Research into the costs of smart meters for electricity and gas DSOs

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1 Introduction

A draft bill amending the Electricity Act of 1998 and the Gas Act of 2000 is currently being considered by the Dutch parliament. If enacted in its current form, this bill would result in a number of changes to the provision of electricity and gas metering in the Netherlands. The key elements of these changes that are relevant for regulation by Energiekamer are:

- making metering a regulated activity by introducing regulated tariffs, and placing an obligation on DSOs to undertake a nationwide roll out of smart meters by over a six year period for all small customers[1], with the rollout planned to start within two years from now, provided Energiekamer's evaluation of the roll-out is positive.
- defining new roles for participants in relation to metering – in particular, making DSOs responsible for the provision and maintenance of meter infrastructure and making suppliers responsible for collecting and processing of raw meter data and communicating it to customers (a non-regulated activity); and
- introducing new standards for the technical infrastructure by introducing a Netherlands Technical Agreement (NTA) as standard for all smart meters in future.

If this legislation is passed, Energiekamer currently expects that the Minister of Economic Affairs will ask Energiekamer to regulate metering tariffs based on the average 2005 gas and electricity metering tariffs, corrected for inflation on an annual basis.

Going forward, with the introduction of smart metering, Energiekamer wishes to understand whether a continuation of this approach (i.e. indexing the 2005 tariffs to inflation on an ongoing basis) would be reasonable given the likely level of costs which will be incurred, and the likely level of wider distribution business benefits which will accrue.

Energiekamer has therefore asked Frontier Economics and Logica to undertake a project to:

- analyse the current understanding of costs and benefits which would be involved for distributors in relation to the rollout of smart metering, and to assess, based on current knowledge, the extent to which the net cost of the rollout could reasonably be funded by the continuation of such tariff arrangements during the rollout period; and
- develop an economic model which will allow Energiekamer to refine this analysis as the level of certainty in relation to the cost and benefit drivers of the smart metering rollout evolves.

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[1] According to the draft bill, small customers are those with an installed capacity below a specific threshold. For electricity, there is a maximum capacity threshold of 3 times 80 A. For gas, the capacity threshold is 40m3 (n) per hour

As detailed in its Request for Proposal[2], Energiekamer expects this research to fulfil the following objectives:

- providing a good insight into the cost structure of smart meters roll-out and operation and any other associated activities which will be subject to a regulated metering tariff in the near future;
- providing a good insight into the development of costs, with a distinction, in particular, between costs incurred during the roll-out phase and costs incurred in the period after this when regular (periodic) replacement of meters occurs;
- providing an estimate of the extent to which cumulative profits or losses would occur in the period to 2014, if the tariffs for the period from 2009 to 2014 were to be determined on the basis of the tariffs for 2005, corrected for inflation.

The outcomes of the research will then serve as a basis for (1) taking a decision on how the metering tariffs will be regulated from 2009 onwards and (2) determining the level of the metering tariffs, should it be needed, on a cost-oriented basis (possibly supplemented by further research in this regard).

The above also implies that the analysis of the costs and benefits of smart meters for final consumers or suppliers is outside the scope of this research. This research is therefore focused exclusively on the impact of smart meters on DSOs. At the time of writing, Energiekamer has not been tasked to analyse costs and benefits for final consumers. Hence, any discussion regarding the 'savings potential' of smart meters either for suppliers or for society as a whole, often illustrated in many international smart metering research studies, is outside the scope of this research. These savings will not have any influence on the DSO metering tariffs.

The roll-out of smart meters can be characterised by a 'split incentive' issue, where the individuals that reap most of the benefits of smart meters (mostly final consumers and suppliers) are different from those that have to bear the most of costs (DSOs). Given that this research focuses exclusively on the impact of smart meters on DSOs, the results presented in this report may be different from those achieved by other international studies. The outcome of this research, however, is as complete as possible for the purpose of assisting the Energiekamer with metering tariff regulation.

With regards to the benefits for DSOs generated by smart meters, a considerable part of them is likely to occur in areas other than metering (such as network management) which are subject to other regulatory mechanisms (e.g. X-factor regulation). At this stage, given that no DSO has any direct experience of a large smart meter base, attempting any allocation of benefits to the different operations would likely be inaccurate. Therefore, we have assumed that these benefits accrue to the metering operation of the DSOs. These benefits from

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[2] Request for Proposal: " Research into the Costs of Smart Meters", Energiekamer, September 2007

smart meters, therefore, are used to offset part of the smart metering costs faced by DSOs, leading to the estimation of smart metering net costs.

Most of this research has been undertaken before the recent changes to the draft bill by the Dutch Tweede Kamer. Whenever possible, the approach has been adapted to accommodate these changes into the analysis, including the possibility to postpone the nationwide rollout by up to two years. However, some minor discrepancies may still be present. For example, our analysis does not take the cost for mandatory installations of smart meters during the "two-year" evaluation period. Instead, we have assumed that a small number of smart meters is installed during these two years, for trial purposes.

The remainder of our report is structured as follows:

- in **section 2**, we set out the context for and scope of our study;
- in **section 3**, we describe the approach we have taken to the study – in relation to deriving cost estimates, and developing the model used for the analysis;
- in **section 4**, we set out our assumptions on costs;
- in **section 5**, we set out our assumption on benefits for DSOs; and,
- in **section 6**, we set out the results of our analysis and issues for further consideration.

2 Context of the study

In this section we set out:

- the scope of our analysis;
- considerations in relation to:
  - the interaction between gas and electricity smart metering rollouts;
  - the treatment of existing metering assets;
  - the treatment of transfers of responsibility in relation to metering activities; and
- the time period for our analysis.

2.1 SCOPE OF ANALYSIS

2.1.1 Costs and benefits considered

As noted in the introduction, the scope of our analysis is limited to the impact – costs and benefits – of metering activities on Dutch *distribution businesses* (DSOs), and comparison of the net metering costs to the current metering tariff levels[3].

There will, of course, be costs and benefits incurred by other energy market participants (and customers) as a result of the deployment of smart meters. For example, to interface with DSOs in order to receive and process meter readings from smart meters, suppliers will need to undertake some level of investment in systems and new processes. Equally, by using meter data to provide customers with value added services or to allow more accurate forecasting of demand data for trading purposes, suppliers may also secure financial benefits.

However, our focus here relates to activities remunerated by the metering tariffs, which is not expected to cover such costs or benefits. Therefore, detailed research on these areas is beyond the scope of this report.

As a result, it is important to note that the analysis we present provides only a partial view of the impact of smart metering on final customers. Experience from other countries indicates that these broader costs and benefits (e.g. impact on demand forecast accuracy, impact on annual energy consumption, impact on peak demand) can be significant. Therefore, the results we present cannot be considered to be representative of the final impact of smart metering on customer bills.

3 The current national electricity metering tariff is fixed by regulation. For gas metering, a number of different tariffs still exist – we have used an average value provided to us by Energiekamer for the purposes of this report.

2.1.2 Categories of distribution business costs and benefits

Costs

The draft bill refers to six categories of distribution cost – Table 1 below maps these costs onto the direct cost elements we use in this study.

Draft bill category	Direct cost elements considered
Physical smart meters for gas and electricity (in accordance with the statutory norms)	Smart meter and communications equipment procurement costs
Depreciation of smart meters taking into account their economic life and the development of new technologies	
The installation of smart meters, taking into account the priorities of suppliers	Smart meter and communications equipment installation costs
The maintenance of smart meters	Smart meter and communications equipment maintenance costs
The use of smart meters	Ongoing communications costs
Other costs incurred in relation to regulated metering activities	Mandatory data provision costs[4], and any further distribution "back office" costs related to smart metering

Table 1: Mapping of cost elements to categories set out in draft bill

Clearly many of these costs – particularly those relating to the asset procurement and installation activities – are influenced by the meter specification defined for the Netherlands (as set out in the "NTA").

We also consider costs not directly associated with smart metering but which are, or could be remunerated through the metering tariff – including the potential cost of stranded traditional metering assets, and the cost of ongoing manual data collection during the period of the rollout[5] etc.

Mandatory data provision costs will be covered in the tariff. Following the draft bill we have assumed that the mandatory service level for data reading covered in the tariff is one meter read per day.

4 Mandatory data provision relates to the data items which, under the NTA specification, retailers may require DSOs to provide (e.g. quarter hourly / daily reads). Other aspects of data provision and validation are not considered as distribution activities and must therefore be remunerated outside the metering tariff. The cost of data provision includes the provision and maintenance of a central metering database containing read data, and "user administration" in relation to that database.

5 Suppliers are expected to become responsible for collecting and validating metering data from 1 January 2010.

As currently defined, the arrangements set out in the draft bill relating to the installation of smart metering equipment allow retailers to have some influence over distribution activities – specifically, they allow retailers to nominate a proportion of their customer base as a "priority" for rollout[6]. The legislation does not place a specific limit on the level of this influence – however, the actual level observed will clearly have an important effect on costs:

- this prioritisation may take DSOs away from the "optimal" rollout pattern, driving up installation costs;
- installations for ad-hoc "priority customers" may require DSOs to use GPRS communication technology – which will impact the level and structure of costs incurred.[7]; and
- the administration of priority installations may increase rollout overhead costs.

The DSOs are allowed to pass these costs back to the suppliers that cause them – therefore the incremental costs do not need to be recovered through the metering tariff. Nevertheless, to inform discussions as to the potential impact of the priority privileges, we identify separately the potential drivers and scale of such possible cost increments. In order to be able to include the impact in our analysis, we have made an assumption that the maximum proportion which any supplier nominates as a priority is 10%.

We note that while it may be possible to define reasonably clearly the direct incremental costs resulting from priority installations, particularly as the number grows, the indirect effects (e.g. the disruption to the optimal rollout schedule for the remainder of sites, worsening of constraints in relation to trained personnel etc) are more difficult to quantify, and hence to charge for as they may not always vary proportionately with the number of priority installations.

Benefits

The introduction of smart metering will clearly reduce ongoing costs for some existing metering activities – most obviously the costs of manual data collection or management of customer reads.

There are also areas in which the installation of smart meters may result in benefits to the wider distribution business – that is, where it will be possible to reduce the cost of existing distribution activities as a result of information provided by smart metering.

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6 Where a customer has a different supplier for electricity and gas, it is possible for one of the suppliers to nominate the customer as a priority, but for the other supplier to leave the timing of the rollout for that customer up to the DSO. We return to this issue in more detail below.

7 Power Line Carrier communications technology requires high customer density to be economic. It should be noted that the use of GPRS technology following a 'priority' request is not the only option. DSOs may decide to roll-out PLC technology to an entire area after receiving a number of priority requests for the same neighbourhood. However, this solution may still imply higher costs than a fully planned and co-ordinated roll-out.

The average across the industry of such wider benefits *could* subsequently be taken into account in the price control of the main distribution business – in other words, the benefits of lower costs could be passed on to customers through the X factor.

If the benefit is passed back to customers through another route at the time of the price control, this would mean that only the present value of benefits accruing to the distribution businesses *between* price controls should be considered from the perspective of the metering tariffs. Following a price control, benefits accruing to the distribution businesses would be passed on to customers through the operation of the normal regulatory regime resulting in a lower allowed network revenue (and hence lower grid fees), and therefore these benefits could not be netted from the metering tariff (as they would not be retained by the DSO).

This is shown diagrammatically in Figure 1.

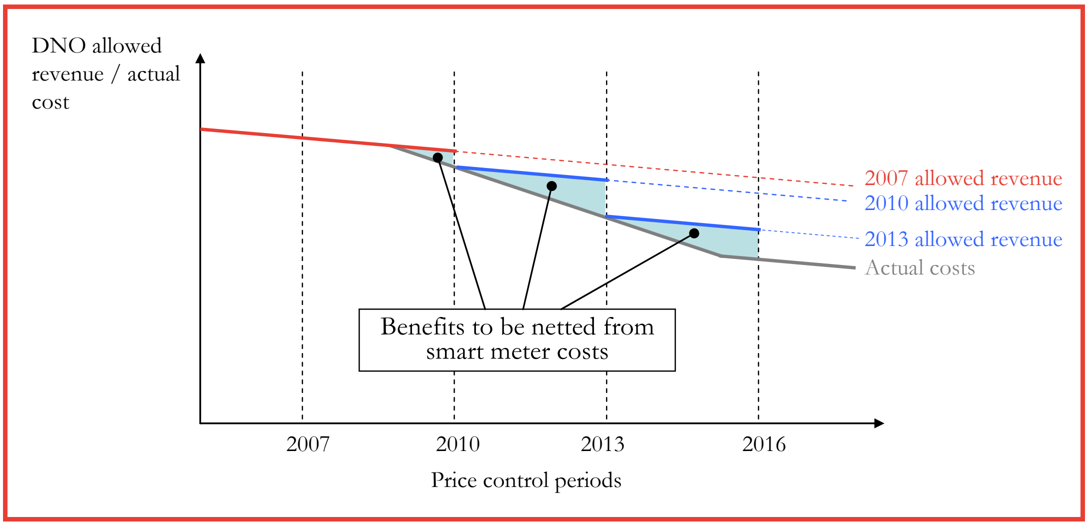

Figure 1: Stylised example of regulatory treatment of wider distribution benefits

However, modelling this outcome would involve making a number of subjective assumptions as to the phasing of such benefits, in a situation where even their existence is uncertain. Therefore, for the sake of simplicity and transparency, we assume in this report that the benefits are left with the DSO in the network price control, and therefore that they should be deducted from gross metering costs in their entirety.

2.1.3 Tariff profiling

The costs incurred by the DSOs in relation to the smart metering rollout will clearly vary year by year. In contrast, the planned regulated tariff for metering services is expected to be relatively stable, as it must be based on the 2005 tariff adjusted by annual inflation as measured by the CPI index.

If this is the case, Energiekamer will need to assess the present value of the net costs of the rollout and subsequent period of operation, and the tariff starting level and profile and understand the extent to which the tariffs are expected to generate a present value of revenue equal the present value of net costs.

It should however be noted that, if a constant tariff (in real terms) is applied, it is likely that in some year the DSOs expenditures will greatly exceed the revenues that can be raised via the metering tariff. This is because during the years of the roll-out, the DSOs will have to incur very high levels of capital expenditure in a short amount of time before returning to a steady-state situation. This may create some short-term financeability problems for DSOs, even if the net present value of the smart meter roll out were positive overall. The requirement to provide the DSOs with a profile of revenue which will ensure their ongoing financeability in the face of a major capital expenditure programme is therefore a challenge that future regulation will need to address.

However, for the purposes of our analysis, we limit our considerations to an assessment of the net costs of the rollout and the revenue which would be associated with 2005 tariffs adjusted for inflation. Considering the options for alternative tariff profiles or their appropriateness is outside the scope of this study.

2.2 TREATMENT OF INTERACTION BETWEEN ELECTRICITY AND GAS ROLLOUTS

As noted in the introduction, smart metering is to be rolled out both for electricity and gas. However, the nature of the smart metering equipment is likely to be different for the two fuels. In particular:

- any single customer site is likely either to have just electricity metering, or a combination of electricity and gas metering. There are few – if any – sites with only a gas supply; and
- in the majority of cases where a gas meter is installed, it is likely that the electricity meter will provide a communications link back to the DSO's systems and possibly a source of power for gas smart metering equipment.

Customer sites which have electricity alone will clearly have just one DSO and one supplier. A large number of dual fuel sites are also served by a combined gas and electricity DSO. However, there are a material number of sites with two DSOs. Irrespective of the network arrangements, any customer site can have one or two energy suppliers.

The reliance of the gas smart meter on the electricity smart meter means that there needs to be co-ordination in relation to the installation and operation of both. With a single DSO and single supplier, this should not cause significant issues. However, issues could arise where there are either:

  - two DSOs supplying the same site; or
  - two suppliers for the same site, who exercise their installation priority rights in different ways.

Below we explore the potential impact of these different arrangements in more detail before describing the approach we have taken to modelling the different scenarios.

Sites with two DSOs

Where a customer site has different DSOs for electricity and gas, *if the gas and electricity DSOs retain an independent installation and/or operation role*, then there will be a significant requirement for co-ordination between the companies.

While carrying out the research, we have been informed that there is an industry-wide agreement whereby electricity DSOs are always expected to lead the smart meter roll-out. This agreement implies that gas DSOs would subcontract the installation of smart meters for their customer base to the relevant electricity DSO. This is expected to be an ongoing agreement, which could also include the operation of the communication equipment and the provision of a consolidated meter reads database.

It is possible that while the total tariff revenue (i.e. the sum of gas and electricity tariffs) may be sufficient to cover the costs of the smart metering rollout, there may be an imbalance in the incidence of costs between gas and electricity DSOs. For example, it is possible that the electricity tariff is insufficient to cover electricity DSO costs, while the gas tariff is more than sufficient to cover the costs incurred by the gas DSOs, or *vice versa*.

Sites with two suppliers

Irrespective of whether a site has one or two DSOs, it may also have one or two energy suppliers. Where there are two suppliers, there are a number of possible ways in which they could exercise their priority privileges with respect to the site.

They may both decide to exercise it in the same way – that is, both identifying the site as a priority, or both excluding the site from their priority list. Alternatively, they may decide to exercise the rights differently.

While in theory it would be possible for a single supplier to exercise their priority privileges in relation to gas and electricity at a customer site in different ways, we do not consider this situation further here.

Modelling approach

For the purposes of the analysis, we have identified various possible scenarios which could be modelled separately, insofar as they generate different purchase and installation costs.

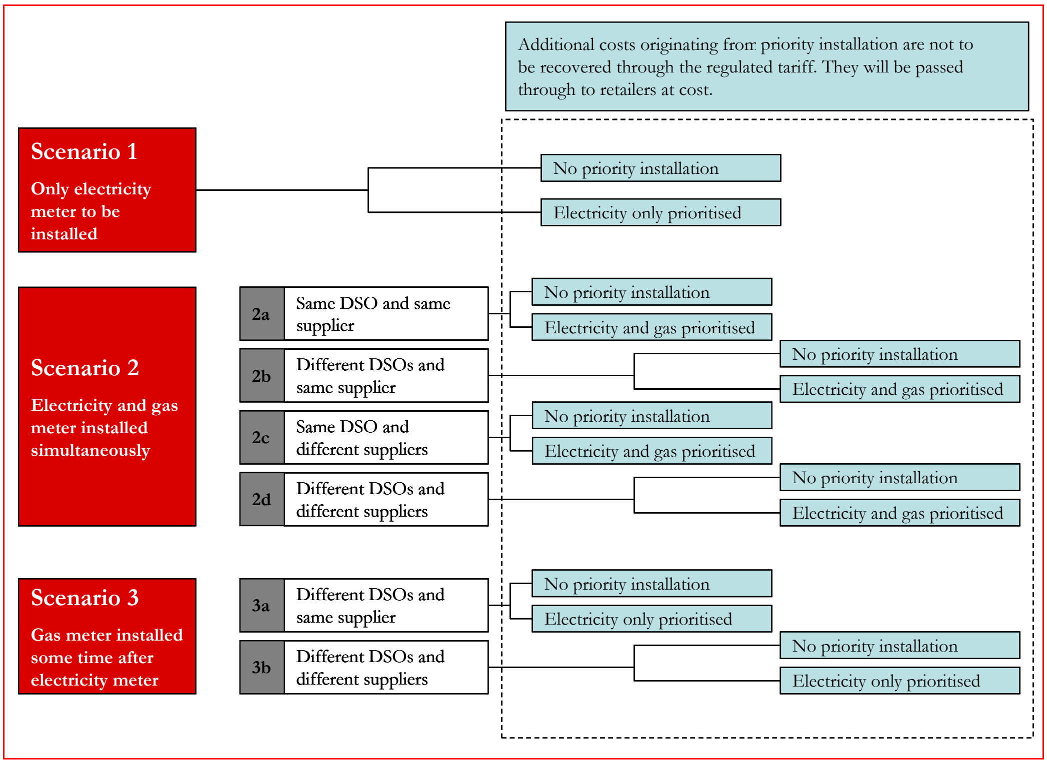

Figure 2: Scenarios considered in the analysis of smart metering costs

We have identified three macro-scenarios, on the basis of the timing of the installation of smart meters for gas and electricity occurs. Two of these scenarios could arise in a number of ways, and hence – at least potentially – involve different levels of cost.

Figure 2 shows a summary of the scenarios that are considered in the analysis.

The three macro-scenarios, along with the ways they could arise, are as follows:

- **Scenario 1: electricity only.** This scenario applies to those sites that only have electricity supply (about 845,000 customers). These cases are straightforward, as by definition only 1 DSO and 1 supplier are involved. Costs will differ depending on whether the electricity supplier chooses to use its priority privileges or not.
- **Scenario 2: simultaneous electricity and gas smart meter installation.** This scenario groups those situations in which the installation of electricity and gas smart meters occurs at the same time. This could arise in the following situations:
  - **2a. Same DSO and same supplier:** this is the most straightforward instance and would probably lead to the lowest costs. The DSO can plan autonomously how and when to replace both meters. While costs *may* still vary according to whether the supplier asks for a priority installation (as in scenario 1), the DSO installs all smart metering equipment at the same time.

- **2b. Different DSOs and same supplier:** in this case, the two DSOs come to an agreement as to the logistics of the installation. Again, costs may vary according to whether the supplier uses its priority privilege – additionally, arriving at this agreement on logistics could itself add to the overall smart meter installation cost.
- **2c. Same DSO and different suppliers:** either supplier could independently ask for a priority installation with respect to their fuel. Irrespective of whether the priority privilege is exercised, the electricity DSO always arranges to install both meters at the same time[8].
- **2d. Different DSOs and different suppliers:** irrespective of how the suppliers use their priority privileges, the two DSOs, with the electricity DSO leading the process, come to an agreement on the logistics of the installation and ensure the meters are fitted simultaneously. Again, coming to this agreement could impose additional cost.

- **Scenario 3: the gas smart meter is installed some time after the electricity smart meter.** This scenario groups those situations where the smart meter installation occurs at different times. Thanks to the afore-mentioned industry-wide agreement, this scenario is unlikely to take place, though we were asked by Energiekamer to address it for completeness. This scenario could arise in the following situations:
  - **3a. Different DSOs and same supplier.** In this case, as opposed to scenarios 2b and 2c, the DSOs do not reach an agreement regarding smart meter deployment – it is assumed that electricity meters are installed first. The cost of the installation may be increased by the exercise of priority privilege (in relation to both fuels) by the supplier.
  - **3b. Different DSOs and different supplier.** Again, the two DSOs do not reach an agreement and smart meter deployment occurs sequentially. Because of the constraints on meter installation, if the gas supplier exercised their priority privilege, the gas installation would still have to be contingent on the electricity supplier also asking for a priority installation[9].

There are clearly a significant number of different potential situations which could be considered. However for the purposes of our analysis here, we focus on only:

- the first two of the three macro-scenarios (e.g. electricity-only installations and simultaneous installation of electricity and gas meters); and

8 If the gas supplier asks for a priority installation, the DSO will install both the electricity and gas metering equipment at the same time in order to ensure the gas meter has communication and power. If the electricity supplier asks for a priority installation, the DSO will install all metering equipment to avoid a second installation visit.

9 In theory, an early gas installation could go ahead if the electricity DSO had installed the electricity smart meter early by chance.

- the impact of whether priority privileges are exercised.

2.3 TREATMENT OF EXISTING METERING ASSETS

All of the costs referred to in the preceding sections related to smart meters, their installation and their ongoing operation. During the rollout, costs will continue to be incurred in relation to traditional meters and smart meters which have already been deployed

2.3.1 Traditional metering assets

During the rollout itself, the costs associated with traditional metering assets will include:

- ongoing reading and meter data management costs (these will fall as an increasing number of traditional meters are replaced);
- ongoing maintenance costs (these will also fall as traditional meters are replaced); and,
- the disposal of traditional metering assets which are not yet fully written off.[10]

Reasonable costs related to traditional metering assets could be considered as valid costs from a tariff perspective. Therefore, in assessing whether 2005 tariff levels, after adjustment for inflation, would be sufficient to cover the costs going forward, these legacy metering costs may need to be added to those related to the smart metering rollout itself – even though the assets in question will not actually be in use.

2.3.2 Smart electricity metering assets

A similar issue arises where traditional electricity metering assets have already been replaced with smart meters which do not conform to the agreed specification in the Netherlands. The principal company for which this is relevant is Oxxio.

We understand that these smart metering assets will be acquired by distribution companies at a price to be agreed by Oxxio and the DSOs. At the time of carrying out the research, this amount was still being negotiated. However, the DSOs provided their estimates of what this amount was expected to be, based on their ongoing negotiations with Oxxio.

For the purposes of this analysis, we have assumed that recovery of this value is the only incremental distribution cost associated with the Oxxio meters.

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10 We note that this value may in turn depend on the nature of the rollout. With a fully optimised rollout, the remaining life of the traditional meters in service could be considered in defining the most appropriate installation programme. In contrast, as more of the rollout becomes externally driven (e.g. through the exercise of priority installation rights by suppliers), the probability of early replacement of relatively young traditional meters may increase.

2.4 TREATMENT OF TRANSFERS OF RESPONSIBILITY

The new legislation will result in shifting activities among DSO's and suppliers. In particular:

- the responsibility for collection, validation and management of meter data will be transferred from the DSO to the supplier[11]; and
- the responsibility for installation of the smart meter will – at least for some installations – be taken on by the supplier (either using the DSO's meter or an asset of their own[12]).

Given that these transfers of responsibility will be described in detail by the Ministry after the completion of this research, we have not sought to analyse them fully in this report. Rather, we assume that the costs remain with the DSO but attempt to define cost inputs such that their implications for the incidence of cost can be considered subsequently once the approach to be taken is clear:

- we identify separately the costs of data collection, validation and management in relation to both tradition and smart meters; and
- we identify separately how many "priority" installation rights are exercised by the supplier, and the direct impact this has on installation costs. Beyond the additional installation costs resulting from the need to undertake point to point installations, we assume that the regulatory arrangements are defined to ensure that even if the responsibility for installation does move from DSOs to suppliers, no additional costs are incurred as a result.

2.5 TIME PERIOD FOR ANALYSIS

At the start of this analysis (November 2007), the proposed start for the full-scale roll out smart meters was assumed to be January 1st 2009. The roll-out was expected to be completed in six years, i.e. by the end of 2014.

Following discussions in the Dutch Tweede Kamer, it has now been agreed to postpone the roll-out by a maximum of two years. During the intervening period (between 2009 and 2011), DSOs are expected to carry out small scale trials to gather further information on the costs and benefits of smart metering. During this time, Energiekamer will carry out evaluations of the trial roll-outs. These evaluations will be used to define the final details and timing for the full roll-out.

At present, the roll-out is therefore scheduled to start at the beginning of 2011. However, our analysis also includes an assessment of the costs and benefits incurred by DSOs in the period 2009-2011, during which they will undertake the necessary trials to prepare for a full roll-out.

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11 This is expected to take place from 1 January 2010.

12 We note that there are a number of potential logistics concerns which could arise if this approach is taken – particularly if the supplier is permitted to fit a meter which is not of an identical type to that used by the DSO, or if there is no obligation on the supplier to co-operate with the DSO to carry out standard testing of the communications link upon installation. However, further analysis of these issues is beyond the scope of this report.

The full roll-out of smart meters is still expected to last six years. Therefore, the rollout of smart electricity and gas meters should have been completed to all small customers by 2016.[13]

It is likely that for a few years following the completion of the rollout, meter maintenance and purchase costs could be below steady state levels – as a result of the fact that the meter stock will all be less than 6 years old. Equally, there will be a significant reduction in the installation resources required by the DSOs.

Leaving potential restructuring costs aside, this could mean that, during this period, DSO costs will below their steady state levels – meaning that, for a given level of long term tariff, there will be some "headroom".

. It is generally accepted that the lifetime of a smart meter is around 15 years. Therefore, in order to calculate the overall balance of costs and benefits over the lifetime of a new meter, our analysis covers the period from 2009 to 2025.

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13 Practically speaking, slightly less than 100% coverage may be achieved – for example, if there are some properties to which the DSO cannot secure access.

3 Approach to the analysis

3.1 OVERVIEW OF APPROACH

Our approach to the analysis can broadly be split into three components:

- collection of input data on costs and benefits – involving review of published data sources, and bilateral discussion with Dutch market participants and meter manufacturers – in order to generate a range for each element of costs and benefits in relation to which there was a broad degree of consensus;
- development of an economic model to estimate likely level of net cost relative to the 2005 tariffs adjusted for inflation; and
- analysis, using the model, of the impact of smart meter roll-out on DSOs.

Our approach is summarised in Figure 3.

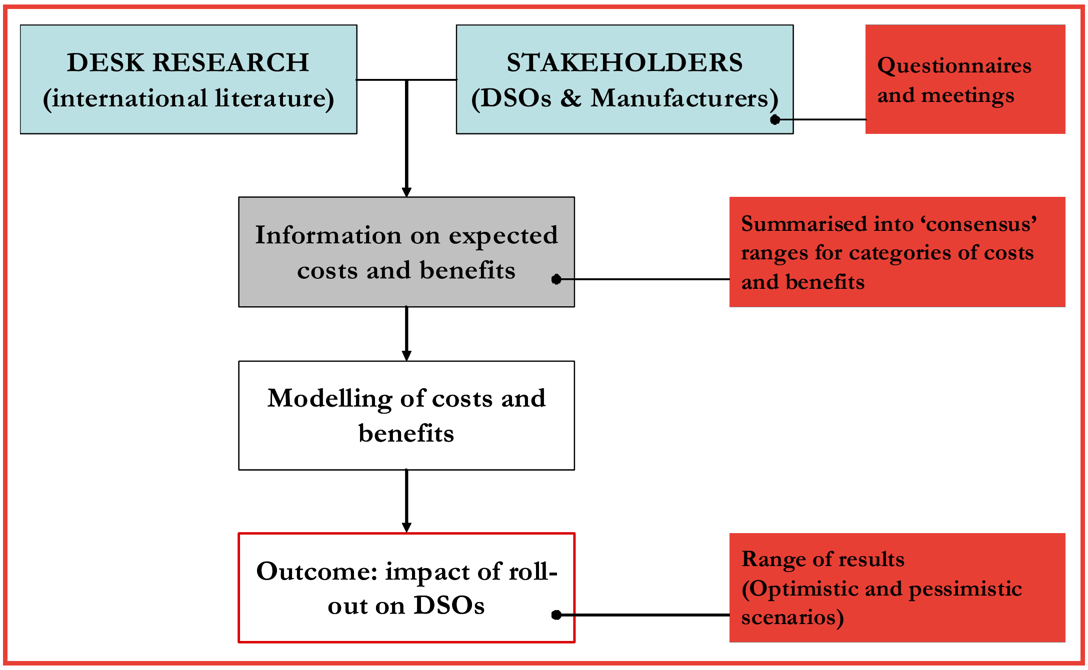

Figure 3: Overview of approach

Source: Frontier Economics

Below we set out the approach followed and/or data sources used in each area.

3.2 COLLECTION OF INPUT DATA

3.2.1 International research

Studies on the costs and the benefits of smart meters have been undertaken in various jurisdictions. In some cases, these were cost-benefit analysis aimed to accompany an actual roll-out of smart meters (for example, the study of the smart meter roll-out in Ontario). In most cases, though, these studies were prepared *prior* to a full roll-out to inform a debate on the likely impacts of smart meters and on their desirability – this is the case with the studies undertaken in the United Kingdom and those previously undertaken in the Netherlands.

We selected the documents that we deemed most relevant for the analysis, which, as noted in previous sections, focuses solely on the likely impact of smart meters on distribution companies. The selection of specific studies on smart meters in the Netherlands has been reviewed and confirmed by Energiekamer. The sources used for the research are as follows:

- 'Smart Meters in Great Britain: the next steps?' Sustainability First, July 2007;
- 'Smart Meters: Commercial, Policy and Regulatory Drivers' Sustainability First, March 2006;
- 'Smart Meters – Costs and Consumer Benefits' Report to energywatch by Eoin Lees Energy;
- Ofgem cost benefit analysis, March 2006;
- Ontario Energy Board – Addendum for Smart Metering Rates, January 2007, Canada;
- 'Overview of advanced metering technologies and costs' Demand Response and Advanced Metering Coalition (DRAM), April 2004, USA;
- 'Domme meters worden slim?' KEMA report, August 2005, Netherlands;
- 'Business case invoering slimme meters' Accenture, December 2005; and
- 'Advanced Interval Meter Communication Study' prepared for Department of Infrastructure, December 2005, Victoria (Australia).

3.2.2 Meetings with stakeholders

There are a number of inevitable limitations to an analysis based on published research. In particular, there will be a number of factors of the Dutch rollout which differ from those in other jurisdictions – for example:

- the meter specification is likely to be different – to the extent that the Dutch specification is not consistent with that adopted in other countries with a larger population, the Dutch market may lose benefits associated with economies of scale in manufacturing;
- the timing and duration of the rollout is likely to be different – in particular, the planned Dutch rollout is relatively quick, meaning that Dutch market participants will effectively be "early adopters" of smart metering. This may in turn mean that the Dutch market does not benefit from reductions in cost of smart metering technologies over the medium term;
- the scale of the rollout will be different – which may mean that individually, the Dutch market participants are unable to place orders with meter manufacturers of sufficient scale to benefit from volume discounts; and

- the labour market situation may be different – which may mean the cost pressures resulting from the need to contract for a large number of meter installers vary from those in other countries.

In order to obtain a more robust view of the situation in the Netherlands, we consulted with distribution companies (DSOs), energy suppliers and meter manufacturers.

We held discussions the companies set out in Table 2.

For each company, we sent out a comprehensive questionnaire dealing with all the aspects associated with the roll-out of smart meters and their subsequent operations. This was then followed up by meetings (or teleconferences) to discuss and clarify the information provided, along with a number of follow up communications on specific elements.

Subsequently, we presented our analysis to all of the DSOs to capture any views and comments as to how we interpreted their inputs.

Type of stakeholder	Stakeholders consulted
DSOs	• Eneco • Nuon • Cogas • NRE • Essent
Suppliers	• Oxxio
Meter manufacturers	• Iskraemeco • Landis + Gyr • Echelon

Table 2: Industry stakeholders consulted during the research

In the remainder of this section we present the structure of the information that we discussed with the industry stakeholders.

It should be noted that we have not performed an audit of the forecasts that stakeholders provided. Our analysis is underpinned by a bottom-up approach, where forecasts of individual cost and benefit components have been assessed separately. During our discussions with industry stakeholder we discussed and compared the assumptions been made and flagged those that appeared unclear. Whenever possible, we attempted to seek further clarification. However, we cannot be completely sure that the costs presented relate solely to the metering business as we did not review all aspects of the DSO cost allocation approaches.

Dutch DSOs and suppliers

We addressed seven areas for data inputs with DSOs:

- **Information on legacy meters**

  We sought to understand the costs associated with the current meter stock, as well as the characteristics of these meters in terms of design life, failure rates and maintenance cost. This information has been used in the research to assess the ongoing costs that DSOs will need to incur to maintain and operate the shrinking pool of legacy meters through the roll-out period. In addition, the information on legacy meter purchase and installation cost, along with information on depreciation lifetime assumptions and current average age has been used to determine the economic stranding cost that will be incurred by DSOs when replacing legacy meters that have not yet exhausted their useful economic life.

- **Expected changes to customer base**

  We asked DSOs to provide information on their customer base, in order to assess the extent of the smart meter roll-out that they would have to carry out. In addition, we asked their opinion regarding the future development of their customer base and, in particular, the overall customer annual growth rate and any expected differential growth rates of segments within that base.

- **Smart meter costs**

  DSOs were asked to provide information on the costs associated with purchasing, installing and maintaining smart meters. Some of the DSOs interviewed had already carried out smart meter trials of varying sizes. This allowed them to provide information based on existing evidence, although we also asked DSOs to consider expected future costs (e.g. taking into account volume discounts, learning from the pilots etc.) In our discussion, we differentiated between single- and three-phase electricity meters and gas meters. The discussion focused initially on purchase costs, with a view to obtain information on current costs, future costs and possible volume discounts on large purchases. We also discussed estimates for installation costs, focusing on the different types of installations that DSOs would have to face. These will depend on the type of property as well as on whether, and to what extent, suppliers use their priority rights.

  Finally we discussed maintenance and ongoing overhead costs, which are closely linked to the expected failure rate of smart meters.

- **Characteristics of smart meter design and roll-out profile**

  As well as discussing smart meter failure rates (present and expected future improvements), we asked the DSOs to provide information on the expected life of the smart meters and the planned roll-out profile over the six year window.

- **Communication costs**

  We also discussed communication costs. We asked about the different types of communication technologies available and whenever possible, DSOs provided estimates of the costs associated with each technology and an estimate of their expected future take-up of each communication solution. As well as taking into account one-off costs (i.e. the communication costs that need to be incurred at the time of the installation of a smart meter) we also discussed the expected ongoing communication costs by technology type.

- **System costs**

  We discussed the costs that DSOs will be expected to incur to upgrade their current back-office and IT systems. DSOs informed us that there were a range of costs to be incurred in this category, including

  - the costs of setting up new back office systems as well as a new Central Data Server (CDS) designed to hold the meter data for access by retailers;
  - rollout planning and associated customer contact management; and
  - project management, technical problem resolution and QA, and IT integration.

- **Potential benefits for distribution companies**

  We concluded with a discussion of the potential benefits of smart meters. Given that the objective of this research is assessing the likely impact of smart meter roll-out on to DSOs, we limited the discussion only to those benefits that may be achieved by distribution companies. In addition to reducing costs related to manual data collection (including those of customer read management and data validation) these included, for example, possible reductions in outage management costs, reduction in energy theft and energy losses.

The discussion with Oxxio followed a very similar structure. Oxxio, as the only supplier offering smart meters to its customers, provided insight on the costs associated with rolling-out, operating and maintaining an operational stock of smart meters, albeit we recognise that there are important differences between a voluntary and a mandatory rollout.

Meter manufacturers

From the outset of the project, we were aware that the DSOs may have a financial incentive to overstate the projected cost of the smart meter rollout for tariff estimation purposes. In addition to the international research, therefore, we also sought information on certain cost categories from meter manufacturers (while again recognising that, outside a genuine commercial enquiry, it is difficult to secure a definitive estimate and that therefore this information should only be used to validate data from other sources).

A number of the major meter equipment suppliers were contacted and participated in the interviews, which were undertaken through questionnaire supported by telephone discussion to allow clarification of the information provided and gain understanding of the context of the answers.

The meter manufacturers participating in the interviews were:

- Iskraemeco;
- Landis + Gyr; and
- Echelon.

The focus of the data gathering fell into two core areas. These were:

- costs and performance associated with traditional metering equipment; and
- costs and performance associated with smart metering equipment

The information obtained in relation to traditional metering equipment included:

- the price of meters based on purchase volumes for the various types of meters in use within the Dutch market;
- the expected design life of the dumb meters; and
- the failure rates of the dumb meters.

The information obtained on smart meters included:

- the price of smart meters based purchase volumes for the various types of meters in use within the Dutch market;
- the impact of the NTA specification on meter costs compared with generic smart meter specifications;
- the expected design life of the smart meters;
- the failure rates of the smart meters;
- the maintenance costs associated with smart meters;
- the communications technologies supported, and the costs of associated communications equipment and communications costs;
- the potential for supply capacity constraints due to global demand for smart meters;
- the variation of meter prices over time; and
- where they could provide one, a view of back office system costs.

3.3 MODEL DEVELOPMENT

In order to process and analyse information received from industry stakeholders as well as from the review of the international literature on smart meters, we developed a model. We also anticipate that this model will be of use to Energiekamer in the future, as inherently uncertain estimates of key cost and benefit inputs become firmer.

This section provides a description of the overall structure of the model.

3.3.1 Overall modelling approach structure

Figure 4 provides and overview of the structure of the modelling approach used.

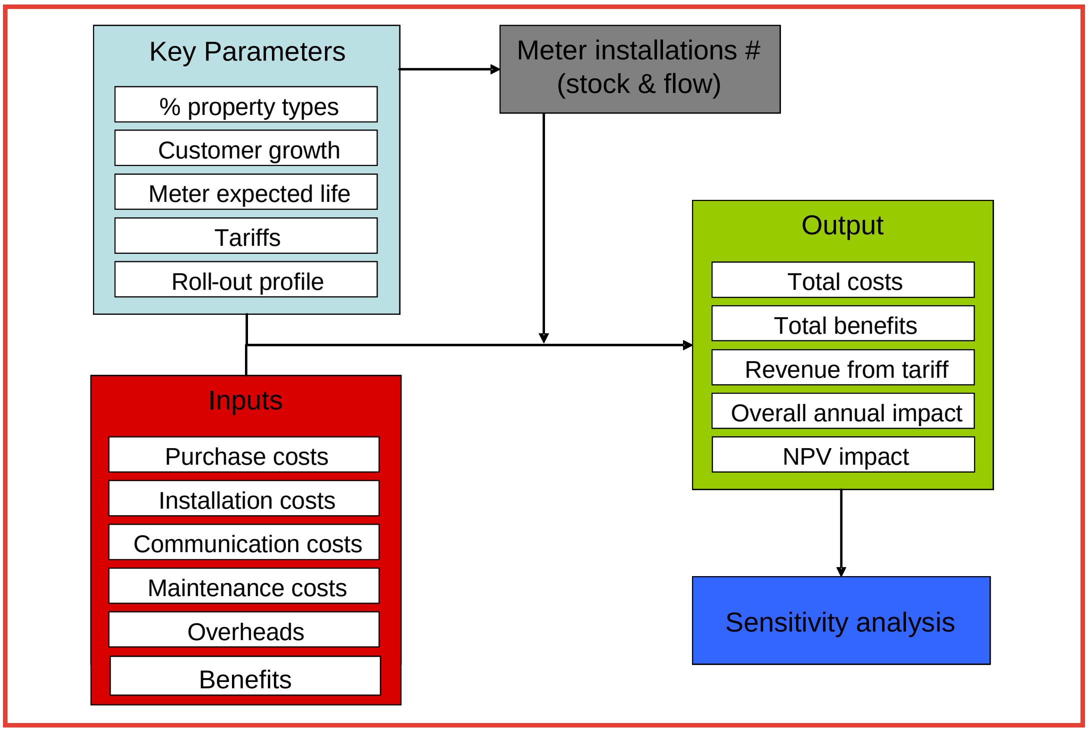

Figure 4: Cost-impact model structure

The modelling time horizon covers the two years of evaluation time before the actual roll-out commences (2009-2011), six years of the rollout (2011-16) and the nine subsequent years of smart meter operation (2016-2025) to cover the expected technical life of a smart meter. In total, the analysis covers a period of seventeen years. All values in the model are in 2008 prices.

Some key parameters, together with the model inputs, determine the characteristics of the scenarios under analysis. These parameters can be modified to calculate different scenarios. The analysis is also based on the calculation, for any given year, of the number of smart meters installed, the number of legacy meters replaced and the overall stock of each type of meter. Installation sites are also grouped according to whether they only have an electricity connection (and therefore only require an electricity meter) and those with dual fuel.

Information on meter expected life is used to calculate the estimated stranding costs for legacy meters.

The information obtained from our desk research and from industry shareholders is used as input for the modelling, on a per-meter or per-installation site basis.

In our modelling, we have combined the information on meter costs (and benefits) with the number of each type of meter, to calculate, for any given year, the net cash impact of smart meter roll-out. Costs, benefits and revenues from tariffs are identified separately. These components are then combined to calculate the net impact of smart meter roll-out, both on an annual cash basis and as net present value (at a discount rate of 5.5% real, a value provided to us by Energiekamer).

Finally, we have carried out some sensitivity analysis of the impact of various inputs and parameters.

3.3.2 Key parameters

The key parameters used in our modelling are the following:

- **Number of meters at the start of the roll-out period (gas and electricity)**: this information provides the starting point of the analysis, as it identifies the overall number of meters that need to be replaced.
- **Rate of annual growth (gas and electricity)**: these parameters sets the customer numbers growth rate. New properties are assumed to be fitted with electricity and gas smart meters.
- **Types of properties**: properties are grouped according to whether they have only an electricity connection or both a gas and an electricity connection.
- **Meter life and remaining average life:** this information is used to calculate the economic stranding cost that DSOs will incur from having to remove legacy meters that have not been entirely depreciated.
- **Information on Oxxio meters (number of meters, average life and capitalised value):** this information is used in the model to calculate the costs associated with dealing with Oxxio meters. It is assumed that Oxxio will be compensated by DSOs for each meter being transferred away from Oxxio. The compensation is assumed to be equal to the undepreciated capitalised value of each meter at the time of replacement.
- **Percentage of atypical legacy meters:** these are meters which differ from most legacy meters used in the network, e.g. because they have been installed directly by the user. Additional costs may be associated with these meters – for example, the meter owner may be expected to be compensated for having the meter removed by the DSOs.
- **Tariffs (gas and electricity):** this information is used in the model to determine the revenues that DSOs are going to raise from each meter in the network in order to offset the costs incurred.
- **Roll-out profile (gas and electricity):** these parameters set the smart meter roll-out profile for both electricity and gas. The user can set the percentage of smart meters (out of the entire meter stock) that will be installed in any given year of the roll-out period.

3.3.3 Model inputs

The structure of the inputs used in the model follows the structure used in our discussion with industry stakeholders.

As a first step, we have identified two main types of inputs for smart meters:

- **Site-specific inputs:** these costs and benefits cannot be attributed directly to individual gas or electricity meters. Rather, they are incurred or achieved for each meter installation (either comprising just one electricity meter or both an electricity meter and a gas meter).
- **Meter-specific inputs**: these inputs can be attributed directly to each meter, either because of their nature (for example, meter purchase costs) or because respondents were able to provide information on a per-meter basis.

The following list provides a description of the site-specific inputs used in the model:

- **One-off communication costs:** these are the costs of purchasing the required communication equipment. Costs for three different technologies (GPRS, PLC and IP) can be taken into account.
- **Ongoing communication costs:** these costs of the ongoing transmission of data from each property (or from the data concentrators, within a PLC solution) to the CDS.
- **Installation costs:** these are the costs of installing smart meters. They are generally based on time and materials and they vary according to the type and difficulty of the installation. The model considers two main types of installation (either 'dense' or 'point-to-point'). The cost of each type also varies according to the difficulty of installation (either 'normal' or 'difficult')[14].
- **Wider distribution benefits:** benefits are assumed to be achieved jointly for each property where smart meters are installed. Benefits include reductions in outage management costs, higher theft detection rates and lower energy losses costs. It is important to note that these accrue almost exclusively as a result of the installation of the electricity meter – there are few, if any gas distribution benefits).

The following list provides a description of the meter-specific inputs used in the model:

- **Meter purchase costs:** these are the cost of buying each type of meter. The model assumes a single type of meter for gas, while for electricity both single- and three-phase meters are considered.
- **Overheads:** these are the additional costs that need to be incurred to roll-out smart meters. They cover setting up a central data server as well as the costs that need to be incurred on an annual basis to acquire and maintain sufficient logistic capability to deploy smart meters[15].

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14 These two dimensions can be considered separately – the first refers to the pattern of installation (whether part of a point to point or dense rollout) whereas the second relates to the property itself and whether the installation is straightforward or would require work in addition to the basic meter fit (e.g. rewiring, replacement of meter board, installation of radio communications equipment, work to address the relative positions of gas and electricity meters, etc.)

15 While overhead costs are defined on a per meter basis, to the extent that they are likely to be incurred up-front (e.g. the development of the CDS) we model them as being incurred in full in the

- **Smart meter maintenance costs:** these are the costs associated with dealing with smart meter failures. They depend on the meter failure rate, the cost of a maintenance visit and the likelihood that the failed meter will need to be replaced by a new one.
- **Other ongoing costs:** these are the costs associated with the overheads of running the metering business, including property, administration, and IT licences and maintenance.
- **Traditional meters:** These costs include maintenance, replacement and reading costs the existing (albeit shrinking) stock of traditional meters until the end of the roll-out period.

3.3.4 Model outputs

On the basis of the parameters and inputs provided, the model calculates the net cash impact of smart meter roll-outs on DSOs. This information is provided on an annual basis, to assess the DSOs cashflow requirements in any given year, as well as a net present value over six and twelve years.

The following list provides a detailed description of the model outputs. These outputs are available separately for gas and electricity.

- **Total smart meters costs: t**his output provides, for each model year, the total costs associated with purchasing, installing and operating smart meters. The information is broken-down into 'one-off costs', which are expected to fall once the roll-out has been completed, and 'ongoing costs', which increase with the size of the stock of smart meters.
- **Additional costs for atypical meters:** these are the additional costs of dealing with atypical meters, which require a more complex installation as well as compensation to be paid to the original meter owner.
- **Compensation for Oxxio meters:** these are the costs incurred by DSOs for taking ownership of Oxxio meters.
- **Traditional meter costs:** these are the costs that DSOs will continue to incur until the end of the roll-out period to maintain and operate the existing (albeit shrinking) stock of legacy meters.
- **Compensation for legacy meter stranding costs:** this is a measure of the economic stranding costs incurred by DSOs when replacing legacy meters that have not yet been fully depreciated.
- **Smart meter maintenance costs:** this is a measure of the ongoing maintenance costs that are incurred by DSOs due to meter failures. These costs increase with the size of the installed smart meter stock.
- **Smart meters benefits:** as well as the costs, the model calculates in each year the savings that DSOs are expected to make thanks to smart meters. Savings

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first year of the rollout (by multiplying them by the final number of meters installed) rather than being incurred in proportion with the stock of smart meters installed in each year.

are achieved on an annual basis and are directly linked to the stock of installed smart meters.

- **Net impact before tariff:** this line item shows the net impact of smart meters before taking the metering tariff revenue into account. It is calculated simply as the difference between costs and benefits.
- **Revenues from tariff:** this is the income that DSOs receive for each meter installed in the network. This amount is expected to grow only with customer growth.
- **Net impact after tariff:** This item shows the actual cash impact for DSOs in any model year
- **Net Present Value:** we have also calculated the Net Present Value (NPV) of the series of net annual impacts. It calculates the NPV for the length of the roll-out period (8 years) as well for a longer period (17 years). The information is also provided on a per-household, per-annum basis.
- **Meter numbers:** For reference, the output also reports the total number of meters in each year as well as the share of smart meters. This provides an indication of the speed of the roll-out.

It is important to note that, while identified separately, the costs of administering the priority installations requested by suppliers is *included* in the net present values calculated.

3.4 DEVELOPMENT OF INPUT PARAMETER SCENARIOS

It is clear that, at this stage in the Dutch smart meter rollout, any cost estimates are likely to be highly uncertain – for example:

- the technology is still maturing;
- DSOs are still evaluating and learning from their pilot programmes;
- no full blown commercial discussions are underway between DSOs and meter manufacturers; and
- the details of the rollout – including factors such as the allocation of responsibilities for parts of the end to end metering process – have not yet been decided by the Dutch government;

For these reasons, all of the data sources which we have drawn on – international research, information from the DSOs and suppliers, and information from meter manufacturers – have specified reasonably wide ranges across most of the cost inputs.

Based on the data provided, we have sought to indentify appropriate ranges for the cost and benefit inputs, and then from these build "optimistic" and "pessimistic" scenarios. For the most part this has been possible – where there were significant outlier observations, we highlight them.

The optimistic and pessimistic scenarios have been constructed by mitigating the "most extreme" responses obtained from stakeholder, as shown in Figure 5. This has been done to obtain more plausible scenarios. If the "more extreme" responses (both lowest and highest) had been used to define the two scenarios, the outcome would have probably been significantly unlikely and, therefore, not strongly informative.

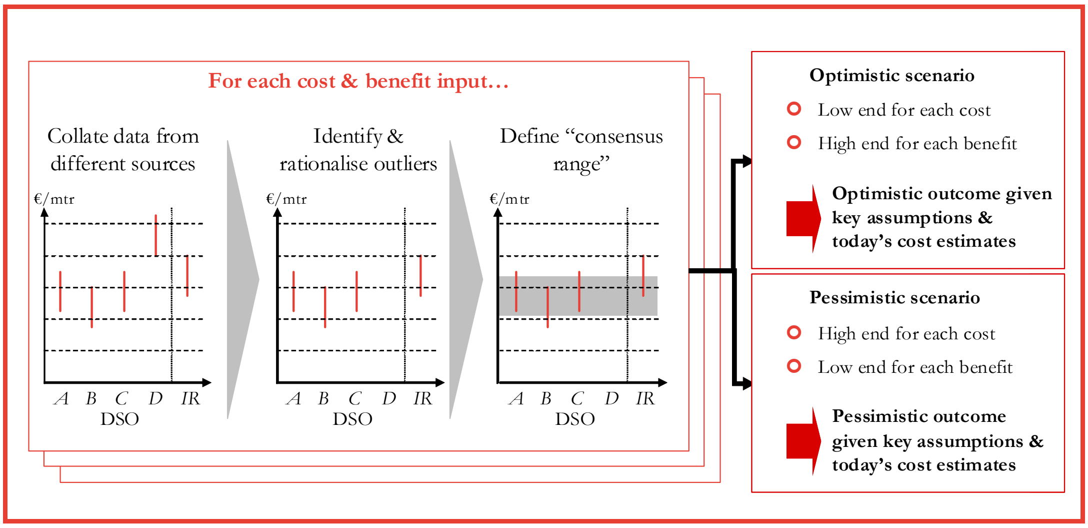

Figure 5: Determination of optimistic and pessimistic scenarios for modelling

Source: Frontier Economics

These optimistic and pessimistic scenarios should therefore be seen as placing plausible bounds on the likely net cost of the Dutch rollout (although, as we note in section 6, there are still a number of risks which could mean the outcome is even beyond these levels).

Given the uncertainty inherent in the cost input data, we have not developed a "central" or "expected" case. We believe that to do so at this stage, given the uncertainty surrounding several aspects of the smart meters roll-out process, would be unjustified.

However, in order to provide an indication of how the optimistic and pessimistic scenarios are sensitive to the assumptions made, we have tested some alternative assumptions. The results of the sensitivity analysis are presented in chapter 6.

4 Cost assumptions

In this section, we set out the key inputs which we have used to estimate the costs of each scenario for the smart metering rollout.

We set out the cost estimates we have collected from:

- international research; and
- discussions with Dutch stakeholders – both meter manufacturers and DSOs and suppliers.

4.1 DATA FROM INTERNATIONAL RESEARCH

The data we collected from our international research which we believe can be considered relevant to the Dutch situation are broken down into the following cost categories:

- **Site-specific costs**
  - Communication costs (both one-off and ongoing) covering the main types of technology (GPRS, PLC and radio)
  - Installation costs, both for electricity and gas meters separately and jointly
- **Meter-specific costs**
  - Meter purchase costs for gas and electricity.
  - Maintenance costs
  - Overheads, mainly data management costs.

We summarise the results of our research below. Throughout, we assume that given the relative immaturity of the technologies under consideration and the rate of technological development, the age of the estimates will be an important consideration in assessing their relevance and reliability.

4.1.1 Site-specific costs

Communication costs: one-off

The following tables present the results of the literature review, separating the various available technologies.

Wireless (GPRS/GSM modem)				
Source	**Min (€)**	**Max (€)**	**Date**	**Comments**
Sustainability First (July 07)	42	56	Jul 07	
Sustainability First (March 06)	49	40	Mar 06	
Victoria, Australia	65	82	Dec 05	

Table 3: Cost of wireless communication equipment (GPRS/GSM modem)

The higher costs reported in Victoria are probably due to the fact the estimate was undertaken when this technology was still being developed. We believe the latest set of estimates from Sustainability First to be the most reliable estimate at present. Hence, for the purposes of this project, we take EUR 42 and EUR 56 per site as a reasonable estimate of GPRS/GSM equipment costs.

Power line carrier (PLC)				
Source	**Min (€)**	**Max (€)**	**Date**	**Comments**
Sustainability First (July 07)	7	7	Jul 07	Extra cost of €7 for data concentrator and €7 for onward transmission medium to retailer
Sustainability First (March 06)	23	28	Mar 06	
Ofgem	14	14	Mar 06	
Enel (Italy)	10	10	Mar 06	
Victoria, Australia	36	36	Dec 05	Extra cost of €33,900 per PLC transceiver for a single bus (single transformer) substation

Table 4: Cost of PLC communication equipment

Again, the cost quoted in the Victoria study appears high if compared with the rest of the sample. Enel's estimates are slightly low: this may be due to the large scale roll-out that Enel carried out as a single operator. Hence the values quoted by Ofgem and Sustainability First may be more relevant for the Netherlands – the cost of the PLC technology for each smart meter site could be assumed to range between EUR 14 and EUR 28.

Communication costs: ongoing

The following tables present the results of the literature review, separating the various available technologies.

Wireless (GPRS/GSM modem)				
Source	**Min (€)**	**Max (€)**	**Date**	**Comments**
Sustainability First (July 07)	7	14	Jul 07	SIM rental costs only. SMS communication charged between €0.04 and €0.08 per text message.
Netherlands	8	60	Aug 05	The central assumption in the report is €20 – it is not clear whether this combines GPRS modem asset costs
Victoria, Australia	3		Dec 05	

Table 5: Cost of GPRS ongoing communications

The range for the Netherlands is very high – based on the other estimates, ongoing costs for this technology could be assumed to range between EUR 11 and EUR 22 with 100 text messages a year on top of the SIM rental cost, and EUR 14 to EUR 29 with 365 text messages a year.

Power line carrier (PLC)				
Source	**Min (€)**	**Max (€)**	**Date**	**Comments**
Victoria, Australia	50	50	Dec 05	Per annum per transceiver

Table 6: Cost of PLC ongoing communications

Only one report provided information on the ongoing costs of PLC communication technology. The information is provided as annual cost per data transceiver. Assuming 100 sites for each transceiver, this is equal to €0.50 per site per annum.

Installation costs

Installation costs should not vary with the type of meter being installed but will vary depending on the volume and whether meters are being rolled out on a geographic basis (e.g. street-by-street) or more selectively (e.g. point-to-point). A geographically concentrated roll out would naturally be less expensive and it would prevent installers needing to duplicate visits to certain areas. It should also be noted that the various studies we reviewed take into account slightly different cost sources in their definitions of 'installation costs'. As such, this information is may be less comparable with the estimates provided by Dutch stakeholders than other cost categories.

Electricity or gas meter individually				
Source	**Min (€)**	**Max (€)**	**Date**	**Comments**
Sustainability First (July 07)	35	42	Jul 07	
Sustainability First (March 06)	28	42	Mar 06	
Washington	3	7	Apr 04	Assuming dense deployment
Northern Ireland	28		Jul 07	
Netherlands	13	45	Aug 05	
Enel, Italy	40		Mar 06	
Victoria, Australia	63	70	Dec 05	For one-phase electricity meters

Table 7: Installation costs for individual meters

Based on the most recent studies, installation costs appear to range between EUR 28 and EUR 45. It might be reasonable to assume that – particularly for a dense installation cost – dual fuel installation costs were around 80% higher than those for a single fuel installation. If this rule of thumb is applied to the range identified here, the range would be EUR 50 to EUR 81 per site.

It should be noted that this estimate is heavily influenced by the underlying assumptions regarding the characteristics of the smart meter roll-out.

4.1.2 Meter-specific costs

Meter purchase costs

The following tables present the results of the literature review for newly fitted electricity and gas meters.

Newly installed electricity meters				
Source	**Min (€)**	**Max (€)**	**Date**	**Comments**
Sustainability First (March 06)	21	24	Mar 06	Assumes a very basic meter (no "additional functions" which are estimated to add €7-10 each)
Energywatch	70	98	Jul 07	Includes incremental operation and maintenance costs
Ofgem	63	63	Mar 06	
Washington	49	139	Apr 04	Includes €14 - €70 communication system costs
Netherlands	40	75	Aug 05	
Enel, Italy	41	41	Mar 06	
Victoria, Australia	48	48	Dec 05	

Table 8: Newly installed electricity meters purchase cost

The energywatch and Washington estimates include communication system and other costs and cannot therefore be immediately compared to the other data. Based on the most recent information available where purchase costs are separately identified, they could be expected to range between EUR 21 and EUR 63, although few specifications would practically allow for purchase costs at the lower end of this range. This is broadly consistent with the Washington estimate.

We note that the literature does not typically differentiate between one and three phase meter costs.

Newly installed gas meters				
Source	**Min (€)**	**Max (€)**	**Date**	**Comments**
Sustainability First (July 07)	56	84	Jul 07	
Energywatch	91	133	Jul 07	Includes incremental operation and maintenance costs
Ofgem	105	105	Mar 06	
Netherlands	35	60	Aug 05	

Table 9: Newly installed gas meter purchase cost

As in the case of electricity meters, energywatch's estimates include additional costs. In general, it should be noted that, due to the differences between the planned roll-out in the UK and the Netherlands, these results cannot be directly compare. Based on the most recent estimates of purchase costs alone, new gas smart meters can be expected to cost between EUR 56 and EUR 105.

Meter maintenance cost

The following table provides an overview of various estimates of maintenance costs. The information is provided on a per annum per meter basis.

Meter maintenance costs				
Source	**Min (€)**	**Max (€)**	**Date**	**Comments**
Sustainability First (July 07)	7	14	Jul 07	
Sustainability First (Mar 06)	7	14	Jul 07	
Ofgem – electricity	2.5	2.5	Mar 06	
Ofgem – gas	2.6	2.6	Aug 05	

Table 10: Meter maintenance costs

Based on the most recent estimates, maintenance costs appear to range between EUR 7 and EUR 14 per meter, or EUR 14 and EUR 28 for each dual-fuel installation site.

Overheads

Very few reports provide estimates on ongoing overhead cost. One of the most recent reports some estimates on data management costs. According to

Sustainability First, data management costs are equal to about EUR 7 – 9 per meter per year, equivalent to EUR 14 – 18 for each dual-fuel installation site.

4.1.3 Summary

The following tables summarise the results of the review of international literature, presenting the range estimates that we believe to be appropriate to be applied to the case of the Netherlands. As noted above, it should be stressed that no comparison between different jurisdictions can be based on a perfect match. Therefore, this information should be used only as a sense-check on the information provided by Dutch stakeholders.

Site-specific costs (per site, per year)		
Cost	**Min (€)**	**Max (€)**
Communication costs (one-off)		
GPRS	42	56
PLC	14	28
Communication costs (ongoing)		
GPRS	14	29
PLC	0.50	0.50
Installation costs		
Separate	28	45
Joint (new meters)	50	81

Table 11: Summary of international literature review: site-specific costs

Meter-specific costs (per meter, per year)		
Cost	**Min (€)**	**Max (€)**
Purchase costs		
Electricity (new meter)	21	63
Gas (new meter)	56	105
Maintenance		
Gas and electricity	7	14
Data management cost	7	9

Table 12: Summary of international literature review: site-specific costs

4.2 DATA FROM METER MANUFACTURERS

Meter manufacturers provided insights on a subset of the data inputs – clearly, they provided no data in relation to installation and (ongoing) communication costs, over which they would have relatively little visibility.

4.2.1 Smart metering assets

Iskraemeco indicated single phase PLC meters costs to be EUR 60 to EUR 80 and EUR 110 to EUR 140 for three phase depending on purchase volumes.

Landis + Gyr indicated higher meter costs. The prices quoted were for GPRS meters, so allowing for the GPRS modem costs at EUR 20, single phase meters were indicated to be EUR 110 to EUR 130 and three phase meters EUR 150 to EUR 180, on a like for like basis.

Echelon indicated costs for single phase smart meters between EUR 59.50 and EUR 79.25 depending on the purchase volumes. Three phase meters were indicated to be between EUR 76 and EUR 98.75.

Iskraemeco and Echelon do not supply gas meters. Landis + Gyr provided gas meter costs, including some allowance for communication with the electricity meter, of EUR 92 to EUR 115 depending on purchase volumes.

The manufacturers indicated costs for GPRS communication components in the range EUR 20 to EUR 30. One manufacturer suggested PLC data concentrator costs around EUR 500 – which, with an allowance for fitting and an assumption of 100 sites per concentrator, would imply EUR 12 per site. Another manufacturer quoted a significantly higher cost – which with fitting and lower utilisation would imply a EUR 45 per site cost.

In general, the manufacturers indicated that orders of over 10,000 meters would fall within the ranges indicated above – the exception being Echelon who indicated that the lower end of their quoted ranges was only consistent with a much higher order volume. Landis + Gyr and Iskraemeco indicated that for smaller volumes (e.g. 1,000 – 5,000) purchases might carry a 5-10% premium. It might be reasonable to assume that a DSO would make around 4 orders per year of the rollout (in order to reduce the cashflow impact of the rollout, manage the logistics operation and reduce exposure to batch quality risk). On this basis, an order size of 5,000 would be consistent with a total meter volume of 120,000 across the rollout.

All the manufacturers indicated smart meter design lives of 20 years. However they placed a caveat on this around the life of the communications components, which they indicated may have a shorter life. They quoted low failure rates (0.3-0.5%) for the metering equipment, but drew a comparison with the failure rates of consumer electronics (c. 2%) for the communications components.

4.2.2 Traditional metering assets

In terms of traditional meter costs, the manufacturers suggested:

- **electricity single phase:** costs in the range EUR 17 to EUR 26; and
- **electricity three phase:** costs in the range EUR 34 to EUR 45.

Iskraemeco does not produce gas meters and Landis + Gyr do not supply gas meters to the Dutch market. Echelon do not supply traditional meters.

Iskraemeco stated that the quoted design life of their traditional meters was 20 years for both single and three phase meters. They also quoted a meter failure rate of 0.1% for single phase meters and a rate of 0.2% for three phase.

Landis + Gyr also indicated a 20 year design life for their traditional meters – however, they stated that it was not uncommon for meters to be in service for up to 40 years for electro-mechanical meters and 20 years for electronic meters. They also quote the design failure rate as being better than 0.3%, and typically 0.2%. Landis + Gyr also produce gas meters and provided the same design life and failure rate figures for their gas meters.

4.3 DATA FROM DUTCH PARTICIPANTS

Our discussions with Dutch DSOs and Oxxio allowed us both to develop a number of assumptions about the nature of the smart metering rollout in the Netherlands which are relevant from the point of view of the costing exercise, and (in combination with the data above) to estimate consensus ranges for each of the cost inputs.

4.3.1 Assumptions relating to nature of rollout

The key rollout assumptions that we have made following on from our bilateral discussions with Dutch participants are as follows:

- where a site has a different DSO for gas and electricity, the DSOs will co-ordinate in all circumstances to ensure that the gas and electricity meters are installed at the same time (i.e. in terms of the three macro-scenarios identified in section 2, only the first two will be relevant);

- all DSOs will seek to build their own Central Data Server to provide meter reads for their sites to retailers. Where the gas and electricity DSO are not the same entity, the gas DSO will secure the meter reading data from the electricity DSO's CDS;
- suppliers will exercise their priority rollout rights early in the rollout – otherwise they would have little value;
- while there are some DSOs planning to use IP communications for their sites (predominantly for newer properties where this is logistically easier to achieve), GPRS and PLC will be the dominant communications technologies;
- where suppliers exercise their priority rights, it will drive DSOs to install GPRS communications technology – as there would be both economic and technical issues with using PLC for individual sites;
- across the period of the rollout, the Netherlands will not benefit significantly from reductions in the purchase cost of smart metering equipment as a result of technology developments and economies of scale in manufacturing. While it is expected that costs will fall over time, the Dutch rollout is accelerated relative to other countries in Europe – and when Dutch DSOs commit to orders, manufacturers may not yet have brought on significant new capacity; and
- smaller DSOs collaborate with the larger companies in relation to the procurement of meters in order to avoid being charged a premium for small batch volumes[16].

4.3.2 Consensus ranges

As noted in the previous chapter, in order to estimate the consensus ranges for each of the cost inputs, we analysed cost estimates provided by Dutch DSOs and suppliers, alongside the public data set out above. We identified where there appeared to be outlier data (or where it appeared that data had been provided on a significantly different basis) in relation to particular inputs and attempted to clarify any inconsistencies. We then identified consensus ranges (based, to an extent, on informed judgement rather than a mechanistic process determined by the lowest and highest cost data provided) for each input. From these ranges we derived an optimistic and a pessimistic scenario.

The data we have collected from Dutch DSOs and suppliers has been provided to us on a confidential basis. Therefore, it is not possible to set out in full detail how we arrived at these consensus ranges.

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16 If a smaller DSO wanted to spread their batch quality risk by using 2-3 manufacturers, and spread their purchases over, say, 5 out of 6 rollout years to spread the cashflow impact, they could find themselves ordering below the 10,000 batch volume indicated by the manufacturers as a potential trigger for premia being charged.

However, in Table 13, Table 14 and Table 15 we summarise the two scenarios we have defined, and highlight cost inputs in which there were significant outliers which we excluded from our estimates.

Site specific costs			
Variable	**OPTIMISTIC scenario**	**PESSIMISTIC scenario**	**Comments**
Mix of communication technology (GPRS/PLC)	65% / 35% in year 1, decreasing to 40%/60% in year 2, decreasing to 30%/70% in year 3 and then staying constant thereafter	65% / 35% in year 1, decreasing to 50%/50% in year 2 and remaining constant thereafter	We have assumed that the number of priority installations is the main driver of the profile of use of GPRS technology. This leads to a higher use of GPRS technology in the first years of the roll-out period. In steady state, some DSOs have stated that they will predominantly used GPRS technology.
GPRS modem cost	EUR 25	EUR 35	One stakeholder indicated substantially higher modem costs – however, this may be because they have been working with a more modular metering solution.
PLC one-off cost	EUR 12	EUR 35	The key factor driving variance in responses here appears to be the assumption on number of sites per concentrator. Most DSOs suggested a ratio of one concentrator to 100 houses – however, other international benchmarks indicate a ratio of 1 to 50 for planning purposes.
GPRS ongoing communication costs	EUR 10	EUR 20	There would appear to be a wide range of communications costs being quoted by the mobile networks. This may depend on the scale of the communications, and on the extent to which usage can be limited to “off peak” (e.g. overnight) which in turn depends on whether quarter-hourly or hourly data is collected, and whether the data is collected daily, weekly or monthly.
PLC ongoing communication costs	EUR 0.30	EUR 1	

Site specific costs			
Variable	**OPTIMISTIC scenario**	**PESSIMISTIC scenario**	**Comments**
Installation costs			
• Dense normal	EUR 70	EUR 75	Difficult installations are assumed to require one additional installer/hour, which is estimated to cost about EUR 50
• Dense difficult	EUR 120	EUR 125	
• Point-to-point normal	EUR 110	EUR 120	
• Point-to-point difficult	EUR 160	EUR 170	
Smart meter maintenance visit costs	EUR 60	EUR 100	Some DSOs indicated that they had used this category to capture some of the “overheads” of the metering business (e.g. property). Others identified ongoing costs (including IT) separately.

Table 13: Consensus ranges – site specific costs

Meter specific costs			
Variable	**OPTIMISTIC scenario**	**PESSIMISTIC scenario**	**Comments**
Smart electricity meter purchase cost (single phase)	EUR 80	EUR 90	The Dutch DSO estimates all fell outside the range indicated by international research. However, their estimates (for NTA compliant meters) were broadly consistent with those from the meter manufacturers.
Smart electricity meter purchase cost (three phase)	EUR 95	EUR 110	While the DSOs presented quite widely varying estimates for three phase meters, meter manufacturers provided a significantly narrower range of responses.
Smart gas meter purchase cost	EUR 90	EUR 100	One DSO presented significantly higher cost estimates for a smart gas meter

Meter specific costs			
Variable	**OPTIMISTIC scenario**	**PESSIMISTIC scenario**	**Comments**
Smart meter expected life (yrs)	15	15	Overall consensus from DSOs regarding expected life
Smart meter failure rate requiring visit[17]	1%	5% in first year, falling to 2% in year 4	The DSOs indicated widely varying expected failure rates[18] - we would not expect this to persist into the rollout. Therefore, for the optimistic scenario we assume that there is a 1% failure rate throughout, whereas in the pessimistic scenario, the failure rate is assumed to reduce to 2% over the rollout period as a result of addressing the fundamental problems with the installations.
Smart meter failure rate requiring replacement	0.5%	1%	One DSO suggested significantly higher number
Overheads one-off costs (EUR per meter)[19]	EUR 20	EUR 46	
Other ongoing costs (EUR per meter)	EUR 3	EUR 4	Some DSOs included IT costs in this element – others included more general overheads

Table 14: Consensus ranges – meter specific costs

17 We note that we have not included a specific consideration to cover the cost of the meter testing facility (our information is that this costs around EUR 1.5m per annum to run). While this cost would have to be funded through the metering tariff, it is relatively small compared to the total sums being considered here.

18 Experience from other markets suggests that some part of the higher observed failure rates in pilots may be due to insufficient testing of communications links prior to the installation being completed and the engineer leaving the site.

19 Principally relating to the development and integration of the CDS system, and the costs of the programme to manage the smart metering rollout

Traditional meter costs			
Variable	**OPTIMISTIC scenario**	**PESSIMISTIC scenario**	**Comments**
Traditional electricity meter purchase cost (single phase)	EUR 20	EUR 25	One DSO suggested a significantly higher number.
Traditional electricity meter purchase cost (three phase)	EUR 40	EUR 60	The range of the DSO estimates was significantly greater for three phase than for one phase. We excluded a number of estimates above this range.
Traditional gas meter purchase cost	EUR 30	EUR 50	One DSO suggested significantly higher costs
Traditional meters installation cost (EUR per meter – both gas and electricity)	EUR 40	EUR 60	
Traditional meters reading cost (EUR per meter – both gas and electricity)	EUR 2	EUR 5	
Traditional meter life (yrs)	25	25	In line with the comments from meter manufacturers, the DSOs indicated that a material number of their traditional metering assets were significantly older than 25 years.
Average legacy meter remaining life (yrs)	7.5	10	To derive this number, we compared actual meter age data with the assumed (rather than actual) legacy meter life – on the basis that this is likely to be the way the DSOs calculate meter depreciation
Traditional meter failure rate (gas and electricity)	0.2%	0.5%	

Table 15: Consensus ranges – legacy meter costs

We asked the Dutch DSOs to indicate their expected rollout profile. There was general consensus that the number of installations in the first year of the rollout would be below the average, and that the same would be true of the final years (as the most difficult and geographically disparate installations were "mopped up"). Once the roll-out has been completed, the smart meter stock will grow according to the annual increase in customer numbers. Therefore, we have adopted a common electricity and gas rollout profile for both the optimistic and pessimistic scenarios. The profile is shown in Figure 6 and Figure 7.

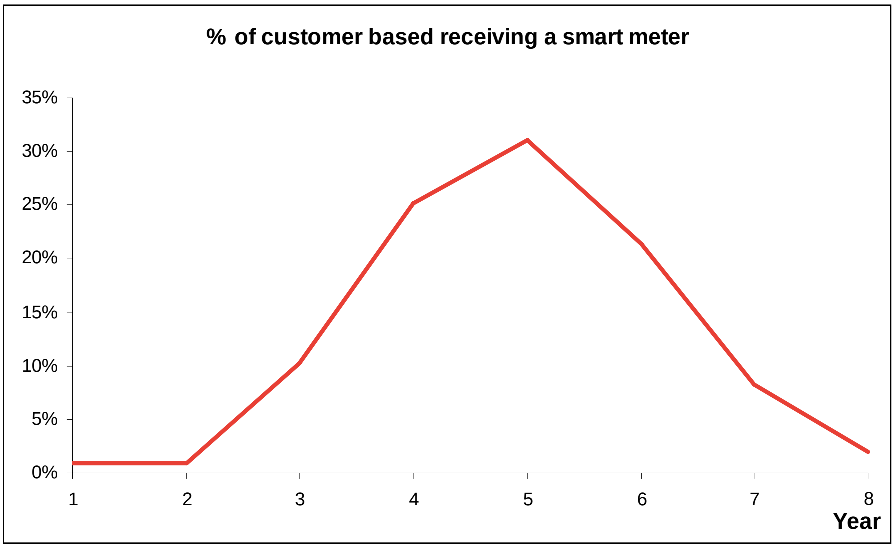

Figure 6: Smart meter roll-out profile until completion

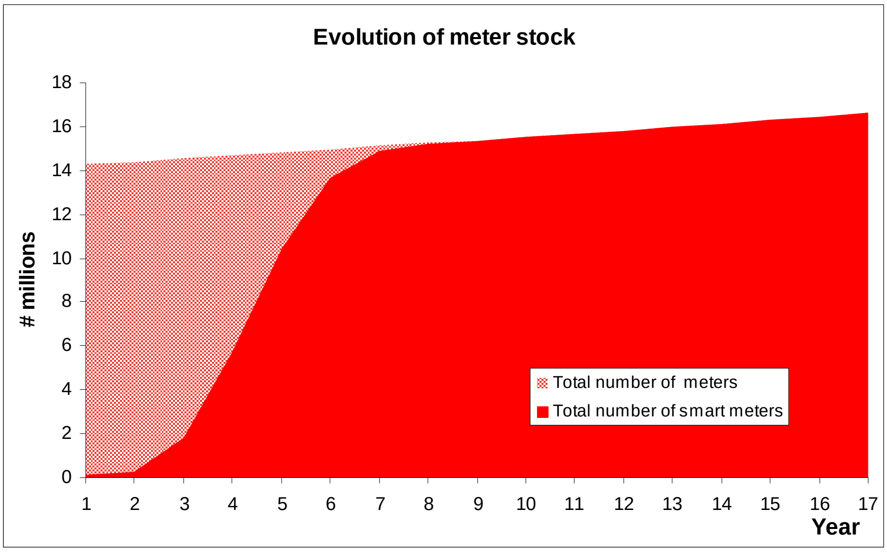

Figure 7: Evolution of gas meters stock

Cost assumptions

Finally, Energiekamer provided us with values for the existing metering tariffs. The current value for electricity is regulated at EUR 24.47 per meter. The value for gas was estimated at EUR 18.90.

5 Benefits assumptions

Given the institutional structure and proposed regulatory arrangements in the Netherlands, the adoption of smart meters is characterised by a 'split incentive' problem. This occurs because most of the benefits from smart meters are expected to accrue to energy suppliers and final consumers, whereas most of the costs (purchase, installation and maintenance) will be borne by the DSOs. This notwithstanding, it is possible to identify some (small) benefits likely to accrue to DSOs. As indicated above, our research focuses only on the latter.

5.1 EVIDENCE FROM INTERNATIONAL LITERATURE

When looking at the business case for smart meters in various jurisdictions, the international literature has identified a set of benefits for the economy as a whole. These include:

- **Meter read costs:** one of the key benefits that would be expected to arise from the introduction of smart meters is a reduction in meter reading costs, given that these meters can be read remotely at low incremental cost.
- **Customer service benefits:** benefits are expected to arise thanks to the reduction of back office and call centre costs. This is because a large proportion of customer service contacts arise from issues with billing and these should reduce as smart meters become widespread.
- **'Green' benefits:** these are the benefits that are expected to arise because of changes in consumption behaviour. There are two potential sources of change in consumption behaviour that may arise from the introduction of smart metering:
  - a reduction in average consumption; and
  - a movement in the timing of consumption from peak to off-peak periods.

  These potential changes in consumption behaviour may then each result in three potential benefits:
  - a reduction in the cost of energy used, as lower demand would lead to lower energy prices, every else being equal;
  - avoided peak capacity costs, as lower demand may lead to certain investment in peak capacity being postponed or reduced; and,
  - reduced carbon emissions.[20]

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[20] We recognise that, in reality, the effect on carbon emissions is more complex than this. In the shorter term, as the power sector is within the EU Emission Trading Scheme (EU ETS), there will be no direct emissions saving from a reduction in electricity consumption. However, benefits will be felt by all entities within the EU ETS that can now choose to buy allowances as a cheaper option than incremental abatement. In the medium / longer term, reductions in electricity consumption may be expected to facilitate equivalent reductions in total allowed carbon emissions.

As noted above, most of the benefits list above that are expected to result from the introduction of smart meters will accrue to energy suppliers (at least initially – competition should ensure they are passed through to customers) or, as in the case of carbon emissions, directly to final consumers and society as a whole.

However, there are three further benefits that have been identified in the literature. They are of a different order of magnitude with respect to those described above but they should be considered in our research as they are expected to accrue directly to DSOs. They can be classified as 'network management' benefits.

- **Electricity outages and restorations:** smart meters may be used by DSOs to track outages more quickly and more accurately.
- **Reduced theft:** Large scale implementation of smart metering would reveal existing theft (both tampering and by-pass). The frequency of accurate meter reads may serve to identify theft and the functionality of the meter may be able to monitor and communicate theft.
- **Reduced technical losses:** Having a complete demand profile for any given node on both the electricity and gas networks should allow network operators to reduce the level of technical losses.

In general, robust information on DSO benefits is difficult to find in the international research. When information is provided, it typically indicates a relatively low level of benefit. For example, Sustainability First (2006) estimated benefits at EUR 1.50 to EUR 3.00 per meter per year across both transmission and distribution.

In contrast, with respect to electricity outages and restorations, in 2007 Ofgem assumed that this could lead to a reduction in customer minutes lost of 10%. This translated into a benefit of EUR 0.06 per electricity meter per year. Ofgem assumed that theft could be reduced by about 25%. This translates into annual benefits of between EUR 0.34 per gas prepayment meter and EUR 0.76 per electricity credit meter. Finally, based on a 1% reduction in technical losses, Ofgem estimated this benefit as EUR 0.10 per electricity meter and EUR 0.03 per gas meter.

5.2 EVIDENCE OF BENEFITS FOR DUTCH DSOS

The objective of our research was to look at the impact of smart meter roll-out on Dutch DSOs. This means that, as well as trying to identify benefits that reduce the cost of undertaking a DSO activity *per se*, we also consider transfers of responsibility for activities away from the DSOs which result directly from smart metering.

Therefore, our research has identified two types of DSOs benefits:

- **Network management benefits**: in line with the international literature, these accrue to DSOs thanks to savings that can be made from improved network management operations

- **Cost savings from transfers of responsibility:** these costs savings accrue to DSOs because the introduction of smart meters is planned to shift the responsibility for legacy meter data collection and validation to suppliers

With regard to 'network management' benefits, in 2005 Accenture carried out a study of the likely impact of smart meters on DSOs. Accenture identified and quantified the following annual benefits for the industry as a whole:

- between EUR 0m and EUR 190m for electricity outage and restoration management;
- between EUR 0m and EUR 310m, thanks to a reduction in fraud; and,
- between EUR 0m and EUR 30m for improved net balancing (reduction in technical losses).

All together, the estimated DSOs benefits ranged between EUR 0 and EUR 530m per year. However, as the large estimation range suggests, these estimates were characterised by a very high level of uncertainty.

We also encountered significant uncertainty in our research, at least in relation to network management benefits. In our meetings with the DSOs, while we were able to identify benefits that fit the categories described above, their quantification proved to be more difficult, with DSOs providing a wide range of estimates.

The reason for the inability of DSOs to pinpoint network management benefits accurately lies mainly in the fact that smart meter benefits become material only when the number of smart meters in the network reaches a critical mass, and when the DSOs have made other necessary investments (e.g. in IT systems) in the rest of their business. While most DSOs have already carried out small scale trials, these provide useful information only with respect to costs. The uncertainty surrounding the estimation of benefits is due, in large part, to the fact that small scale roll-outs cannot reproduce the effects of the required level of market penetration. Therefore, our assumptions on smart meter benefits must rely solely on relatively broad-brush estimates being directly provided by DSOs.

This notwithstanding, our research was able to identify a range of estimates that we used in the modelling exercise. It should be noted that these values are more conservative than those calculated by Accenture in 2005 as they reflect the DSOs' caution in this area.

Table 16 shows the range of benefit assumptions that were used in the modelling. To be consistent with the approach used in the previous section, the cost savings are smaller in the optimistic scenario than in the pessimistic scenario.

DSOs annual benefits (per meter)			
Variable	**OPTIMISTIC scenario**	**PESSIMISTIC scenario**	**Comments**
Network management benefits	EUR 2.40	EUR 1.50	These are assumed to accrue from year 3 of the rollout, on the grounds that a certain density of metering and investment within the wider business are both needed in order to deliver them.
Cost savings due to transfer of responsibility	EUR 2.00 (per dumb meter still installed)	EUR 5.00 (per dumb meter still installed)	This is the cost of data reading and validation for each meter. These costs decline during the roll-out period as smart meters are being installed
Total benefits	**EUR 4.40**	**EUR 6.50**	

Table 16: Consensus ranges – DSOs annual benefits per meter

Overall, DSOs are assumed to be able to save between EUR 4.40 to EUR 6.50 per meter per annum thanks to the combined impact of network management benefits and cost savings achieved thanks to the transfer of responsibility regarding data collection and validation.

Table 17 shows the total savings that DSOs are expect to achieve on an annual basis by the end of the roll-out period.

DSOs annual benefits (total)		
Variable	**OPTIMISTIC scenario**	**PESSIMISTIC scenario**
Network management benefits	EUR 18.5m	EUR 11.6m
Cost savings due to transfer of responsibility	EUR 30.1m	EUR 78.5m
Total benefits	**EUR 48.6m**	**EUR 90.1m**

Table 17: Consensus ranges – DSOs maximum annual benefits - total

This value ranges between EUR 48.6m and EUR 90.1m. The estimates are considerably lower than those identified by the Accenture study.

These estimates should therefore be considered conservative. It should also be noted that these values are intended to apply to the whole of the Dutch market. In practice, however, given that smart meter benefits depend on the scale of the roll-out, given the need to reach a critical mass, smaller DSOs may expect to achieve significantly lower benefits than larger DSOs. The analysis of these distributional issues is, however, outside the scope of our research.

6 Results of analysis and issues for further consideration

In this section, we present:

- an overview of the main results of our analysis of the impact of smart meter roll-out on DSOs for both the optimistic and the pessimistic scenarios, which have been defined in the previous two sections;
- an analysis of the assumptions that explain the differences between the optimistic and pessimistic scenarios and their relative impact. This represents as assessment of the degree of the current level of uncertainty on certain key assumptions.
- a discussion of the relative contribution of individual costs and benefits components to the overall impact of smart meter rollout on DSOs;
- an analysis of the potential impact of alternative assumptions regarding meter and communication equipment purchase costs; and,
- an overview of issues which have emerged from our discussions with stakeholders, and which could have a significant impact either on costs or on the overall success of the rollout.

6.1 MAIN RESULTS OF OUR ANALYSIS

First, we turn to a presentation of:

- the annual cashflow implications of the smart meter roll-out and operation for the DSOs;
- the cumulative impact, both in aggregate terms and separately for electricity and gas; and,
- the impact of 'more extreme' scenarios based on the full range of values provided by DSOs.

The results of our analysis – with the exception of annual cashflow impacts – are expressed as Net Present Value (NPV).

The NPV is a measure that is often used by investors to determine whether to carry out an investment. Investments typically require an initial expenditure upfront, while the returns normally are obtained at a later date. The NPV is a measure which is used to summarize the investment's overall financial impact into a single number.

In order to calculate the NPV of an investment, all present and future cashflows generated by the investment (negative and positive, if any) are discounted to a common reference year, normally the present year. This makes it possible for future cashflows occurring at different points in time to be compared on the same basis. Once discounted, future cashflows can be added together into a single value (NPV). This is illustrated in Figure 8.

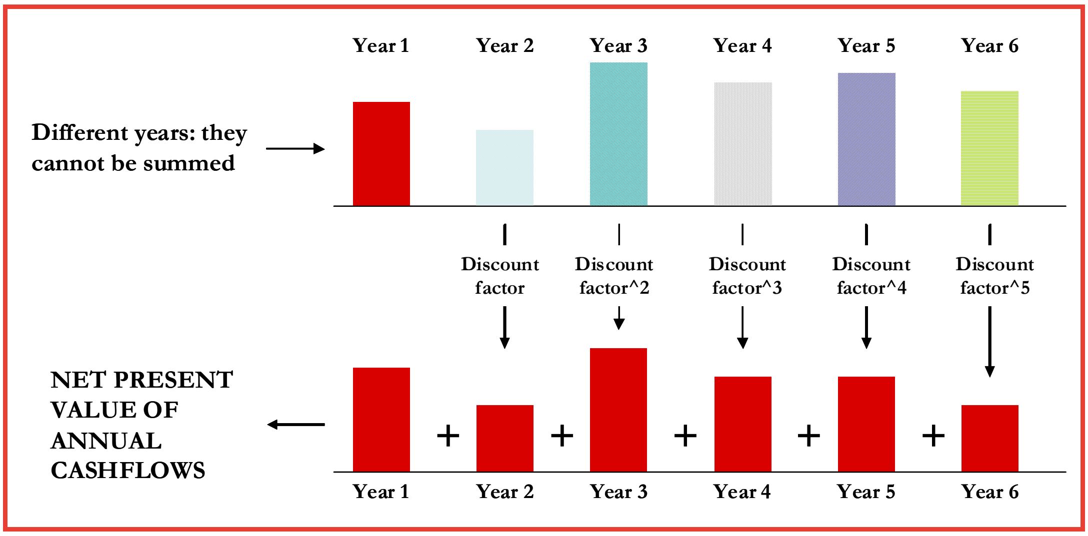

Figure 8 : Illustration of NPV calculation

The logic behind the NPV is that individuals tend to prefer smaller amounts today, rather than larger amounts in the future. The discount rate used to calculate the NPV is a measure of this preference, and of the risks associated with future cashflows. In carrying out our analysis, we have used a discount rate equal to 5.5% per annum, which is equal to the Weighted Average Cost of Capital (WACC) used by Energiekamer in regulation.

A negative NPV indicates that the present value of the investment's costs exceeds the present value of the investment's benefits. In this case, from a financial perspective, the investment should not be undertaken. On the other hand, a positive NPV indicates that, by the end of the project lifetime, the benefits will have exceeded the costs. In this case, the investment is worth making.

The NPV results presented below always summarise the net impact of the smart meter rollout on DSOs, i.e. the total costs incurred by DSOs (described in Section 4) less the total benefits accruing to DSOs (described in Section 5).

All NPV results have been calculated over a 17-year period. The length of the analysis period has been determined on the basis of the average technical and economic lifetime of smart meter, which is expected to be 15 years. In addition, we have included a 2-year waiting period from 2009 to 2011, which will be used by Energiekamer for the evaluation of rollout trials. For the purpose of the analysis, we have assumed that during these two years only a minimal number of meters will be installed, for trial purposes.

Moreover, we have assumed that the average 2005 metering tariffs for gas and electricity, adjusted for inflation, are the only source of metering revenues for DSOs throughout the analysis period.

Finally, as described in chapters 1 and 2, the costs and the benefits accruing to suppliers and final consumers are outside the scope of this research and have not been included in the NPV calculations.

6.1.1 Annual cashflow impacts

As discussed above, DSOs are expected to incur negative cashflows during the years of the roll-out, but they can benefit from positive cashflows before the actual roll out commences and after it has been completed.

Figure 9 (Optimistic Scenario) and Figure 10 (Pessimistic Scenario) show the total net cashflows of DSOs for each year of the analysis period for the Optimistic and Pessimistic scenarios respectively. Under the Optimistic scenario (Figure 9) annual net cashflows are negative for the first four years of the roll-out and turn positive thereafter, thanks to the revenues from metering tariffs and smart meter benefits.

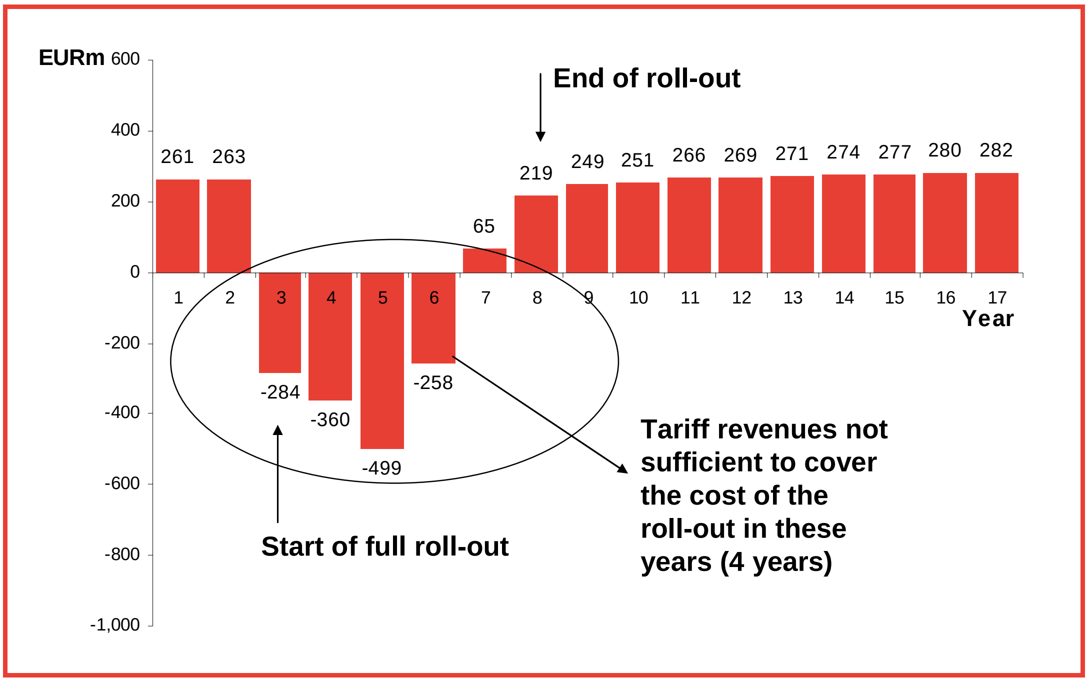

Figure 9: Total annual net cashflows – Optimistic scenario

In the Pessimistic scenario (Figure 10), the annual net cashflow in the first five years of the roll-out is significantly negative and is only partly compensated by positive cash flows from the sixth year onwards.

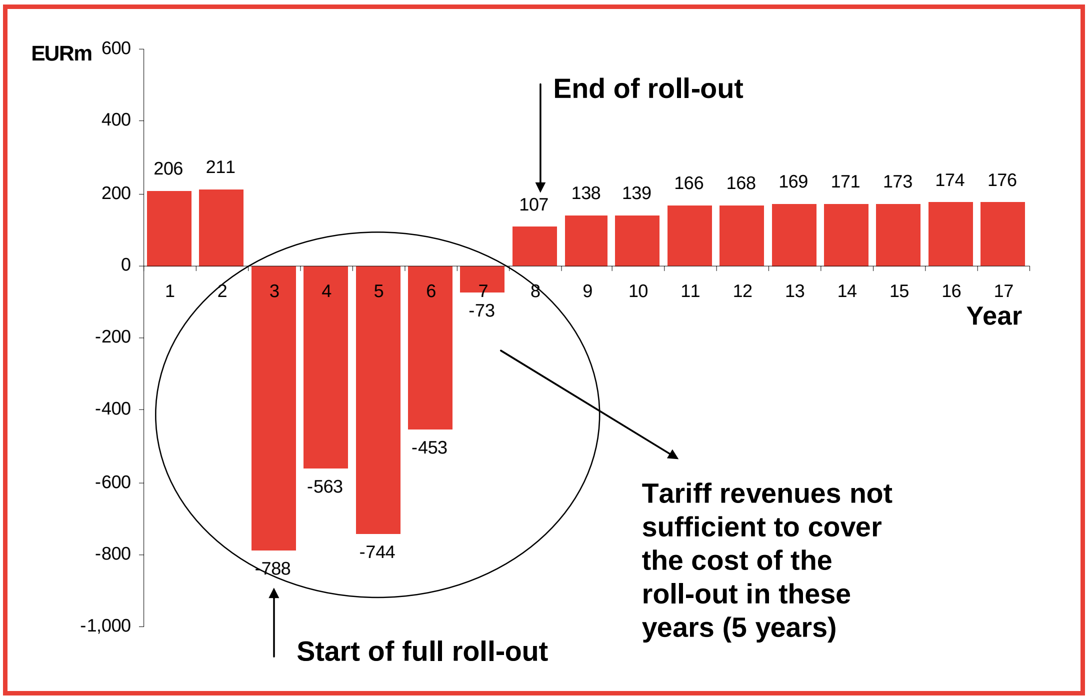

Figure 10: Total annual net cashflows – Pessimistic scenario

Having negative cashflows during the first years and positive cashflows in later years is pattern common to most investments. However, it is the relative size of these cash movements which determines the overall profitability of the investment. As described above, this is summarised using the NPV. This notwithstanding, looking at annual cashflow can also provide a useful indication of whether an investment is viable. Companies can face annual cashflow constraints (for example, a significant negative cashflow may result in a downgrade of the company's credit rating, which could have significant knock on implications across the business). If the expected cash outlay in a given year goes beyond this constraint, then the whole investment may not be feasible, even if the total NPV over the total assessment period is positive.

In this case, the very negative cash flows in the early years of the roll-out (especially in the Pessimistic scenarios) may raise doubts as to the ability of the DSOs to finance the investment out of positive cashflows elsewhere, even if the initial losses are gradually compensated over time.

This analysis shows that DSOs may therefore encounter financeability constraints due to the very high capital expenditure they need to incur during the roll-out. The analysis of the financeability of the roll-out of smart meters goes beyond the scope of this analysis. This notwithstanding, it is clearly an issue that deserves further consideration. The charts below show the results of the cashflow analysis separately for gas and electricity. While the amounts involved are different, the same cashflow patters can be observed.

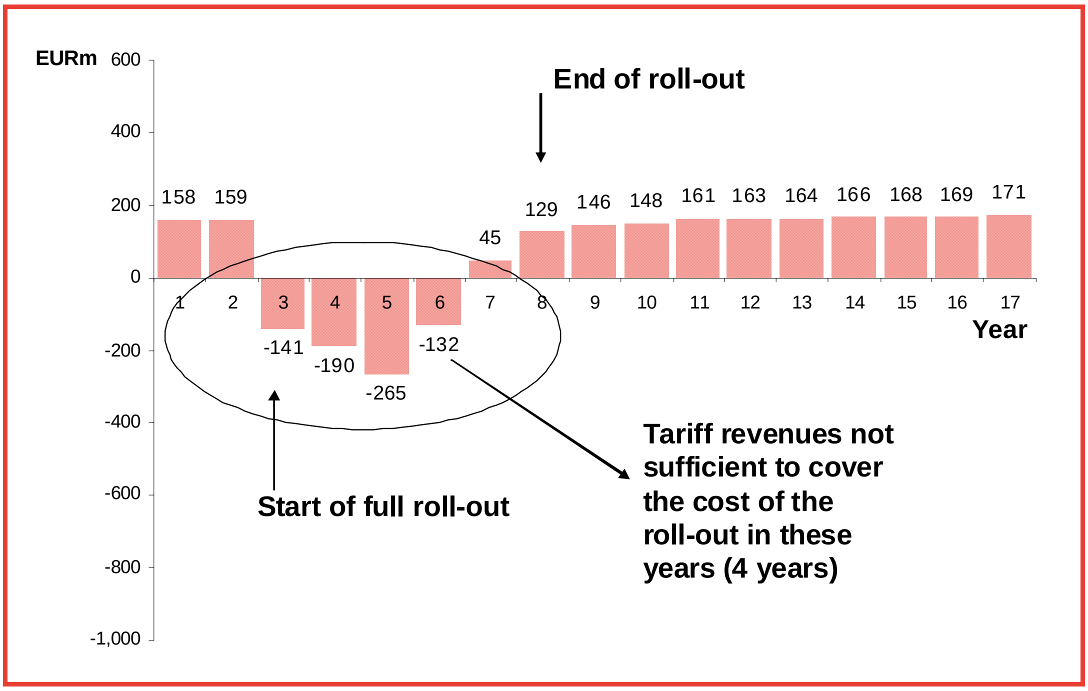

Figure 11: Annual net cashflows – Electricity – Optimistic scenario

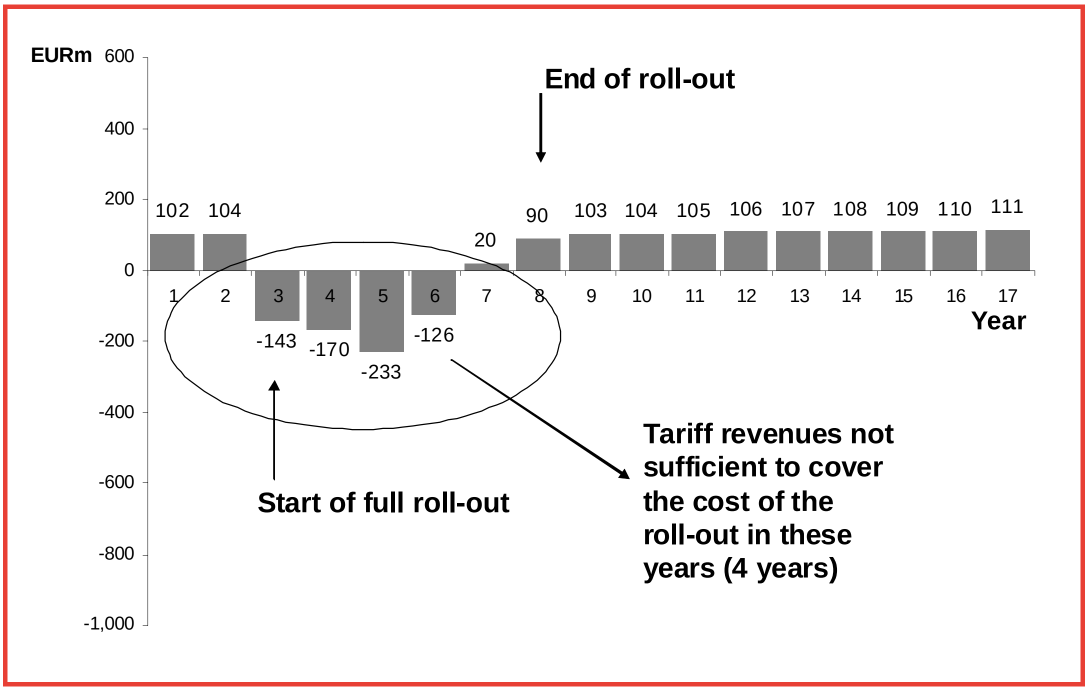

Figure 12: Annual net cashflows – Gas – Optimistic scenario

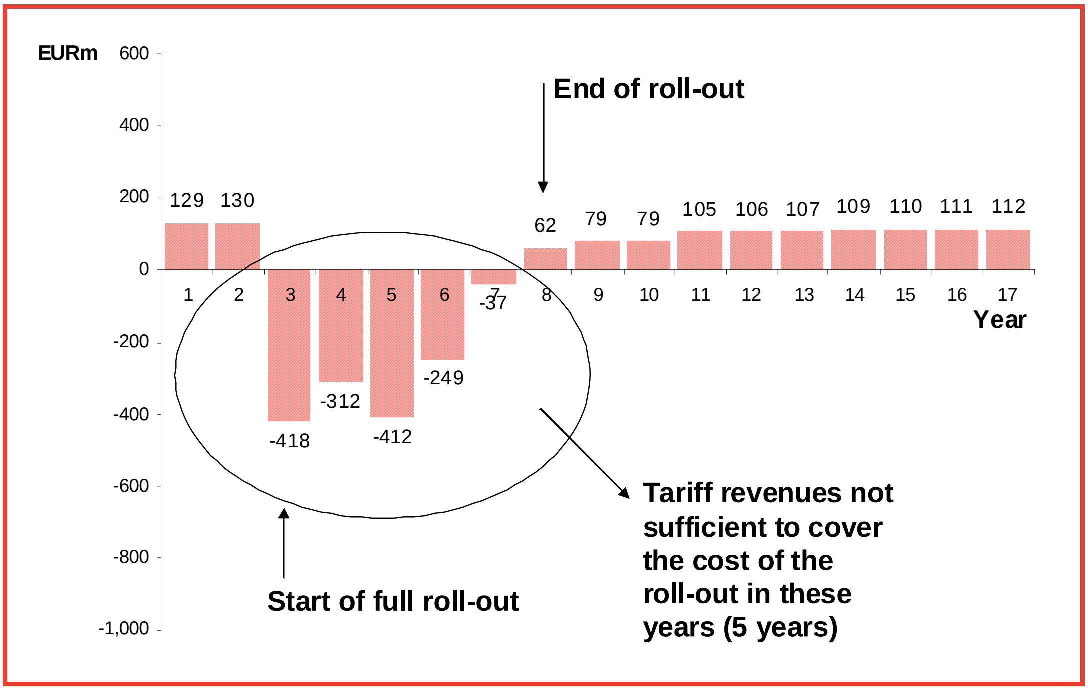

Figure 13: Annual net cashflows – Electricity – Pessimistic scenario

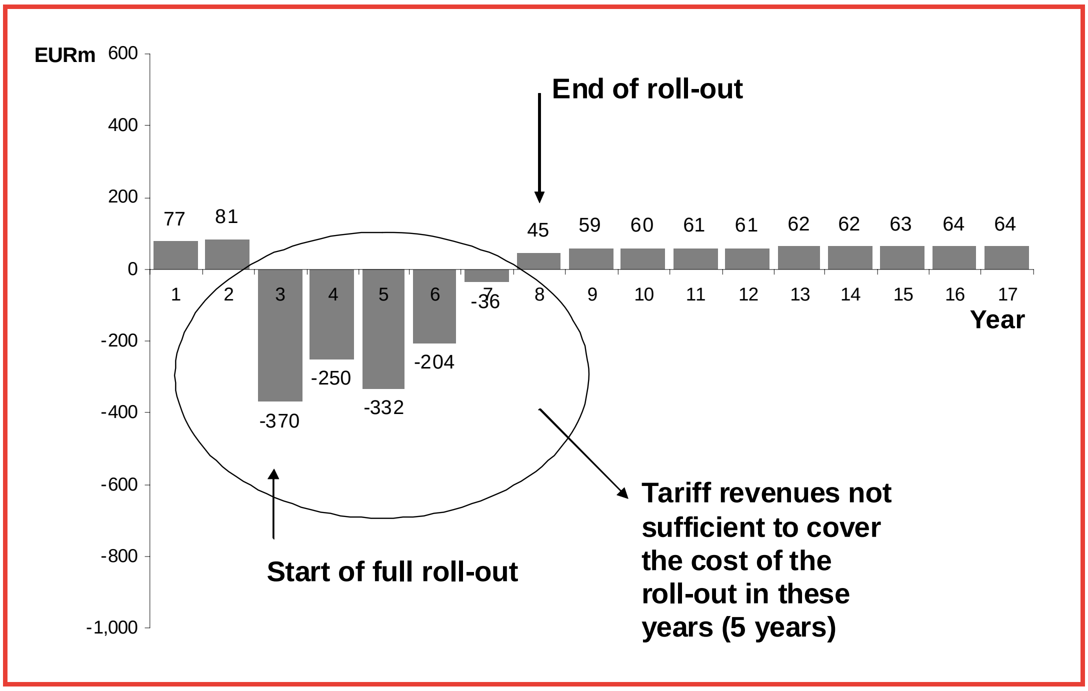

Figure 14: Annual net cashflows – Gas – Pessimistic scenario

6.1.2 Cumulative impact of smart meter roll-out

The cumulative impact of the smart meter roll-out over 17 years, in NPV terms, is shown in Figure 15

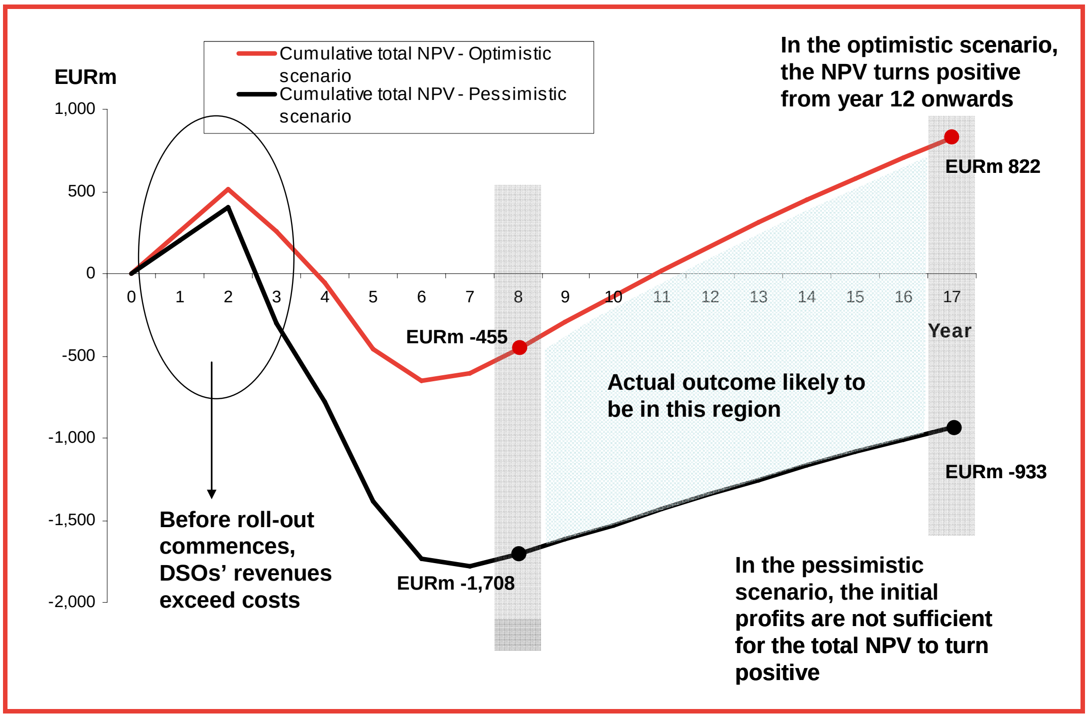

Figure 15: Cumulative NPV impact of smart meter roll-out - TOTAL

For each year of the period under analysis, we have calculated the NPV value of the smart meter roll-out. In other words, the chart shows, for each year, what the overall NPV of the roll-out would be if it was terminated in that particular year. The NPV calculation is based on net cashflow values, where the rollout's benefits are offset by the rollout's costs.

The figure shows the results for both the optimistic and the pessimistic scenarios. For both scenarios, after an initial increase in the first two years, when metering revenues are higher than metering costs, the cumulative NPV shows a sharp drop during the first years of the roll-out when DSOs need to incur upfront costs for meter purchase and installation. The cumulative NPV then increases, thanks to the fact that DSOs cease incurring meter purchase and installation costs, while they receive smart meter benefits and revenues from metering tariffs.

However, despite a reduction in costs towards the end of the roll-out period and thereafter, the cumulative NPV turns positive only in the Optimistic scenario, from Year 12 onwards, while it remains negative in the Pessimistic scenario. This means that, if all assumptions in the Pessimistic scenarios are fulfilled, the DSOs are not expected to be able to recover the initial losses made during the roll-out period. Given that the most probable outcome is somewhere in between the Pessimistic and Optimistic scenarios, there is a sizeable chance that DSOs may not be able to recover the costs of the roll-out.

The separate analysis of the cumulative NPV of the roll-out of electricity and gas meters shows very similar results, as illustrated by Figure 16 and Figure 17. In the Optimistic scenario, the cumulative NPV for gas turns positive only in Year 15, while for electricity, it turns positive from Year 13 onwards.

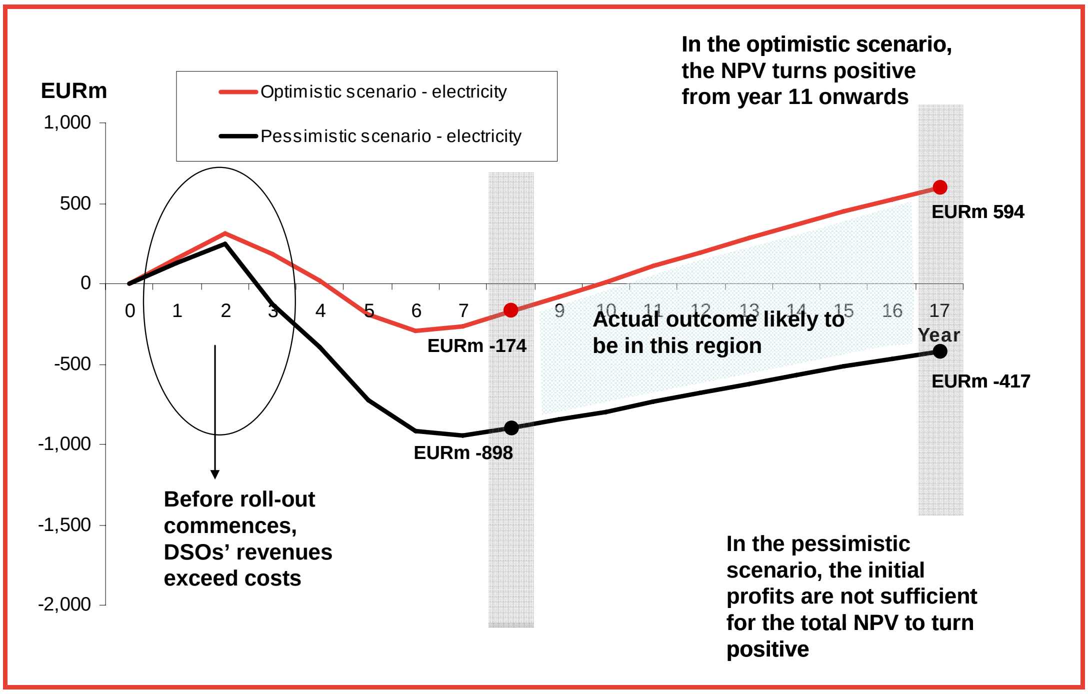

Figure 16: Cumulative NPV impact of smart meter roll-out - ELECTRICITY

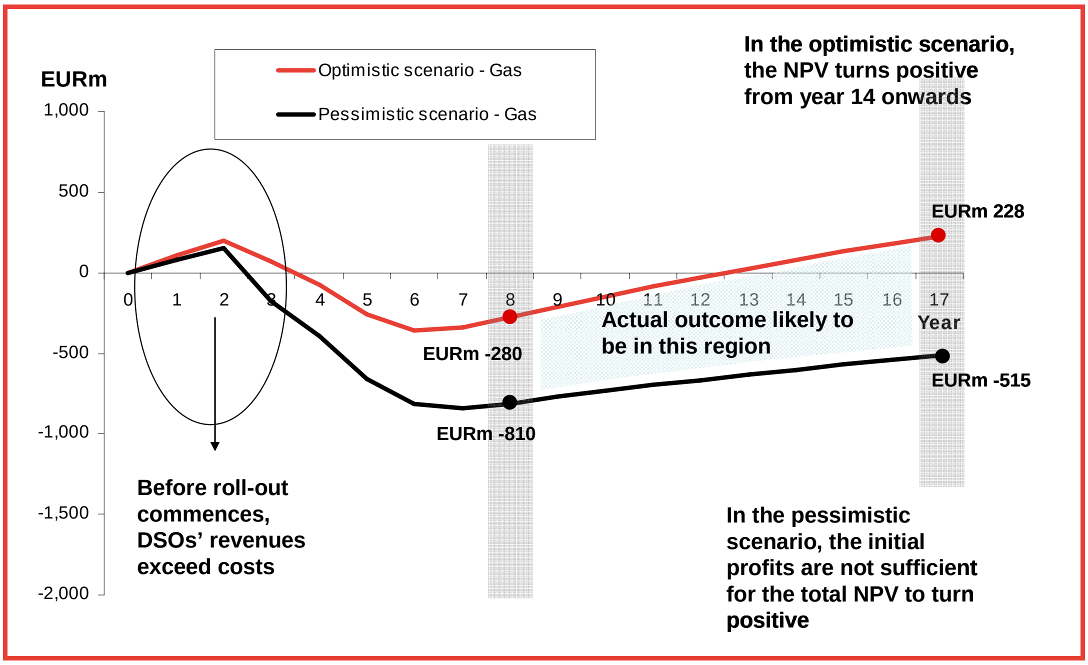

Figure 17: Cumulative NPV impact of smart meter roll-out - Gas

The results of the cumulative NPV analysis are summarised in Table 20 and Table 21.

Time period	Elec	Gas	TOTAL
At the end of roll-out (year 8)	EURm -174	EURm -280	EURm -455
At the end of analysis period (year 17)	EURm 594	EURm 228	EURm 822

Table 18: Summary of NPV analysis – Optimistic scenario

Time period	Elec	Gas	TOTAL
At the end of roll-out (year 8)	EURm -898	EURm -810	EURm -1,708
At the end of analysis period (year 17)	EURm -417	EURm -515	EURm -933

Table 19: Summary of NPV analysis – Pessimistic scenario

6.1.3 'More extreme' scenarios

As discussed in Chapter 4 and 5, the selection of the 'consensus' ranges underpinning the Optimistic and Pessimistic scenarios illustrated here was based on the determination of values that realistically represent the weight of responses received by the DSOs. We therefore deliberately excluded 'more extreme' responses that would have increased the gap between an Optimistic scenarios and its Pessimistic counterpart.

In this section, for illustration purposes, we briefly present the overall NPV impact of two 'more extreme' scenarios which we have labelled 'Very Optimistic' and 'Very Pessimistic' scenarios (it is important to note that in constructing these more extreme scenarios, we continue to exclude clear outliers in the cost and benefit inputs).

The cumulative NPV of these scenarios is shown in Figure 18.

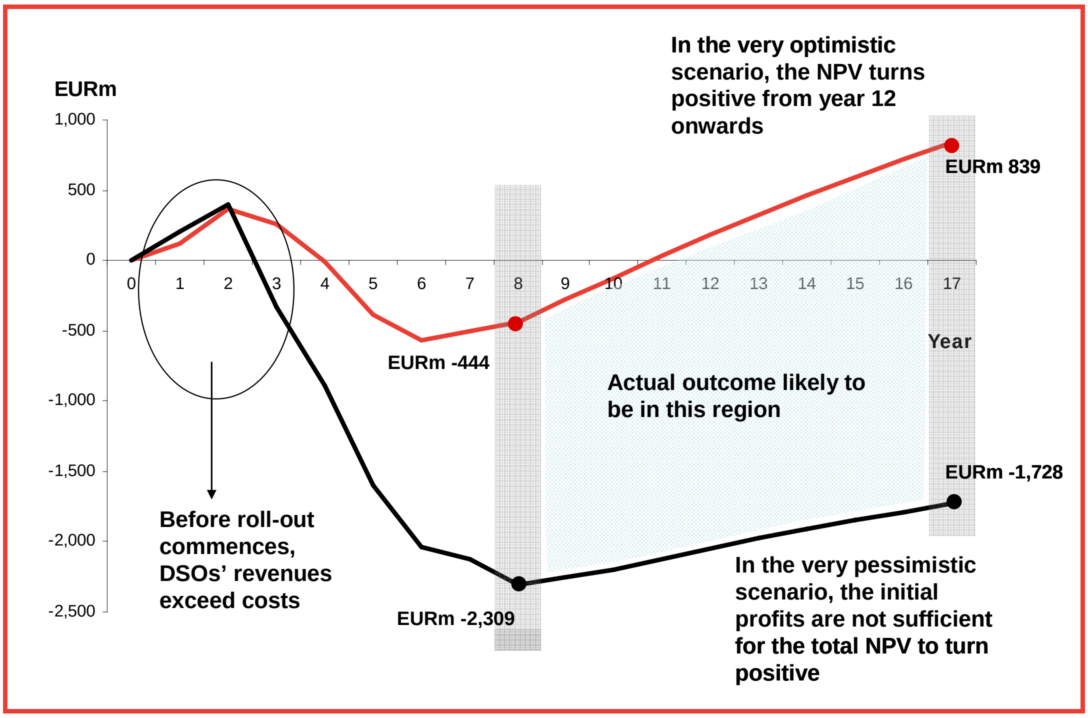

Figure 18: Cumulative NPV of 'more extreme' scenario - TOTAL

6.2 DIFFERENCES BETWEEN OPTIMISTIC AND PESSIMISTIC SCENARIOS: SOURCES OF UNCERTAINTY

As seen in the previous section, the difference between the outcomes under the optimistic scenario and pessimistic scenario, both measured at the end of the roll-out and at the end of the analysis period, is significant.

The range of values we used for the analysis represents the degree of uncertainty that the industry is currently facing.

In this section, we break down the difference between the NPV results of the optimistic and pessimistic scenarios to understand the main sources of uncertainty that the industry is facing at the moment.

The breakdown of the NPV difference between the two scenarios is shown in Figure 19.

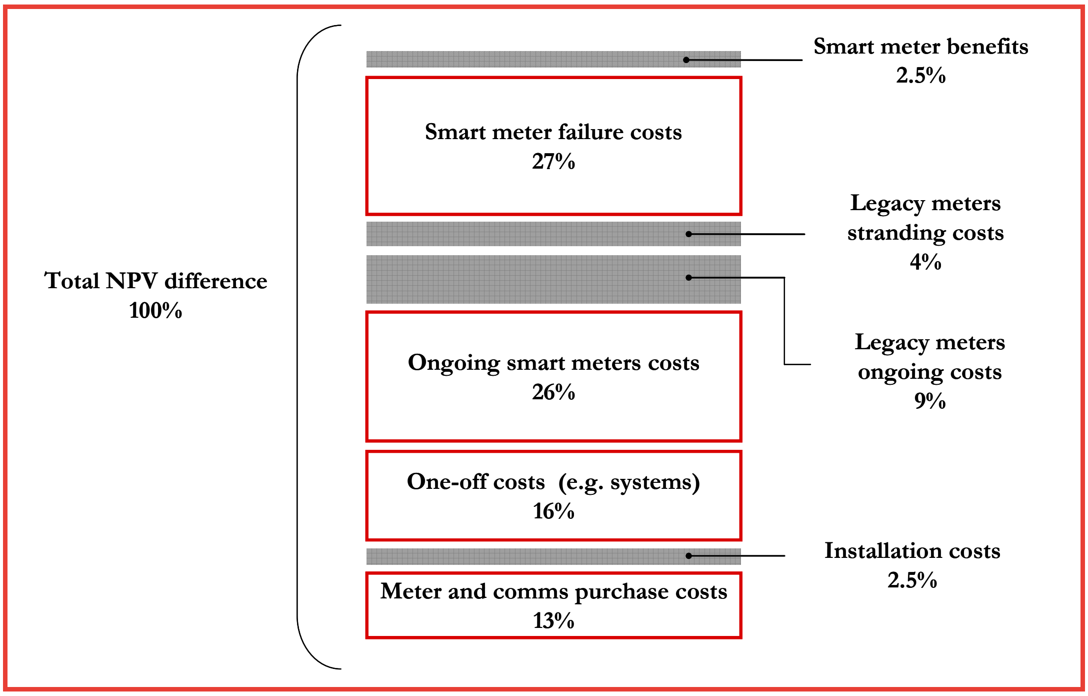

Figure 19: NPV difference between Optimistic and Pessimistic scenarios

It can be seen that the main source of difference between the two scenarios is the uncertainty relative to the actual level of smart meter failure costs. According to all the stakeholders we met, smart meters are expected to have a higher failure rate than legacy meters. However, as only limited trials have been carried out, it is difficult for DSOs to quantify the actual failure rate that they will face once their entire customer base has been converted to smart meters. Therefore, the range of assumptions used in this case is broad. In the Optimistic scenario, we have assumed a constant failure rate equal to 1%. In the Pessimistic scenario, the initial failure rate is assumed to be 5% (the rate currently observed in some of the largest rollouts in the Netherlands), declining to 2% by the end of the roll-out period.

There is also a significant degree of uncertainty regarding the ongoing smart meter costs. The main source of uncertainty relates to the communication costs that DSOs will need to face. This depends in turn on the communication technology mix that will be eventually installed as well as on the communication patterns that will be required (e.g. whether use of GPRS networks can feasibly be restricted to off peak hours). The mix of communications technology is partly a matter of DSO preference (some DSOs indicated a preference for PLC, while one DSO stated that their firm intention was a wholly GPRS based rollout) and partly a function of the expected exercise of priority rights by suppliers (which will almost certainly require GPRS communications). The range of different preferences on communications technology may in turn reflect differences within networks (e.g. different population densities) or may reflect different views on technology development and robustness.

The other main sources of uncertainties are the one-off costs that DSOs will need to incur, both for the actual meters and for the communication equipment and the meter and communication equipment purchase costs.

With respect to the actual meters, the evolution of their purchase costs is still unclear, especially considering that the demand for smart meters will increase significantly during the time of the roll-out. The uncertainty relating to meter and communication equipment purchase costs originates from the fact that it is still difficult to determine the relative proportion of each communication technology (GPRS vs. PLC).

Finally, DSOs have quoted a wide range of estimates in relation to legacy meter ongoing costs (especially meter reading costs). This uncertainty accounts for about 9% of the NPV difference between the two scenarios.

Other elements such as legacy meters stranding costs, smart meter benefits and installation costs account for most of the remaining difference between the two scenarios. With regards to installation costs there is still a degree of uncertainty relative to the extent to which the use of priority installations by suppliers will affect overall installation costs.

6.3 ANALYSIS OF THE RELATIVE IMPACT OF INDIVIDUAL COST AND BENEFIT COMPONENTS

As noted in paragraph 3.3.4, the model that we have developed to support this research calculated the single cost and benefit components that contribute to the determination of the overall net present value of the smart meter roll out.

In this section, we identify the relative contribution of each cost or benefit component to the final NPV value of the roll-out of smart meters. We show the results of this analysis for both the Optimistic scenario and the Pessimistic scenario. However, the relative contribution of each component to the final results is broadly similar across the two scenarios.

In order to illustrate the relative contribution of each component to the final NPV result, we use a 'NPV Build-up' chart, which shows the magnitude and the direction of the impact of each cost and benefit to the overall net present value.

Figure 20 shows the NPV build-up for the Optimistic scenario. From left to right, the chart shows all the costs that contribute to reducing the value of the overall NPV. The chart shows that meter and communication purchase costs, installation costs, one-off programme costs and ongoing smart meter costs are the most important cost components. The possible compensation for Oxxio meters, the ongoing costs associated with a dwindling pool of legacy meters, the stranding costs due to the disposal of undepreciated legacy meters and the smart meter failure costs contribute to costs to a lesser extent. Costs are for the most part compensated by the revenues obtained from metering tariffs and, to a much smaller degree, by the DSOs benefits generated by smart meters.

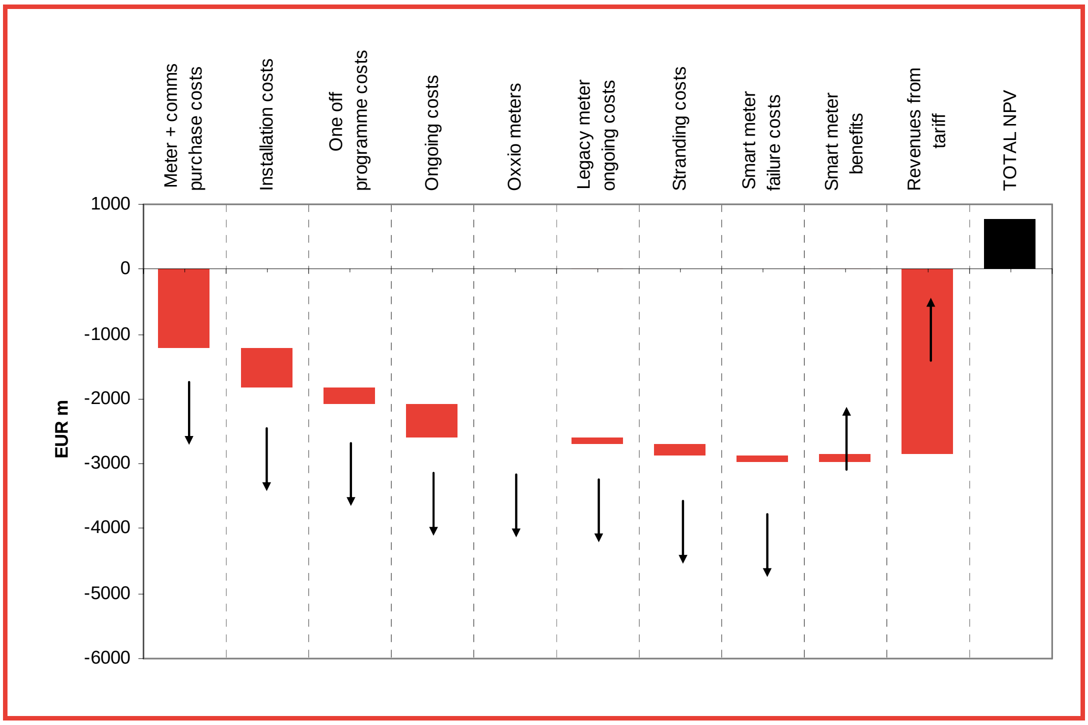

Figure 20: NPV build-up - Optimistic scenario

Figure 21 shows the same analysis for the Pessimistic scenario. In relative terms, the results of the analysis are essentially the same as those identified for the Optimistic scenario. The only notable difference is that, in this case, the costs associated with smart meter failures are higher that the expected stranding costs. This is due to the assumption of much higher failure rates in the Pessimistic scenario.

As highlighted above, the smart meter benefits and the revenues from the metering tariff are not sufficient for the total NPV to be positive at the end of the 17-year period under analysis.

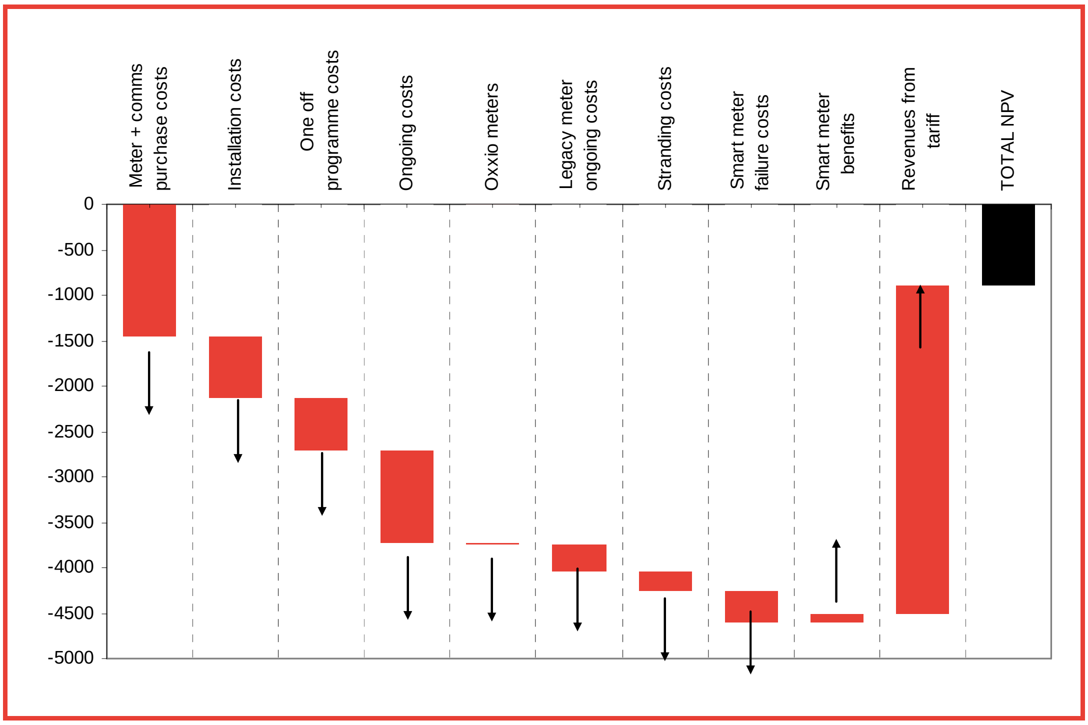

Figure 21: NPV build-up - Pessimistic scenario

6.4 ALTERNATIVE SCENARIOS

During our research, we noted that there was a higher degree of uncertainty relative to the level and evolution of costs in three main areas. Specifically, the stakeholders showed different views on the impact of legacy meter stranding costs, on the evolution of meter purchase costs and on the evolution of communication costs.

Therefore, the last part of the analysis has been dedicated to exploring the impact of alternative scenarios on the final NPV, with respect to both the base Optimistic scenario and the base Pessimistic scenario.

In particular, we considered the impact of three alternative scenarios, as follows:

- **Removal of stranding costs.** We explored the impact of removing the negative impact of stranding costs from the final NPV calculations. One possible rationale for not allowing the costs of stranded legacy meter assets would be that DSOs were able to cover the full costs of legacy meters before the introduction of smart meters thanks to the metering tariffs which were well above cost levels.
- **Reduction of communication costs.** Thanks to technological improvements, communication costs may be expected to reduce in real terms over time, leading to significant savings for DSOs. We tested this assumption by reducing the cost of communication equipment (both one-off and ongoing) by 2% in real terms on an annual basis for the first eight years of the period under analysis and keeping it constant thereafter.

- **Reduction of smart meter purchase costs.** The cost of smart meters could fall over time as manufacturers are able to exploit economies of scale in production. This would be possible thanks to the higher volumes of meters they may be required to produce. We tested this assumption by reducing all purchase costs by 2% in real terms on annual basis for the first eight years of the period under analysis and keeping it constant thereafter.

Table 20 and Table 21 show the results of the sensitivity analysis, comparing total NPV of the alternative scenarios with the outcome of both the base Optimistic and Pessimistic scenarios.

Optimistic scenario	Alternative scenario NPV	Base scenario NPV	NPV Difference
Removal of stranding costs	988m	822m	166m
Reduction of communication costs	1,022m	822m	200m
Reduction of smart meter purchase costs	917m	822m	95m

Table 20: NPV impact of alternative scenarios – Optimistic scenario

If all three events were to occur at the same time, in the Optimistic scenario this would imply an overall increase in NPV equal to EUR 461m.

Pessimistic scenario	Alternative scenario NPV	Base scenario NPV	NPV Difference
Removal of stranding costs	-691m	-933m	242m
Reduction of communication costs	-852m	-933m	81m
Reduction of smart meter purchase costs	-820m	-933m	113m

Table 21: NPV impact of alternative scenarios – Pessimistic scenario

Even if all these events were to occur at the same time, in the Pessimistic scenario this would imply an overall NPV increase equal to EUR 436m. The total NPV would be, however, still significantly negative.

In conclusion, the scenarios analysed in this section suggest that the overall results of the analysis are only moderately sensitive to changes in the assumptions. In all three cases, while the total NPV of the rollout improves somewhat, the overall outcome of the analysis remains substantially the same.

6.5 KEY ISSUES FOR FURTHER CONSIDERATION

Having undertaken this analysis, below we set out a number of further issues which have been raised during our study but which have not been considered quantitatively.

6.5.1 Differences between DSOs

The modelling set out above has been carried out for the Netherlands as a whole. However, there are a number of factors which are likely to drive different results at the individual DSO level. It will be important to take these into account when determining the approach to regulating the smart meter rollout.

Scale

Many jurisdictions do not consider the scale of DSOs when setting regulated tariffs, on the argument that if DSOs are below efficient scale, customers should not be forced to bear the resultant additional costs.

In relation to smart metering, the size of each DSO will be an important determinant of the costs they incur in a number of ways:

- the size of the DSO will – if no arrangements for collaboration in relation to smart meter procurement are made – determine its ability to access volume discounts from meter manufacturers (or, alternatively expose them to technology risks by forcing them to order from one manufacturer alone); and
- there are a number of fixed cost components to the smart metering rollout – not least, the requirement to implement new IT systems to collect and manage the meter data. With a per unit meter tariff, these fixed costs may result in smaller DSOs experiencing greater financial difficulties than their larger counterparts.

In addition to this effect, some of the smaller DSOs indicated to us that – particularly where they were only the gas DSO and a larger DSO provided electricity service – they would be reliant on larger DSOs for some installations.

If the larger DSOs are rolling out meters to c. 2m households, they will effectively be carrying out an average of around 330,000 installations a year – in other words, they may install on average in a year more meters than a small DSO has in their entire territory. The larger DSO may therefore wish to roll out meters to the smaller DSO territory much more quickly than would be ideal from the point of view of the smaller DSO. In extreme cases, the smaller DSO may face the prospect of having the majority of their meter base from similar meter batches – and therefore being exposed to significant risk of class faults.

Regional differences

There are a number of aspects of a DSO's service territory which will drive costs – and differences in those drivers will therefore result in different financial impacts of the smart meter rollout between businesses.

Important cost drivers will include:

- **customer density**: PLC as a communications technology is better suited to densely populated areas – in more rural areas, DSOs may have to rely to a greater extent on GPRS communications, which has a significantly different upfront and ongoing cost profile; and
- **property age profile**: older houses are more likely to involve a "difficult" meter installation than newer properties – as a result of the increased probability of the need for rewiring or replacement of the meter board, and the locations of the gas and electricity meters (and their locations relative to each other).

Meter types

As a result of our research, it is clear that there are significant differences between the DSOs in terms of the proportion of single phase and three phase meters currently installed.

It is not clear whether these differences are driven by historic custom and practice (i.e. whether the DSOs would all now choose to install a more consistent mix of meters) or whether there are factors about the loads served by some DSOs which drive a technical requirement for more three phase metering.

Given the significant difference between one and three phase meter procurement costs, this issue will clearly need further consideration to avoid delivering windfall gains or losses to individual DSOs.

Mix of gas and electricity customers

Given the differences noted above in relation to the net cost relative to tariff for gas and electricity customers separately (resulting from different incidence of both costs and wider distribution benefits, most of which are focused entirely on the electricity network), it is clear that DSOs which have an imbalance between the number of gas and electricity customers they serve are likely to experience a different financial impact from those with a more balanced portfolio.

6.5.2 Availability of skilled meter installation resource

The accelerated timeframe for completion of roll-out of smart metering in the Netherlands will create a need to access a large skilled meter installation resource base within 12-18 months from the start of the full rollout, currently planned for 2011 at the latest.[21]

A number of the DSOs indicated that they were already experiencing above inflation contractor cost increases. We have modelled installation costs as being flat in real terms throughout the rollout period (which can be interpreted as assuming that any installation productivity improvements are offset by above inflation increases in hourly rates). Clearly if contractor cost inflation continues

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[21] Note that the level of priority installations will tend to increase the time spent per installation, further increasing the demand for installation resource.

to outstrip inflation (without these increases being matched by increases in productivity), there will be upwards pressure on the total installation bill.

6.5.3 Meter cost variation over time

As we noted in section 4, we make the assumption that meter costs will stay broadly constant in real terms across the rollout period, on the basis that the rollout is accelerated relative to others being planned, and therefore will not benefit significantly from improvements in technology or significant additions to manufacturing capacity resulting in greater economies of scale.

However, a number of geographic markets are looking at accelerated implementations of smart metering. This could lead to a situation where demand is likely to outstrip existing supply capacity with little incentive for a long term increase in supply capacity due to a potential future lull in demand. This then could place an upward pressure on meter prices. Were this to occur during the Dutch rollout, there could be material upward pressure on procurement costs.

6.5.4 Gas meter availability

The modelling assumes that the roll-out is undertaken on a dual fuel basis. The availability of gas meters compliant with the NTA meter specification is crucial to being able to roll-out on this basis.

However, NTA compliant smart gas meters are not currently available on the market. If the manufacturers are not able to deliver appropriate volumes of compliant meters in the early stages of the rollout, this could either lead to a delay to the commencement of implementation or incremental costs due to the requirement to undertake multiple installation visits.

6.5.5 Priority installation rule

We have assumed that priority installation rights are exercised in the first two years of the rollout, in order that suppliers maximise the benefit which they can capture. We have further assumed that all such customers have to have a GPRS communications solution.

However, we have assumed that the proportion of "difficult" installations among these customers is the same as that nationally. To the extent that suppliers use their priority installation rights to secure early installations for customers who represent a relatively poor credit record, then the incidence of "no access" installation attempts may be disproportionately high. This may in turn materially increase the costs borne by DSOs early in the rollout. Therefore, while our research explicitly considers the additional costs associated with carrying out priority installations in addition to the simple difference in costs between dense and point-to-point installation, there is significant uncertainty on the final impact of the priority installation rule. This will also depend on the extent and the ways in which suppliers will decide to use it.

6.5.6 Alternative communications technologies

We model the deployment of both PLC and GPRS communications technologies. The use of IP broadband communications was identified by one survey respondent – particularly for newer houses – and future-proofing against future communication technologies also needs to be considered.

We have implicitly assumed that:

- PLC and GPRS are the core communications technologies and it is then a decision for individual DSOs to build investment cases for alternative communication technologies based on achieving a return within the regulated tariffs; and

- the regulated metering tariff should recover the expected mix of GPRS and PLC communications solutions, rather than being set relative to the cost of that expected to be the cheapest technology, and then allowing DSOs to implement the other if they have an internal business case.

These assumptions will clearly need to be debated.

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