SmartRegions

Description of the SmartRegions tool - for calculation of economic, environmental and social costs and benefits of smart meters and smart metering services

SmartRegions Deliverable 3.1

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FOR A SUSTAINABLE FUTURE

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1 Introduction

According to the Third Legislative Energy Package, smart metering systems are to be installed to 80% of all homes in EU by 2020. 100% of the homes should have smart metering systems within 2022. However, the introduction of smart metering systems is dependent on a positive outcome of a smart metering impact study.

This report describes a tool that aims to support the decision makers, energy utilities and other relevant target groups in their assessment of costs and benefits related to smart meter deployment and improved energy services. The main features of the present tool are based on the cost/benefit tool developed in the ESMA project [1], modified and adapted to the objectives of the SmartRegions project. The tool calculates the cost/benefit for the main actors involved in metering deployment, energy services and the customers, and also the socio economic impacts related to improved energy efficiency, demand response to price and reduction in CO2 emission from optimized power production

The tool meets the following objectives:

- Provide a list of the major benefits and costs associated with smart metering
- Allow different implementation scenarios to be examined so that the financial implication of different options could be examined (smart meters with and without real-time displays).
- Identify reasonable input values that could be used in smart metering cost benefit analyses.
- Provide a means to identify the interplay of costs and benefits between stakeholders depending on which benefits are included and how the different energy markets are organized.
- Including environmental and social costs and benefits in the evaluation of smart metering systems
- Evaluate the effects of different categories of smart metering energy services – according to some predefined parameters.

The tool consists of two versions – a simplified and an extended version.

The simplified version (SmartRegions Tool) is focusing on electricity meters only, and the extended version includes calculations related to gas, heat and water meters.

The SmartRegions tool is translated into 8 different languages.

2 Scope of the Cost/Benefit analysis

Creating benefits from the extensive investments of smart meters to a major part of the end users throughout Europe depends on the cost effective roll out of equipment and the success of creative and innovative energy services aiming at changing the use of electrical energy to the best for the society.

Smart metering technology is a powerful enabler with its potential highly dependent on how the technology is utilized by utilities and supported by their regulators. It is important to note that the instalment of the new meters doesn't create *per se* any benefits for others than the DSOs who are reducing the meter reading and fraud cost considerably (and for many DSOs these costs are quite low today). This means that considerable efforts need to be allocated to the development and promotion of new products and services leading to adaptive consumption dependent on the actual conditions of the energy generation and power transfer and motivation for general energy conservation.

Active contribution from many actors is needed in order to achieve the wanted outcome. Positive cost benefit for all parties is needed in order to create and maintain sound businesses. The big challenge seems to be to manage the allocation of the most evident benefits related to environmental and other socio economic impacts to the actors involved. The economic incentives motivating customers for the wanted changes in energy consumption are key factors in this context.

The new smart meters are read automatically and make it possible to reduce the sampling interval considerably compared to older meter technologies. This means that for many customers cost reductions will be possible by adapting to real time prices, provided that the billing includes comparable resolution of the price signals.

Figure 2.1 illustrates an example of how the socio economic benefits can be transformed to price incentives for end users in the Norwegian market environment

The example is based on the Norwegian deregulated power market where the electricity price signal made available to the customers consists of an energy part (market-driven price) and a network part (monopoly, power system infrastructure-driven price). Subsidies and direct funding can also be included.

Development of the different price signals are regulated at the authority level. The Regulator gives directives to the monopoly part (Distribution System Operators) and the market participants are regulated by the Competition Authority. The different stakeholders develop their price signals to the customers according to the respective regulations.

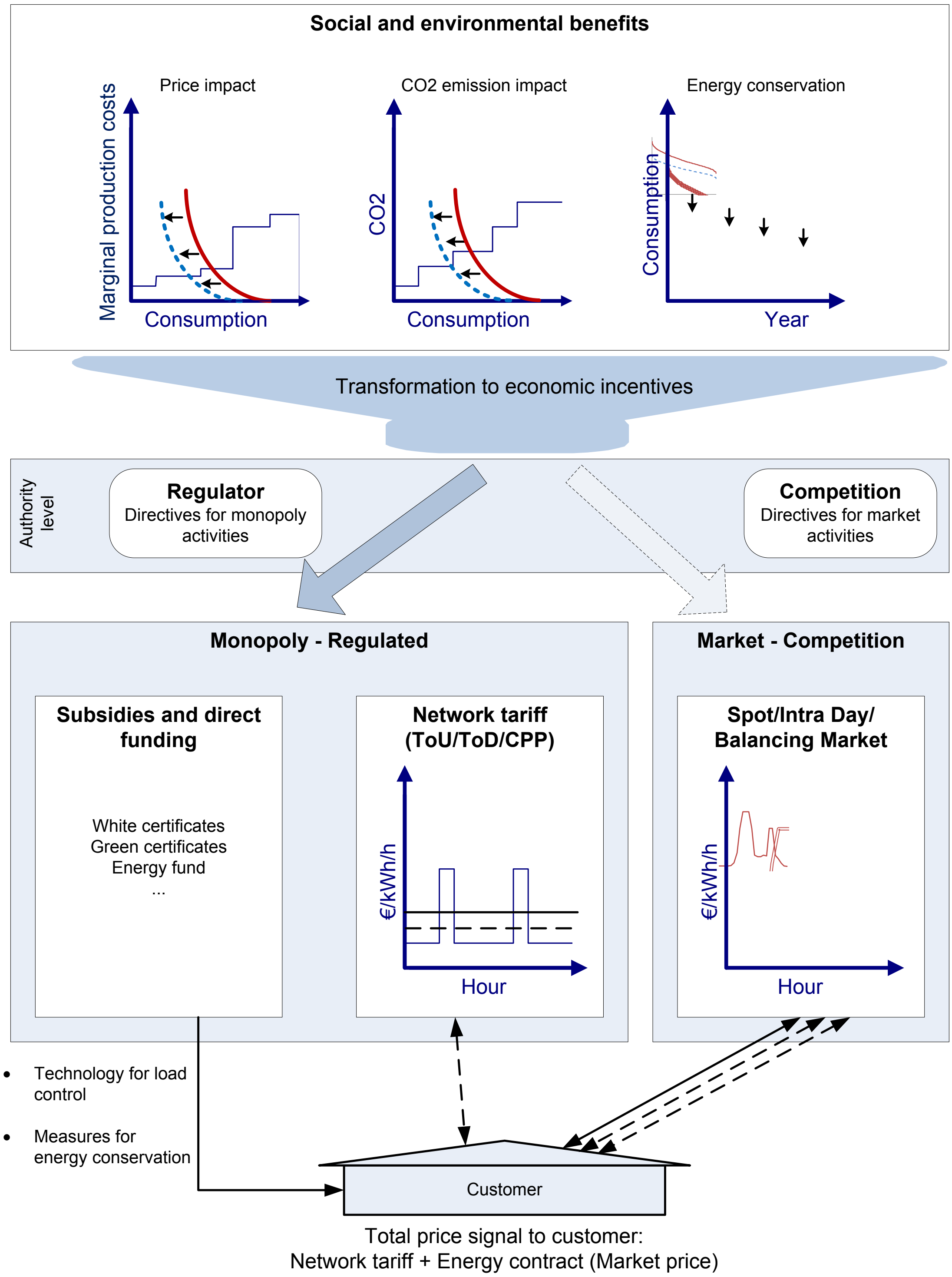

Figure 2.1 Transforming social and environmental benefits into the customers' price signals [SINTEF]

Implementation of smart metering technology involves complex interactions that may generate many new sources of benefits. The interaction of technology and behaviour customer response requires changes in how utilities analyse the investments to ensure that all the potential benefits are recognized [2].

According to [3] the benefits from the introduction of smart energy meters (including the communication infrastructure), can be divided into five categories:

1. *Reduction of the cost-to-serve*. Reduced meter reading costs, ability to quickly generate an accurate bill, prevention of fraud and non-payment etc.

2. *Energy savings*. Savings through direct feedback regarding the energy consumption or trough demand response.

3. *Improved functioning of several market mechanisms*. It can become easier to switch supplier, more efficient handling of customer complaints, customer retention through improved service provision, real-time pricing, time-based tariff structure, additional services etc.

4. *Increase in the security of supply*. More reliable grid design and more efficient operation of the grids, easier detection and analysis of fault, shorter outage times etc.

5. *Promotion of the implementation of a smart meter infrastructure*. More intelligent use of the energy infrastructure, development of new services, decentralized energy generation and more optimized charging of electric vehicles.

An example of a societal cost benefit analysis performed for the Netherlands is presented in [4]. The results of this analyses is that the largest benefits are energy savings for consumers, reduced costs because of more transparency in the market and less costs for handling complaints at the energy suppliers. The largest costs are related to the smart meters and communication infrastructure, and to the cost for the feedback (monthly) to the consumers. Nevertheless, it is specified that this societal cost-benefit analysis is performed for the whole country, and is therefore not comparable with a survey conducted for an individual market player.

A framework for identifying the potential benefits from smart metering is presented in [2]. The framework contains a categorization that achieves the following:

- Captures all sources of benefits but avoids double counting of benefits.

- Recognizes the distributed nature of benefits and accommodates identification by customer class or other distinction.

- Groups the benefits according to how they are measured, in such a way that estimation algorithms can be derived.

- Provides a means for monetizing the benefits.

The framework is presented in Figure 2.2. It accommodates mapping of the benefits commonly attributed to smart metering. Because the primary benefits (power related investments and electrical energy consume reductions, reduced outages, lower emissions from generating electricity) are evaluated in different ways, it is necessary to find a way of translating these benefits into monetary terms. The first four benefit sources constitute directly attributable benefits and the last two are collateral benefits, as indicated by the dashed lines in the figure.

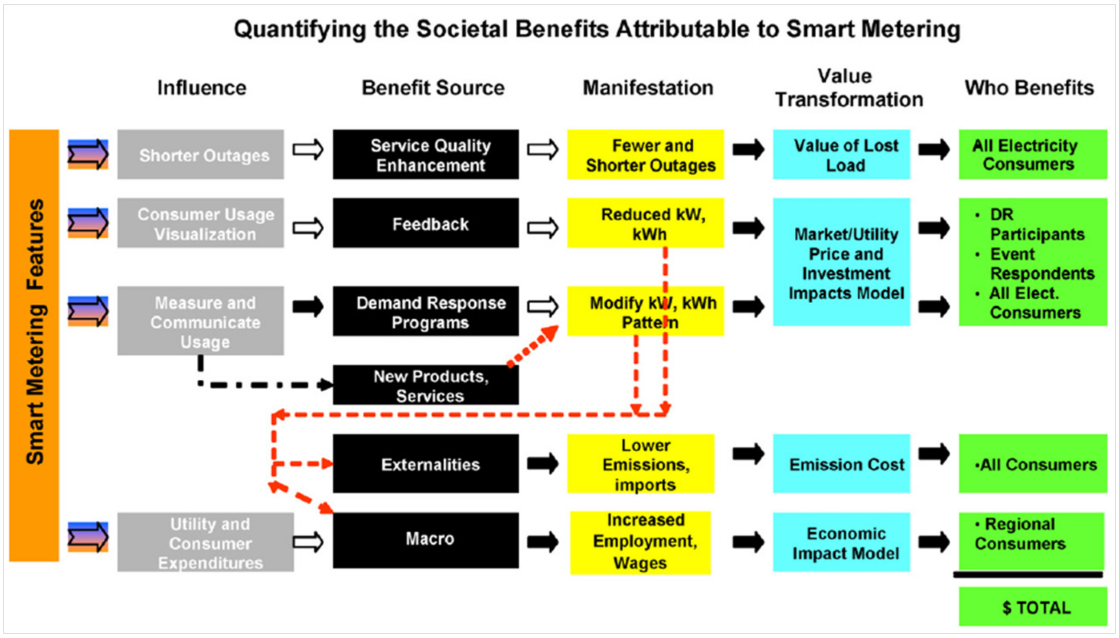

Figure 2.2 Source and Measurement of Societal Benefits [2]

Traditional cost/benefit analysis attempts to calculate the monetary values of potential effects (cost or benefit), and reduces the analysis to a single dimension [5]. A weakness of this method is that economic values may be inappropriate in many cases, but an advantage is that specifying costs and benefits into a single dimension gives a result expressed in a single parameter.

Including more dimensions into the analysis such as CO2 emission and energy efficiency, makes a multi-dimensional analysis and is able to promote a holistic approach to the energy consume.

Several cost/benefit analyses have been performed when evaluating new smart metering technology. Examples of what such analyses include are changes in demand, operational efficiency (reduction in operating costs for distribution and retail businesses) and improvements in service quality (distribution and retail) [6].

The main cost/benefit items discussed in [3] are energy savings by consumers, savings on customer service costs, efficiency improvements as a result of the number of supplier switches and savings on the meter reading costs.

A tool is developed in attempt to structure the different parameters included in the calculations of the benefits for both smart meters and smart metering services. The calculations are related to economic, social and environmental costs and benefits.

3 Description of SmartRegions tool

The tool will calculate the cost/benefit based on a number of input variables – independent of the actual country of application. This makes it a Europe wide applicable tool with the possibility to perform several calculations for different countries by changing the input variables.

The objective of the tool is to calculate the economic, social and environmental aspects related to installation of smart meters for electricity and new smart metering services for the different energy carriers. An illustration of the work related to the SmartRegions tool is presented in Figure 3.1.

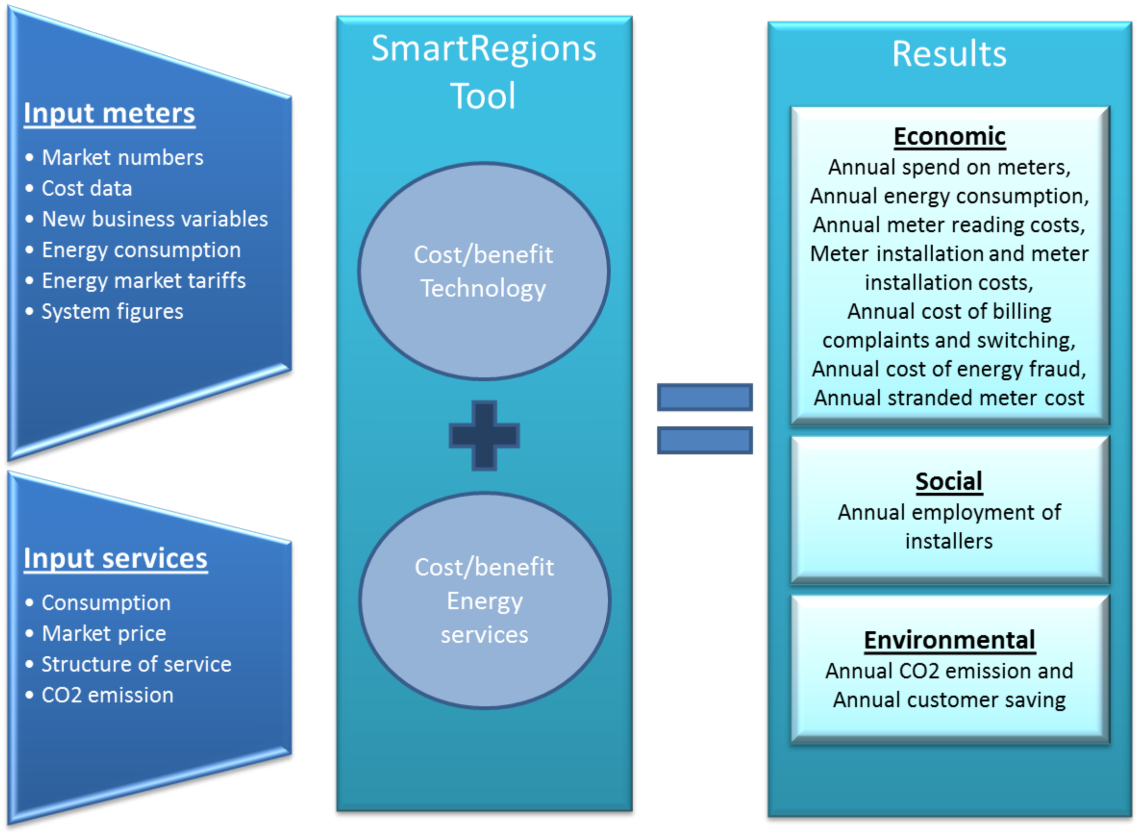

Figure 3.1 The structure of the tool - with input data and results

The tool is developed in a simple and an extended version. The extended version of the tool contains calculations for electricity, gas, heat and water meters. The simplified version is focusing on electricity only.

The description in this chapter is dedicated to the simple version. In the chapter related to the extended version the differences from the simple version are explained.

The simple version of the tool is focusing on smart meters and new smart metering services related to electricity. This version is translated into eight different languages: English, Norwegian, Dutch, Spanish, German, Finnish, Polish and Romanian.

The tool is developed as an Excel-file, with several sheets for information, input data and results.

The following sheets are implemented in the simple tool:

- Introduction – information about the tool. Selecting country, region and customer type for which the calculations should be performed.
- Input_variables – Input to the calculations regarding deployment of smart meters. Definition of the stakeholders involved.
- Input_Load and prices – Load curves and market prices (hourly values)
- Input&Result services – Input variables for calculations of the different smart metering services.
- Cost_Benefit meters – graphs with results from the calculations.
- Stakeholder Results_metering – graphs with results from calculation of benefits for stakeholders involved.

A general structure of the tool is that yellow cells are to be filled in by the user (or selected from a drop-down list in the specific cell). The other cells should not be changed.

3.1 "Introduction" sheet

On the introduction sheet it is possible to select a country for which the calculations should be performed. When selecting a country, the specific language will be selected and estimated input values for that country will be presented in the "Input_Variables" sheet (See chapter 3.2). The flags indicate the countries from which the estimated input variables are specified.

It is important to check the relevance for the respective country/area and the quality of the input data thoroughly since the quality of these data highly influences the results.

The introduction page is presented in Figure 3.2.

Figure 3.2 Introduction sheet of the simple tool

A drop-down list is specified in each of the yellow cells. The drop-down list in the yellow cells is only visible when the cell is selected.

3.2 "Input_Variables" sheet

The SmartRegions tool calculates the costs/benefits related to deployment of smart metering technology for electricity. The input variables related to this is specified in the "input_Variables" sheet.

The maximum number of years to be included in the model is set to 30, and the user is free to define the number of years for rollout of the meters (up to 30 years). Net Present Value (NPV) for any given period up to 30 years can be obtained.

The different input variables are according to the following categories:

- Market numbers (Information about the country the calculations are valid for)
- Cost data (meters, communication infrastructure and employment)
- New business variables (Income from additional services)
- Energy consumption (Energy consumption for the customers included in the calculation, and estimated energy efficiency due to new services – with direct or indirect feedback to the customers regarding their own electricity consumption.)
- Energy market tariffs (Tariff related to generation, transmission and distribution)
- System figures (Estimated efficiency in percentage for different tasks)

The input variables are presented in Appendix 2.

When selecting a country in the "Introduction" sheet, estimated values for that country are presented in the "Default values" column. If the user wants to use these values in the calculations, the values should be copied to the yellow cells. Only the values in the yellow cells are used in the calculations.

Definition	Units	Value		Notes/Source
Market numbers				
Year of model	years	30	Default values	Maximum number of years modelled - NPV for any given period up to 30 years can be obtained in the Stakeholder Results worksheet
Currency unit used in model		Euros	Euros	
Discount rate	%	10 %	10 %	The figure reflects a market rate for money and could be lower if a monopoly business were doing the analysis
Total number of electricity customers - year 0	integer	2.70E+07	27000000	
Annual increase in number of electricity customers	%	1.00 %	1 %	Assumption
Market share of electricity prepayment meters (constant for all meter types and years of model). Set to 0.0 to neglect prepayment	%	25 %	25 %	
Total number of years to roll_out_all meters	years	10	10	Comparable period to UK, Dutch, and other national plans
Number of years to ramp up rate to full annual installation rate	years	2	2	Could be shorter with mature technology, reasonable if including testing
Expected service life of simple electricity meters	years	20	20	
Maximum service life of smart electricity meters	years	16	16	Assumption
Probability factor for replacement of smart electricity meters	#	0.6	0.6	Estimate chosen to smooth meter replacement programme
Cost Data				
Cost of a simple electronic credit electricity meter	Euros	11	11	Assumption
Cost of a simple electronic prepayment electricity meter	Euros	66	66	Assumption
Cost of a credit electricity meter (smart meter)	Euros	63.8	63.8	Assumption
Cost of a prepayment electricity meter (smart meter)	Euros	63.8	63.8	Assumption
Cost of customer display - there is assumed to be one customer display for each smart electricity meter.	Euros	16.5	16.5	
Cost of GSM module for smart meter	Euros	16.5	16.5	Assumption
Cost of PLC module for smart meter	Euros	5.5	5.5	Assumption
Cost of data concentrator	Euros	467.5	467.5	Assumption
Volume discount figure – the cost of smart meters are assumed to fall according to the equation: (1/LN((yrn-1)/mtr_cst_red_fact))^0,4	real	5 %	5 %	This gives a cost reduction of 50% over the first 5 years
Annual inflation rate	%	2 %	2 %	Assumption

Figure 3.3 Input variables

The tool is as flexible as possible regarding to the different organisations of the electricity business in European countries. A number of costs and benefits can be allocated to different parties depending on the regulatory or market conditions in a given country. To allow the model to deal with these circumstances, table presented in Figure 3.4 is provided [1]. The user is able to choose which stakeholder is related to which cost and benefit. This allows three different scenarios to be modelled:

1. A vertically bundled market where the RESC is responsible for all aspects of metering as well as operation of the low voltage (LV) network

2. A market split between the energy retail company and the DSO

3. A fully unbundled market where metering has been contracted to independent service providers

The Stakeholders are:

- Retail energy supply company (RESC)
- Distribution system operator (DSO)
- Meter asset provider (MAP)
- Meter operator (MOP)
- Data collector (DC)

	Stakeholder
Cost	
Meter provision	DSO
Meter installation, operation and maintenance	DSO
Meter data collection, mdms system	DSO
Benefit	
Better response to customer complaints	DSO
Reduced cost of LV network	DSO
Meter management	DSO
Energy purchase	RESC
Reduced cost of switching	DSO
White certificates	

Figure 3.4 Specification of stakeholders

The worksheet "Stakeholder Results_ID_DF" provides graphs showing the relative costs and benefits for each of the stakeholders.

The model does not attempt to reconcile the overall business positions of the different stakeholders. The fact that, for example, in an unbundled market the Meter Asset Provider (MAP) is responsible for the cost of the meters but does not receive any benefits is a reflection of reality. It is necessary for (probably) the RESC or DSO to cover the costs of the MAP in a separate commercial arrangement.

3.3 "Input_Load and prices" sheet – load profiles and market prices

The benefits of different *smart metering energy services* are related to an assumed load profile and the estimated changes in the consumption due to different predefined smart metering services.

In the simplified tool the benefits of different smart metering services are based on changes in predefined load curves for households, office buildings and others. The data within the "own data" category can be changed by the user (yellow cells).

In the sheet "Input_Load and prices" there are different predefined load curves for different customer categories in the regions Northern Europe, Central Europe and Southern Europe (See Figure 3.5). The market prices are hourly values for a whole year.

Hourly load curves for one day

The user of the tool can perform calculations based on some predefined profiles, or implement other load curves in the "Other" category

	[kWh/h]	[kWh/h]	[kWh/h]		[kWh/h]
		Northern Europe			
Hour	**Household**	**Office Building**	**Own data**	Hour	**Household**
1	2.54	111.85	Not implemented	1	0.26
2	2.44	107.13	Not implemented	2	0.20
3	2.42	106.38	Not implemented	3	0.18
4	2.41	112.67	Not implemented	4	0.17
5	2.46	125.56	Not implemented	5	0.18
6	2.56	123.88	Not implemented	6	0.21
7	2.84	149.51	Not implemented	7	0.37
8	3.04	210.08	Not implemented	8	0.52
9	2.99	281.42	Not implemented	9	0.55
10	2.91	301.32	Not implemented	10	0.54

Figure 3.5 Input data for load curves

The level of the load curves is adjusted according to the yearly energy consumption specified in "Input_Variables". The calculations can only be performed for one customer group at a time.

3.4 "Input&Result services" - Implemented smart metering energy services

When using the tool the number of customers in action is specified for each case. This implies that the calculations can be performed for a single customer, a group of customer or all the customers in a country. The calculations related to the effect of different services are based on the predefined input load pattern. The load pattern should represent the consumption for the number of customers in question. The benefits are a result from estimated demand response according to the different smart metering services.

This chapter describes the different types of typical smart metering energy services implemented in the SmartRegions tool. The different services are made flexible, which means that the user of the tool can analyse their own services according to different input variables.

The implemented services are:

- Indirect feedback (IF)
- Direct feedback (DF)
- Time-of-Day Day and Night Tariff (ToDDN)
- Real Time Pricing (RTP)
- Balancing Services / Direct load control (BS)

The different smart metering services can not be combined.

Initial values (Calculated based on values specified for cost/benefits)	Units	Electricity	Description
CO2 Day period start	integer	8	Start hour of the day period with CO2 defined from production
CO2 Day period stop	integer	20	Stop hour of the day period with CO2 defined from production
Fixed annual fee	Euros/year	300	Fixed annual fee per year. A yearly value in monetary terms
Energy fee per kWh	Euros/kWh	0.121	The energy fee per used energy unit (kWh) - in actual monetary terms
Connection fee per month	Euros/month		The connection fee in monetary terms per month
CO2 emission from production day	tonCO2/kWh	2	Specify the CO2 emission from the production of energy during the night
CO2 emission from production night	tonCO2/kWh	1	Specify the CO2 emission from the production of energy during the day

Indirect Feedback (IF)	Units	Electricity	Description
Average reduction	%	3 %	Energy savings due to service

Direct Feedback (DF)	Units	Electricity	Description
Average reduction	%	4 %	Energy savings due to service

ToD Tariff Day/Night (ToDDN)	Units	Electricity	Description
Day-period start	integer	8	The start hour of the day period (hour 1 starts at 00:00)
Day-period stop	integer	16	The stop hour of the day period
Reduced load during day period	%	30 %	% energy reduction during day period
Increased load during night period	%	50 %	% of energy reduced during day period that will be used during night period. If 100% no energy saving is achieved.
Fixed annual fee	Euros/year	400	Fixed annual fee per year. A yearly value in monetary terms
Energy fee day per kWh	Euros/kWh	0.121	The energy fee during the day per used energy unit (kWh) - in actual monetary terms
Energy fee night per kWh	Euros/kWh	0.121	The energy fee during the night per used energy unit (kWh) - in actual monetary terms
Connection fee per month	Euros/month		The connection fee in monetary terms per month
CO2 emission per kWh day	tonCO2/kWh	2	The CO2 emission per produced kWh/h during the defined day period
CO2 emission per kWh night	tonCO2/kWh	1	The CO2 emission per produced kWh/h during the defined night period

Real Time Pricing (RTP)	Units	Electricity	Description
Load shift from day to night (energy)	%	20 %	Reduced consumption in peak price hours. If the percent value is set to zero, no reduction in consumption is achieved due to the price
Fixed annual fee	Euros/year	400	Fixed annual fee per year. A yearly value in monetary terms
Connection fee per month	Euros/month		The connection fee in monetary terms per month
CO2 emission average production	tonCO2/kWh	1.5	CO2 emission in average per produced energy unit

Balancing services / Direct load control	Units	Electricity	Description
Start hour for disconnection	integer	8	Specify the hour when disconnection starts.
Hour for reconnection of load	integer	10	Specify the hour when reconnection is performed.
Reduced load during disconnection	%	20 %	Percentage reduced load in disconnection period.
Increased load when reconnecting	%	10 %	Percentage increased load in the hour when reconnection is performed.
Fixed annual fee	Euros/year	400	Fixed annual fee per year. A yearly value in monetary terms
Energy fee day per kWh	Euros/kWh	0.121	The energy fee during the day per used energy unit (kWh) - in actual monetary terms
Energy fee night per kWh	Euros/kWh	0.121	The energy fee during the night per used energy unit (kWh) - in actual monetary terms
Connection fee per month	Euros/month		The connection fee in monetary terms per month
CO2 emission per kWh day	tonCO2/kWh	1.2	The CO2 emission per produced kWh/h during the defined day period
CO2 emission per kWh night	tonCO2/kWh	1	The CO2 emission per produced kWh/h during the defined night period

Figure 3.6 Smart metering energy services implemented in SmartRegions tool

The benefits calculated from the different services are:

- Reduced energy consumption (kWh/year) (*Environmental criteria*)
- Reduced CO2 emission (tonnCO2/year) (*Environmental criteria*)
- Reduced cost for the customer(s) (Euros/year) (*Economic criteria* – due to reduced costs/*Social criteria* – Implications on standard of living)

The benefits are calculated by comparing initial costs for the initial consumption with the changed consumption and the new price structure. A positive change corresponds to a reduction of the considered variable (for example costs) and a negative change reflects an increase of costs.

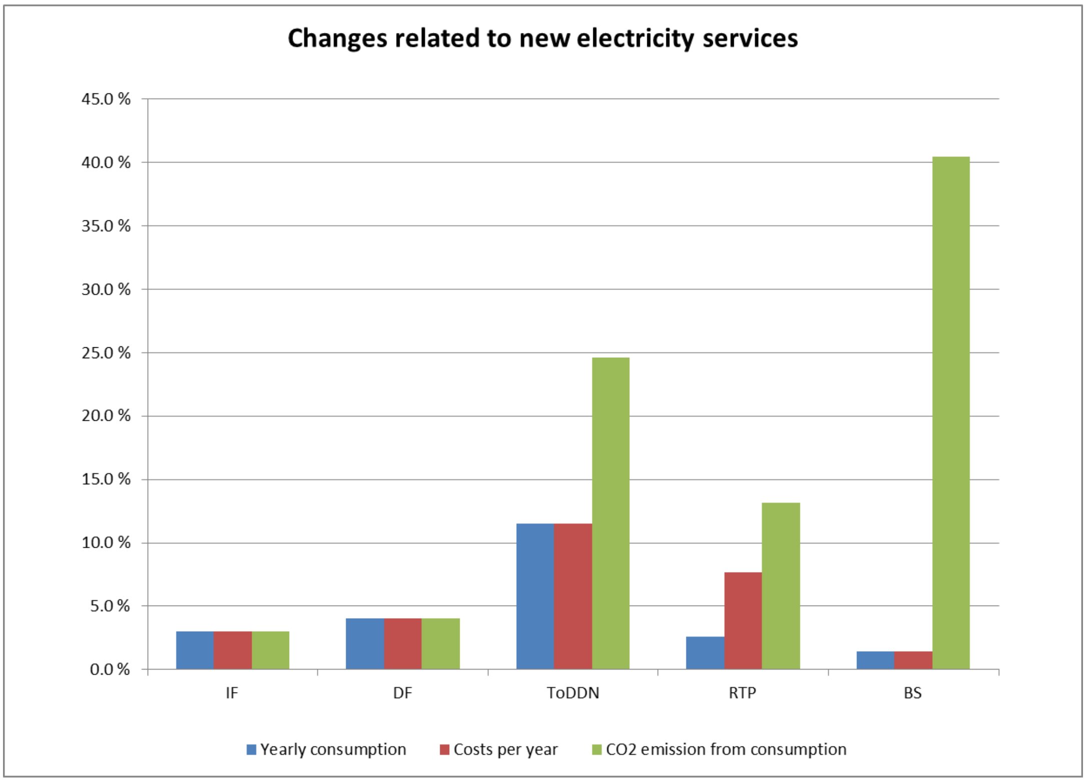

Figure 3.7 Example of calculated benefits

The calculated benefits are the benefits from the changes in consumption for the number of customers included in the analysis. These calculations do not include the costs related to deployment of the meters or the development/maintenance of the actual smart metering services.

3.4.1 Initial values

The main initial data are related to energy consumption, the energy price and the CO2 emission both from production and consumption of energy.

CO2 emission from energy production

The average CO2 emission in [tonnCO2/kWh] is specified for the production of electricity during day and night. The user of the tool can specify when the day and night period occurs. This is done by specifying the start and stop hour of the day period.

Input variables to be specified:

- CO2 Day period start
- CO2 Day period stop
- CO2 emission from production day [tonnCO2/kWh]
- CO2 emission from production night [tonnCO2/kWh]

If the start and stop of the day period is not defined, the CO2 emission from production during night is used in the calculations. If the start is specified as “1” and stop is specified as “24” only the CO2 emission from production during the day is used in the calculations.

Energy price

The price of electricity is divided in three parts. The first part is a fixed annual fee per year, which represents a yearly value in monetary terms. The second part is an energy fee per energy unit (kWh or m^3) and the third part is a montly connection fee. If a part should not be included in the calculations, the value is set to “zero”.

Input variables to be specified:

- Fixed annual fee per year. A yearly value in monetary terms.
- The energy fee per energy unit (e.g. €/kWh or €/m^3) - in actual monetary terms.
- The connection fee in monetary terms per month.

3.4.2 Indirect Feedback (IF)

In Indirect Feedback customers receive information about their usage from their bills or other feedback mechanisms. Information is historical.

Input variables specified for the IF ("Input_Variables" sheet):

- Average reduction per year (%)

The energy reduction is a percentage reduction of the consumption every hour – or in average for a selected period. The calculations use the same CO2 values and energy costs as those specified for the initial calculations, since the "Indirect Feedback"-service gives smart metering and updated information about the consumption – with no new price incentives.

3.4.3 Direct Feedback (DF)

Direct Feedback is similar to “Indirect Feedback” except that the customers are provided with a real or near real time feedback display. It is assumed that this scenario is in addition to “Indirect Feedback”, customers will continue to receive more informative bills in addition to their in-house display feedback [1].

Input variables specified for the DF ("Input_Variables" sheet):

- Average reduction year (%)

The energy reduction is a percentage reduction of the consumption every hour – or in average for a selected period. The calculations use the same CO2 values and energy costs as specified for the initial calculations, since the "Direct Feedback" service gives smart metering and updated information about the consumption – with no new price incentives.

3.4.4 Time-of-Day Day - Night tariff (ToDDN)

The ToD Day-Night Tariff has a peak price period during the day and a lower price period during the night. The start and stop of the peak price periods can be defined by the user. (According to the load curve and regulations in the selected country, in a similar way as used for the definition of the CO2 emission periods in the initial calculations - see chapter 3.4.1.)

Input variables to be specified for the ToD Day-Night tariff:

- Day-period start. The start hour of the day period (hour 1 starts at 00:00)
- Day-period stop. The stop hour of the day period
- Reduced load during day period. % energy reduction during day period
- Increased load during night period. % of energy reduced during day period that will be used during night period. If 100% no energy saving is achieved
- Fixed annual fee
- Energy fee day per kWh
- Energy fee night per kWh
- Connection fee per month
- The CO2 emission per produced kWh/h during the defined day period
- The CO2 emission per produced kWh/h during the defined night period

An illustration of how to use the different input variables for the ToD Day-Night tariff is presented in Figure 3.8.

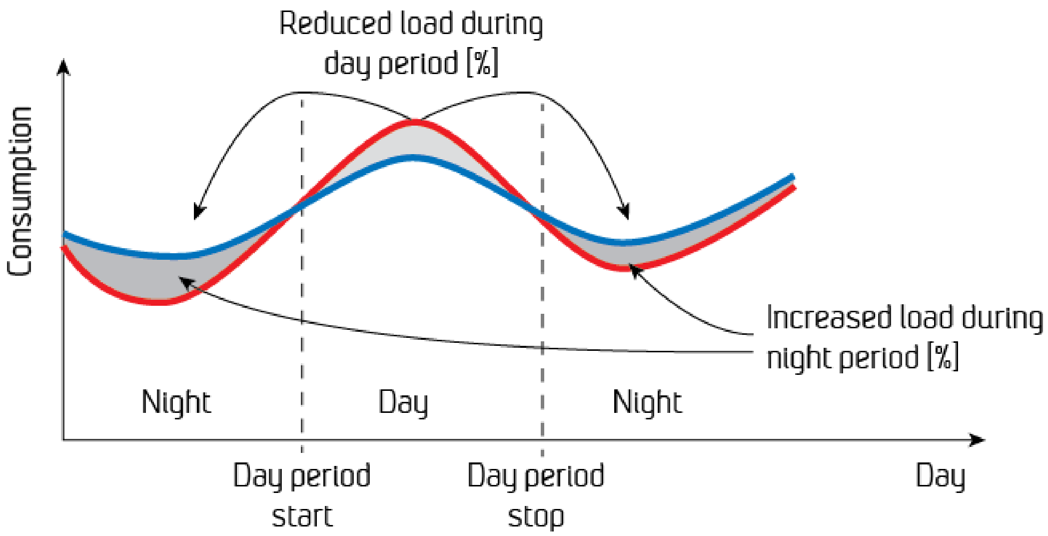

Figure 3.8 Illustration of the ToD Day-Night tariff

3.4.5 Real Time Pricing (RTP)

The Real Time Pricing tariff gives the customer the hourly market price for the energy. With this service it is assumed that technology for load control in the peak price hour is available. A percentage reduction in this hour can be set. If the percentage is set to zero, the consumption is not reduced due to the price.

Input variables to be specified for the RTP tariff:

- The hourly market price (energy fee per energy unit). Defined in “Input Load and Services”. If hourly prices are not available, an hourly profile with average values should be calculated. The values are specified in €/kWh for each hour of the 8760 hours.
- The reduced consumption (%) in the peak price hours. If the percentage value is set to zero, no reduction in consumption is achieved due to the price.
- Fixed annual fee
- Connection fee per month

3.4.6 Balancing services / Direct load control (BS)

With the balancing services an amount of demand is disconnected for some hours via smart metering technology and the possibility for remote load control. The first hour of both disconnection and reconnection are specified. The CO2 emission from production of energy in both the connection and disconnection periods is specified.

An example of a balancing service with the reduced consumption during disconnection (load control period) and the increased consumption during reconnection is presented in Figure 3.9. The load curve is the average load curve for a Norwegian household customer.

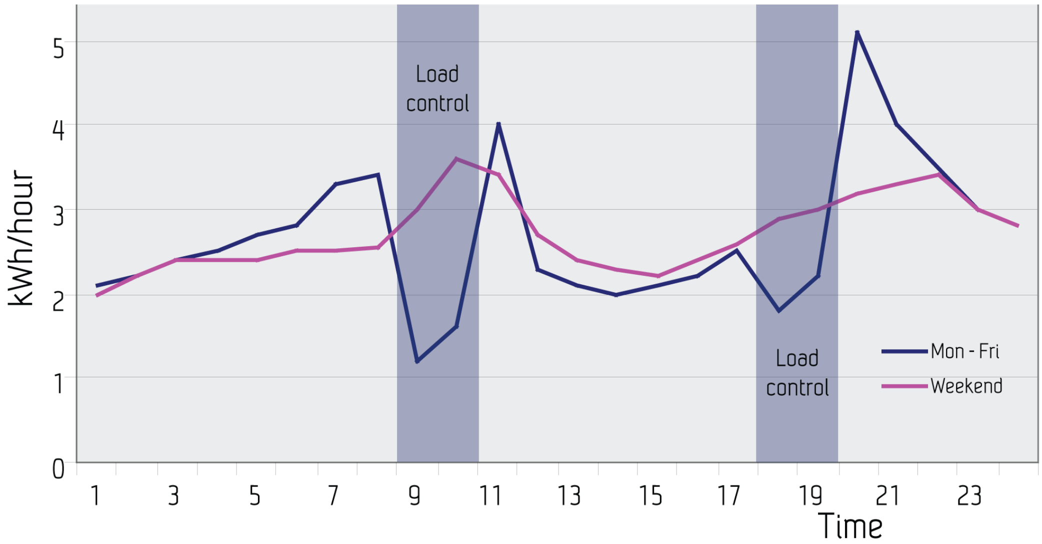

Figure 3.9 Example of a balancing service for a household customer [7]

Input variables to be specified for the BS tariff:

- Start hour for disconnection. Specify the hour when disconnection starts.
- Hour for reconnection of load. Specify the hour when reconnection is performed
- Reduced load during disconnection. Percentage reduced load in disconnection period
- Increased load when reconnecting. Percentage increased load in the hour when re-connection is performed
- Fixed annual fee per year. A yearly value in monetary terms
- Energy fee day per kWh. The energy fee during the day per used energy unit (kWh) - in actual monetary terms
- Energy fee night per kWh. The energy fee during the night per used energy unit (kWh) - in actual monetary terms
- Connection fee per month. The connection fee in monetary terms per month
- CO2 emission per kWh day (tonnCO2/kWh). The CO2 emission per produced kWh, hourly sampled during the defined day period
- CO2 emission per kWh night (tonnCO2/kWh). The CO2 emission per produced kWh, hourly sampled during the defined night period

3.5 "Cost Benefit Indicators" sheet

In the tool the benefits are not calculated directly, but rather the costs to provide metering and other relevant services are calculated for three different scenarios: “Business as usual” (BAU), “Indirect Feedback" (IF) and “Direct Feedback” (DF). The cost/benefit analysis is carried out by comparison of the costs of the different scenarios.

Because of differences in the organisation of the business in each country, it is important to evaluate the specific benefits for each stakeholder.

The economic, social and environmental indicators related to deployment of new smart meters for electricity calculated with the tool, are presented in Figure 3.10. A description of how the criteria are calculated is presented in Table 3.1 and an example of a graph illustrating the indicator "Annual spend on meters" is presented in Figure 3.11.

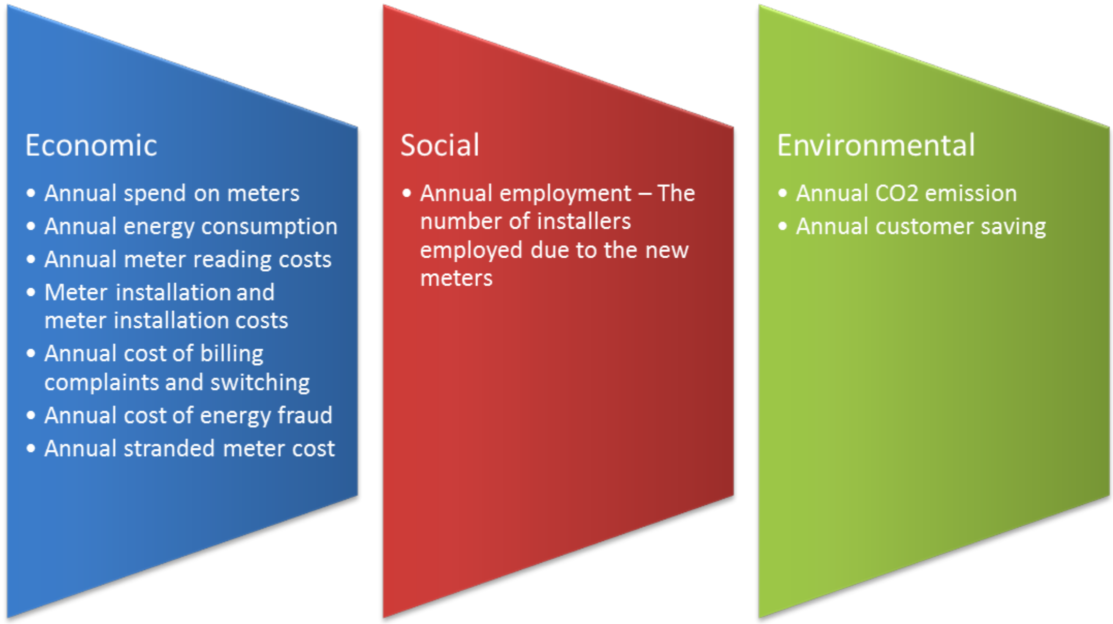

Figure 3.10 Cost Benefit indicators calculated

Table 3.1 Calculations of indicators

Economic	
Annual spend on meters	= Cost of credit electricity meters + Cost of pre-payment electricity meters + Cost of displays + Cost of GSM modules + Cost of PLC modules + Cost of PLC concentrators
Annual energy consumption	= Energy consumption registered by simple electricity meters + Energy consumption registered by Smart electricity meters

Annual meter reading costs	= Annual cost of manual reading of the electricity meters + Annual cost of acquiring data from smart electricity meters with PLC modules + Annual cost of acquiring data from smart electricity meters with GSM communication
Meter installation and meter installation costs	=Total annual cost of simple electricity meter installation + Total annual electricity meter maintenance costs
Annual cost of billing complaints and switching	= Total cost of electricity meter billing complaints (BAU) + Total cost of electricity customer switching their energy provider (BAU)
Annual cost of energy fraud	= Cost of electricity fraud for simple customers + Cost of electricity fraud for customers with smart meters
Annual stranded meter cost	Stranded cost of credit electricity meters + Stranded cost of pre-payment electricity meters = Number of old credit electricity meters replaced * Cost for simple credit electricity meter * ((1- Average age of legacy electric meters in year n / Expected service life of simple electricity meters)) + Number of old pre-payment electricity meters replaced * Cost for simple credit pre-payment electricity meter * (1-(Average age of legacy electric meters in year n / Expected service life of simple electricity meters))
Social	
Annual employment of installers	= Number of electricity meters installers + Numbers of PLC concentrators installers = Number of days used for installation of electricity meters / Working days per year + Number of days used for installation of PLC concentrators / Working days per year
Environmental	
Annual CO2 emission	= Overall energy consumption * CO2 emission from consump-tion (per year)
Annual customer saving	=Total electricity charge with simple credit meters - Total electricity charge due to new smart meters (with indirect or direct feedback)

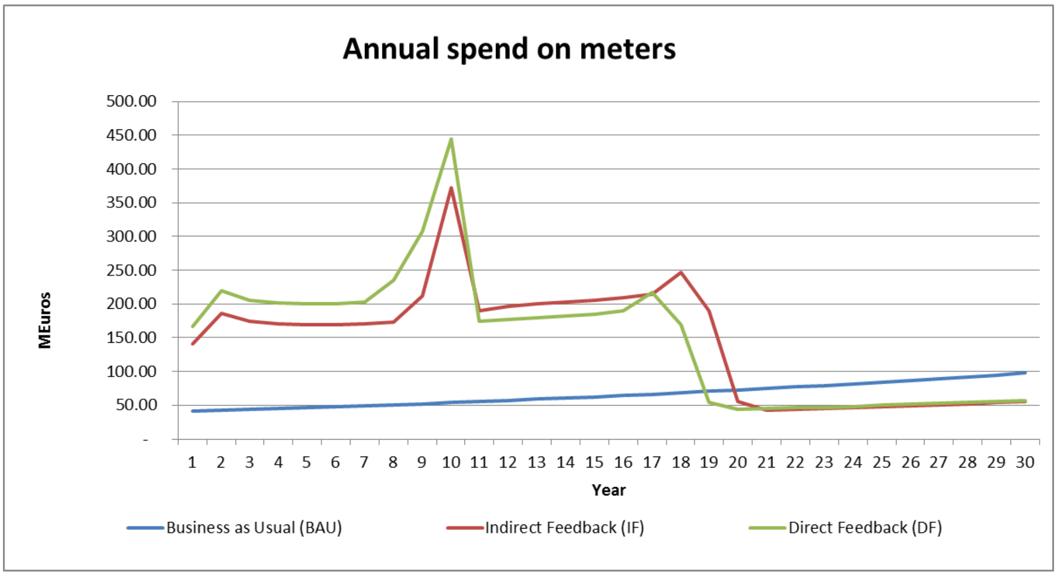

Figure 3.11 Cost/Benefit indicator related to "Annual spend on meters"

3.6 "Stakeholder Results_IF_DF" sheet - Actors and functions involved

Because the organisation of metering is different across Europe, it is difficult to make a general tool including all the alternatives. Costs and benefits are calculated for some predefined functions, and by allocating the responsibility for these functions to the correct stakeholder (in "Input_Variables" sheet – chapter 3.2), the costs and benefits for the relevant stakeholders are calculated. An example is presented in Figure 3.12.

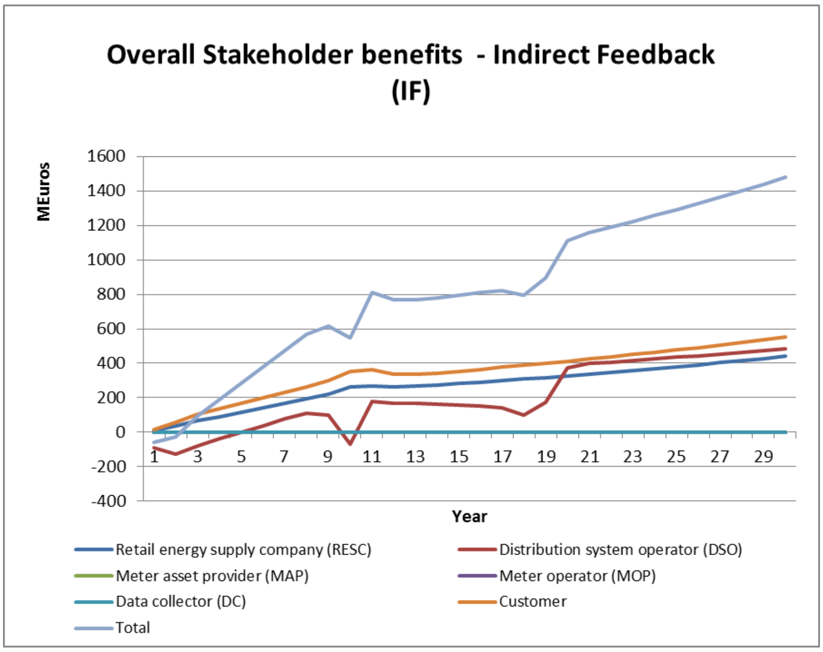

Figure 3.12 Example of benefits calculated for the Indirect Feedback services and stakeholders involved

The functions implemented in the tool are presented in Table 3.2 and Table 3.3.

Table 3.2 Calculation of cost functions

Cost functions	**Calculations**
Meter provision	= Cost of smart credit electricity meters + Cost of smart pre-payment electricity meters + Cost of GSM modules + Cost of PLC modules + Cost of PLC concentrators
Meter installation, operation and maintenance	= Annual cost of electricity smart credit meter installations + Annual cost of electricity smart pre-payment meter installations + Annual cost of PLC concentrators installations + Annual cost of simple credit electricity meter replacements + Annual cost of simple pre-payment electricity meter replacements + Annual cost of smart credit electricity meter replacements + Annual cost of smart credit pre-payment electricity meter replacements
Meter data collection, meter data management system (MDMS)	= Annual cost of manual reading of the electricity meters + Annual cost of acquiring data from smart electricity meters with PLC modules + Annual cost of acquiring data from smart electricity meters with GSM communication + Costs for meter data management system

Table 3.3 Calculation of benefit functions

Cost functions	**Calculations**
Better response to customer complaints	= Cost of simple electricity meter billing complaints Cost of smart electricity meter billing complaints
Reduced cost of LV network	= Improvement in operation of the low voltage network * Total electricity consumption of the smart meters * Proportion of the electricity tariff allocated to distribution and metering costs * The average share of costs allocated to Capital and Operation activities * Electricity tariff

Cost functions	Calculations
Meter management	= (simple credit electricity meters + simple pre-payment electricity meters) *(Daily cost of electricity installer / Average number of simple prepayment electricity meters installed per day) * Fraction of meters needing a meter management visit each year based on total meter population)
Energy purchase	= Energy purchase cost for simple electricity meter customers + Energy purchase cost for smart electricity meter custom-ers
Reduced cost of switching	Total cost of electricity customer switching (simple meter) - Total cost of electricity customer switching (smart meter)
White certificates	= (Total initial electricity consumption - Total electricity consumption due to new smart meter) * Financial value of electricity reduction arising from White Certificates.

4 Extended version of the tool

The main difference between the SmartRegions tool and the extended version is that the extended version of the tool is focusing on electricity, gas, heat and water, in a holistic way, while the smart metering services are based on more detailed data (hourly values for one year).

The calculations related to the deployment of smart meters and the evaluation of the smart metering energy services are equal in both versions of the tool.

When introducing other meters than the electricity meters it is assumed that these new meters will use the same communication infrastructure as for the electricity meter. This means that when introducing three new energy carriers in the calculations, not all the different input variables are increased with a factor of three.

The benefits of different *smart metering energy services* are based on hourly load curves for the different energy carriers, for a whole year, which is 8760 values, and the estimated changes in the consumption due to different predefined smart metering services.

The market prices are hourly values for a whole year. The hourly values for both the load and the market prices for electricity, gas, heat and water should be implemented.

The load curve in use should be realistic for the case to be analysed. Dependent on the load level, the curve can represent one single customer, a group of customers (city, distribution area etc.) or a whole country.

When making the load curve, the user should be aware of the possibility that it might not be realistic that all customers agree about a service. A “realistic” load curve might represent the consumption of a proper group of customers.

In [3] the customers and the possibilities for energy savings were grouped as following (Numbers from The Netherlands):

- *Those who are already convinced (25%)*.These customers have introduced energy saving, driven by social responsibility and environmental awareness. The savings potential is average, since this group already have performed actions to save energy.
- *Those who are hard to reach (30%)*. These customers are individualistic, with little environmental awareness and mainly interested in comfort and convenience. Costs play a limited role. The saving potential is low.
- *Those who can be reached (45%)*. These customers have more environmental awareness than previous group, but are cost-conscious. Both the environmentally aware behaviour and the cost-conscious behaviour can be enhanced, and the savings potential is greatest in this group.

If a user does only have access to weekly or monthly values regarding the consumption s/he should calculate them into average hourly values or other estimations, because the calculation of daily changes in consumption is dependent on hourly values. An illustration of the difference between hourly and monthly values is presented in Figure 4.1.

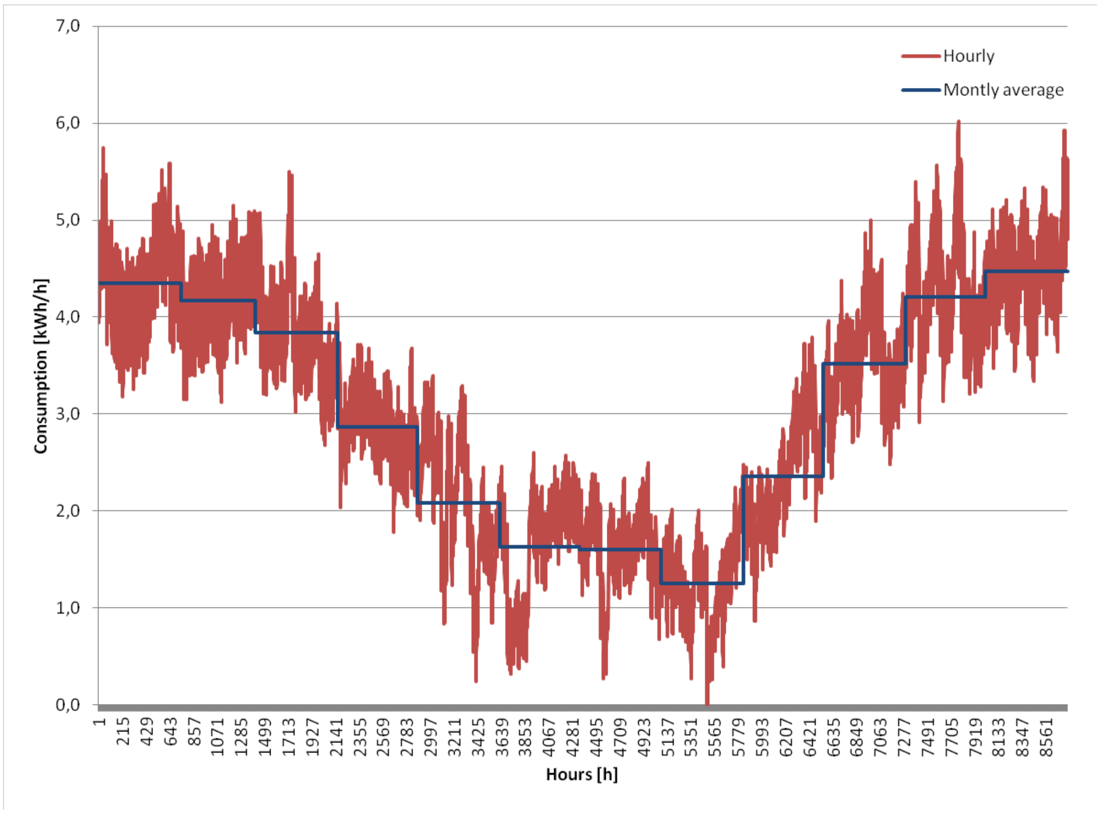

Figure 4.1 Different load curves for hourly and monthly meter data

Real hourly data are important to be able to calculate the benefits of services related to reduced peak load. Monthly average values are not sufficient when calculating ToD Day-Night tariff.

5 Summary

This report describes the SmartRegions tool that aims to support the decision makers, energy utilities and other relevant target groups in their assessment of costs and benefits related to smart meters deployment and improved energy services. The main features of the present tool are based on the cost/benefit tool developed in the ESMA project [1], modified and adapted to the objectives of the SmartRegions project. The tool calculates the cost/benefit for the main actors involved in metering deployment, energy services and the customers, and also the socio economic impacts related to improved energy efficiency, demand response to price and reduction in CO2 emission from power production

The focus is on the simplified version related to electricity, but a description of the differences with the extended version related to electricity, gas, heat and water is included.

The benefits of different smart metering energy services are related to a load profile for the different energy carriers, and the estimated changes in the consumption due to different predefined smart metering services. The different smart metering energy services can not be combined.

It is important to check the relevance for the respective country/area and the quality of the input data thoroughly since the quality of these data highly influences the results.

The following results related to **deployment of new smart meters** for **electricity** are calculated with the SmartRegions tool:

- Economic - Annual spend on meters, Annual energy consumption, Annual meter reading costs, Meter installation and meter installation costs, Annual cost of billing complaints and switching, Annual cost of energy fraud and Annual stranded meter cost
- Social - Annual employment of installers
- Environmental - Annual CO2 emission and Annual customer saving

A simple version focusing on electricity is developed. This is available in 8 different languages. When selecting a country, one also gets the actual language and suggestions of default values for the specific country.

In the simple version the benefits for the different services are calculated based on the selected customer type, region and yearly consumption. In the extended version the benefits for the different services are calculated based on an initial load curve for electricity, gas, heat and water. The benefits are a result from estimated demand response according to the different services. The different smart metering services cannot be combined. The meter communication infrastructure is considered the same for all energy carriers.

The following services are implemented in the SmartRegions tool:

- Indirect feedback (IF)
- Direct feedback (DF)
- Time-of-Day Day and Night Tariff (ToDDN)
- Real Time Pricing (RTP)
- Balancing Services / Direct load control (BS)

The benefits calculated from the different **services** are:

- Reduced energy consumption (kWh/year) (*Environmental criteria*)
- Reduced CO2 emission (tonnCO2/year) (*Environmental criteria*)
- Reduced cost for the customer(s) (Euros/year) (*Economical criteria* – due to reduced costs/*Social criteria* – Implications on standard of living)

The simple and extended version of the tool will be downloadable from the website of the SmartRegions-project: www.smartregions.net

6 References

[1] ”Smart Metering Financial Toolkit”, European Smart Metering Alliance (ESMA), D13, EIE/06/031/S12.448010 – ESMA, www.esma-home.eu

[2] “Societal Benefits of Smart Metering Investments”, Bernard Neenan and Ross C. Hemphill, 2008 Elsevier Inc., The Electricity Journal, October 2008, Vol. 21, Issue 8

[3] “Smart meters in the Netherlands. Revised financial analysis and policy advice”, KEMA, Arnhem, 13 July 2010

[4] “Smart Metering for Households: Cost and Benefits for the Netherlands”, Hans-Paul Siderius, Aldo Dijkstra, SenterNovem

[5] “Extending cost-benefit analysis for energy investment choices”, David Simpson and James Walker, Butterworth & Co Ltd., 1987

[6] “Cost Benefit Analysis of Smart Metering and Direct Load Control: Phase 1 Overview Report”, Report for the Ministerial Council on Energy Smart Meter Working Group, NERA Economic Consulting, www.nera.com, 17 September 2007

[7] “Market Based Demand Response. Research Project summary”, TR A6775, O. S. Grande, H. Sæle, I. Graabak, December 2008, SINTEF Energy Research, www.sintef.no/mabfot/

Appendix 1 Abbreviations

BAU	=	Business as usual
BB	=	Better Billing
BS	=	Balancing Services /Direct load control
DC	=	Data collector
DF	=	Direct Feedback
DSO	=	Distribution System Operator
IF	=	Indirect Feedback
LV	=	Low Voltage
MAP	=	Meter asset provider
MOP	=	Meter operator
RESC	=	Retail Energy Supply Company
RTF	=	Real Time Feedback
RTP	=	Real Time Pricing
ToD	=	Time-of-Day

Appendix 2 Input variables for the simple tool

A2.1 Input variables

There is a large amount of input variables into the tool, and this account for a wide variety of situations. The input variables can be used to re-structure the model, for example it can be made electricity only by setting the number of gas meters to zero [1]. No assumptions are made as to which way smart metering is implemented.

The input variables implemented in the simple tool are presented in the tables below. For the simple tool suggested values for different countries are suggested.

Abbreviations used in the tables are:

BAU = Business As Usual. Metering is left unchanged and the meters are only replaced as they reach the end of their operation.

Indirect Feedback. Customers receive information about their usage from their bills or other feedback mechanisms. The information is historical.

Direct Feedback. Real time feedback is similar to “Better Billing” except that the customers are provided with a real or near real time feedback display. It is assumed that this scenario is in addition to “Better Billing”, customers will continue to receive more informative bills in addition to their in-house display feedback.

Pre-Payment. All scenarios contain the option of offering prepayment meters to a proportion of customers. Prepayment can be disabled by setting the proportion of the market using pre-payment to 0.0%.

Table A2.6.1 Input variables for cost/benefit calculations

Definition	Unit
Market numbers	
Year of model	years
Currency unit used in model	
Discount rate	%
Total number of electricity customers - year 0	integer
Annual increase in number of electricity customers	%
Market share of electricity prepayment meters (constant for all meter types and years of model). Set to 0.0 to neglect prepayment	%
Total number of years to roll_out_all meters	years
Number of years to ramp up rate to full annual installation rate	years

Definition	Unit
Expected service life of simple electricity meters	years
Maximum service life of smart electricity meters	years
Probability factor for replacement of smart electricity meters	#
Cost Data	
Cost of a simple electronic credit electricity meter	Euros
Cost of a simple electronic prepayment electricity meter	Euros
Cost of a credit electricity meter (smart meter)	Euros
Cost of a prepayment electricity meter (smart meter)	Euros
Cost of customer display - there is assumed to be one customer display for each smart electricity meter.	Euros
Cost of GSM module for smart meter	Euros
Cost of PLC module for smart meter	Euros
Cost of data concentrator	Euros
Volume discount figure – the cost of smart meters are assumed to fall according to the equation: (1/LN((yrn-1)/mtr_cst_red_fact))^0,4	real
Annual inflation rate	%
Average number of PLC meters connected to each data concentrator	integer
Daily cost of electricity installer	Euros/day
Days per year worked by electricity meter installers	integer
Average number of simple credit electricity meters installed per day	integer
Average number of simple prepayment electricity meters installed per day	integer
Average number of credit electricity meters (smart meters) installed per day	integer
Average number of prepayment electricity meters (smart meters) installed per day	integer
Average number of smart electricity meters with display installed per day - same for prepayment and credit	integer
Average number of PLC concentrators installed in a day	integer
Daily cost to employ a manual meter reader	Euros/day

Definition	Unit
Average numbers of meters read by a manual meter reader	integer
Annual frequency of electricity meter reads – this is all reads, successful and unsuccessful, that require a visit to the property	integer
Annual frequency of smart electricity meters reads per year. This is the planned frequency – allowance for failed calls is made elsewhere.	integer
Annual rental cost per SIM card. This can also be used for any fixed cost element for a communications network	Euros/ year
Cost per call for GSM (or equivalent) calls to individual meters.	Euros/call
The number of planned GSM (or equivalent) calls compared to the actual calls allowing for communications failures.	%
Relative communications message length on the basis of individual meter calls compared to a bundle of meter messages sent via a concentrator Average length of meter message (bundled) / Average length of meter message (individual)	%
Average number of simple meter failures as a percentage of the total population	%
Average number of smart meter failures as a percentage of the total population	%
Proportion of PLC and GSM enables meters Defined as no PLC meters divided by no of GSM meters	%
Investment in meter data management system in year 0. Costs per year.	Euros/ year
Costs related to upgrading the meter data management system. (For example to be able to handle meter data from more customers.) Only one upgrade is possible.	Euros/ year
Year of upgrading the meter data management system - in year from year 0 (the starting year when the first investment is performed)	integer
New business variables	
Fraction of customers that attract the new business.	%
Additional income that the meter operator may charge to other parties for additional services offered with the smart metering communications system. The income is net of any additional costs. Se t to 0.0 if no such income is envisaged.	Euros/ year

Definition	Unit
Energy consumption	
Total annual electricity consumption in year 0 of all the customers included in the model	kWh
Average annual increase in electricity consumption of the customers included in the model	%
Average reduction of electricity consumption in first year after fitting the smart meter.	%
Average reduction of electricity consumption in second year after fitting the smart meter.	%
Average reduction of electricity consumption in third year after fitting the smart meter.	%
Average reduction of electricity consumption in fourth and subsequent years after fitting the smart meter.	%
Average reduction of electricity consumption in first year after fitting the smart meter and the display.	%
Average reduction of electricity consumption in second year after fitting the smart meter and the display.	%
Average reduction of electricity consumption in third year after fitting the smart meter and the display.	%
Average reduction of electricity consumption in fourth and subsequent years after fitting the smart meter and the display.	%
Average annual power consumption of a simple credit electricity meter	kWh/year
Average annual power consumption of a simple prepayment electricity meter	kWh/year
Average power consumption of a credit electricity meter (smart meter)	kWh/year
Average annual power consumption of a prepayment electricity meter (smart meter)	kWh/year
Average annual power consumption of in-house display (of whatever kind fitted).	kWh/year
Energy market tariffs	
Proportion of the electricity tariff allocated to generation costs.	%
Proportion of the electricity tariff allocated to transmission costs.	%

Definition	Unit
Proportion of the electricity tariff allocated to distribution and metering costs.	%
Proportion of the electricity tariff allocated to retail costs. elec_tariff_gen_prop + elec_tariff_trans_prop + elec_tariff_dist_prop + elec_tariff_supp_prop = 1	%
Fraction of RESC income that is profit	%
For the electricity Distribution System Operator, the average share of their costs allocated to Capital and Operation activities: defined as: Operating costs/Capital costs	%
System figures	
A defined value for potential improvements in the operation of the low voltage network. Defined as percentage reduction in costs.	%
A defined value for potential improvements in the capex costs of the low voltage network. Defined as percentage reduction in costs.	%
Average number of complaints received each year as a fraction of total electricity customers for the BAU case	%
Average number of complaints received each year as a fraction of total electricity customers for the smart meter case.	%
Average fractional improvement in number of complaints received arising from the different scenarios	%
Average cost of dealing with a single electricity complaint	Euros/call
Average percentage reduction in the cost of dealing with an electricity customer complaint as a result of having smart metering	%
Average number of electricity customers switching each year as a fraction of total customers	%
Fractional improvement in number of electricity customer switches per year	%
Average cost of carrying out an electricity customer switch	Euros/ switch
Average reduction in percentage of cost to carry out an electricity customer switch as a result of smart metering systems	%
Fraction of meters needing a meter management visit each year based on total meter population	%

Definition	Unit
Increase in the RESC margin on product sales arising from new services enabled by smart metering systems with display	%
Average percentage electricity loss due to fraud	%
Average reduction in the level of electricity fraud due to the use of smart metering. Defined as: Fraud level (smart metering) / Fraud level (BAU)	%
Financial value of electricity reduction arising from White Certificates.	Euros/ kWh
A percentage figure for the lower cost for the RESC to purchase electricity by using smart metering systems data to better understand their customers demand profiles	%
A percentage figure for the lower cost for the RESC to purchase electricity by using smart metering to offer demand response and avoid purchasing expensive peak power	%
When the RESC offers demand response tariffs it should return some of its savings to the customer to make it worth their while responding. Defined as: RESC saving / Customer saving	%

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