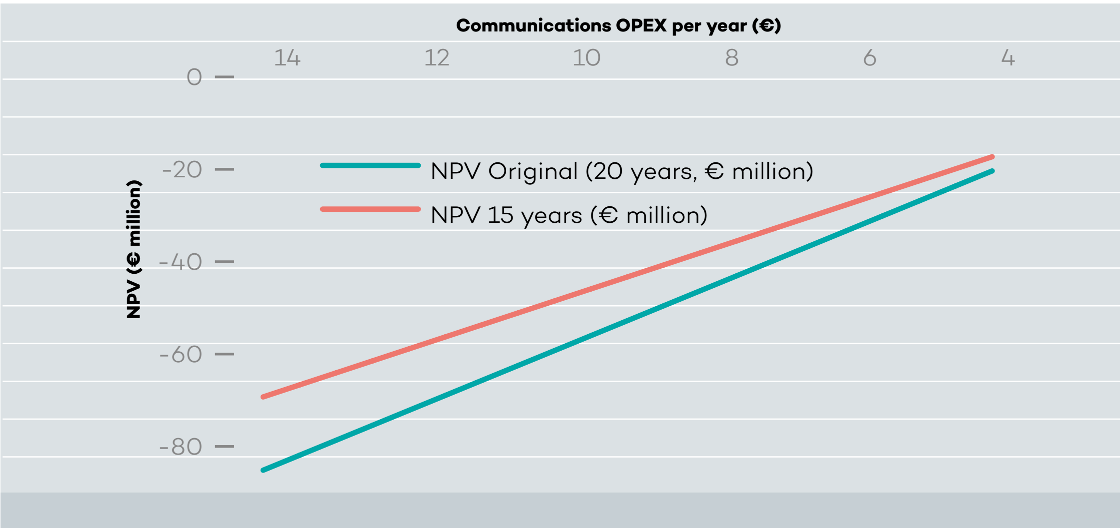
The estimated communications and data transfer costs amount to around €14.20/ metering point per year on a non-discounted basis using UMTS technology. This cost compare with a value of around €4.10/metering point estimated for the Wallonia CBA, where primarily PLC, in combination with GPRS, is proposed as the communications medium.[16] The Brussels CBA, written in 2011, notes that PLC is not an appropriate technology for transferring data every 15 minutes. Recent developments in PLC has shown that in most situations PLC can adequately transfer data every 15 minutes, consistent with the minimum functionality requirements, including in places where this may only have been possible every hour or up to a day. Where it is possible to use PLC technology in Brussels significant cost savings are anticipated, which will have an important impact on the CBA as the results are highly sensitive to the communications

16 While it is noted that the two regions are not directly comparable as Wallonia has a larger customer base than Brussels, the latter should benefit from economies of density. In practice, the solution proposed for Brussels does not have an explicit capital cost of communications as the meter is considered a one-box solution.

costs. In the case of a 15-year modelling period, a €5 per metering point per year reduction in communications costs can result in a cost saving in NPV terms of around €27 million. Similarly, in a 20 year modelling timeframe a reduction of only €5 per metering point in communications costs results in a €33 million cost savings in NPV terms. Due to a linear relationship, these savings would be doubled for a reduction to a value close to that in Wallonia, as illustrated in the graph below:

Figure 7 **Evaluation of sensivity of the project NPV to changes in the annual communications cost**

(€/metering point/year and €)



The CBA does not provide information to isolate the costs allocated to the new meter box and circuit breakers for those customers where replacement is considered necessary. A typical cost of a meter box is €20 while the circuit breaker is likely to cost around €12-15. To the extent to which these activities can be considered as related to ongoing distribution services already financed in the tariff, the CBA may be allocating up to €35 per metering point, multiplied by the proportion of affected customers, to activities that are not directly related to the smart metering programme. However, the MS notes that in some cases when the customer switches off the power at the main switchbox, meter reading via PLC is rendered impossible due to the meter becoming isolated. In this case, the overall system of switches may need to be revisited at the same time as the communications technology strategy.

6.2.4. Conclusions and specific recommendations

The Brussels CBA contains various assumptions that may need to be revisited and further reflected upon, and which may be of sufficient magnitude to change the overall result without adjusting any of the key input assumptions. This is particularly evident with the communications costs and the inclusion of meter replacement costs without a corresponding terminal value of benefits.

The MS is recommended to:

- Provide greater specification of the cost breakdown, particularly the inclusion of unit costs, which would assist in understanding the results.
- Use a consistent approach to replacement of metering equipment: either using a modelling period equal to the expected life of the metering equipment; or permitting replacement and including a terminal value that reflects the expected benefits that will accrue beyond the modelling period. The existing 20-year period with replacement is likely to overstate net costs.
- Review the communications infrastructure, and in particular the potential to apply PLC.
- Review the replacement of meter boxes and switches and the extent these are required for the development of smart grid services and enhancing the distribution network in general as well as the installation of smart meters.

6.3. Belgium – Flanders

6.3.1. Key methodological assumptions

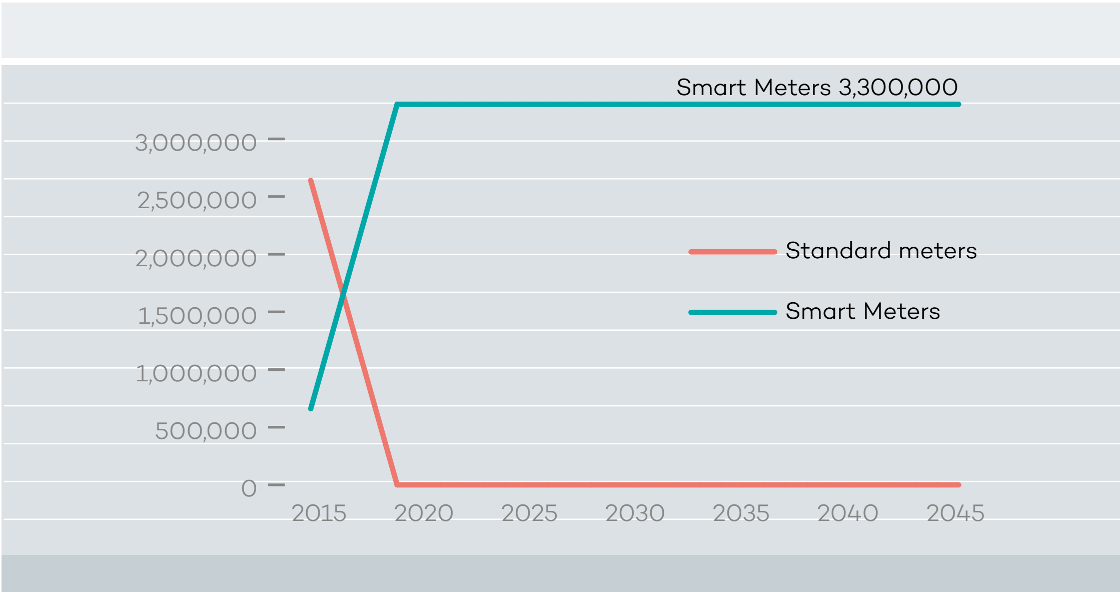
The approach adopted in recreating the dynamics of the Flanders CBA is top-down in nature given the MS primarily reports aggregated costs and benefits on a net present value basis. The key dynamics of the CBA have been recreating by estimating annual profiles for costs and benefits taking into account:

- The smart meter roll out profile
- The estimated costs developed for the analysis in section 3.1
- Key benefits included in the CBA and their controlling parameters

The Flanders CBA does not include a breakdown between capital and operating costs. As a breakdown of this nature is required to develop an accurate profile of costs over time, a proxy breakdown for each key expenditure category (smart meters, communications, IT etc.,) has been determined from the share of capital and operating costs in the respective categories in the Brussels and Wallonia CBAs, both which show a similar breakdown.

A five year roll out is proposed resulting in a total of 3.3 million electricity smart meters being installed as follows (dates from original CBA):

Figure 8 **Cumulative profile of electricity smart meters and standard meters, Flanders**



Total costs are the same as in the previous section except that avoided standard metering costs are treated as a negative cost instead of a positive benefit. In the case of particular cost categories:

- Meter related capital costs (meter plus installation) are assumed directly proportional to the annual number of meters installed. The key control variable is the per-metering point investment cost, whose value is estimated so that the total cost, after multiplying by the number of meters installed, equals the total estimated capital cost of meters using the discount rate in the CBA (5.5%).
- All capital investment in information technology (€110.48 million) is assumed to take place in the first year.
- An additional item of €40 million is included for undefined costs stated in the CBA that are assumed to apply evenly over the analytical period.
- Operating costs for each respective cost category are assumed proportional to the number of smart meters installed, and become constant once full rollout is in place. The value of key control parameters are adjusted to result in the same NPV of costs as in the earlier analysis. Key control parameters (all €/metering point/year) are: IT maintenance costs; network management costs; communications/data transfer costs; and costs of replacement/failure of smart meters.

A similar approach to operating expenditure is applied to estimate the annual profile of key benefits. Key control parameters (€/metering point/year) are: reduction in meter reading and operational cost, reduction in O&M costs, reduction in technical losses, electricity cost savings, reduction in commercial losses and outage reduction.

6.3.2. Key findings

The reported results for a joint rollout based on the original period (30 years), and estimated periods of 15 and 20 years (both measured from the start of the rollout period) are set out in the following table.

TABLE 36

SUMMARY RESULTS: FLANDERS, GAS AND ELECTRICITY - ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (30 years)	15 years	20 years
Costs	1,731.27	1,256.62	1,545.74
Benefits	1,613.50	1,024.49	1,238.91
Net benefits	**-117.77**	**-232.13**	**-306.83**
Results	Negative	Negative	Negative

The relationship between the various modelling periods is not linear as the results have been developed on the basis that there is meter replacement that is capitalised after 15 years. In practice, costs are then potentially overstated significantly in the case of the results of the 20-year roll out period set out above, as a full allocation of replacement costs is included, without including the corresponding benefits in the modelling period.

Based on the same approach adopted as in section 5.3 the estimated results for an electricity-only roll out are summarised below:

TABLE 37

SUMMARY RESULTS: FLANDERS, ELECTRICITY ONLY - ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (30 years)	15 years	20 years
Costs	1,564.70	1,140.96	1,471.07
Benefits	1,380.00	924.98	1,118.56
NET BENEFITS	**-184.70**	**-215.98**	**-352.51**
Results	Negative	Negative	Negative

The estimated results for electricity-only are slightly less negative than in the case of electricity and gas for a 15-year analytical period, and more negative for 20- and 30-year periods. The results are more negative for 15- and 20- year periods than for 30 years, in the case of a 20-year period for the treatment of meter replacement.

A breakdown of key cost and benefit items in the case of electricity is set out below:

TABLE 38

KEY COST AND BENEFIT ITEMS, FLANDERS CBA, €MILLION, NPV BASIS

	Original (30 years)	15 years	20 years
CAPEX			
Investment in smart meters	899.48	682.98	899.48
Investment in Information Technology	121.53	121.53	121.53
Avoided investment in conventional meters	-314.00	-238.42	-245.13
TOTAL CAPEX	**707.01**	**566.09**	**775.88**
OPEX			
IT maintenance costs	153.47	102.86	124.39
Network management and front end costs	200.00	134.05	162.11
Communications/data transfer costs	75.00	50.27	60.79
Replacement/failure of smart meter systems	379.22	254.17	307.37
TOTAL OPEX	**807.69**	**541.36**	**654.66**
OTHER COSTS			
Others not defined	50.00	33.51	40.53
TOTAL OTHER COSTS	**50.00**	**33.51**	**40.53**
TOTAL COSTS	**1564.70**	**1140.96**	**1471.07**
BENEFITS			
Reduction in meter reading and meter operations costs	536.00	359.26	434.45
Reduction in operational and maintenance costs	200.00	134.05	162.11
Reduction in technical losses of electricity	10.00	6.73	8.12
Electricity cost savings	359.00	240.62	290.98
Reduction of commercial losses	200.00	134.05	162.11
Reduction of outage times	75.00	50.27	60.79
TOTAL BENEFITS	**1380.00**	**924.98**	**1118.56**
NET BENEFITS	**-184.70**	**-215.98**	**-352.51**

The same data is summarised below on a per-metering point basis:

TABLE 39

KEY COST AND BENEFIT ITEMS, FLANDERS CBA, €/METERING POINT, NPV BASIS

	Original (30 years)	15 years	20 years
CAPEX			
Investment in smart meters	272.57	206.96	272.57
Investment in Information Technology	36.83	36.83	36.83
Avoided investment in conventional meters	-95.15	-72.25	-74.28
TOTAL CAPEX	**214.25**	**171.54**	**235.12**
OPEX			
IT maintenance costs	46.51	31.17	37.69
Network management and front end costs	60.61	40.62	49.12
Communications/data transfer costs	22.73	15.23	18.42
Replacement/failure of smart meter systems	114.92	77.02	93.14
TOTAL OPEX	**244.75**	**164.05**	**198.38**
OTHER COSTS			
Others not defined	15.15	10.16	12.28
TOTAL OTHER COSTS	**15.15**	**10.16**	**12.28**
TOTAL COSTS	**474.15**	**345.75**	**445.78**
BENEFITS			
Reduction in meter reading and operations costs	162.42	108.87	131.65
Reduction in operational and maintenance costs	60.61	40.62	49.12
Reduction in technical losses of electricity	3.03	2.04	2.46
Electricity cost savings	108.79	72.92	88.18
Reduction of commercial losses	60.61	40.62	49.12
Reduction of outage times	22.73	15.23	18.42
TOTAL BENEFITS	**418.18**	**280.30**	**338.96**
NET BENEFITS	**-55.97**	**-65.45**	**-106.82**

6.3.3. Observations

A key feature of the Flanders CBA is the inclusion of capital expenditure to replace the (to-be) installed smart meters after 15 years. In the case of both a 15-year analytical period and a 20-year period assuming that no replacement is required, this cost is unnecessary.

The following table shows the overall results for 15 and 20 modelling year periods, removing meter replacement. These results are compared to the original estimate, which assumes a 30-year modelling period and meter replacement.

TABLE 40

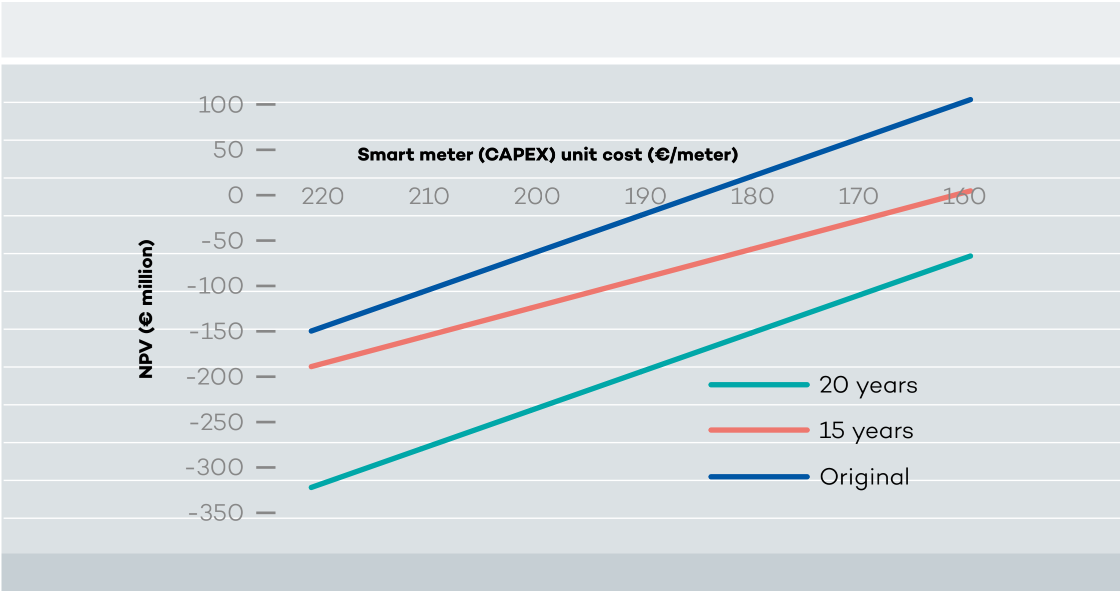
SUMMARY RESULTS: FLANDERS, ELECTRICITY ONLY – REMOVING METER REPLACEMENT (€ MILLION, NPV BASIS)

	Original (30 years)	15 years	20 years
Costs	1,564.70	1,100.76	1,300.93
Benefits	1,380.00	924.98	1,118.56
NET BENEFITS	**- 184.70**	**-175.78**	**-182.37**
Previous net benefit	-184.70	-215.98	-352.51

In practice the results are similar under all three approaches, which reflects that operating expenditure and benefits are relatively equalised once the full roll out is in place. However, note that the assumption on operating expenditure is derived from total costs based on comparable data from the CBA reports in Brussels and Wallonia. To the extent that this data is not comparable to Flanders, the overall results – or at least their sensitivity to different modelling periods - will be affected accordingly.

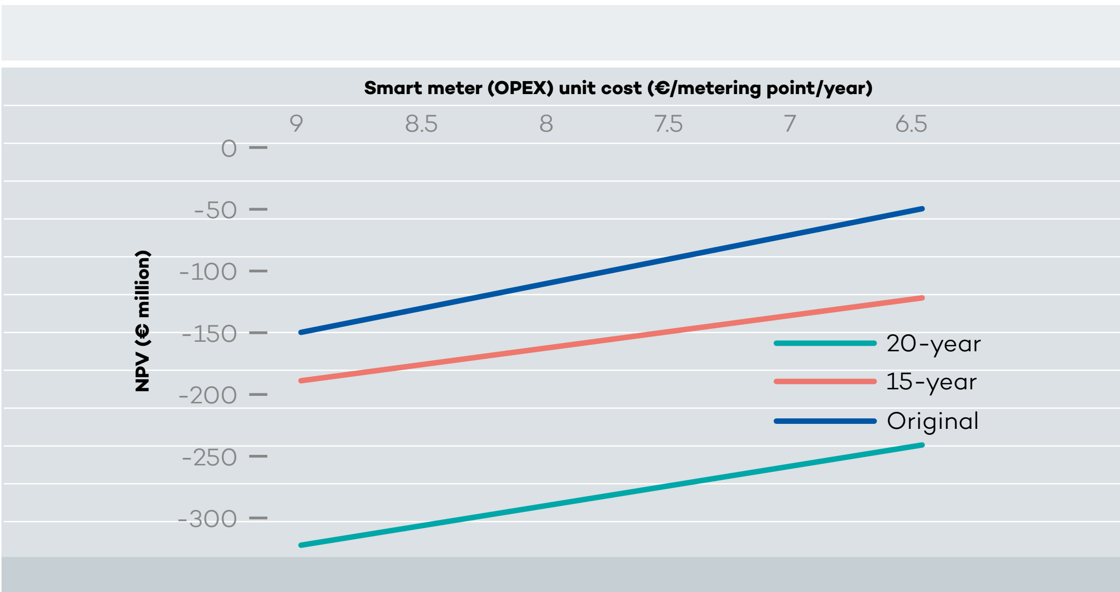
The CBA results are also highly sensitive to the assumptions on the meter capital costs and associated operational expenditure. Based on the capital and operating cost breakdown the unit capital cost of a smart meter in Flanders is estimated at €220 in the analysis. The following graph shows that a reduction in the meter cost to the levels of the unit cost estimated in Brussels (€163) would result in a positive overall NPV under the 30 year modelling periods and a value close to zero under a 20 year modelling period. Note the result for 20 years remains negative, but would become positive if the earlier correction for meter replacement in included.

Figure 9 **Flanders CBA Relationship between Project NPV and smart meter capital costs**



Similarly, the results are sensitive to relatively small changes in the annual cost of operating expenditure – attributed to replacement and failure of smart metering systems. Given replacement is already built into the CBA, the amount allocated for failure and other replacement appears high.

Figure 10 **Flanders CBA Relationship between Project NPV and smart meter related operating costs**



Note that the above analysis is based on data that includes meter replacement after 15 years. Adjusting for this factor, most notably in the 20-year analytical period, would produce NPV values that are far more positive for the same change in smart meter costs.

6.3.4. Conclusions and specific recommendations

A key difficulty in analysing the dynamics of the Flanders CBA has been the lack of a breakdown between capital and operating costs. In practice, a key driver of the negative result is the assumption adopted on smart meter costs and the replacement/failure rate of these smart meters. The values for these variables appear high, including against local comparators. Adjusting for replacement, and where efficiencies can be achieved in these variables, including to the values reported in neighbouring jurisdictions, the overall result would be changed.

The MS is recommended to:

- Provide greater specification of the cost breakdown, particularly the inclusion of unit costs, to better assist in understanding the results
- Include a breakdown between capital and operating expenditure
- Review the treatment of meter replacement
- Review the overall costs of meters, including capital and recurrent costs especially in light of data reported in the CBAs of neighbouring jurisdictions

6.4. Belgium – Wallonia

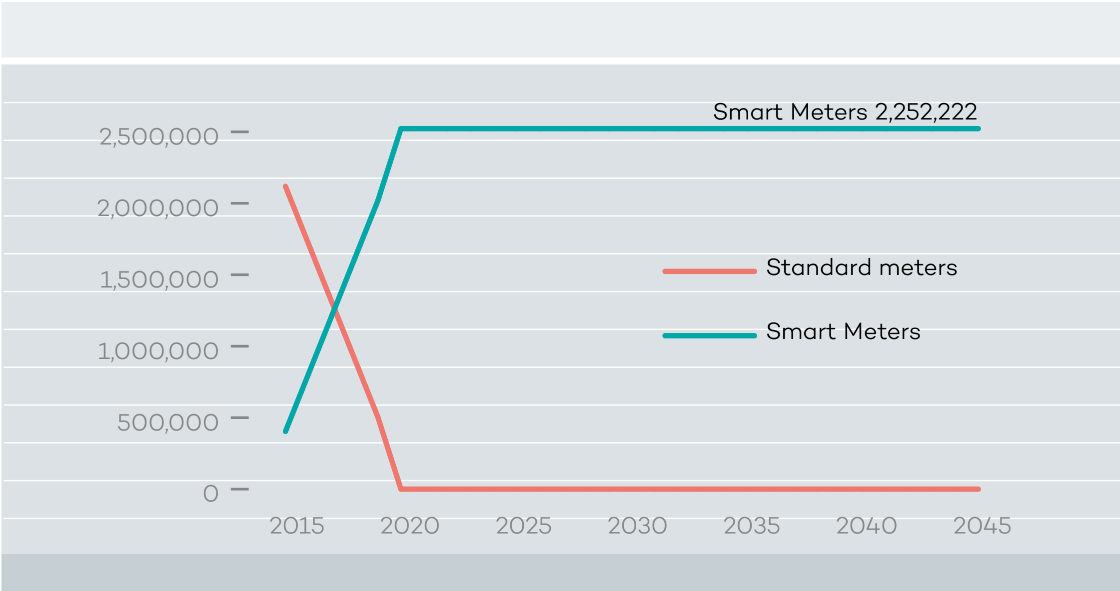
6.4.1. Key methodological assumptions

The approach adopted in recreating the dynamics of the Wallonia CBA is top-down in nature given the MS reports principally aggregated costs and benefits on a net present value basis. The key dynamics of the CBA have been recreating by estimating annual profiles for costs and benefits taking into account:

- The smart meter roll out profile
- The estimated breakdown between capital and operating costs developed for the analysis in sections 3.1 and 5.4
- Key benefits included in the CBA and their controlling parameters

A six year roll out is proposed resulting in 2.522 million electricity smart meters being installed. It is assumed these are installed in a linear manner as follows (dates from original CBA):

Figure 11 Cumulative profile of smart meters and standard meters, Wallonia



Total costs are as per the previous section except that avoided standard metering costs are treated as a negative cost instead of a positive benefit. In the case of particular cost categories:

- Meter related capital costs (meter plus installation), and the capital component of communications costs, are assumed directly proportional to the annual number of meters installed. The key control variables are the per-metering point investment and communications costs, whose values are estimated so that the total cost, after multiplying by the number of meters installed, equals the total estimated capital cost of meters and communications costs respectively using the discount rate in the CBA (5.5%).
- All capital investment in information technology (€74.6 million) is assumed to take place in the first year.
- Customer engagement costs (€10.1 million) are spread equally over the six years of rollout.
- Operating costs for each respective cost category are assumed to be proportional to the number of smart meters installed, and become constant once full rollout is in place. The value of key control parameters are adjusted to result in the same NPV of costs as in the earlier analysis. Key parameters (all €/metering point/year) are: IT maintenance costs; network management costs; communications/data transfer costs; and the costs of replacement/failure of smart meters.

A similar approach to operating expenditure is applied to estimate the annual profile of key benefits. Key control parameters (€/metering point/year) are: reduction in meter reading and operational cost, reduction in O&M costs, reduction in technical losses, electricity cost savings, reduction in commercial losses and reduction in CO_2 emissions.

6.4.2. Key findings

The reported results for a joint rollout based on the original period (30 years), and estimated periods of 15 and 20 years (both from the start of the rollout period) are set out in the following table:

TABLE 41

SUMMARY RESULTS: WALLONIA, GAS AND ELECTRICITY - ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (30 years)	15 years	20 years
Costs	2,232.43	1,471.50	2,005.13
Benefits	2,046.52	1,344.86	1,748.63
NET BENEFITS	**- 185.91**	**- 126.63**	**- 256.50**
Results	Negative	Negative	Negative

The relationship between the various modelling periods is not linear, as the results have been developed on the basis that there is meter replacement that is capitalised after 15 years and communications equipment replacement capitalised every 8 years. In the case of a 20-year roll out period costs are potentially overstated significantly due to the full allocation of meter replacement costs, without including the corresponding benefits in the modelling period. The impact of the communications costs, while non-linear, is not as critical to the overall results due to its smaller size.

Based on the same approach adopted as in section 5.4 the estimated results for an electricity-only roll out are summarised below:

TABLE 42

SUMMARY RESULTS: WALLONIA, ELECTRICITY ONLY - ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (30 years)	15 years	20 years
Costs	1,729.79	1,147.96	1,547.36
Benefits	1,567.29	1,029.94	1,339.16
NET BENEFITS	**- 162.50**	**- 118.02**	**- 208.20**
Results	Negative	Negative	Negative

The findings indicate that an electricity-only roll out does not change the results substantially for the original modelling period. The reasons include that:

- A disproportionate share of costs are allocated to the electricity only analysis – for example, 80% of communications costs and 73% of smart meter costs, while
- A disproportionate share of benefits are also allocated to the electricity only analysis. In the case of gas, the main benefits only relate to the operational costs of meter reading and meter operations. No gas (nor electricity) consumption benefit is included

A breakdown of key cost and benefit items in the case of electricity is set out below:

TABLE 43

KEY COST AND BENEFIT ITEMS, WALLONIA CBA, €MILLION, NPV BASIS

	Original (30 years)	15 years	20 years
CAPEX			
Investment in smart meters	863.28	547.93	834.51
Investment in Information Technology	74.57	74.57	74.57
Investment in Communications	41.07	28.55	34.80
TOTAL CAPEX	**978.92**	**651.06**	**943.88**
OPEX			
IT maintenance costs	158.12	103.91	126.97
Network management and front end costs	68.78	45.20	55.23
Communications/data transfer costs	131.80	86.61	105.84
Replacement/failure of smart meter systems	382.06	251.07	306.79
TOTAL OPEX	**740.75**	**486.78**	**594.83**
OTHER COSTS			
Customer engagement programme	10.12	10.12	8.65
TOTAL OTHER COSTS	**10.12**	**10.12**	**8.65**
TOTAL COSTS	**1729.79**	**1147.96**	**1547.36**
BENEFITS			
Reduction in meter reading and meter operations costs	322.49	211.92	275.55
Reduction in operational and maintenance costs	8.20	5.39	7.01
Electricity cost savings	262.60	172.56	224.37
Reduction of commercial losses	896.71	589.27	766.19
Competitiveness	77.29	50.79	66.04
TOTAL BENEFITS	**1567.29**	**1029.94**	**1339.16**
NET BENEFIT	**-162.50**	**-118.02**	**-208.20**

The following table sets out the same numbers on a per-metering point basis:

TABLE 44

KEY COST AND BENEFIT ITEMS, WALLONIA CBA, €/METERING POINT, NPV BASIS

	Original (30 years)	15 years	20 years
CAPEX			
Investment in smart meters	342.27	217.24	330.86
Investment in Information Technology	29.57	29.57	29.57
Investment in Communications	16.28	11.32	13.80
TOTAL CAPEX	**388.12**	**258.13**	**374.23**
OPEX			
IT maintenance costs	62.69	41.20	50.34
Network management and front end costs	27.27	17.92	21.90
Communications/data transfer costs	52.26	34.34	41.96
Replacement/failure of smart meter systems	151.48	99.54	121.64
TOTAL OPEX	**293.69**	**193.00**	**235.84**
OTHER COSTS			
Customer engagement programme	4.01	4.01	3.43
TOTAL OTHER COSTS	**4.01**	**4.01**	**3.43**
TOTAL COSTS	**685.82**	**455.14**	**613.49**
BENEFITS			
Reduction in meter reading and meter operations costs	127.86	84.02	109.25
Reduction in operational and maintenance costs	3.25	2.14	2.78
Electricity cost savings	104.11	68.42	88.96
Reduction of commercial losses	355.52	233.63	303.77
Competitiveness	30.65	20.14	26.18
TOTAL BENEFITS	**621.39**	**408.35**	**530.95**
NET BENEFIT	**-64.43**	**-46.79**	**-82.55**

In practice the results, while negative, are not unduly so given the high absolute values of the costs and the benefits.

6.4.3. Observations

A key feature of the Wallonia CBA –as is the case with the other Belgian jurisdictions– is the inclusion of capital expenditure to replace the (to-be) installed smart meters after 15 years. In addition, the CBA allows for the replacement of communications equipment after 8 years. With a 30-year modelling period, meter replacement is an appropriate assumption. However, under a shorter 15-year or extended 20-year period the full inclusion of meter replacement costs is unnecessary.

The following table shows the overall results for 15 and 20-year modelling periods removing meter replacement, while maintaining communications replacement. A comparison is made with the previous analysis, including the NPV under a 30-year modelling period that includes meter replacement.

TABLE 45

SUMMARY RESULTS: WALLONIA, ELECTRICITY ONLY – REMOVING METER REPLACEMENT (€ MILLION, NPV BASIS)

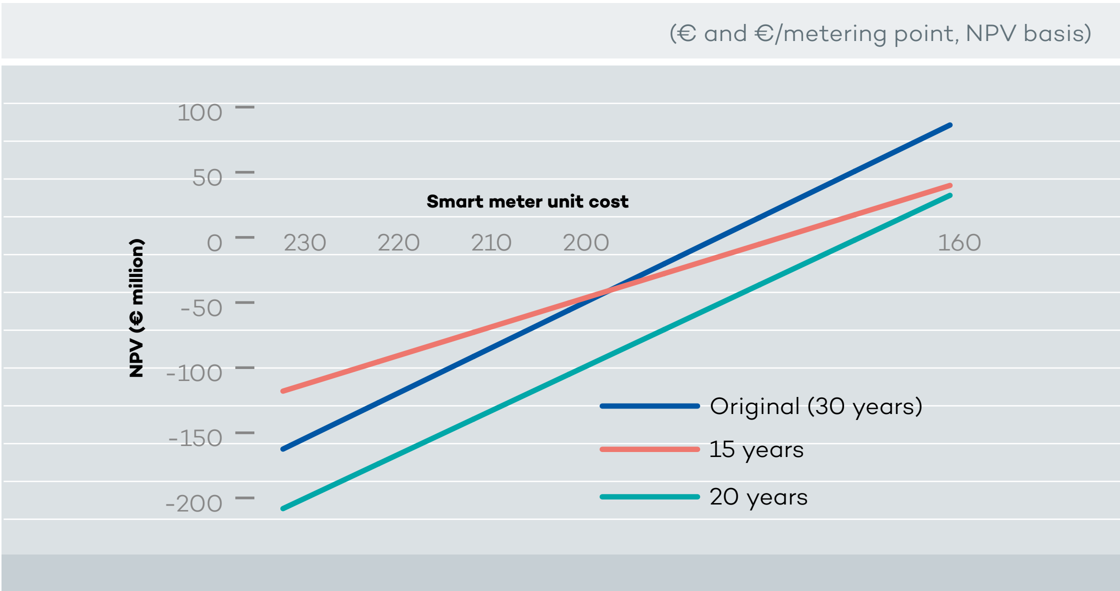
	Original (30 years)	15 years	20 years
Costs	1,729.79	1,083.73	1,196.56
Benefits	1,567.29	1,029.94	1,339.16
NET BENEFITS	**- 162.50**	**- 53.79**	**142.61**
Previous net benefit	-162.50	- 118.02	- 208.20

In the case of a 15 year modelling period a much smaller negative net benefit applies (less than half), while in the extended 20 year analytical period a positive results is estimated, reflecting that the additional annual benefits in moving from a 15 year period to a 20 year period are significantly higher than operating expenditures.

Smart meter costs in Wallonia (including installation) were shown as one of the highest of all the jurisdictions in section 3 In the analysis undertaken in this section the control cost (back-solved cost) of a smart meter (including installation) in Wallonia was calculated at €232, which compares with €220 in Flanders and €163 in Brussels.

The following figure shows how the NPV of the smart metering programme varies based on potential cost savings in smart metering costs. The graph shows that based on similar unit cost values to those in Brussels (a €70 reduction) the NPV of the project is positive under all modelling periods and without adjusting for meter replacement costs.

Figure 12 **Sensitivity of the results of the Wallonia CBA to changes in smart meter unit costs**



6.4.4. Conclusions and specific recommendations

Understanding the dynamics of the Wallonia CBA is facilitated by it being on a 30-year modelling period with meter replacement, and due to capital and operating costs being separately identified. In practice, a key driver of the negative results produced is the smart meter costs, which are assumed to be higher than those in neighbouring jurisdictions. As the overall results, while negative, are not unduly so, efficiencies in smart meter purchase and installation costs would have a significant result on the overall viability of the project.

The MS is recommended to:

- Provide greater specification in the cost breakdown (unit costs etc.), to assist in understanding the results
- Review the overall costs of meters, especially in light of data from neighbouring jurisdictions
- Consider the potential consumption impact in the CBA. This may require additional pilots to assess the likely customer response to the introduction of smart metering systems

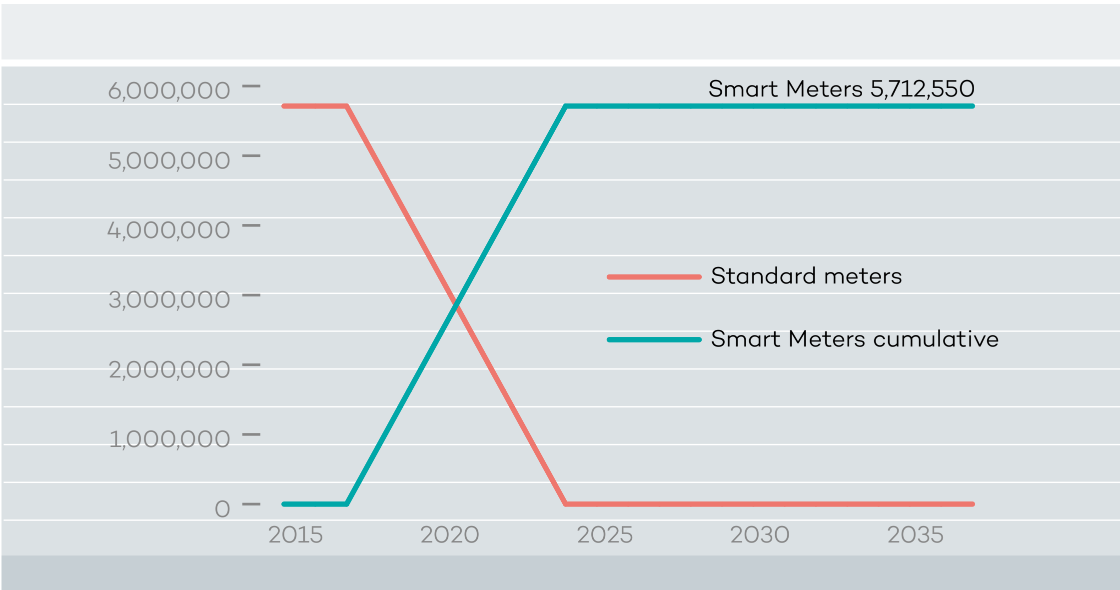
6.5. Czech Republic

6.5.1. Key methodological assumptions

The approach in recreating the dynamics of the Czech Republic CBA is an adjusted top-down approach since the key data provided in the CBA are nominal totals for the analysis period, combined with some unit costs. In most cases unit costs and benefits as well as the profile over time was estimated from the total costs and benefits taking into account the roll out profile and the discount rate.

The roll out assumes a 100% coverage of metering points over a period of 7 years from 2018 to 2024 in a linear manner as in the following graph. At the end of the roll out all LV customers are covered with smart meters (all points of delivery equipped – total of 5,712,550), while a large-scale roll-out is not included for large customers (LV customers account for approximately 38% of the energy demand). A further 12-year implementation period is set out in the CBA, based on 5 years of full operation and 7 years of selected operation as the meters reach the end of their assumed 12-year life. For the purpose of this exposition, and consistent with the analysis in section 3.1 a 19 year modelling period is applied.

Figure 13 Cumulative profile of smart meters and standard meters, Czech Republic



A constant profile of capital expenditure is assumed during the roll out, reflecting the number of meters installed, except for IT investment for which 50% is assumed to occur one year before the start of the rollout in 2017, and 50% in 2018. The avoided investment in conventional meters is reported as a negative cost (instead of a benefit) and follows the same pattern.

Other benefits and operating expenditure follow the cumulative rollout, where the values for subsequent years when rollout is completed (2024) remain constant. IT maintenance costs are an exception, where 50% of the total costs are assumed to apply in 2017, with the rest applying over the remainder of the rollout profile.

6.5.2. Key findings

For the proposed rollout covering all the LV supply points, the estimated results are strongly negative in the original assumed modelling period of 19 years, and in periods of 15 and 20 years. The result is more negative the longer the modelling period because annual operating expenditures are assumed greater than annual benefits.

TABLE 46

SUMMARY RESULTS: CZECH REPUBLIC - ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (19 years)	15 years	20 years
Costs	2,070.07	1,937.91	2,098.50
Benefits	575.94	475.28	597.96
NET BENEFITS	**-1,494.13**	**- 1,462.64**	**- 1,500.54**
Results	Negative	Negative	Negative

A breakdown of key cost and benefit items is set out below:

TABLE 47

KEY COST AND BENEFIT ITEMS, CZECH REPUBLIC CBA, €MILLION, NPV BASIS

	Original (19 years)	15 years	20 years
CAPEX			
Investment in smart meters	960.87	960.87	960.87
Investment in Information Technology	253.81	253.81	253.81
Investment in Communications	249.79	249.79	249.79
Distribution	337.57	337.57	337.57
Avoided investment in conventional meters	-728.34	-728.34	-728.34
TOTAL CAPEX	**1073.69**	**1073.69**	**1073.69**

	Original (19 years)	15 years	20 years
OPEX			
IT maintenance costs	519.22	455.40	532.95
Network management and front end costs	2.62	2.19	2.72
Communications/data transfer costs	159.81	133.07	165.56
Scenario management costs	21.00	17.48	21.75
Replacement/failure of smart meter systems	200.98	167.35	208.22
Distribution	23.97	19.96	24.83
TOTAL OPEX	**927.60**	**795.45**	**956.03**
OTHER COSTS			
Sunk costs of previously installed meters	7.78	7.78	7.78
Security	22.91	22.91	22.91
Others not defined	38.08	38.08	38.08
TOTAL OTHER COSTS	**68.77**	**68.77**	**68.77**
TOTAL COSTS	**2070.07**	**1937.91**	**2098.50**
BENEFITS			
Reduction in meter reading and meter operations costs	192.06	159.92	198.97
Reduction in operational and maintenance costs	217.20	180.86	225.02
Electricity cost savings	15.25	12.30	15.92
Reduction of commercial losses	151.43	122.20	158.05
TOTAL BENEFITS	**575.94**	**475.28**	**597.96**
NET BENEFITS	**-1,494.13**	**- 1,462.64**	**- 1,500.54**

The same data on a per-metering point basis is set out in the following table:

TABLE 48

KEY COST AND BENEFIT ITEMS, CZECH REPUBLIC CBA, €/METERING POINT, NPV BASIS

	Original (19 years)	15 years	20 years
CAPEX			
Investment in smart meters	168.20	168.20	168.20
Investment in Information Technology	44.43	44.43	44.43
Investment in Communications	43.73	43.73	43.73
Distribution	59.09	59.09	59.09
Avoided investment in conventional meters	-127.50	-127.50	-127.50
TOTAL CAPEX	**187.95**	**187.95**	**187.95**

	Original (19 years)	15 years	20 years
OPEX			
IT maintenance costs	90.89	79.72	93.29
Network management and front end costs	0.46	0.38	0.48
Communications/data transfer costs	27.97	23.29	28.98
Scenario management costs	3.68	3.06	3.81
Replacement/failure of smart meter systems	35.18	29.30	36.45
Distribution	4.20	3.49	4.35
TOTAL OPEX	**162.38**	**139.25**	**167.36**
OTHER COSTS			
Sunk costs of previously installed meters	1.36	1.36	1.36
Security	4.01	4.01	4.01
Others not defined	6.67	6.67	6.67
TOTAL OTHER COSTS	**12.04**	**12.04**	**12.04**
TOTAL COSTS	**362.37**	**339.24**	**367.35**
BENEFITS			
Reduction in meter reading and meter operations costs	33.62	27.99	34.83
Reduction in operational and maintenance costs	38.02	31.66	39.39
Electricity cost savings	2.67	2.15	2.79
Reduction of commercial losses	26.51	21.39	27.67
TOTAL BENEFITS	**100.82**	**83.20**	**104.67**
NET BENEFITS	**-261.55**	**-256.04**	**-262-68**

6.5.3. Observations

The gap between costs and benefits is extremely high. However, there are various factors built into the CBA that may overstate the true gap. These include:

- The inclusion of rewiring costs that may potentially be considered a general distribution activity rather than a specific component of smart metering activities
- Relatively high meter costs and IT maintenance costs
- Low assumed consumption benefits

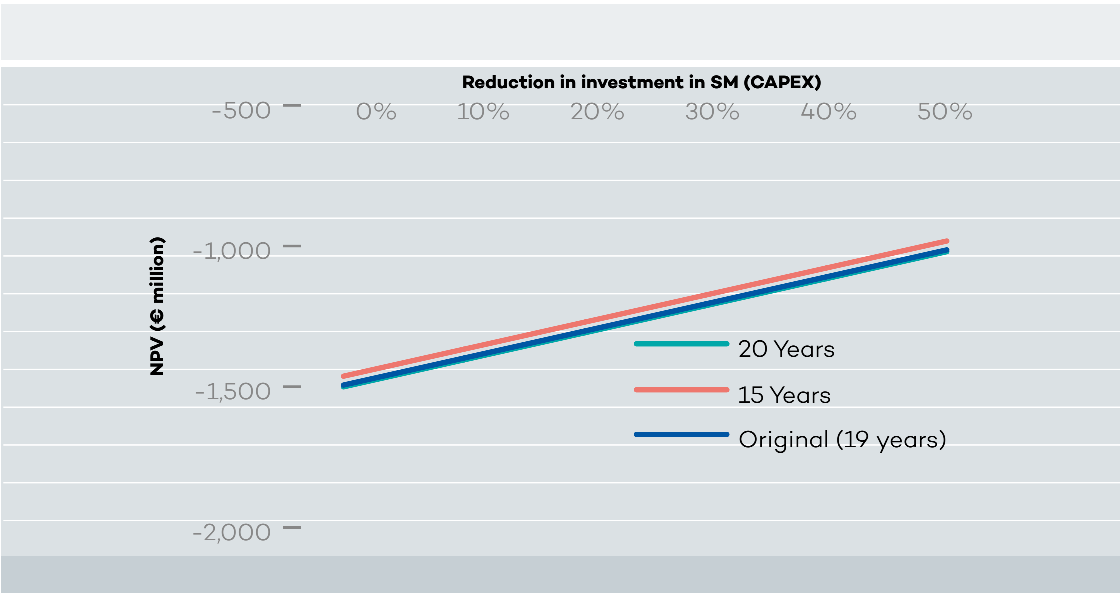
The amount included in the CBA for rewiring is significant, accounting for €338 million of additional costs in each of the three modelling periods.(17) The MS advised that rewiring is essential to allow smart meters to be installed in place of standard meters due

17 *This value has been estimated from the sum of the following items in the CBA: Adaptation of Consumers' Points of Delivery (OM) with HDO for Advanced Metering Management (AMM); OM adaptations for AMM Metering Equipment (MZ); OM adaptation -self-standing feeding; and Distribution Transformer Station (DTS) inspection before and after implementation.*

to the configuration of switches. In practice, this issue should be investigated further, and to the extent to which this change is necessitated by the performance of the distribution network rather than the metering system per-se, the allocated costs should be adjusted accordingly.

The CBA notes that meter costs are expected to fall over time. With this in mind, the following graph shows how the NPV changes with efficiencies in the smart meter costs:

Figure 14 **Czech Republic –sensitivity of NPV to changes in smart meter capital costs**



While benchmarking across countries has its limitations, IT costs in the Czech Republic CBA are higher than most other MS, and in some cases significantly so. The following graph illustrates the relationship between the project NPV and IT operational costs, indicating a reasonably sensitive relationship:

Figure 15 Czech Republic CBA – sensitivity of results to changes in IT maintenance costs

In practice, high IT costs reflect the use of a data communications hub. Further examination of the benefits of this system is recommended to confirm this solution is most optimal in the Czech Republic.

An additional consideration is that no consumption reduction benefit is considered in the CBA. The exclusion has been justified on the grounds that the HDO system in place already maintains the consumptions patterns at their optimum levels. The overall estimated benefits are sensitive to the presence of a consumption impact, though given the huge negative net benefits the overall result is unchanged. For example, for a 1% reduction in consumption following a full roll out the NPV of benefits are estimated to rise by €66 million and €86 million respectively in the 15- and 20- year scenarios.

6.5.4. Conclusion and specific recommendations

The Czech Republic CBA provides strong negative results, which largely reflects the limited benefits considered applicable. A review of these benefits, particularly the consumption impact is recommended. At the same time, the costs of smart metering are assumed high; in the case of re-wiring the direct relation of this activity with smart metering installation should be investigated further. Greater efficiencies in meter purchasing costs and operating expenditure would reduce the negative net benefit, though without a fundamental review of the benefits a positive result is unlikely.

The MS is recommended to:

- Reconsider the inclusion of costs of re-wiring that may be incurred at the time of meter installation
- Review of the overall benefits available through smart metering, including the use of pilot projects to evaluate customer behaviour, particularly in the presence of the HDO system
- Review the overall cost of meters and the proposed IT infrastructure in the light of available benefits and experience in other countries
- Clarify the issue of meter certification. If the national requirements for certification every 12 years is an impediment to installing meters that have a much longer useful life a review of national regulations may be justified

6.6. Germany

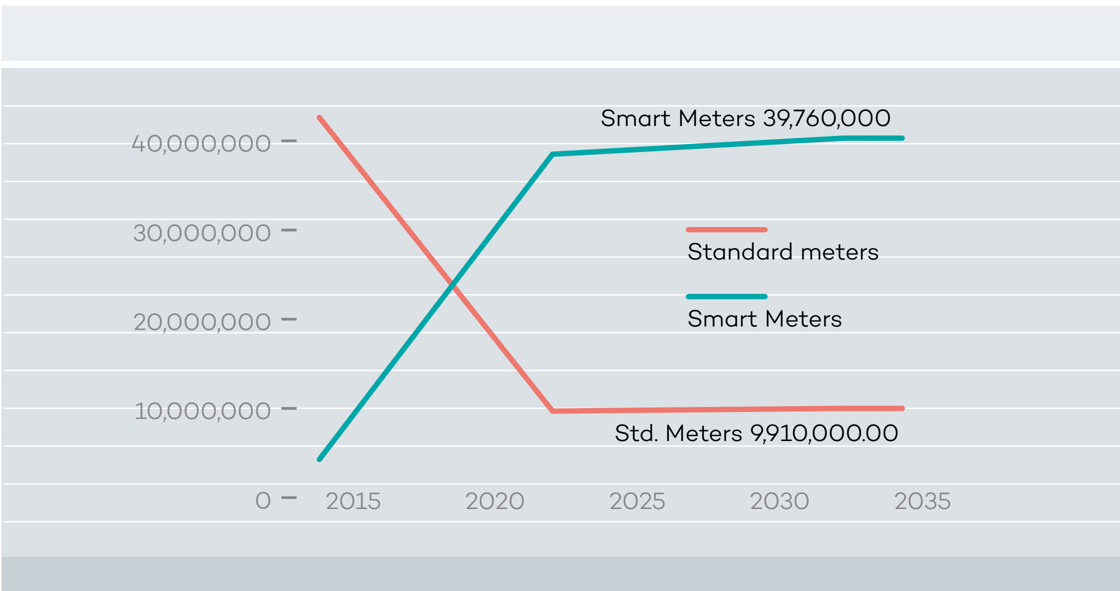
6.6.1. Key methodological assumptions

The approach adopted in recreating the dynamics of the Germany CBA is largely bottom-up in nature due to the presence of several unit costs and benefits in the CBA report.

Costs are broken down between capital and operating expenditure, with 38.5 million electricity smart meters installed over 8 years. Subsequently installation of smart meters reflects growth in customer numbers.

Based on these assumptions the following profile of smart meters and standard meters applies (dates from original CBA).

Figure 16 Cumulative profile of smart meters and standard meters, Germany



The model includes replacement of all capital equipment under the following timescales:

- Smart meters – every 13 years
- Communications equipment – between 8-13 years
- IT equipment – every 8 years

6.6.2. Key findings

The reported results based on the original modelling period, and estimated periods of 15 and 20 years (both from the start of the roll out period) are set out in the following table. Note that the MS CBA has a stated modelling period of 20 years, which covers 18 years from the start of the roll out (i.e., the roll out starts in year 3 of the CBA).

The results presented below reflect the number of years from the start of the roll out, with the MS CBA considered as having a period of 18 years. Put another way, a modelling period of 20 years in this section is equivalent to a modelling period of 22 years in the terminology of the MS CBA.

TABLE 49

SUMMARY RESULTS: GERMANY CBA - ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (18 years*)	15 years	20 years
Costs	15,980.44	13,252.31	17,296.57
Benefits	15,701.08	13,011.72	17,433.27
NET BENEFITS	**-279.37**	**- 240.59**	**136.69**
Results	Negative	Negative	Positive

The key results for 15 and 18 years are negative, with the negative net benefit for 18 years similar to that reported by the MS in its CBA. However, the benefits and costs are closely aligned, and extending the analysis by 2 years to a 20-year modelling period results in a positive finding.

A breakdown of key cost and benefit items is set out in the following table:

TABLE 50

KEY COST AND BENEFIT ITEMS, GERMANY CBA, €MILLION, NPV BASIS

	Original (18 years)	15 years	20 years
CAPEX			
Investment in smart meters	7064.69	6147.08	7605.92
Investment in Information Technology	2823.65	2208.47	2823.65
Investment in Communications	1536.13	1371.02	1635.40
Investment in In-home display	1284.49	1117.65	1382.90
Avoided investment in conventional meters	-2966.07	-2960.46	-2969.38
TOTAL CAPEX	**9742.90**	**7883.76**	**10478.49**
OPEX			
IT maintenance costs	500.46	475.44	327.41
Communications/data transfer costs	5053.03	4305.70	5706.78
Replacement/failure of smart meter systems	263.35	219.43	302.25
Training costs	420.70	367.98	481.64
TOTAL OPEX	**6237.54**	**5368.55**	**6818.08**
TOTAL COSTS	**15980.44**	**13252.31**	**17296.57**
BENEFITS			
Reduction in meter reading and meter operations costs	1937.17	1298.09	2395.87
Deferred/avoided distribution capacity investments	1213.80	1115.29	1274.65
Deferred/avoided transmission capacity investments	354.95	311.64	381.69
Deferred/avoided generation capacity investments	2891.91	2545.39	3105.91
Electricity cost savings	9228.24	7676.87	10190.68
Reduction of commercial losses	58.52	50.66	63.39
Reduction of outage times	16.49	13.79	21.08
TOTAL BENEFITS	**15701.08**	**13011.72**	**17433.27**
NET BENEFIT	**-279.37**	**-240.59**	**136.69**

The following table sets out the same data on a per-metering point basis:

TABLE 51

KEY COST AND BENEFIT ITEMS, GERMANY CBA, €/METERING POINT, NPV BASIS

	Original (18 years)	15 years	20 years
CAPEX			
Investment in smart meters	183.50	159.66	197.56
Investment in Information Technology	73.34	57.36	73.34
Investment in Communications	39.90	35.61	42.48
Investment in In-home display	33.36	29.03	35.92
Avoided investment in conventional meters	-77.04	-76.90	-77.13
TOTAL CAPEX	**253.06**	**204.77**	**272.17**
OPEX			
IT maintenance costs	13.00	12.35	8.50
Communications/data transfer costs	131.25	111.84	148.23
Replacement/failure of smart meter systems	6.84	5.70	7.85
Training costs	10.93	9.56	12.51
TOTAL OPEX	**162.01**	**139.44**	**177.09**
TOTAL COSTS	**415.08**	**344.22**	**449.26**
BENEFITS			
Reduction in meter reading and meter operations costs	50.32	33.72	62.23
Deferred/avoided distribution capacity investments	31.53	28.97	33.11
Deferred/avoided transmission capacity investments	9.22	8.09	9.91
Deferred/avoided generation capacity investments	75.11	66.11	80.67
Electricity cost savings	239.69	199.40	264.69
Reduction of commercial losses	1.52	1.32	1.65
Reduction of outage times	0.43	0.36	0.55
TOTAL BENEFITS	**407.82**	**337.97**	**452.81**
NET BENEFIT	**-7.26**	**-6.25**	**3.55**

6.6.3. Observations

Key notable features of the above analysis and the assessment of the proposed specification of the German system include the following:

- The treatment of the replacement of capital equipment, including meters, communications and IT infrastructure

- Extremely high communications costs, reflecting the use of GPRS as the principal source of communications technology
- Relatively high IT costs, which reflect the large number of DSOs involved in the project
- A relatively high penetration of IHDs

These factors are considered in turn.

The CBA assumes that over a 22 year period all smart meters are fully replaced (9-year roll out plus 4 years plus 9 years replacement). As a consequence a 15 year modelling period will capture 2 years of additional replacement (9+4+2=15), a 18 year period 5 years of additional replacement (9+4+5=18), and a 20 year period 7 years of additional replacement (9+4+7=20). However, the data reported in the above table is likely to overstate net costs as costs of replacement are fully included in the CBA, but the majority of benefits provided by these replaced meters will arise outside the modelling period. Similar considerations apply for IT investment (captured twice in the 15 and 18-year periods and 3 times in the 20-year period).

To evaluate the sensitivity of the NPV to the assumption on replacement, for the 15 and 20-year analysis periods the results have been re-run assuming no meter replacement and a single replacement of IT infrastructure. The results become strongly positive as indicated in the following table:

TABLE 52

SUMMARY RESULTS: GERMANY – REMOVING METER REPLACEMENT (€ MILLION, NPV BASIS)

	Original (18 years)	15 years	20 years
Costs	13,252.31	12,232.95	14,877.27
Benefits	15,701.08	13,011.72	17,433.27
NET BENEFITS	**2,448.77**	**778.77**	**2,555.99**
Previous net benefit	-279.37	-240.59	136.69

In the case of communications costs it is understood that a high proportion of GPRS (80%) and also an expensive form of GPRS (€25 per connection point per year) is considered necessary to permit remote control of various devices (for example, solar panels) and not just for remote meter reading. In this sense, the allocation of some of these costs to other services may be appropriate. The sensitivity of the results to the communications cost is high. For example, the following graph estimates the impact on the NPV of the project of changing the communications mix, reducing the proportion of GPRS in favour of PLC:

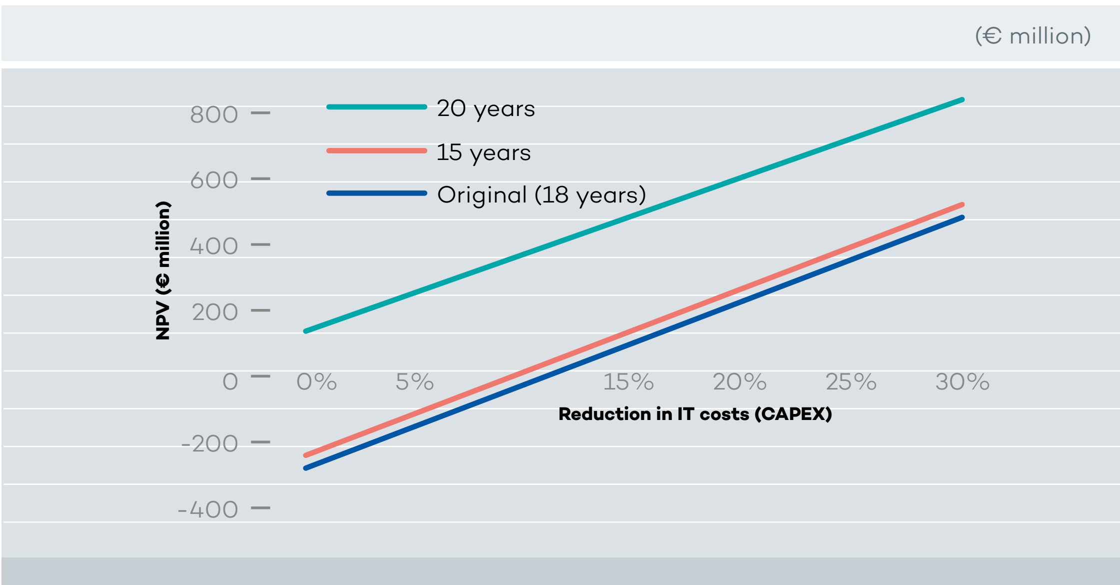
Figure 17 Germany CBA: Estimated relationship between NPV and GPRS penetration

Note that a linear relationship between the 3 modelling periods does not arise due to the impact of the timing of meter replacement costs on the overall NPV.

The impact of a small change in communications mix is significant, with net benefits rising to between €100 million and €700 million depending on the modelling period with only a 10% greater penetration of PLC (10% less penetration of GPRS).

The impact of potential cost reduction in IT, which in theory may be facilitated should greater cooperation between DSOs be possible, is set out in the following table:

Figure 18 Germany CBA: Impact on project NPV of cost reductions in IT capital costs



The sensitivity of the results is evident in that in all scenarios a 10% reduction in IT costs results in a €250-300 million increase in net benefits.

It is also possible that the use of IHDs could be greater targeted to those customer groups that explicitly require the physical infrastructure in their home so as to respond to the new incentives created by smart metering systems, without compromising the benefits that can be reaped by other customers.

The following graph shows the variation in the NPV where it is possible to reduce the proportion of households with IHDs from the current assumed value of 50% maintaining benefits constant.

Figure 19 **Germany CBA - Sensitivity of NPV to changes in the penetration of in-home displays**

6.6.4. Conclusions and specific recommendations

The German CBA in its existing form produces marginally negative results. The results are highly sensitive to changes in key assumptions, a point raised by the consultant that undertook the national CBA. Adjusting for several important factors – for example, meter replacement, communications mix - can also produce a large change in the overall result without adjusting any of the key unit cost or benefit assumptions. In particular, the treatment of replacement appears to allocate costs to the CBA that do not have corresponding benefits due to these arising beyond the modelling timeframe. In addition, it appears that the communications infrastructure facilitates a wide variety of smart grid solutions, which would indicate that either a share of the total communications costs is allocated to smart grid solutions, or the relevant smart grid benefits are included in the analysis.

In addition, where cost efficiencies are possible, most notably in communications costs and information technology –for example if cooperation between DSOs is possible– then the analysis may produce correspondingly higher net benefits.

The MS is recommended to:

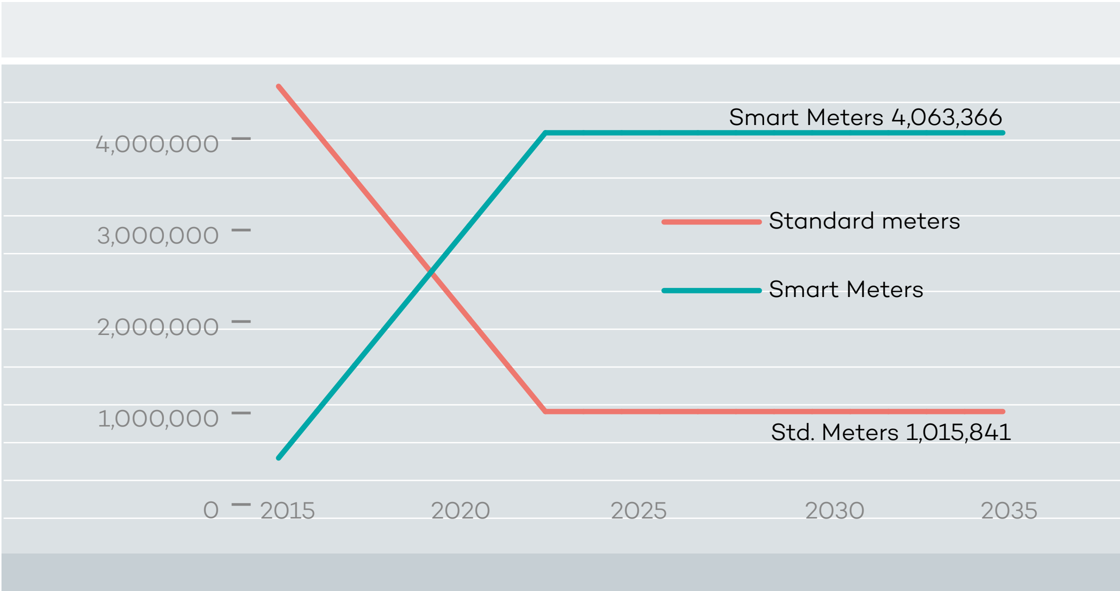
- Include a detailed breakdown of costs and benefits in the CBA to enable better understanding of the key drivers of the results.
- Clarify the approach to replacement so that the full benefit of any assets included are adequately captured within the modelling period either directly or using a terminal value.
- Reconsider the treatment of the proposed infrastructure and communications solution in the CBA where services that are broader than simply smart metering related ones are incorporated. Reflecting these broader benefits the CBA should either a) include these benefits within the CBA, or b) allocate a share of the costs to these additional services and reduce the costs included in the smart metering CBA accordingly.
- Revisit overall communications costs, particularly based on actual experience whereby DSOs are searching for PLC based solutions that are less costly than the use of GPRS.
- Explore the extent to which greater cooperation between DSOs can result in a reduction in IT costs. The CBA could incorporate this functionality using cluster groups with different costs.
- Develop the 80% roll out scenario as the base case. Other scenarios proposed by the MS involve a lower roll out based on energy volumes, which is likely to impose significant additional costs in maintaining dual systems of meter reading and data transfer.

6.7. Hungary

6.7.1. Key methodological assumptions

The approach adopted in recreating the Hungarian CBA is top-down in nature given that aggregate annual cost figures are given, while the benefits are represented as proportional decreases from the revenue bases. The “Scenario 1” assessment has been recreated, in which an eight-year linear rollout starting in 2015 is proposed, covering 80% (4,063,366) of metering points by 2022.

Figure 20 Cumulative profile of smart meters and standard meters, Hungary



In developing a profile of costs and benefits over time from the original data, the following values for a number of input parameters were assumed:

- No. of manual meter readings saved per year: 1
- Average billing cost per client with smart meters: €0.50/metering point per year
- Customer care cost/client/year (baseline): €2/metering point per year
- Peak Load Transfer: 2%
- % of clients requesting incremental contracted power: 1%

6.7.2. Key findings

The results of the rollout based on original period of 18 years, together with estimated periods of 15 and 20 years are represented in the following table. As can be seen the CBA generates a negative net result in all three cases.

TABLE 53

SUMMARY RESULTS: HUNGARY - ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (18 years)	15 years	20 years
Costs	985.06	929.43	1,017.09
Benefits	668.93	563.54	732.06
NET BENEFITS	**-316.13**	**-365.89**	**-285.04**
Results	Negative	Negative	Negative

A breakdown of key cost and benefit items is set out below:

TABLE 54

KEY COST AND BENEFIT ITEMS, HUNGARY CBA, €MILLION, NPV BASIS

	Original (18 years)	15 years	20 years
CAPEX			
Investment in smart meters	390.54	390.54	390.54
Investment in Information Technology	28.56	28.56	28.56
Investment in Communications	78.13	78.13	78.13
Investment in In-home display	47.72	47.72	47.72
TOTAL CAPEX	**544.95**	**544.95**	**544.95**
OPEX			
IT maintenance costs	18.15	16.28	19.22
Network management and front end costs	88.98	76.38	96.24
Communications/data transfer costs	142.38	122.21	154.00
Replacement/failure of smart meter systems	119.60	102.66	129.36
Call centre/customer care	28.59	24.55	30.92
Training costs	0.04	0.04	0.04
TOTAL OPEX	**397.74**	**342.12**	**429.78**
OTHER COSTS			
Customer engagement programme	0.20	0.20	0.20
Sunk costs of previously installed meters	42.11	42.11	42.11
Others not defined		0.06	0.06
TOTAL OTHER COSTS	**42.36**	**42.36**	**42.36**
TOTAL COSTS	**985.06**	**929.43**	**1017.09**
BENEFITS			
Reduction meter reading and meter operations costs	59.01	50.65	63.83
Reduction in technical losses of electricity	18.06	15.17	19.81
Electricity cost savings	30.93	25.97	33.91
Reduction of commercial losses	79.59	67.52	86.73
BENEFITS NOT INCLUDED IN EC RECOMMENDATION			
Generation efficiency (Wholesale price reduction)	279.01	234.31	305.93
Competitiveness (Retail price reduction)	202.33	169.92	221.86
TOTAL BENEFITS	**668.93**	**563.54**	**732.06**

The following table sets out the same costs and benefits on a per-metering point basis:

TABLE 55

KEY COST AND BENEFIT ITEMS, HUNGARY CBA, €/METERING POINT, NPV BASIS

	Original (18 years)	15 years	20 years
CAPEX			
Investment in smart meters	96.11	96.11	96.11
Investment in Information Technology	7.03	7.03	7.03
Investment in Communications	19.23	19.23	19.23
Investment in In-home display	11.74	11.74	11.74
TOTAL CAPEX	**134.11**	**134.11**	**134.11**
OPEX			
IT maintenance costs	4.47	4.01	4.73
Network management and front end costs	21.90	18.80	23.68
Communications/data transfer costs	35.04	30.08	37.90
Replacement/failure of smart meter systems	29.43	25.26	31.83
Call centre/customer care	7.04	6.04	7.61
Training costs	0.01	0.01	0.01
TOTAL OPEX	**97.89**	**84.20**	**105.77**
OTHER COSTS			
Customer engagement programme	0.05	0.05	0.05
Sunk costs of previously installed meters	10.36	10.36	10.36
Others not defined	0.00	0.01	0.01
TOTAL OTHER COSTS	**10.43**	**10.43**	**10.43**
TOTAL COSTS	**242.42**	**228.73**	**250.31**
BENEFITS			
Reduction in meter reading and meter operations costs	14.52	12.47	15.71
Reduction in technical losses of electricity	4.45	3.73	4.87
Electricity cost savings	7.61	6.39	8.35
Reduction of commercial losses	19.59	16.62	21.34
Benefits not included in EC Recommendation			
Generation efficiency improvement (Wholesale price reduction)	68.66	57.66	75.29
Competitiveness (Retail price reduction)	49.79	41.82	54.60
TOTAL BENEFITS	**164.62**	**138.69**	**180.16**

6.7.3. Observations

A notable feature of the Hungarian CBA is the importance of two benefits that are not explicitly included in Recommendation 2012/148/EU, both related to reduction of energy prices (Retail price due to increased competitiveness, and Wholesale price reduction due to Generation efficiency improvement). These two benefits comprise a big part of total benefits, at around 72%. The formulas used are represented below:

Wholesale price benefit =*Wholesale Price reduction (%) * Wholesale price * Energy from transmission * %Roll-out complete*

Retail price benefit = *Retail Price reduction (%) * Retail price * Energy delivered * %Roll-out complete*

It should be noted that no consumption reduction impact from smart meter rollout has been considered. However, potentially this could be justified by the inclusion of a price impact (reduction in wholesale and retail prices) in place of a volume impact. In practice, the modelling is very sensitive to the consumption effect, whereas if 2% of consumption reduction were to be assumed possible in Hungary, this would generate sufficient additional benefits over a 20-year analytical period to result in a positive net benefit with the existing 6% discount rate.

On the cost side, the CBA includes investment in IHDs. However, given that no consumption impact is assumed in the chosen scenario ("Scenario 1") the inclusion of this investment can be questioned. Moreover, no benefit from the avoided cost of standard metering systems is included in the CBA. Even a relatively small benefit –for example €20-40 per metering point– were included, it would be sufficient to make the results relatively marginal in nature.

While the CBA assumes an asset life of 15 years, the MS notes that meters are subject to a local requirement for re-calibration every 10 years, which may limit their effective life in practice. If this is the case, a review of local legislation may be required.

In general, the results are relatively insensitive to changes in the discount rate.

6.7.4. Conclusions and specific recommendations

The Hungarian CBA (Scenario 1) shows negative results, in which costs do not appear to be unduly high compared to those of other MS. A key difficulty in interpreting the analysis is that benefits generally do not following the approach in Recommendation 2012/148/EU, with more than 72% of total benefits accounted by two items not explicitly included in the Commission's recommended methodology. As a result, and given other benefits appear low (for example, commercial loss reduction), a review of the benefits, including through the use of pilot project is supported to better understand the customer reaction to smart metering systems.

It should be noted that the MS considers a number of additional roll out scenarios that result in much higher costs but also positive net benefits, supporting the inclusion of additional meter functionality. Any update to the CBA should consider the most appropriate institutional structure and functionality requirements for the smart metering systems.

The MS is recommended to:

- Review the key benefit drivers. A key reason for this review is that the results place disproportionate weight on factors that are not included as core benefits in the Commission's methodology, and which are not considered applicable in most other CBAs. In this regard, the development of pilot projects to better understand customer response to smart metering systems is supported.
- Disseminate the results of the CBA to promote transparency and debate on smart metering. We understand that the CBA, while shared with the project team, is not yet publicly available.
- Clarify the treatment of avoided metering costs, and to include it in the CBA where not already present. Other costs, for example related to IHDs, should be included only where positive benefits are anticipated to arise.
- Focus in subsequent revisions on the scenarios with more advanced functionality as these produce the greatest net benefit.
- Consider implementing a roll out encompassing all customers, not just domestic and small commercial ones, to reduce the costs of running duplicate systems (smart and non-smart).

6.8. Lithuania

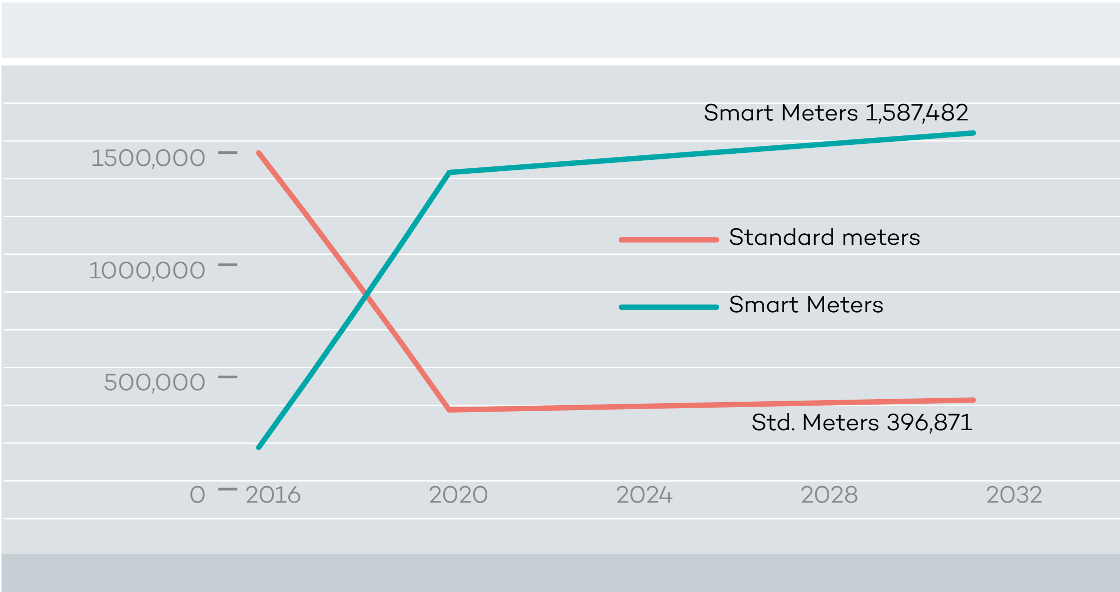
6.8.1. Key methodological assumptions

The approach adopted in recreating the dynamics of the Lithuania CBA is bottom-up in nature due to the inclusion of unit costs and benefits in the report, and a detailed time profile.

Unit costs are broken down between capital and operating expenditure, while a five-year roll out is proposed resulting in a total of 1.411 million electricity smart meters being installed in the first instance. The report allows for subsequent growth in the number of smart meters as result of increases in the consumer population.

The time profile for the roll out is as follows:

Figure 21 **Cumulative profile of smart meters and standard meters, Lithuania**



The CBA provides a detailed year-by-year breakdown of capital and operating costs. It has not been possible to fully reconcile these costs with the reported unit costs. However, due to the capital and operating costs in the CBA being reported on an annual basis, these annual numbers have been applied in subsequent calculations.

The benefits have been estimated from the data in the CBA using a combination of bottom-up and top-down approaches. In the case of three of the benefits, namely Consumption Reduction, Peak Load Transfer and CO2 emission reduction, the estimated benefits reported here do not exactly match the ones stated in the Lithuanian CBA.[18]

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18 *The calculation of the Consumption Reduction benefit in this section amounts to €97 million in the original period of analysis (14 years), while the report gives €34 million for the same benefit. The following formula for calculating annual Energy savings from reduction in consumption was used:*

Cons. reduction (%) [18] ** Elec. Cons* $_t$ ** Price* [18] ** % Roll Out complete* $_t$

In the above, the consumption reduction is a weighted average percentage of possible reduction for all four categories. The price is estimated as the electricity generation price plus 50% of transfer and distribution component (220 LTL/MWh = 64 EUR/MWh).

In case of Peak Load Transfer (PLT), a figure of €32.5 million was estimated, while in the CBA this benefit amounted to 18.2 million euros. The formula used was the following:

PLT (%) ΔPeak and non-peak wholesale generation margin * Energy Delivered* $_t$ ** % Roll Out complete* $_t$

The PLT represents the weighted average peak load transfer (%) for all four categories.

There was also a significant difference in the benefit of reduction of CO_2 *emissions. Part of the* CO_2 *benefit difference comes from the fact that the Absence of Standard Meter Electricity Cost was included as a Reduction in Technical Losses, hence this reduction (in MWh) accounts towards the* CO_2 *benefit, together with the Consumption Reduction. This reduction, however, does not explain the whole discrepancy, since the estimate for this benefit amounts to 7.2 million euros, while the CBA report provides 1.7 million euros. The following formula was applied:*

(Cons. reduction (MWh)$_t$ *+Reduction in Tech. losses (MWh)*$_t$*) ** CO_2 *content ** CO_2 *value*

The CO_2 *content is estimated at 0.424 tonnes/MWh, while the* CO_2 *value is 9.44 EUR/tonne (32.6 LTL/tonne).*

6.8.2. Key findings

For the proposed 80% coverage of supply points with smart meters, the analysis shows negative result in all three instances (original 14 years, 15 and 20 year modelling periods), though the net benefit is only slightly negative in the 20 year modelling period.

TABLE 56

SUMMARY RESULTS: LITHUANIA, ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (14 years)	15 years	20 years
Costs	232.1	237.7	261.9
Benefits	184.7	197.6	256.7
NET BENEFITS	**- 47.4**	**- 40.1**	**- 5.2**
Results	Negative	Negative	Negative

A breakdown of key cost and benefit items is set out below:

TABLE 57

KEY COST AND BENEFIT ITEMS, LITHUANIA CBA, €MILLION, NPV BASIS

	Original	15 years	20 years
CAPEX			
Investment in smart meters	159.59	160.65	165.24
Investment in Information Technology	5.87	5.87	5.87
Investment in Communications	22.16	22.35	23.16
Avoided investment in conventional meters	-22.26	-22.26	-22.26
TOTAL CAPEX	**165.36**	**166.61**	**172.01**
OPEX			
IT maintenance costs	13.70	14.36	17.25
Network management and front end costs	18.70	20.09	26.08
Communications/data transfer costs	29.79	32.01	41.60
Replacement/failure of smart meter systems	1.20	1.28	1.62
Training costs	0.18	0.18	0.18
TOTAL OPEX	**63.57**	**67.91**	**86.72**

	Original	15 years	20 years
OTHER COSTS			
Customer engagement programme	1.35	1.35	1.35
Others not defined	1.84	1.84	1.84
TOTAL OTHER COSTS	**3.18**	**3.18**	**3.18**
TOTAL COSTS	**232.11**	**237.70**	**261.91**
BENEFITS			
Reduction in meter reading and meter operations costs	7.08	7.53	9.55
Reduction in technical losses of electricity	13.15	14.07	18.33
Electricity cost savings	129.51	138.63	180.55
Reduction of commercial losses	27.73	29.63	38.27
Reduction of CO_2 emissions	7.20	7.70	10.03
TOTAL BENEFITS	**184.66**	**197.56**	**256.73**
NET BENEFIT	**-47.45**	**-40.14**	**-5.18**

The same data on a per-metering point basis is set out below:

TABLE 58

KEY COST AND BENEFIT ITEMS, LITHUANIA CBA, €/METERING POINT, NPV BASIS

	Original	15 years	20 years
CAPEX			
Investment in smart meters	113.06	113.82	117.07
Investment in Information Technology	4.16	4.16	4.16
Investment in Communications	15.70	15.83	16.41
Avoided investment in conventional meters	-15.77	-15.77	-15.77
TOTAL CAPEX	**117.15**	**118.04**	**121.86**
OPEX			
IT maintenance costs	9.71	10.18	12.22
Network management and front end costs	13.25	14.23	18.48
Communications/data transfer costs	21.11	22.68	29.47
Replacement/failure of smart meter systems	0.85	0.91	1.15
Training costs	0.13	0.13	0.13
TOTAL OPEX	**45.04**	**48.12**	**61.44**

	Original	15 years	20 years
OTHER COSTS			
Customer engagement programme	0.95	0.95	0.95
Others not defined	1.30	1.30	1.30
TOTAL OTHER COSTS	**2.26**	**2.26**	**2.26**
TOTAL COSTS	**164.44**	**168.41**	**185.56**
BENEFITS			
Reduction in meter reading and meter operations costs	5.01	5.34	6.77
Reduction in technical losses of electricity	9.31	9.97	12.98
Electricity cost savings	91.76	98.21	127.92
Reduction of commercial losses	19.64	20.99	27.11
Reduction of CO_2 emissions	5.10	5.46	7.11
TOTAL BENEFITS	**130.83**	**139.97**	**181.89**
NET BENEFIT	**-33.61**	**-28.44**	**-3.67**

6.8.3. Observations

The results for the original modelling period (14 years) differ from those reported in the previous section as the calculations undertaken for Consumption Reduction, Peak Load Transfer and CO2 emission reduction using the MS own data support higher benefits for each of these categories. Due to adjusting for these factors, the overall results become relatively inconclusive particularly where the modelling period is extended beyond 15 years.

6.8.4. Conclusions and specific recommendations

A relatively low cost solution is proposed for smart metering systems in Lithuania. At the same time, relatively low benefits are reported, resulting in a finding that could be classified as inconclusive. In this regard further analysis on the benefit side is supported, particularly regarding customer behaviour to the introduction of smart metering systems and key assumptions, for example, the electricity price. In addition, further review of the costs is supported due to difficulties in reconciling unit costs and reported costs.

The MS is recommended to:

- Provide greater details on the calculations, as it has not been possible to recreate the costs in the CBA. In addition, the calculations can be reviewed as a different profile of benefits has been obtained in this report from the CBA using the same input data.
- Review, in further detail, the key benefits to better understand customer response to the introduction of smart metering systems.

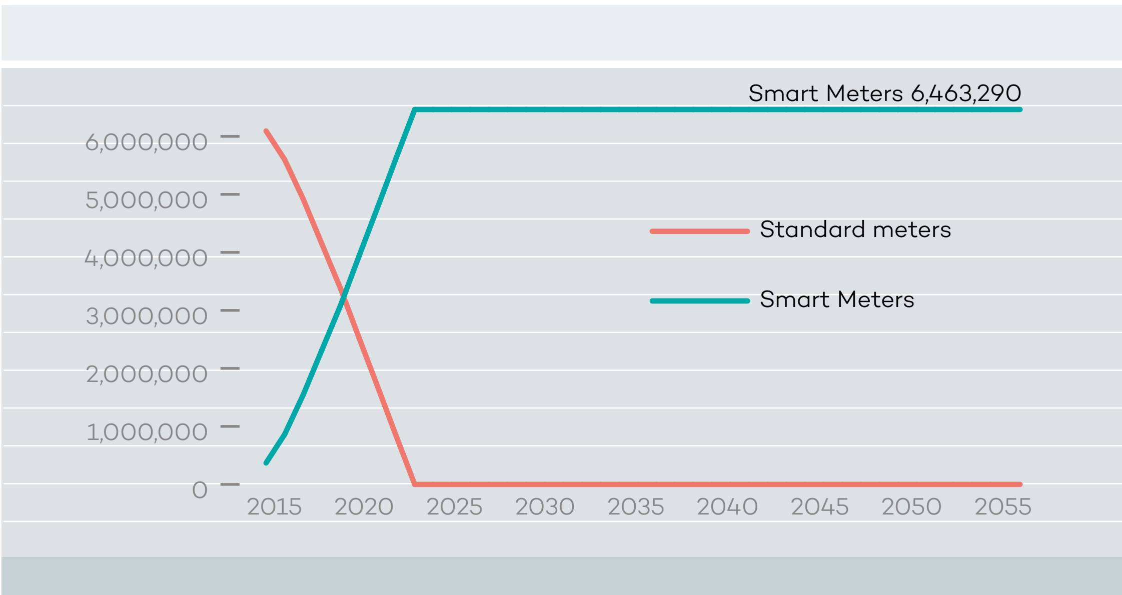
6.9. Portugal

6.9.1. Key methodological assumptions

The approach adopted in recreating the dynamics of the Portuguese CBA is bottom-up in nature due to the inclusion of unit costs and benefits in the report.

Unit costs are broken down between capital and operating expenditure, while a nine year roll out is proposed resulting in a total of 6.46 million electricity smart meters being installed as follows (dates from original CBA and based on a linear installation profile).

Figure 22 Cumulative profile of smart meters and standard meters, Portugal



Other key assumptions applied include the following:

- Capital costs associated with information technology are spread equally over four years
- Capital costs associated with communications is proportional to the smart meter roll out
- Operating expenditure and benefits rise in proportion with the roll out

Due to the calculation being developed from unit costs and benefits, the results in this section differ from those in the previous sections and those reported in the CBA. As the costs have been most closely reconciled to those reported in the CBA if meter replacement is not included, it is suggested that the reported results for 15 and 20 years most closely approximate the key dynamics of the CBA.

6.9.2. Key findings

The results of the CBA are strongly positive in the MS modelling period (40 years) and those of 15 and 20 years (both from the start of the rollout period).

TABLE 59

SUMMARY RESULTS: PORTUGAL, ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (40 years)	15 years	20 years
Costs	495.60	451.50	469.90
Benefits	1033.9	737.73	842.37
NET BENEFITS	**538.28**	**286.22**	**372.44**
Results	Positive	Positive	Positive

A breakdown of key cost and benefit items is set out below:

TABLE 60

KEY COST AND BENEFIT ITEMS, PORTUGAL CBA, €MILLION, NPV BASIS

	Original (40 years)	15 years	20 years
CAPEX			
Investment in smart meters	346.00	346.00	346.00
Investment in Information Technology	28.53	28.53	28.53
Investment in Communications	180.06	180.06	180.06
Avoided investment in conventional meters	-236.59	-236.59	-236.59
TOTAL CAPEX	**318.00**	**318.00**	**318.00**
OPEX			
IT maintenance costs	35.28	28.17	31.14
Communications/data transfer costs	43.28	37.42	39.86
Meter reading	81.80	50.65	63.66
Training costs	17.28	17.28	17.28
TOTAL OPEX	**177.63**	**133.51**	**151.94**
TOTAL COSTS	**495.63**	**451.51**	**469.94**

	Original (40 years)	15 years	20 years
BENEFITS			
Reduction in meter reading and meter operations costs	209.17	156.18	202.37
Reduction in technical losses of electricity	32.21	23.66	24.61
Electricity cost savings	616.32	510.30	563.56
Reduction of commercial losses	165.58	113.72	127.68
Reduction of outage times	10.63	7.07	7.81
TOTAL BENEFITS	**1033.90**	**810.93**	**926.03**
NET BENEFIT	**538.28**	**286.22**	**372.44**

Note: no replacement is included in the costs reflecting a 40-year analysis period. The overall cost of the smart meters in these calculations (€346 million) is slightly lower than in the MS CBA (€364 million).

The same data on a per-metering point basis is set out in the following table:

TABLE 61

KEY COST AND BENEFIT ITEMS, PORTUGAL CBA, €/METERING POINT, NPV BASIS

	Original (40 yrs)	15 years	20 years
CAPEX			
Investment in smart meters	53.53	53.53	53.53
Investment in Information Technology	4.41	4.41	4.41
Investment in Communications	27.86	27.86	27.86
Avoided investment in conventional meters	-36.61	-36.61	-36.61
TOTAL CAPEX	**49.20**	**49.20**	**49.20**
OPEX			
IT maintenance costs	5.46	4.36	4.82
Communications/data transfer costs	6.70	5.79	6.17
Meter reading	12.66	7.84	9.85
Training costs	2.67	2.67	2.67
TOTAL OPEX	**27.48**	**20.66**	**23.51**
TOTAL COSTS	**76.68**	**69.86**	**72.71**

	Original (40 yrs)	15 years	20 years
BENEFITS			
Reduction in meter reading and meter operations costs	32.36	24.16	31.31
Reduction in technical losses of electricity	4.98	3.66	3.81
Electricity cost savings	95.36	78.95	87.19
Reduction of commercial losses	25.62	17.60	19.75
Reduction of outage times	1.64	1.09	1.21
TOTAL BENEFITS	**159.97**	**125.47**	**143.27**
NET BENEFIT	**83.29**	**55.61**	**70.56**

6.9.3. Observations

We have been informed that Portugal is in the process of issuing a revised CBA report that will include various revised assumptions reflecting the changed economic circumstances of the country. In particularly, we understand that consumption benefit may be significantly reduced due to the belief that the scope to reduce consumption may have been exhausted by the current economic situation in the country. In addition, real increases in electricity tariffs are to be incorporated into the modelling.

A key issue with the CBA in Portugal is the discount rate. In the current CBA a discount rate of 10% is used, which we understand will also be applied in the forthcoming revised CBA. The impact of using this high rate is significant. For example, the subsequent table sets out the costs and benefits that would apply in the current analysis assuming the assumption of a 5% discount rate instead of 10%. The overall result does not change, but the magnitude of the net benefits increases significantly, including in the 15 and 20-year period, which are considered most representative of the key dynamics.

TABLE 62

PORTUGAL – SUMMARY CBA RESULTS WITH DISCOUNT RATE OF 5%: ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (40 years)	15 years	20 years
Costs	725.95	593.39	634.11
Benefits	2,412.93	1,267.02	1,524.64
NET BENEFITS	**1,686.98**	**673.63**	**890.53**
Original results (10% discount rate)	538.28	286.22	372.44
Change from original results	+1,148.70	+387.41	+518.09

In practice, the available data does not support a discount rate of 10%. The following graph illustrates the difference in the risk premium of euro-denominated bonds issued in Portugal and Germany and shows a current premium of well below 200 basis points.

Figure 23 **Difference in risk premium – bonds issued in Portugal and Germany, 2011-15**

Source: www.countryeconomy.com

6.9.4. Conclusions and specific recommendations

The existing CBA in Portugal shows positive results for all modelling periods. However, we understand that a revised CBA is about to be issued, which is likely to revise a number of key assumptions. However, we understand that a discount rate of 10% will be used. Trends in bond yields suggest that the risk premium has declined significantly since the production of the existing CBA, and that a much lower rate is now applicable.

The MS is recommended to:

- Review the discount rate. While we understand that the use of a 10% discount rate may reflect Government practice in social cost-benefit analyses, it is at odds with experience in other European countries and bond market data.
- Undertake further metering trials to evaluate whether customer behaviour has changed significantly in recent years.
- Apply a shorter modelling period in any revision to the CBA (ideally over the economic life of the meter). If a longer period is applied meter replacement should be built into the analysis, without distorting the overall costs.
- Review overall barriers to implementation given that the existing CBA shows strongly positive results.

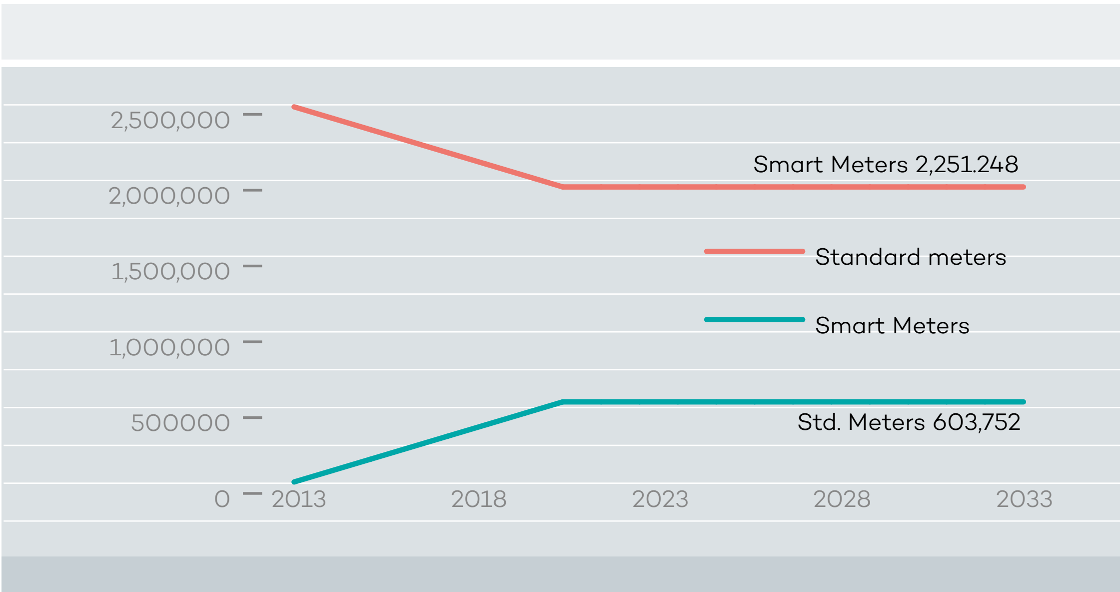
6.10. Slovak Republic

6.10.1. Key methodological assumptions

The approach adopted in recreating the dynamics of the Slovak Republic CBA is a mix of bottom-up and top-down calculations. For the costs, bottom up calculations are possible due to the inclusion of unit costs in the report. In the case of benefits, top-down assessment has been undertaken to develop unit benefits, and annual profiles from aggregated values due to the presence of an annual breakdown of benefits in 2020, the first year of full roll out.

Unit costs are broken down between capital and operating expenditure, while an eight year roll out is proposed resulting in a total of 603,752 electricity smart meters being installed as follows (dates from original CBA and based on a linear installation profile).

Figure 24 Cumulative profile of smart meters and standard meters, Slovak Republic



Other key assumptions applied in recreating the dynamics of the CBA include the following:

- Capital costs associated with information technology are spread over 4 years, with half the total occurring in the first year
- Capital costs associated with communications is proportional to the smart meter roll out
- Operating expenditure and benefits rise in proportion with the roll out

As information on some of the key inputs for the benefits calculation was not available, these were estimated from the aggregated figures taking into account the rollout schedule and the discount rate. In developing a profile of benefits over time from the original data values for a number of input parameters were assumed:

- Average billing costs per client with smart meters: €6.75 per metering point per year
- Customer care cost/client/year (baseline): €1.9 per metering point per year
- Peak load transfer: 2%
- % of clients requesting incremental contracted power: 1%
- Average non-supplied minutes/year: 120
- % reduction of client compensations: 0.5%
- CO2 content (energy saved): 0.559 tonnes/MWh

The profile of capital expenditure calculated from the unit costs is around 15% higher than that stated in the CBA. However, full alignment of the operating expenditure has been possible. The difference between the yearly profile of total CAPEX and that in the MS report is set out below:

TABLE 63

SLOVAK REPUBLIC TOTAL ANNUAL CAPEX DIFFERENCE (€ MILLION)

Year	2013	2014	2015	2016	2017	2018	2019	2020
Own calculations	11.877	9.977	9.977	9.977	9.027	9.027	9.027	9.027
MS Report	10.394	8.673	8.504	7.873	7.856	8.084	8.205	8.353

6.10.2. Key findings

For the roll out proposed –covering 23% of the LV supply points and accounting for 53% of total annual LV electricity consumption– the estimated results are strongly positive in the MS modelling period (20 years) and that of 15 years (both from the start of the roll-out period). Note as a 20 year modelling period is applied the first and third columns are equal in this case.

TABLE 64

SUMMARY RESULTS: SLOVAK REPUBLIC, ORIGINAL PERIOD, 15 YEARS AND 20 YEARS (€ MILLION, NPV BASIS)

	Original modelling period (20 years)	15 years	20 years
Costs	103.33	94.62	103.33
Benefits	185.56	147.32	185.56
NET BENEFITS	**82.23**	**52.70**	**82.23**
Results	Positive	Positive	Positive

A breakdown of key cost and benefit items is set out below:

TABLE 65

KEY COST AND BENEFIT ITEMS, SLOVAK REPUBLIC CBA, €MILLION, NPV BASIS

	Original	15 years	20 years
CAPEX			
Investment in smart meters	55.38	55.38	55.38
Investment in Information Technology	5.08	5.08	5.08
Investment in Communications	0.64	0.64	0.64
TOTAL CAPEX	**61.10**	**61.10**	**61.10**
OPEX			
IT maintenance costs	8.57	6.80	8.57
Communications/data transfer costs	33.66	26.73	33.66
TOTAL OPEX	**42.23**	**33.53**	**42.23**
TOTAL COSTS	**103.33**	**94.62**	**103.33**
BENEFITS			
Reduction in meter reading and meter operations costs	15.28	12.13	15.28
Reduction in technical losses of electricity	8.46	6.72	8.46
Electricity cost savings	119.90	95.20	119.90
Reduction of commercial losses	39.40	31.28	39.40
Reduction of outage times	0.37	0.29	0.37
Reduction of CO_2 emissions	2.15	1.70	2.15
TOTAL BENEFITS	**185.56**	**147.32**	**185.56**

The same data on a per-metering point basis is set out in the following table:

TABLE 66

KEY COST AND BENEFIT ITEMS, SLOVAK REPUBLIC CBA, €/METERING POINT, NPV BASIS

	Original	15 years	20 years
CAPEX			
Investment in smart meters	91.72	91.72	91.72
Investment in Information Technology	8.42	8.42	8.42
Investment in Communications	1.05	1.05	1.05
TOTAL CAPEX	**101.19**	**101.19**	**101.19**

	Original	15 years	20 years
OPEX			
IT maintenance costs	14.19	11.27	14.19
Communications/data transfer costs	55.76	44.27	55.76
TOTAL OPEX	**69.95**	**55.53**	**69.95**
TOTAL COSTS	**171.14**	**156.73**	**171.14**
BENEFITS			
Reduction in meter reading and meter operations costs	25.30	20.09	25.30
Reduction in technical losses of electricity	14.02	11.13	14.02
Electricity cost savings	198.59	157.67	198.59
Reduction of commercial losses	65.27	51.81	65.27
Reduction of outage times	0.61	0.48	0.61
Reduction of CO_2 emissions	3.55	2.82	3.55
TOTAL BENEFITS	**307.34**	**244.01**	**307.34**

Note that due to the different methodology applied the exact breakdown by benefit categories is not identical to that in the previous section.

6.10.3. Observations

The specification of the CBA is not compliant with the requirement of an 80% roll out. However, a key observation from the analysis is that the CBA is strongly positive, though this reflects the limited roll out covering those customers with the highest energy consumption.

To evaluate possible impacts of expanding the rollout on the overall viability of the project extremely simple calculations have been undertaken on the effect of a 100% roll out – assuming:

- All capital and operating costs would increase in proportion to the additional number of metering points (currently 22% of the total number of meters in the country), except that in the case of smart meters additional customers would receive one phase rather than three phase meters (€26.80 difference in price, including installation).
- Benefits of meter reading and operations would increase in proportion to the additional number of metering points (currently 22%), while all other benefits are volume related (currently 53% of total volumes are covered by the roll out scenario).

For the 15 and 20 year modelling periods the following breakdown of cost and benefits are produced:

TABLE 67

HIGH LEVEL SCENARIO ON 100% ROLL OUT, SLOVAK REPUBLIC CBA, € MILLION, NPV BASIS

	15 years	20 years
CAPEX		
Investment in smart meters	186.60	186.60
Investment in Information Technology	22.10	22.10
Investment in Communications	2.77	2.77
TOTAL CAPEX	**211.46**	**211.46**
OPEX		
IT maintenance costs	29.58	37.26
Communications/data transfer costs	116.20	146.36
TOTAL OPEX	**145.78**	**183.62**
TOTAL COSTS	**357.24**	**395.09**
BENEFITS		
Reduction in meter reading and meter operations costs	52.73	66.42
Reduction in technical losses of electricity	12.68	15.97
Electricity cost savings	179.61	226.22
Reduction of commercial losses	59.03	74.35
Reduction of outage times	0.55	0.70
Reduction of CO_2 emissions	3.21	4.05
TOTAL BENEFITS	**307.82**	**387.71**
NET BENEFITS	**-49.42**	**-7.37**

The results, while negative, show that on the high level and conservative assumptions adopted there are strong grounds to investigate the net benefits of a widespread rollout. This is particularly evident as the results potentially understate the net benefits of a widespread roll out for various reasons:

- Costs are likely to be overstated as in practice some economies of scale in IT and communications would be envisaged to arise. In addition, the CBA does not include allowance for avoided standard meters, which should reduce the gap between costs and benefits more generally.
- Some benefits –for example, commercial loss reduction– may be more evident for smaller domestic customers.

We understand that the Slovak Republic is considering recalculating the entire CBA. The above findings while highly indicative in nature suggest that consideration of a full, or 80% roll out, should be undertaken as the scope for a positive roll out appears to exist.

6.10.4. Conclusions and specific recommendations

The CBA produced only considers a partial rollout and should be reworked to look at the impact of at least 80% penetration of smart metering systems. The results, albeit for a subset of the population, strongly support the introduction of smart metering systems, which suggests that a much broader roll out can have strong economic benefits.

The MS is recommended to:

- Re-run the CBA assuming an 80% roll out, not just for compliance purposes, but also because the preliminary findings indicate that a positive result may be achieved
- Clarify the treatment of avoided standard meter costs, which do not appear to be included in the analysis

7. Elements for the successful roll-out of smart meters

7.1. Introduction

This section considers, at a broad level, regulatory and non-regulatory elements that can support the successful roll out of smart meters. The objective is to complement the analytic findings in this report in developing recommendations.

The elements that can support a widespread roll out may be relatively direct or indirect in nature. Direct measures include those that address key framework conditions for the successful and efficient roll out of smart meters. Indirect measures include aspects such as funding mechanisms and programmes (for example, energy efficiency) that have many complementary features with smart metering.

Key framework issues with a direct impact on the success of a smart-metering roll out include:

- Elements that shape the content and context of a smart metering project – including the legal and regulatory framework, key organisations, functionalities, interoperability requirements, adherence to standards, technological architecture, and time frame.
- Measures that aim to reduce the net cost of a smart metering project (e.g. standardising features and compliance requirements to technical standards which maximise competition in the supply of equipment).
- Elements aimed at promoting greater consumer involvement.

Other (indirect) elements that enhance the value of smart metering projects include:

- Financing issues – including the incorporation of smart meters in energy efficiency projects.
- EU policies in various areas, including: carbon and other pollutants emissions; Consumer protection; The wholesale electricity and ancillary services market design; The technical features of electric appliances and on building automation; Research and development; and Electrical mobility.

Examples of uses for smart meters include the following areas:

- Electric vehicle charging
- Net metering

In general, many of the elements for the successful roll out of smart meters refer to other related systems such as Smart Grids. This overlap arises as the full potential benefits of advanced technologies including smart metering can only be best realised together with the expansion of other parts of the system containing Smart Grids.

Key elements for the successful roll out of smart metering systems are summarized below and grouped in the following table according to whether they are addressed at an EU and/or MS level:

TABLE 68

CORRELATION OF ELEMENTS WITH ADDRESSED LEVEL

	Elements for the successful roll out of smart meters	Level
	DIRECT (FRAMEWORK) ISSUES	
1	Single lead organisation	EU, MS
2	Cost optimized solutions	MS
3	Deployment strategy options	EU, MS
4	Maximize synergies	MS
5	Tariff development	MS
6	Consumer protection measures	EU, MS
7	Monitoring, evaluation and impact assessment	EU, MS
	Funding-related issues	
8	Further support of granting eligibility for smart metering within energy efficiency projects	EU
9	Certification of energy savings	EU
10	Research and development of innovative products and services	EU
	Policy-related issues	
11	Promoting harmonization/cohesion	MS
12	Assistance for implementation of the Energy Efficiency Directive	EU, MS
13	Linkage with other initiatives	EU
	Use cases of smart metering systems	
14	Intelligent charging stations and support of decentralized management	EU, MS
15	Distributed generation	EU, MS

7.2. Key (direct) framework considerations

The following represent key framework considerations.

7.2.1. Single Lead Organization

The appointment of a single lead organization at the national level (e.g., a regulatory agency) for the roll out of smart meters can facilitate a successful roll out in a number of ways:

- Enabling the development of a coherent legal and regulatory framework for the establishment of a smart metering system

- Determining clear roles and responsibilities for market participants
- Facilitating and strengthening coordination between different participants, especially in countries where the electricity market liberalization has led to complex arrangements for the operation, regulation and certification of metering systems

The use of single lead organization could also support better the streamlining and simplification of key processes – for example, the issuing of required certifications for metering and communications equipment.

7.2.2. Cost optimized solutions

Consistent with the analysis of the CBAs, key factors conducive to favourable CBA outcomes include:

- The selection of appropriate technology choices for smart metering systems that meet interoperability requirements, and which are in line with the minimum functionalities considered necessary to maximize benefits at least cost.
- The use of appropriate IT solutions.
- The ability of the proposed smart metering model to accommodate future developments in technology and the market (e.g. smart grids), thus minimizing the risk of early obsolescence of the selected metering equipment. In devising the systems, end customers should not disproportionally bear the risk of error in the choice of smart metering equipment.

The recommended list of common minimum functional requirements that every smart metering system for electricity should fulfil (Recommendation 2012/148/EU) could be further updated, incorporating when necessary essential new elements of meter functionality, in order to ensure that they remain relevant.

The rapid technology advances warrants regular review of the smart meter functionalities and in particular, consideration of the potential for technological obsolescence and the promotion of interoperability. In particular, the selection of upgradeable or modular smart meters offers the advantage of flexibility in switching between, or mixing communications technologies, since communications costs are generally large and communications infrastructure can provide service not only to the smart meters but also to future smart grids expansion.

Regular revision of communications technologies and associated costs can ensure the introduction of cost-efficient communication protocols and systems. Where effective communication using lower cost methods and technologies, (e.g. communications using Radio Frequencies or PLC) could be preferred instead of other more complex and expensive technologies (e.g. fibre optics, GPRS, etc.).

The cost effectiveness of smart metering needs to also consider the state of distribution grids, metering, billing, level of consumption (including potential for savings), in the respective MSs.

7.2.3. Effective deployment strategies

Any smart meter deployment strategy should allow the optimization of the available resources in the MS.

The introduction of smaller or pilot smart meter projects can provide important information related to a roll out, though the costs and benefits obtained in a pilot project may not necessarily be representative of the costs and benefits that may arise in a wider roll out. For example, real life experiences from large-scale roll out indicate that actual installation costs might be significantly lower than in pilot projects.

The dissemination of lessons learnt including those from countries that have already been engaged in a widespread roll out of smart metering systems (e.g., Italy, Sweden, Finland and Malta) is critical. Of particular relevance is to understand the transferability of international experience due to different local conditions, for example with respect to technical and commercial losses.

Effective deployment strategies require effective engagement strategies to ensure that smart metering technologies can bring tangible benefits to the end-consumers, enabling them to better control their energy consumption and to achieve energy savings. Visual displays can increase the costs of the smart meter roll out, but can also help consumers to become more aware of their consumption and react to price and other incentive signals. However, the deployment of the technology alone may not deliver the expected results unless consumers are involved at the early stage of the roll out.

More generally, it is important to develop well-crafted engagement strategies tailored to different customer segments, which build on their different loads, attitudes, concerns and social norms. These education and engagement activities should address different segments within each sector (households, commercial, industrial and public). Attention needs to be placed on demand response programmes to ensure they are relevant to key population groups, and to the design of consumer interfaces with a view to simplify interaction, and minimize the risk of a rebound effect.

Greater customer focus is necessary for the introduction, acceptance and full utilization of smart meters. Educational initiatives and involvement of individuals, communities and special groups can promote customer focus in the smart meter deployment strategy. Early consumer involvement in the smart meter deployment can help to allay fears of high costs, accuracy of measurements, health risks, protection of personal data, etc.

Particular arrangements can ensure that consumers can take advantage of the functionalities of smart meters and smart grids. Awareness campaigns and educational or training programs can help, as can programmes such as building automation, which can promote energy savings and move consumption away from peak hours.

7.2.4. Maximize synergies

Seeking to maximise synergies among network industries such as electricity, gas, water and district heating can reduce the overall (per-meter) cost of smart metering devices.

Where the joint provision of infrastructure (for example, electricity and gas) facilitates promotes joint net benefits, MS should be encouraged to the extent possible to undertake a joint roll out. A key requirement is that joint roll out occurs where all parties (utilities and customers) benefit, and in ways that avoid particular groups of consumers bearing undue costs – for example those that use gas only for one specific energy use (e.g. cooking).

At the same time, it has to be recognized that policy drivers and implementation considerations relative to electricity smart meters are, in the majority of cases, different from those relevant to gas smart meters.

Smart meters can form part of an enabling infrastructure towards the achievement of wider objectives and array of services provided to consumers. Therefore, a smart meter roll out would be more attractive when it complements wider infrastructure programs that contribute towards the achievement of energy efficiency and sufficiency of energy.

7.2.5. Tariff development

The development of suitable tariffs (e.g. time-of-use pricing) is a pre-requisite for the achievement of specific benefits, particularly those related to time of use behaviour. This process needs to start early on to ensure that the customers would take advantage of such tariffs immediately upon smart meter installation.

The development of dynamic tariff programmes are important in complying with clean energy targets through its capacity to promote:

- The introduction and expansion of net metering services
- The increase of the network flexibility potential
- The introduction of dynamic response programs
- Self-consumption of renewable sources combined with the delivery of on-site generated energy to local distribution facilities

7.2.6. Consumer protection measures

An important framework issue is to ensure consumer protection for low income, elderly and disabled consumers is not compromised, and indeed can be promoted through smart metering systems. Special attention needs to be paid when setting mandatory dynamic rate designs that could be disadvantageous to those consumers who cannot shift usage to off-peak times (particularly elderly and disabled people), because they may experience higher energy bills. In these cases, the introduction of special categories of rates and exceptions to the rules applied to accommodate the welfare of vulnerable groups may be necessary.

Taking into account the remote disconnection smart meters functionalities, there may be a need to review the regulation of disconnection procedures. Such regulation must also include procedures and disconnection times for consumers with small-unpaid bills.

A related issue is ensuring data protection and security from cyber-attacks. Any collection of data by smart meters and its subsequent processing must comply with EU law on the protection of personal data, in particular Directive 95/46/EC and the national legislations transposing it, as well as several other pieces of EU legislation. In this regard, the Commission is working on specific to the sector guidance. On 10 October 2014, the Commission adopted its recommendation (2014/724/EU) on the Data Protection Impact Assessment (DPIA) Template for Smart Grid and Smart Metering Systems, for which data controllers in MS are encouraged to apply the Template when rolling out smart metering systems. The Template is fully in line with the forthcoming General Data Protection Regulation, anticipating the legal obligations rising from therein. A complete implementation of this template shall ensure that no security or privacy issues should arise when implementing smart metering systems.

7.2.7. Monitoring, evaluation and impact assessment

Ongoing monitoring and evaluation is critical even once a roll out is occurring. It is important to develop structured processes in order to monitor and evaluate the impact of the smart meter roll out projects in a dynamic way. The continuous monitoring and evaluation of the impact of the smart metering projects should be incorporated in a continuous communication between the EU and among the MS in order to dynamically develop common messages regarding upcoming widespread rollouts of smart metering systems.

The lessons learnt can then be incorporated into Impact Assessments of mandatory features/functionalities that guarantee the successful roll out, and the continuous review of open standards and interoperability by MS.

7.3. Funding related considerations (indirect)

7.3.1. Further support of granting for smart metering within energy efficiency projects

Financial support could be provided for the installation of smart meters as part of energy efficiency projects in buildings. Smart meters can facilitate knowledge on energy consumption patterns and effective energy management, which are essential to the long-term energy planning of an organization. Through the information provided by the smart metering system, the identification of the potential for energy savings and improvements can be elaborated, and renovation projects prioritized, evaluated and implemented in a cost efficient manner according to the specific energy needs of the organization.

7.3.2. Certification of energy savings

The introduction of smart meters could also facilitate a scheme for the certification of realized energy savings. These white certificates could be used as inputs in other initiatives and funding programs, for example, reduction in energy pricing through the acquisition of a number of points, the purchase of energy efficient products or the access to tax relief schemes.

7.3.3. Research and development of innovative products and services

In reference to EU policies for research and development of innovative products and services, further strengthening of EU-funded programs could also be considered. In this respect, a coordinated support is needed for initiatives to further develop and promote smart meter technologies in the general context of smart buildings and smart grid integration. In such a way, the promotion and demonstration of cost-effective innovative solutions in smart metering projects could potentially lead to significant benefits to market stakeholders and consumers. In addition, buildings with installed smart meters could be considered for financial support eligibility in cases where EU-funded research programs use such buildings as pilot demonstration units for products and services developed under these programs.

7.4. Policy related considerations (indirect)

7.4.1. Promoting harmonization and cohesion

Smart Metering is a key enabling technology for the EU to meet its ambitious environmental and energy efficiency goals, and more generally facilitate an efficient and effective use of natural resources. The use of smart meters could also further facilitate the harmonization and cohesion policies and other relative initiatives at the EU level. Obviously such policy harmonization and cohesion at EU level would be additionally strengthened with the further strengthening of coordination among the EU Directorates-General that are involved with the introduction of smart meters in EU MS.

Overall, at the EU level, it is important to highlight the interconnection of policies and to stress the obligation to comply with relative EU legislation referring to smart meters to capture all potential benefits.

7.4.2. Assistance for implementation of the Energy Efficiency Directive

Smart metering can assist utilities and end users (such as SMEs) in meeting the obligations under Articles 7 and 8 of the Energy Efficiency Directive 27/2012 to realize energy savings.

Indicative schemes could include the following:

- The provision of encouragement and support to SMEs (as envisaged in Energy Efficiency Directive 2012/27/EU, Article 8) to undergo energy audits and energy management systems with obligatory installation of smart meters in order to achieve high energy savings accompanied from installation of smart meters and energy management strategies along with information from energy audits.
- The encouragement and support of utilities to promote smart meters as part of a prerequisite set of tools in order to achieve energy savings to the final customers

included in the overall utility company strategy towards the target for annual energy savings of 1.5% for every year from 2014 to 2020 (Article 7, Energy Efficiency Directive, 2012/27/EU). This strategy could engage other stakeholders (manufacturers of smart meters, ESCOs etc.) to cooperate so as energy savings at the end-use side are maximized and the savings realized are used to offset the smart meter costs. Application of a scheme of this type could be beneficial to all parties involved (customers, ESCOs, utilities, manufacturers). In this perspective, EU policies on technical features of electric appliances and on building automation could be further supported so that automation and control features of buildings can be improved in order to satisfy new needs and operation with a customized pattern based on the knowledge acquired from smart meters (e.g. intelligent thermostats).

7.4.3. Linkage with other initiatives

For the achievement of synergies and complementarities, it is necessary to link the roll-out of smart meters with other suitable initiatives currently ongoing in the European Union.

For example, the Covenant of Mayors is a movement involving local and regional authorities, voluntarily committed to the enhancement of energy efficiency and the wider use of renewable energy sources in their jurisdictions. At present, public entities, institutions and organizations (e.g. municipalities, provinces, energy agencies) covering a total of 191 million inhabitants have entered the agreement, while obligatory plans for monitoring the progress achieved towards the set targets have been submitted. The introduction of smart meter deployment plans for the electricity supply to public buildings, street lighting, and the electrification of other infrastructure in the public domain could provide certain advantages for increased energy savings along with measures and actions promoted in the Sustainable Energy Action Plans (SEAPs).

7.5. Use cases of smart meters

7.5.1. Intelligent charging stations

An example of the use of smart meters is in intelligent charging stations, which are essential to the development and promotion of electric vehicles. Although public charging stations should be considered as a part of a separated system (technical, organisational, IT, etc.) which provides functionalities and services focused on support of the expansion of use of electric vehicles, the use of smart meters can assist in its development. This system needs to cooperate with billing system (through central data hub or data systems of utilities and suppliers).

Standardized technology already makes it possible to recharge the batteries of electric cars in universal outlets, where the introduction of smart meters for remote reading and effective management of energy flows could further facilitate the introduction of clean vehicles. Apart from this type of technology, vehicle to home technologies can be applied to support end-users charging, storing and managing energy according to need and peak hours scheme in order to benefit even more from the installation of smart meters.

7.5.2. Distributed generation

The introduction of distributed energy renewable sources is another important pillar of EU energy policy to increase energy security and independencies. The integration of intermittent renewable energy sources depends on implementation of Smart Grids with smart metering as a part of the whole system. In this perspective, further developments in this area are feasible with the dynamic and harmonized expansion of Smart grids together with smart meter projects. In particular, net metering, energy storage and smart meters are technologies that support the decentralized management of energy according to needs and pricing schemes. Therefore, the contribution of smart metering systems towards the introduction of more efficient decentralized energy management schemes needs to be further explored and promoted to concerned stakeholders.

8. Key Findings and Recommendations

The following general findings and recommendations are provided based on the review of, and analysis undertaken on the various CBAs, and in the general context of the previous section.

8.1. Key Findings

The key findings are grouped under a number of common headings.

8.1.1. Methodology and Functionality

- Comparison between the MS CBAs is difficult even with relatively broad compliance with the requirements of Recommendation 2012/148/EU. A consistent approach to some key issue (modelling period, meter replacement, cost allocation, functionality etc.,) would promote comparability, and potentially provide positive results in some cases without any change in key input parameters.
- In general, there is a positive relationship between activated functionalities in the metering system and the resulting net benefits. This is particularly evident with remote operation (reading, disconnection) and information provided to customers, including in scenarios that deploy dynamic pricing. The cost of building in additional functionality in the meters is generally low as increased functionality is typically software related.
- Data privacy and cyber security is an increasingly important issue in some MS. The response to these issues has the potential to raise costs and/or reduce benefits without appropriate regulatory or policy measures that link privacy and security to functionality in particular.
- There is not necessarily a consistent approach to the use of visual displays. Some CBAs include the costs of IHDs despite not showing concomitant benefits, while others focus primarily on indirect feedback to customers. The role of direct feedback is critical, while it is also important not to prescribe a particular technological solution – some MS report that IHD have an important role in creating demand responses, others show benefits from computer-based applications, while commercial opportunities potentially exist for third parties via mobile-based applications.
- The approach to the discount rate is relatively standard, with one notable exception. Current evidence on bond yields does not support a wide divergence at this time.
- Some MS note that local regulations necessitate meter certification in periods that are less than the economic life of smart meters. Where this is the case, the potential to receive the full benefits of the smart meters may be jeopardised, as meters will need to be replaced or removed while still providing strong benefits.
- System architecture is not common across MS, with some noting that there is a need to replace switches at the same time that smart meters are installed to enable

data transfer by PLC or other forms of communications in all periods, including where the customers has turned off power in the property.

- In cases where there is a negative or inconclusive finding in the MS CBA some users or user groups may have higher benefits from smart meters and should have the opportunity to request one.

8.1.2. Cost related issues

- The predominant cost driver is the meter and associated installation costs. Meter-related costs vary significantly across the CBAs, in part reflecting wide divergence in estimates of the type and cost of the smart meter, differences in labour costs (installation), and complementary investment (for example, meter boards and wiring) identified in some cases. In practice, experience from large-scale rollouts supports costs towards the lower end of the range identified in the CBAs.
- A consistent approach to meter replacement is not incorporated into all CBAs. In some cases, meter replacement is included in the CBA without allowing time for the respective benefits to accrue, either via the modelling period or a terminal value benefit. In practice, the simplest arrangement is to align the modelling period to the asset life of the meter, thereby avoiding meter replacement issues.
- There is not a consistent approach to cost allocation, or the attribution of benefits that may apply to services outside smart metering. At times infrastructure is introduced simultaneously with the smart meters – for example, wiring, new meter boxes – that potentially provides general benefits to the distribution system as well as facilitating smart meter implementation. In other cases communications technology may provide the potential to sell non-meter related services, include smart grid services that are not reflected in the CBA.
- There is a wide range in communications technologies and costs across MS, which have significant impact on the results. The use of GPRS or UMTS communications infrastructure instead of PLC greatly increases overall costs, at the same time that advances in PLC technology support its widespread use for data transfer where feasible. A re-evaluation of communications technology and costs appears appropriate in some cases.

8.1.3. Benefit related issues

- The key driver of benefits in most cases is the electricity efficiency and shifting benefits (electricity cost savings) available to customers, with important benefits also obtained by the DSO from savings in meter reading and operations costs and reduction in commercial losses. The CBAs suggest that relatively basic functionality can facilitate significant savings in meter reading costs and commercial losses. However, to obtain fuller benefits, particularly those related to the provision of real time information and electricity cost savings, greater meter functionality is required.

- The avoided cost of standard meters is not included in all CBAs either directly or indirectly through adjustment to the smart meter cost. This benefit (or negative cost) should be incorporated in all analyses.
- The approach to peak load deferral is not consistent. Any reduction in technical losses should be accompanied by a reduction in peak load, which is not reflected in all CBAs.

8.1.4. Communications

- There is not a common approach to the dissemination of results. Some CBAs are not in the public domain, while others are not readily accessible. Effective dissemination of results is an important step towards customer and broader stakeholder engagement.
- Due to technological change and experience from rollouts, there is a need for regular revision of costs and benefits. The revision is particular important in cases where roll out has been initiated to better understand key cost and benefit drivers, to inform the public of the accrued benefits, and to adjust the programme where necessary.
- As rollouts proceed or are planned, the dissemination of information and best practices across MS remains a critical issue.

8.2. Recommendations

Key recommendations are set out in the following tables consistent with the above headings:

TABLE 69

KEY RECOMMENDATIONS

Category	Finding	Recommendation	Addressed Parties
A. METHODOLOGY AND FUNCTIONALITY			
Harmonization of methodology	Wide range of approaches to CBA adopted makes comparison difficult	Review of Recommendation 2012/148/EU should be undertaken to establish a base case for the CBAs of all MS, harmonizing critical values (modelling period, cost allocation, meter replacement, functionality)	**European Commission**
Functionality to be incorporated in the core CBA scenario	Positive link between functionalities and net benefits apparent in some cases	MS should review the functionality built into the CBA scenarios, particularly those that allow for effective demand response and in turn cost reductions for consumers and avoided network/ generation costs	**Member States**
		The positive impacts of having the full set of functionalities available for all consumers should be further analysed.	**European Commission**

Category	Finding	Recommendation	Addressed Parties
Cyber-security	MS concerns over cyber-security are increasing, which is affecting proposed functionalities in some cases. One example is the decision in the Netherlands to remove the option of remote switch on/off.	The work of the Commission's Expert Group 2, which is currently mapping cyber-security issues by functionality, is critical. The group is tasked to consider mitigation measures based on best available techniques, including mitigation measures for cyber-attacks. A reference document is to be produced by the end of 2016. The EC is encouraged to follow up on cyber-security aspects in order to produce standard recommendations for all MS	**European Commission**
Data privacy and security issues related to implementation	Data privacy is of growing concerns in some MS, leading to the adoption of different solutions and technologies. One example is the communications gateway system adopted in Germany	Implementation of Commission recommendation 2014/724/EU on the Data Protection Impact Assessment (DPIA) template for Smart Grid and Smart Metering systems is critical to ensure no security or privacy issue arises when implementing smart metering systems.	**Member States**
Treatment of visual displays	Wide range of approaches to visual displays permitted, but consistent approach not always applied in CBAs	Due to fast pace of technological developments CBAs should consider most cost effective option, particularly in developing pilot projects.	**Member States**
Discount rate	General consistency in approach to the discount rate adopted but with PT an outlier	Divergences from core values across the EU (currently 4-6%) should be clearly justified	**Member States (specifically PT)**
Meter certification/life	In some MS local regulations require meter certification for periods shorter than the economic life of the meter	Review of local legislation and regulations essential to not impede an economically justified widespread roll out	**Member States (particularly CZ, HU)**
Technical architecture	Impediments to roll-out of smart meters identified in some MS (e.g., circuit breakers upstream of the meter may not be of use if smart meters are operational)	The EC is encouraged to work closely with the MS to assess whether existing regulations should be reviewed to adapt these to the Smart Grid environment	**European Commission**

Category	Finding	Recommendation	Addressed Parties
Potential for opt-in approaches	In cases where a large-scale rollout is not proposed, particular customers may benefit from the installation of smart metering systems	Customers should have the right to request the installation of a smart metering system at a fair price. One way to facilitate this would be allow the retailers to install a smart meter (in parallel or replacing the existing one). Since the electricity network is not property of the retailer, the communications solutions must be either independent (GPRS, ADSL, etc.) or negotiated with the utility (PLC)	**Member States**
B. COST RELATED ISSUES			
Dispersion in meter costs	There is a wide range in meter costs that reflect divergences in the estimates of the type of meter, the cost of the meter, installation and associated works. The variation is greater than would be expected considering interoperability requirements	There is a need to consider standardized metering solutions in CBAs as opposed to tailored solutions used in pilots or specific requests to manufacturers	**Member States**
		The MS need to ensure compliance with interoperability requirements in the 3rd Package as they relate to metering technology. Interoperability should necessarily lead to greater standardization of metering solutions and hence cost reductions due to economies of scale.	**Member States**
Treatment of meter replacement	There is a potential overstatement of cost in some CBAs due to inclusion of costs of meter replacement without full associated benefits	Equivalent treatment of costs and benefits required in the case of meter replacement. Simplest approach is to align modelling period with the asset life without replacement	**Member States (specifically BE-BR and DE in relation to meter replacement)**
Cost allocation between metering and other services	A number of costs/ services that are not directly meter-related are included in some CBAs	Apportionment of common costs to metering services when the infrastructure provides additional benefits that are not included in the CBA should be clearly justified (e.g., smart grid, distribution enhancement, and other utility services)	**Member States**
Communications technology and cost	There are a wide range in communications technologies and costs that significantly affect overall CBA result	MS should review communication technology, particularly where widespread use of GPRS or UMTS is proposed in the light of developments with PLC	**Member States**

Category	Finding	Recommendation	Addressed Parties
C. BENEFIT RELATED ISSUES			
Avoided cost of standard metering	The avoided cost of standard metering is not included, or is unclear in some CBAs	The avoided cost of standard metering is a key benefit that should be included in all CBAs	**Member States (treatment in NL, BE-WA, HU, SK unclear)**
Approach to peak load transfer	The approach to peak load transfer is not fully coherent in many cases	The relationship between dynamic pricing and peak load deferral and between technical losses and peak load deferral should be investigated further. Experience shows that peak load reduction, at a minimum, reduces technical losses.	**Member States**
D. COMMUNICATIONS			
Public dissemination of results	Some CBAs are not in the public domain or easily accessible	Public reporting of CBA findings is essential to engage key stakeholders, including the public, prior to a widespread roll out.	**Member States**
Updates to CBA reports	Technological change and experience from roll-out provides important new data for the MS in question	Regular revision in CBAs for changes in costs and findings of pilot projects and experience in widespread rollout is supported.	**Member States**
	Change in circumstances of MS provides important EU-wide information	The Commission's benchmarking report should be updated consistent with amendments/updates in MS CBAs.	**European Commission**

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