FORCE MOTRICE

A.T. KEARNEY

‘Assessment of Smart Metering Models: The Case of Hungary’

Improved Final Report

18 June 2010

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Glossary

ATK	A.T. Kearney Ges.m.b.H.
BPL	broadband on powerline
CBA	cost-benefit analysis
DSO	distribution system operator
ERGEG	European Regulators' Group for Electricity and Gas
EU	European Union
FM	Force Motrice Zrt.
HEO (MEH)	Hungarian Energy Office (Magyar Energia Hivatal)
MUC	multi utility controller
NPV	net present value
NT	network tariff
PLC	power line communication
R&D	research and development
ROI	return on investment
SM	smart meter(ing)
TSO	transmission system operator

This study was prepared based on the assignment from the Hungarian Energy Office and the World Bank with the close cooperation of Force Motrice Zrt. and A.T. Kearney Ges.m.b.H. All main statements of the document reflect the mutually developed opinion of the consultants; the selection methodology, the model evaluation and the recommendations for implementation were developed and formulated together. In the introduction of the relevant international experiences and examples and of the main changes in the technological environment and their expected evolution, we relied on the international experiences of A.T. Kearney. The introduction of the Hungarian regulation environment, the specialties of district heating and the environmental effects based on the Hungarian energy efficiency scenarios, as well as, the development of the model for the calculations of the cost-benefit analysis were performed by Force Motrice Zrt.

1. Executive Summary

In Hungary, the task to prepare the regulation related to Smart Metering complying with the EU directive falls under the responsibility of the Hungarian Energy Office (HEO). In 2009, the HEO commissioned a consortium formed by consulting firms Force Motrice Zrt. and A.T. Kearney Ges.m.b.H. with the preparation of a smart metering study. The HEO received a subsidy from the World Bank for its preparation.

The objective of the study is to examine the options for **introducing smart metering** in Hungary, and to **make a recommendation for the method and scheduling of the introduction**.

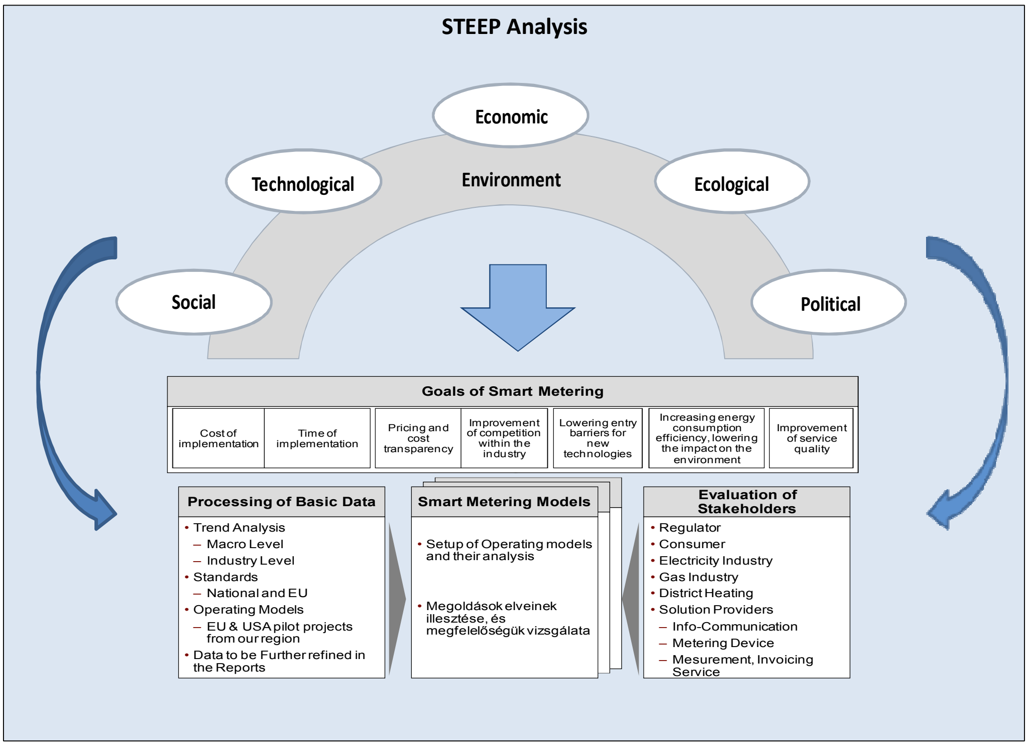
In order to support the regulatory work of the Hungarian Energy Office in the topic of introducing smart metering, in agreement with the principals, the study established the **evaluation framework**, selected – out of the theoretically possible operating models – the models that seem viable in the domestic environment, analyzed those in detail, and as a result of these it formulated **the model** for introducing smart metering in Hungary **that has the highest utility in totality**. Beyond selecting the model it outlined the **alternatives of the introduction** and important decision points for the Hungarian Energy Office. Both the principal and the consulting consortium paid particular attention to scheduling the work in a way that makes possible a **broad discussion of the study**. The conciliation process was supported by deep interviews with the affected participants (industry players, consumers, technology providers and regulators), plenary meetings connected to project milestones, cluster workshops, and the transparent publishing of the finalized working documents on the Internet.

Based on expert analyses along the targeted goals, international benchmarks, conclusions of pilot projects, multiple rounds of debates with the Hungarian Energy Office and industry players, cost-benefit analysis, and sensitivity analysis/tests, our consulting consortium **recommends the Area Smart Metering Data Acquisition and Service Company Model (abbreviated: Area SM Operator Model) to be implemented in relation with the Hungarian smart metering concept.** At the same time we split the recommendation into two parts:

- the consulting consortium definitely recommends the definition of a legally separated meter operator role (SM Operator) beside the current utility players;
- the consulting consortium recommends the establishment of the Area SM Operator Model under the assumption that the competition of multiple players decreases the implementation risk, and that this is regarded by the current economic policy as a more important criterion than the higher financial benefit that can be expected from the single player Central SM operator model.

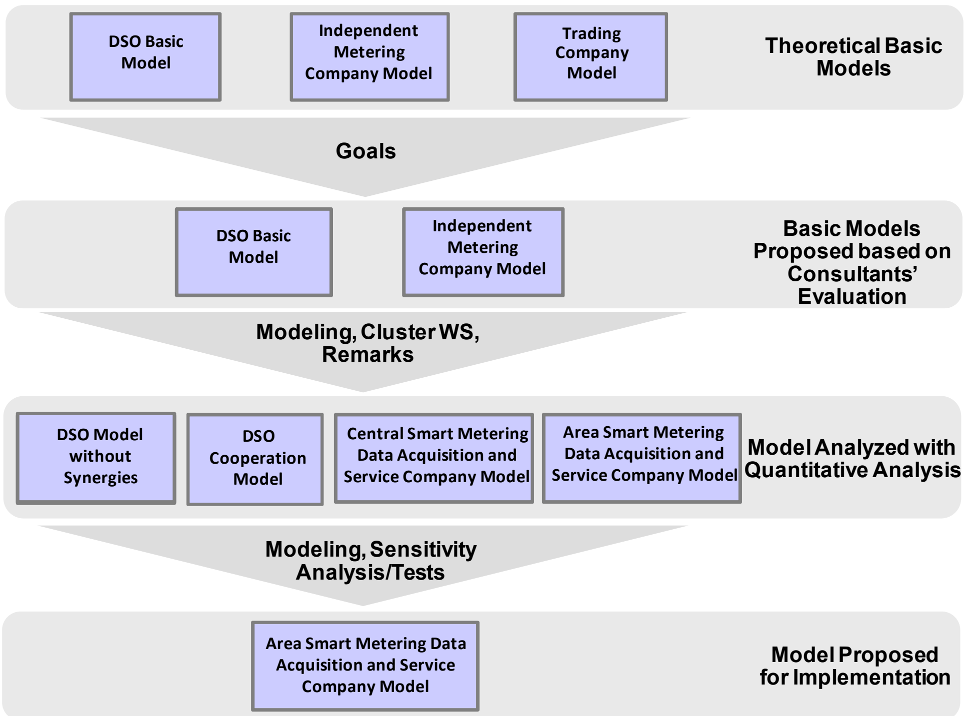
The finalized three-phase study has captured the **goal system** for smart metering based on a wide basis of information with regards to its methodology, followed by an examination of relevant international examples and **environmental factors** and review of the opinion of stakeholders; based on these the study set up **models that have been compared based on quantitative and qualitative criteria**.

Figure 1.: Methodology for selecting the smart metering models (STEEP Analysis)



The model recommended by the consortium for introduction has reached its final form by executing the logical steps illustrated in the following figure:

Figure 2.: Methodology for selecting the smart metering models (logical flow)

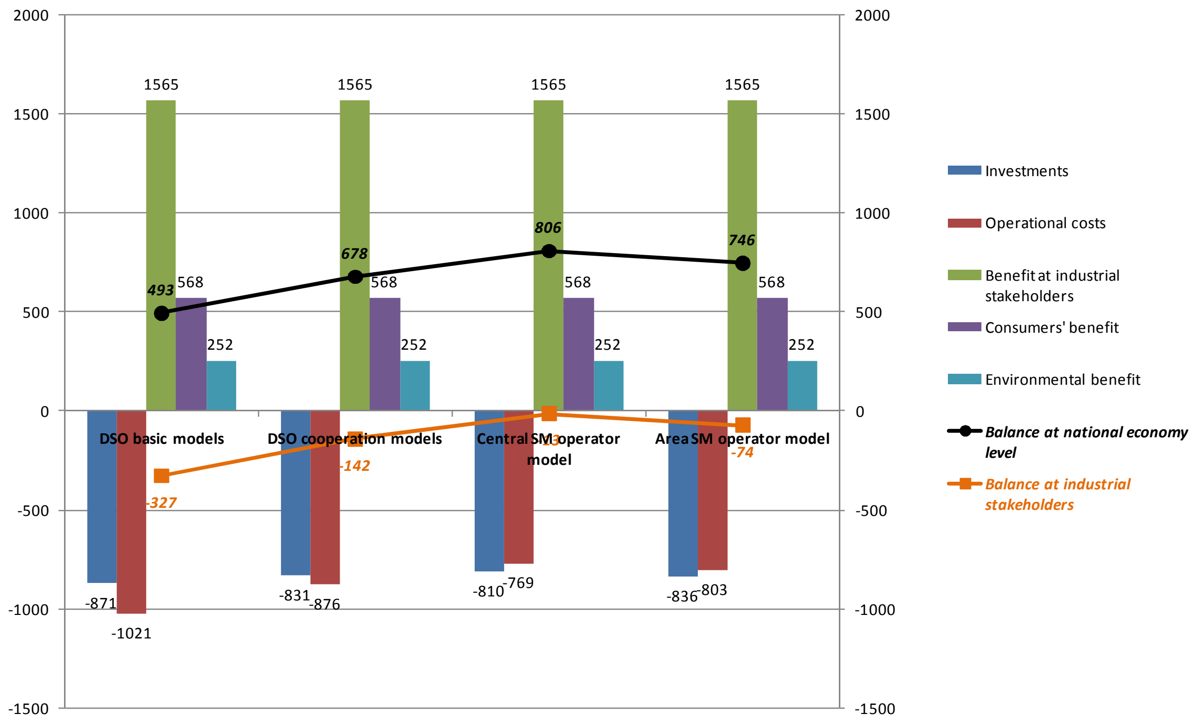


We have made the following main statements based on the comparison of individual models:

- Due to the significant investment and operational costs, the only appropriate model to introduce **shall ensure synergies** by coordinating separate individual utilities (multi-utility solutions).
- **Meter operator models** fit better to the **„multi-utility" philosophy** related to smart metering, while the **Distributor (DSO) model** is closer to the **current domestic practice**;
- Although the best result was generated by the **centralized meter operator model** based on the cost-benefit analysis, **we do not recommend** its implementation **because of the risks of a new monopoly** that could be established nationally in the field of operating measurement systems;
- The **'Area SM Operator'** model may provide appropriate protection against the establishment of a 'measurement monopoly' while maintaining the multi-utility nature.
- According to our recommendation **DSOs and TSOs would not be banned** from acquiring ownership in meter operator companies (legal separation without ownership unbundling), this way they could participate themselves as owners in establishing the operator companies.

The **Area SM operator model provides a quantitatively higher return on investment in totality** compared to the 'Distributor models', while providing the possibility for players outside the current utilities industry to contribute to the capital cost of implementation and to the establishment of the new data processing capabilities.

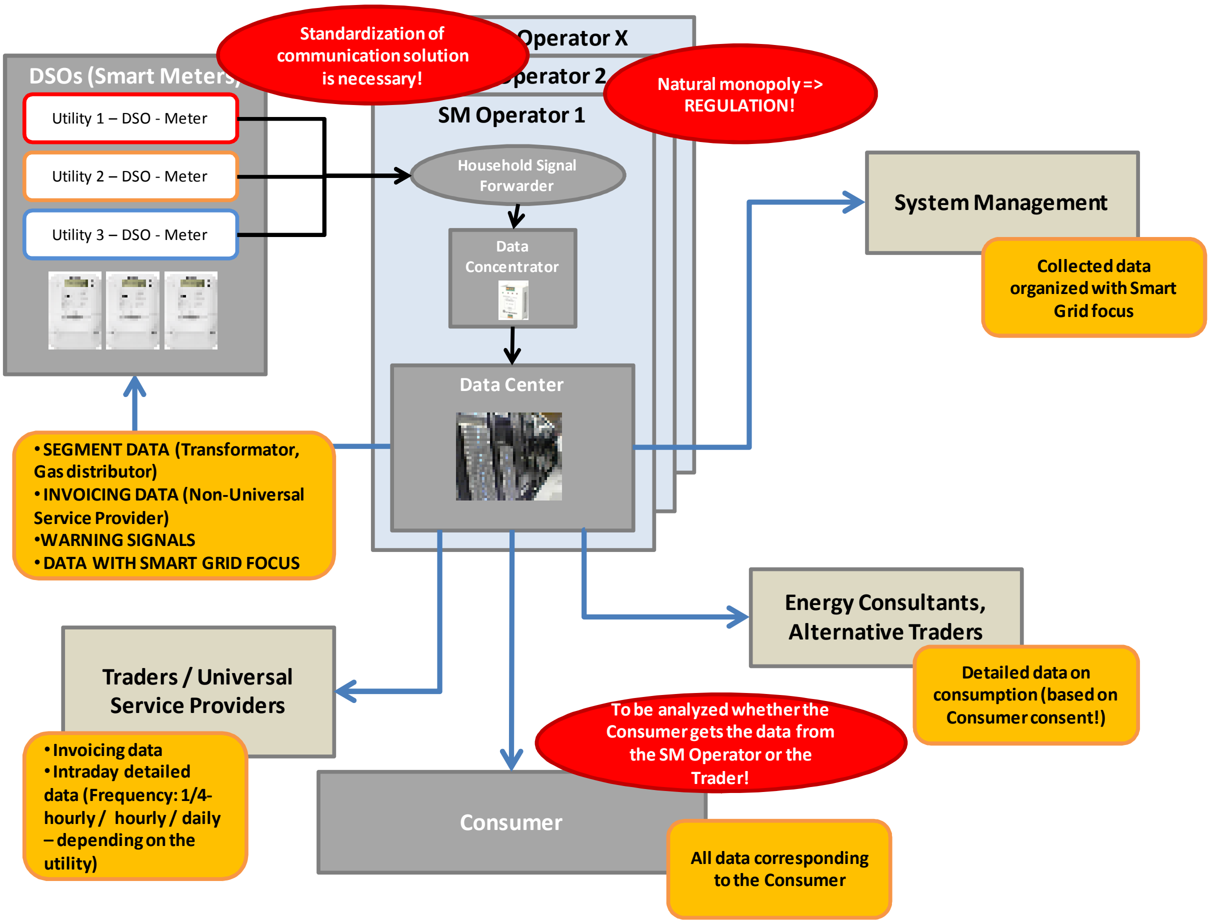
Figure 3.: Comparison of the ROIs of examined models assuming a quick implementation schedule - (Entire period, with residual value, million USD)[1]



By enabling competition, and **when comparing performances (benchmarking),** there is a preference for the Area SM operator model. The Central SM operator requires the regulator to create a new monopolistic service provider, bear its risks and perform its coordination tasks. On the contrary, in case of the Area SM operators the performances of local monopolies – that would also need to be regulated – could be compared with each other, and **periodically a competition could be created for the service provision rights.** Since the Area SM operators' model provides to a larger extent both the competition between participants and the possibility of appearance of quickly developing technologies, the study recommends to the regulatory authorities the preparation of detailed legal regulation for this direction.

[1] For a detailed explanation of the model and conclusions of quantitative comparison between individual models (the cost-benefit analysis), please see the detail presented in Chapter 5.

Figure 4.: Roles and data access permissions in the smart metering system to be established



The most important base characteristics of the model recommended for introduction can be summarized as follows:

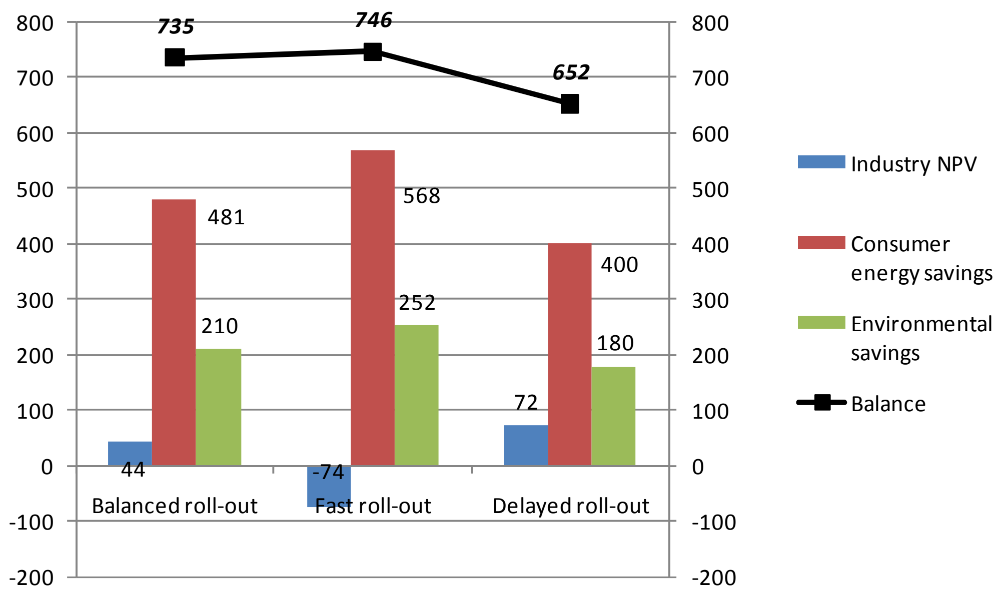
- The smart metering instruments/devices are installed at the end consumer according to the selected roll-out schedule. The **smart metering equipment is owned by the distributor** (it appears in the distributor's accounts) who is responsible for installing, maintaining, and inspecting them.
- A **new player** would be introduced onto the energy market: the area smart metering data acquisition and service company (Area SM Operator). Any player within or outside the industry may set up a SM operator company, but strictly and exclusively **by legal separation**. Area SM operators are under the regulation of the Energy Office.
- The SM Operator **bears responsibility as part of the concession for the remote reading and processing of data on a given territory of the country**. The SM Operator having a natural monopoly is responsible for forwarding the data coming from measuring instruments to the data concentrator, then for transferring the data to the data center.
- **The trader continues to own the contractual relationship with the consumers**.

- The **SM operator hands over data to trading companies and distributors on a contract basis** with predefined data content and frequency. It may charge a controlled fee for the service (regulated activity).
- **Based on authorization from the consumer** the SM Operator may hand over the data/information obtained during operations to energy consultants and alternative traders for further processing (for example, to advise the consumer regarding the most favorable commercial offers), or it may perform these activities itself (generating extra income through this activity). The transaction can be executed only upon full compliance with **data security criteria**.

For the introduction of the Area SM Operator model we recommend that relatively **large-scale pilots** should have an important role. This way **the risk of the applied measurement, data transfer, and processing technology can be decreased;** the regulatory environment can be refined; the **standards** that are expected to be established by then **can be taken into consideration**; and a more reliable picture regarding the expected trends in the domestic consumer behavior may be achieved.

Sensitivity tests of economic modeling run for the different implementation schedules also show that although the quickest access to **consumer benefits** (energy savings) is best supported by the **shortest possible introduction period**, at the same time the early introduction **puts significant extra burdens on the industry players**, primarily due to the sunk costs resulting from the premature exchange of still functioning traditional meters. During the period of pilots the exchange of traditional meters **to new metering equipment can be done gradually** in the first years (taking into consideration the normal change cycle), and in this way decrease the sunk costs.

Figure 5.: The effect of different SM implementation schedules on ROI (Area SM operator model, entire lifecycle, with residual value, million USD)



Taking into consideration the above conclusions, should the HEO decide to undertake a rollout of smart metering in Hungary, we recommend the following implementation steps:

- **Smart Metering Regulation (Phase 1)**
  The objective of this phase is to create/modify the regulatory environment necessary for the launch of smart metering pilot projects. The rules need to be aligned with the final SM regulation to established later. We consider it important that the future SM Operators, due to their natural monopoly, be under authority (HEO) supervision.

- **Finite Number of domestic Smart Metering Pilot Projects (Phase 2)**
  The objective of this phase is to run domestic smart metering pilot projects.
  Any player within or outside the industry may participate in the given pilot, but a stand-alone (legally separated) company should be created even for the purpose of the pilot. Our recommendation for the minimum size of the pilot is 10,000 consumers / pilot, possibly in a multi-utility setup.

- **Evaluation of the Pilot Projects (Phase 3)**
  The objective of this phase is to become familiar with and evaluate the results of the smart metering pilot projects, discuss the experiences, fine tune the regulation and prepare area concession tenders.

- **Inviting tenders for non-overlapping territorial concessions that cover the entire area of the country (Phase 4)**
  Our recommendation is to establish concessional areas (territories) across the whole geographical territory of the country. Metering companies can obtain meter operator 'licenses' for the individual territorial concessions for a concession fee. The main condition for applying for a concession license: successful pilot project implementation in Phase 2.

- **Implementation of the meter operator model by the concession winner on each given territory (Phase 5)**
  The advantage of the introduction across several steps (relying on pilots) is that the assumptions presenting significant uncertainty factors can be tested in practice during the pilots, so that the final implementation will employ the best scheduling and content with high probability.

Regarding the deadline for introduction the following high-level time scheduling seems realistic for the individual phases of the implementation:

- 2010-2011: preparatory regulation
- 2011: launch of pilot projects
- 2013: closure and evaluation of pilot projects, invitation for concession tender
- 2014: domestic roll-out of smart metering / launch

These deadlines would suggest that, given significant time until a 2014 roll-out, we may assume with high probability that smart meters will be available at lower prices and EU standards will likely already be established.

Finally, we would like to mention two further areas touched in the study, where the analysis carried out can only be a considered a first phase requiring further examination that looks into the topic much more deeply.

1) **The connection between smart metering and smart grids:** Smart metering – although providing several additional functions and services in itself – in fact becomes a base component of the grid, enabling more efficient execution of operations and investments, as well as optimization of energy production. Therefore, during the introduction of smart metering not only the measurement, the player performing the measurement, and the data handling need to be regulated, but simultaneously options for establishing additional services should be supported (or at least not limited). An example of one such an area is the market for peak consumption limitation as a result of establishing the capability to control consumption; or the possibility to create commercial offers enabling the switching between gas vs. electricity; making households available as a type of storage capacity.
2) **Inclusion of further utilities in the area of smart metering:** The study reviewed the area of district heating, where it found significantly lower opportunities to be exploited – this is due mainly to the technological and measurement characteristics of district heating. The reason for this is the currently missing stable technical solution for providing accurate measurements on a household level with an economically rational level of cost. However, on the level of households, there is a possibility to measure another utility, water usage, through smart metering. It is important that the regulation keeps this possibility open, and it should strive to accept access solutions that enable the connection of additional service providers to the established system with low costs.

2. Introduction of the Project

2.1 Background of the Project

In Hungary, the task to prepare the regulation related to Smart Metering complying with the EU directive falls under the responsibility of the Hungarian Energy Office (HEO). In 2009, the HEO commissioned a consortium formed by consulting firms Force Motrice Zrt. and A.T. Kearney Ges.m.b.H. with the preparation of a smart metering study. The HEO received a subsidy from the World Bank for its preparation.

The study was prepared based on the close cooperation of Force Motrice Zrt. (FM) and A.T. Kearney Ges.m.b.H. (ATK), and all findings in it represent the common opinion of consultants involved in the project. The consulting consortium's working schedule was set to define and evaluate the most optimal model, based on the common thinking of the two members. The organization and execution of the workshops and analyzing the information of the stakeholders on the progress of the project were also performed together.

The study mainly relied upon ATK's international experiences in the introduction of the relevant international experiences and examples, and also for the description of the changes in the technological environment and its evolution. The analysis of the national regulation, the assessment of the features and specialties of the district heating market, the introduction of the effects on the environment based on the different domestic energy efficiency scenarios and the preparation of the model for the Cost-Benefit Analysis (CBA) were performed mainly by FM.

2.2 Project Target

The HEO and the World Bank set the following targets for the project:

- Prepare a study that analyzes the possibilities and conditions of the introduction of smart metering in Hungary and makes recommendations regarding the creation of legislative background, the schedule, and especially the method for the introduction.
- The expectation towards the study is that it processes results that can be utilized in a wider environment (not only in Hungary), so the World Bank can provide its customers with the generally applicable result of the study and share its practical experiences regarding smart metering.

2.3 Project Scope, Main Tasks

The HEO defined the scope of the analysis and the main tasks of the project, as follows:

In the field of electricity and gas it is necessary:

- to process the European smart metering literature and the theoretical and practical solutions and experiences;
- to analyze the Hungarian national market and regulation circumstances;

- to assess the currently used domestic measurement systems, and to obtain the views of network operators;
- to work out proposal (versions) for the functions and requirements of smart metering, including the requirements of standardization, integrated measurement and later development;
- to analyze the conditions of the introduction of smart metering and to introduce the expected consequences; effect analysis; cost/profit analysis; proposal for the schedule of the introduction;
- to organize workshops with the guidance of the HEO and with the involvement of the industry players and experts and to process the opinions.

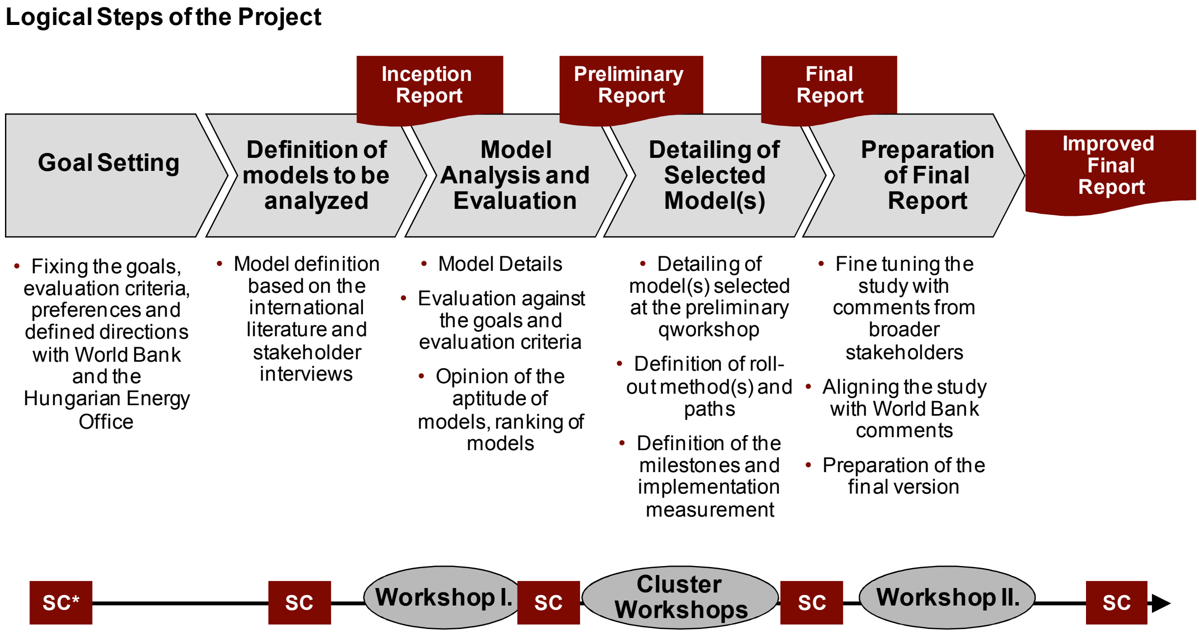
In the field of district heating it is necessary:

- to assess the possibilities of measurement of the produced and released/sold electricity and/or produced and released/sold thermic energy in the case of linked production;
- to assess the possibility of measurement at the delivery point between the heat producer and the heating service provider, in synch with the previous point;
- to assess the possibility of measurement of district heating of community institutions;
- to assess the possibility of measurement of public consumer district heating centers;
- to evaluate the possibility of utilization of smart metering.

2.4 Project Steps

In the case of the 'Smart Metering' project we have broken down the preparation of the study into five logical steps for the better understanding and management:

Figure 6.: Logical steps of the smart metering project



The analysis framework, i.e. the final structure of our methodology, was presented at the first milestone, in the Inception Report. This paper contained the targets, details the areas to be examined by the project, lists the opinions of the most important stakeholders and those models that we wanted to evaluate in the following phases based on the methodology introduced.

During the phase of model evaluation, we evaluated and detailed the domestic possibilities of the introduction of smart metering. This model was properly detailed to be able to compare the different models' adequacy to the criteria detailed in the analysis framework. The Preliminary Report also contained the evaluation of the models assessed and their recommended ranking.

In the 'breakdown of models' step we detailed the two most appropriate models considering introduction, detailed regulatory environment and the measurement of implementation; furthermore, we prepared a fine tuned Cost-Benefit Analysis (CBA) and sensitivity analysis/tests based on more accurate basic data.

In the Final Report we introduce the detailed model options analyzed both by professional opinion and based on figures (CBA). Moreover, we detail the smart metering model recommended for implementation including its most important features, the proposed roll-out, and the regulation needs generated.

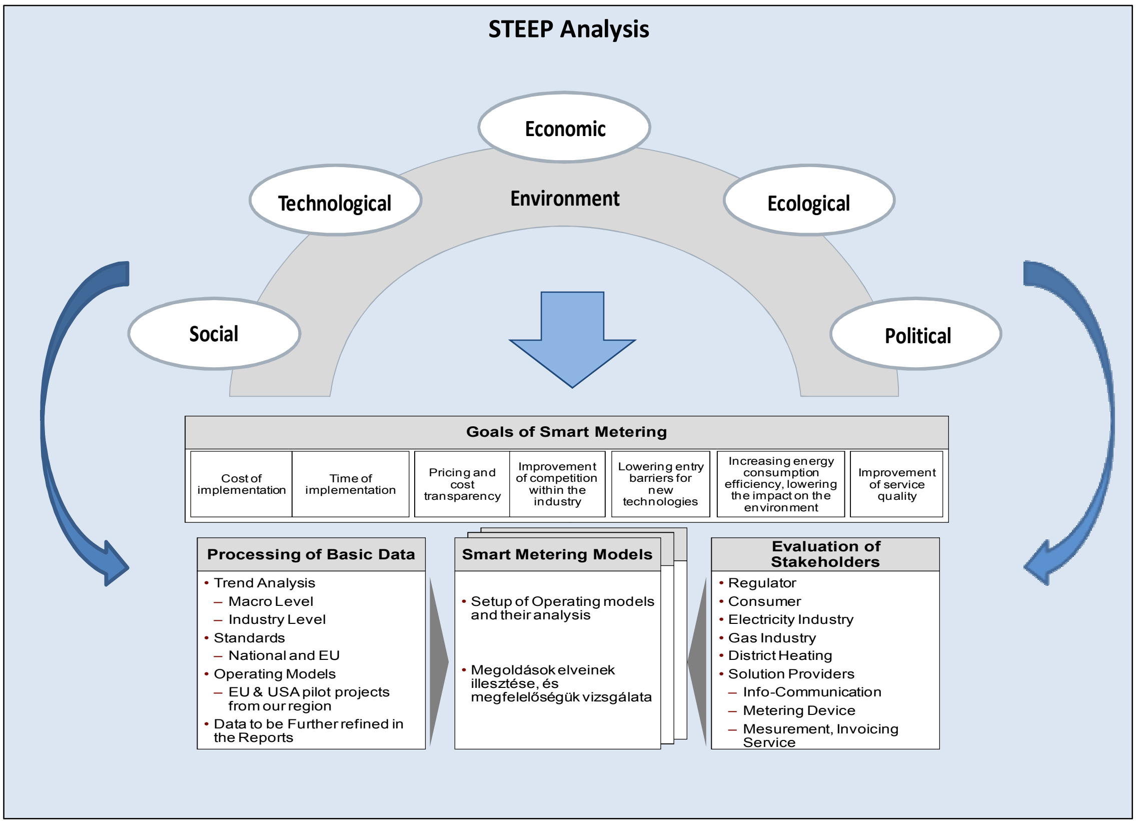
3. Evaluation Framework

3.1 STEEP Analysis Framework

In order to obtain the most comprehensive result from the assessment of the models against the evaluation criteria as defined by the consortium, we performed a wide evaluation with the utilization of the STEEP Analysis framework. The evaluation areas for the STEEP background analysis are the following:

- ’S’ – Social
- ’T’ – Technological
- ’E’ – Economic
- ’E’ – Ecological
- ’P’ – Political/Legal

Figure 7.: Connection between the STEEP analysis and the smart metering model evaluation system



The main objective of the STEEP analysis is to provide an evaluation framework for the development and implementation of a strategy, strategic plan, solution or product. The content, factors and features of the different areas/environments are summarized below:

- **Social factors** – contain those social and cultural factors like the composition of society, growth rate, age, attitudes, expectations, habits, etc. Trends resulting from social factors and features affect products and services of the different companies and institutions, and the needs for these.
- **Technological factors** – (with the involvement of ecological and environmental aspects) comprise such as: R&D, automation, technological incentives and contents, rate of technological change. Entry barriers, expected minimum level of efficiency/productivity and the necessary outsourcing decisions can be defined based on the assessment of these technological factors. Furthermore, the technological changes and improvements affect cost, quality and result in innovation.
- **Economic factors –** contain the growth rate of the economy, interest rate, exchange rates, inflation rate, costs, benefits, etc. These factors influence the most the operation and decision making of companies and institutions.
- **Ecological factors –** comprise weather conditions, climate and elements regarding climate change. Apart from these, the increasing environmental awareness of companies and institutions must be involved in these evaluation criteria, as the different products and services of these entities have strong effect on climate change and, therefore, on the environment.
- **Political/Legal factors –** evaluate the degree of government intervention into the economy. With special regard to tax policy, labor act, environmental regulation, trading barriers and political stability. In addition, the government has strong effect on national healthcare, education and infrastructure. Apart from these, those legal regulation elements, legal framework and government decrees and statutes belong here that influence the operation of the different entities.

Naturally, we adopted the STEEP Analysis specifically for the evaluation of those elements that must be taken into consideration for the implementation of smart metering.

3.2 Effects of the Social Environment

When assessing the social environment we primarily focused on households, as the main target group of smart metering. The benefits of smart metering are realized mainly at the consumers as the result of energy awareness (consumption reduction, especially for gas) and the market stimulation effect of smart metering. The benefit figures arising from the return calculations performed within the framework of the project showed that the implementation of smart metering is viable only in case the supposed consumer benefits exceed the short term additional burdens of the industry regarding the development and operation of the smart metering system.

Currently, there are approximately 5.5 Million electricity and 3 Million gas consumption meters (electricricity: <3*80 A, gas: <20 m^3/h consumption level) on the Hungarian household energy market. The Hungarian consumption level of the focus utilities, although lagging on average their the EU counterparts, is increasing similarly to them. Consumer awareness and commitment to environment protection has slightly increased since the liberalization of the market, but is still behind the levels of other developed countries (especially the US and the developed EU members). Due to the lower consumption level, the potential for savings can also be expected at a lower level.

The possibilities for our main study to analyze consumer attitudes, behavior and the expectable consumer reactions were limited. We thought that it would be important to further survey the public in order to obtain deeper and more exact knowledge on the details of the consumer side of the energy market (consumer/market background, consumer habits, attitudes, consumer expectations) and the knowledge of consumers on smart metering.

Our consulting consortium would like to thank the representative domestic electricity and gas sector companies that recognized the need for such missing an important analysis and agreed that a national survey carried out against a unified methodological framework is the best interest of all stakeholders involved.

Based on our initiative, an overall representative market/consumer survey was carried out in parallel with the smart metering project, financed and supported by EDF, E.ON and ELMŰ-ÉMÁSZ groups. The overall target of the market/consumer survey is to prepare a market survey study in order to get knowledge of the consumers – as stakeholders – expectations for the consulting consortium performing market modeling, regulation and implementation preparation. As a result, the main purpose of the study was to obtain knowledge on:

- what the decision-makers of the Hungarian households understand from the smart metering concept
- the advantages they see
- the possibilities of implementation and,
- the construction (financial, operational, etc.) to be applied.

The overall aspect of the survey is supported by a qualitative and a quantitative phase building on each other and by the territorial coverage providing national representation.

During the qualitative phase, Millward Brown Hungary Kft. (a market research company) evaluated the primary impressions and opinions of consumers through 6 focus teams and interviews carried out in small towns. During the quantitative phase, a representative sample of 800 people was carried out by Millward Brown Hungary on the aspects of smart metering and the consumer attitudes towards it.

The following is a short summary of the quotes and results of the different phases.

Main Conclusions of the Qualitative Phase

Based on the opinions of consumers regarding utility service providers it can be stated that the consumers have several caveats towards utility companies:

- Untraceable price increases, to which customer sensitivity is high
- Incomprehensible invoices, therefore they feel taken advantage of
- Non-transparent consumption
- Problems with customer service, slow processing of complaints
- Irrational actions
- Lack of competition

- Non-consequential communication: although they promote energy efficiency, the consumers feel that utility companies have interest in higher consumption

As a summary, it can be assessed that the two main sources of these statements are untraceability/complexity and the lack of competition.

The above aggregated opinions suggest that the consumers need more transparency and calculable service and information on their utility consumption; in addition they require more competitive and diversified services and tariffs. All these are expected with more efficient and understandable communication (including the invoices and data of their consumption) from the different utility companies.

Consumers, due to the fact that their invoices are perceived as high and incomprehensible, try to save utility costs somehow. Behind this willingness to save there is always money saving consideration, without exception.

Only the fee to be paid is important in the case of their invoices; consumers do not care about the units consumption (ie joules). Their consumption is not judged against these, but only based on the amount invoiced to them. Consumers do not want to contribute to smart metering if it is compulsory, they do not consider this fair. At the same time they do perceive that, in the end, they, as consumers/tax payers, are the ones who pay for the service, therefore they are willing to contribute with 1/3 of the costs but they would like to obtain some kind of financing solution: payment in installments, loan, etc.

The role of environment protection is marginal, it can be perceived as a positive externality.

After the liberalization of the market and as a result of the international and national economic situation of the recent years, consumer awareness has started to develop. Energy savings and environmental protection is getting more attention in the case of certain consumers but, in order to reach more consumers, new solutions, wider spectrum of services and more targeted communication, consumer-friendly actions and flexibility from service providers are necessary.

Regarding smart metering, we came to the conclusion that, based on the analysis of societal/consumer attitudes and from the increasing consumer awareness, price sensitivity and information needs point of view; consumers are open to the introduction of such a solution as the functionalities and benefits provided by smart metering highly meet the expectations of consumers. The consumers are willing to contribute to the cost of the functionalities that provide them with added value (e.g. displays and the advantages arising from them). During the survey, the consumers understood the main advantages of the concept but, at the same time, they were skeptical as they feel that these functionalities could be provided by the meters currently in use.

Main Conclusions of the Quantitative Phase

Use of Utilities

In case of the electricity invoice, flat rates are preferred, and in the case of gas it is still representing a high percentage. As a result the continuous measurement and prompt reading can be attractive for many consumers. But, as we saw during the qualitative phase, flat rates can be considered as a version of payment in installments (the main benefit of this is to avoid a high final invoice), and therefore it is recommended to keep this possibility for the consumers. Awareness for this is very high, and most people surveyed knew the amount of the last invoice of the each utility.

These high overhead costs make consumer more sensitive to savings. As we experienced during the qualitative phase, this is not the result of environment protection considerations, but the aim to decrease the cost for the households. Similarly, they keep in mind the amount to be paid and not the amount of energy consumed.

Savings have high priority in all households questioned: they are seeking solutions that do not require additional investments (i.e. limiting usage, optimizing heating, careful water utilization). Energy efficient light bulbs and household machines are the most common saving solutions that require investment (due to their relatively low price).

Internet penetration is considerably low in the households considering themselves as 'energy-savers', therefore, in the case of this target group, the ability to leverage internet platforms is questionable. But, taking into consideration the possibility of internet penetration until the 2020 deadline (for smart metering), this should not remain an obstacle.

Willingness to Change Service Provider

Out of the four utilities, consumers are the least satisfied with the district heating service. This is possibly the result of the high servicing fees and the discomfort associated with the service itself (switch on in Autumn and switch off in Spring).

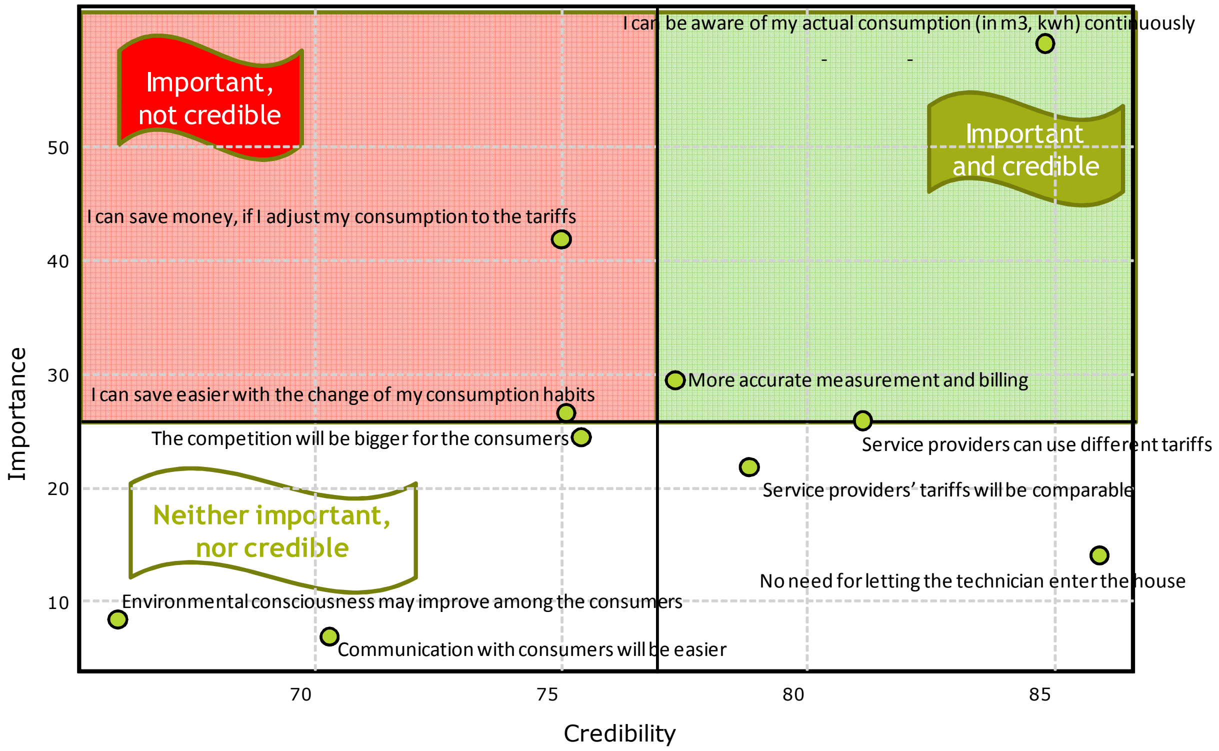
Only 10% of the consumers were thinking of changing their service provider. This is significantly higher in case the consumer is dissatisfied with the quality of service. But, even in this case, only 20% of the dissatisfied customers were considering switching, as a maximum.

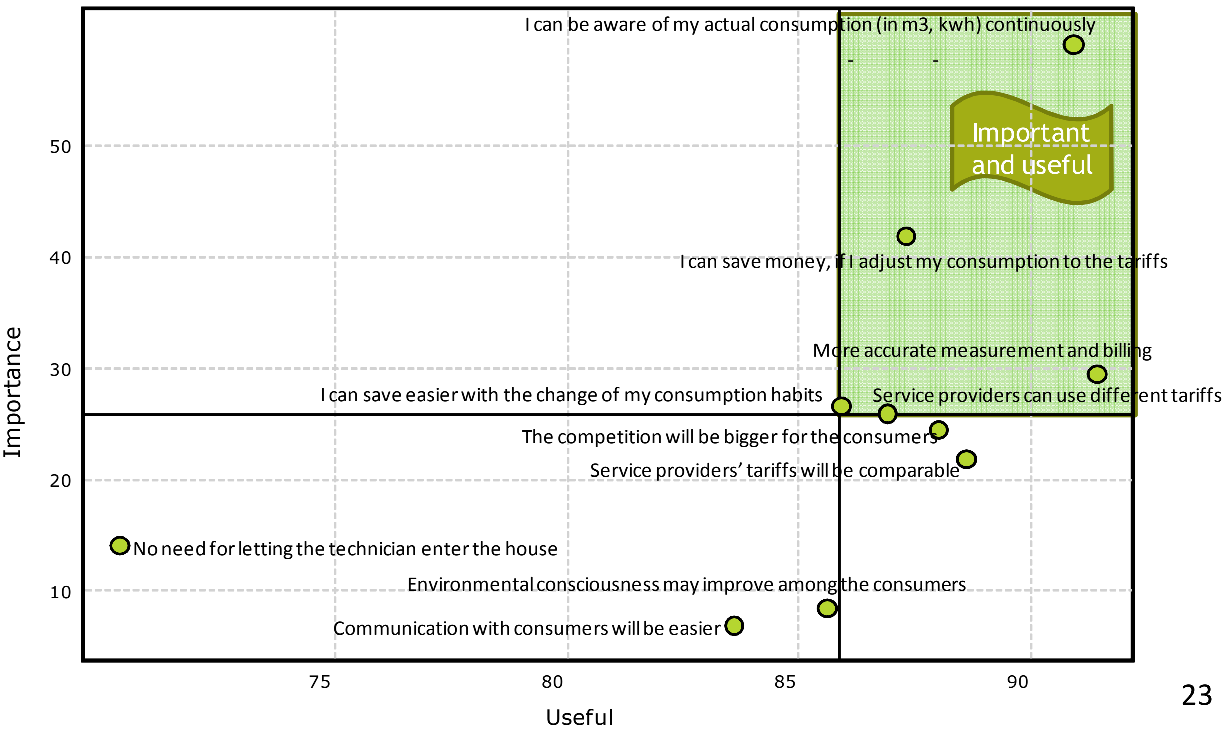
Significant willingness to change can only be experienced in the case of gas, i.e. consumers today do not think about changing before options are provided. Price is the main motivator in the case of gas.

Opinions on the Smart Metering Concept

In general the smart metering concept is accepted by the consumers, with the rate of total rejection being low. However, the response is not entirely positive. Tracking consumption and savings are considered as advantages. The main advantages were understood, as in the qualitative phase. The majority considers the new concept as believable, although some uncertainty and lack of confidence is present. This could be reduced with proper communication. Although the elements of the concept are considered as important, two respondents out five do not consider smart metering solution as useful due to the lack of confidence. This derives from the previously mentioned problem: ‘existing meters cannot be used for this purpose?’

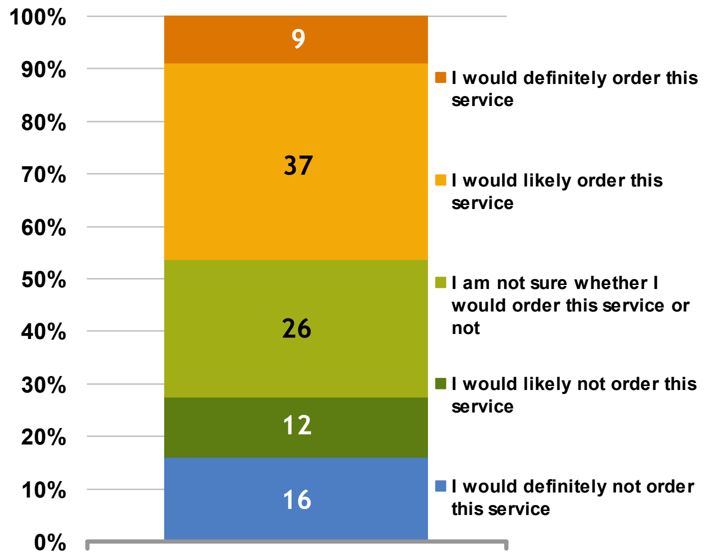
The possibility for savings is interesting for the consumers. The accurate measurement is an advantage for them. The following figures represent the most important features of smart metering regarding importance-credibility and importance-usefulness:



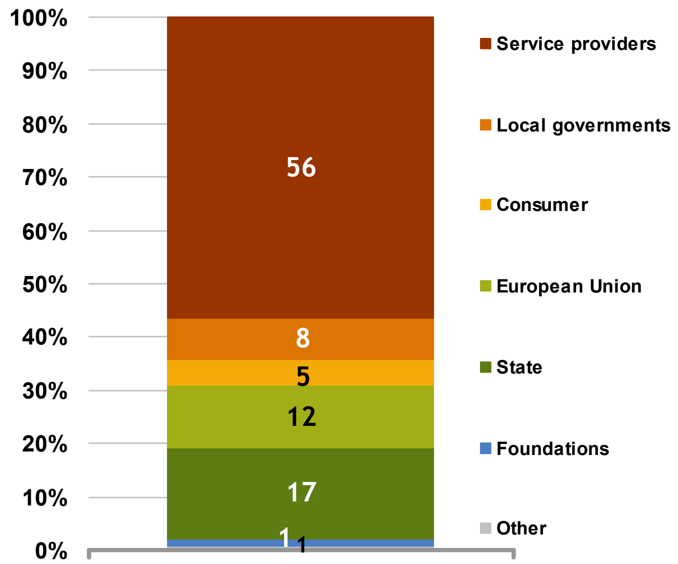


Possibility of Ordering, Financing

After getting information on smart metering, less than half of the respondents stated that they want smart meters in their homes.



Despite positive reception of the new concept, the willingness to cover the costs of installation by the consumers is very low; they would not want to pay additional amount for it. The majority considers it as a task of the service provider.



In case it is absolutely necessary, they would like to pay in installments to the service provider the costs of installation that, based on their opinion, would be covered for them by the savings resulting from the advantages provided by the smart meters.

This result is in line with the experiences obtained during the qualitative phase: making the solution compulsory would seriously limit the willingness to pay. Moreover, those surveyed did not get information on the level of potential savings during the interviews, so their skepticism is understandable.

Regarding smart metering, we came to the conclusion that, based on the analysis of societal/consumer attitudes and from the increasing consumer awareness, price sensitivity and information needs point of view; consumers are open to the introduction of such a solution as the functionalities and benefits provided by smart metering highly meet the expectations of consumers. The consumers are willing to contribute to the cost of the functionalities that provide them with added value (e.g. displays and the advantages arising from them). During the survey, the consumers understood the main advantages of the concept but, at the same time, they were skeptical as they feel that these functionalities could be provided by the meters currently in use.

3.3 Effects of the Technological Environment

Technological advances can lead to significant benefits, most of which have a secondary affect on the other STEEP areas. Supporting the roll-out of smart metering will have primary technological impact on areas such as R&D activity and rate of technological change. Once introduced, smart metering will lower the barrier to entry of additional technologies, attracting innovation into the energy business. In the long term, this can lead to technological shifts, significantly impacting costs and quality.

These impacts will be the largest directly in the energy industry. Smart metering, when coupled with its related technologies, is a strong enabler for production technologies, especially alternate, green, distributed, and micro production. Moreover, by making it possible to have variable pricing, smart metering can drive the uptake of electrical devices currently slowed by the high cost of electricity (consider electrical automobiles). The ultimate impact cannot be forecasted as there will likely be unanticipated technological advances as well.

3.3.1. Smart Meter Description

For the current project we use the following definitions for smart metering:

The smart meter is a new technology that ensures continuous metering of consumption and the availability of data for both the consumers and the energy suppliers. The smart metering enables new types of Energy services.

Smart meters present an opportunity for consumer to save on consumption, while also providing infrastructure operators a way to increase their efficiency

Electrical meter and smart meter description

Conventional Electrical Meter

The Ferraris-meter:

- Basically unchanged for 50 years
- A standard of reliability and affordability
- No additional functionality
- Met all requirements to date

Key functionality:

- Measures electricity consumption of 1 and 3 phases
- Additional communication capability not available
- Maximum 2 registers to read electricity consumption
- Mechanical counter / display

Smart Meter

Smart meter:

- While used for many years at industrial clients, not yet distributed in a widespread manner (households)
- Includes measurement and communication capability
- Makes manual reading obsolete through remote reading capability

Key functionality:

- Flexibly, digital consumption measurement
- Enables separate tariffs based on time and a more transparent invoice
- “Communicates” with consumer
- Extensive control and regulatory functions

3.3.2. Technologies Related to Smart Metering

Although this study focuses on smart metering only, we should mention that a critical mass of smart meters is an enabler to the introduction of other innovative technologies. Three should be highlighted: Smart Grid, Broadband over Powerline, and the smart home. Smart Grid and Broadband on Powerline are briefly introduced in the Attachment 6.

The smart home leverages the information available, especially from variable electricity pricing, and adapts to decrease prices and increase efficiency. In its simplest form, electricity is priced in time zones, and inhabitants attach timing devices to certain appliances to only be used during the lower priced times. Some households may agree to real-time pricing. Initially, a remote pricing display within the home would allow the inhabitants to view the price of electricity and adopt their activities appropriately. The true smart home, however, adopts automatically. Appliances would monitor the price of electricity and act accordingly. For example, when prices drop below a threshold, a washing machine would turn on or an electrical car would start charging. Alternatively, when the price is high, air conditioning and even lighting would switch to efficiency mode, trading some performance for savings.

3.3.3. Specialties of District Heating

District heating service as a utility is more complex from the smart metering point of view and has not been in the focus of smart metering studies and pilot projects due to its technological requirements and complexity.

Taking into consideration the system of district heating service in Hungary, three different important actors should be considered, the heat generation plants, service providers distributing heating to the place of use and the consumers of the district heating service.

In Hungary there are 220 district heating operators in 93 settlements, while the number of serviced flats/households is 650 thousand. This represents 16 % of the flats on a national level. The strategic program[2] on the dissemination of renewable energy sources states the following regarding district heating: *'The centralized form of covering the heating market demand is the heating service, when consumers are provided with centrally produced heat energy through a heat conduction pipeline system. The heating energy market of cca. 63 PJ represents a relatively small portion (cc. 1/6) of the total heat demand; and 2/3 of it is produced in conjunction with electricity generation. Unlike the case of the gas and electricity service, in the case of heating due to its technological characteristics, there is no existing national network or cooperating systems at the level of the different towns and settlements; nor are there different isolated systems operating within the boundaries of the same town. The majority (over 80%) of the fuels used for heat generation is gas, and the renewable energy sources used for the same purpose represent only 1,5%."*

District heating does not constitute unified systems at national level, but their operations are regulated, like in the case of electricity and gas, by a unified framework act. Act XVIII. of 2005 on district heating, in the case of products (steam and heated water), provides the possibility for official pricing (set by authorities), in case the service is provided for the public, but this is only possible for heat producers/generators over 50 MW of heat performance. Price definition and setting activities of heating service are performed by local municipalities.

The regulation of district heating lists the following actors on the heating market: heat producer/generator, heating service provider and the end user (and the fee payer as an additional category).

Compared to the electricity and gas market models, in case of district heating, the heating service provider operates the entire infrastructure – performs the task of the DSO and, as a Trader, sells the heat flowing through the pipeline.

From the end user/consumer point of view it is a significant difference compared to the other network energy systems, that metering is not performed at the end user/consumer, but basically at the district heating center or heat receiving station. Section 5 of Paragraph 43 of the Act states that, although there is the possibility to perform metering at end user/consumer level, basically, the costs of it must be covered by the end user/consumer

[2] Strategy on increasing the use of renewable energy sources in Hungary 2008-2020

and not by the service provider. 'The amount of heat used can be measured and calculated by building subsections (e.g. by individual apartments), in case the end users/consumers bear the costs of the installation of certified meters to measure the amount of heat and the necessary modifications of the their heating installations, and they provide proper conditions for the metering activity.

The following is a summary of the most important features regarding the metering and fee calculation activities in the field of district heating:

- The classical grouping of the district heating industry: producer/generator, service provider and user.
- The measurement/metering is not performed at the place of use, but in most cases, at the district heating energy center or heat receiving station.
- Service providers send the invoices on consumption to the consumers; meanwhile the metering device is measuring the total consumption of the entire building. Currently separate cost distributor companies perform the splitting of the heating costs (by using a cost divider) for the different consumers. As these cost divisions/splits do not reflex the actual consumption of the consumers as numerous factors must be taken into consideration, the consumers are not satisfied with their heating consumption fees. (The cost correction factors are applied based on the consensus of the neighbors; therefore there are many disputes among the consumers with different types of flats: height, location in the building, etc.)
- In the case of the meters, a 4-year calibration period is applied in the district heating service, while this is longer in the case of gas and electricity.
- Three values must be measured in the case of district heating: quantity, the temperature of incoming water, and the temperature of outgoing water; therefore there are three possibilities for mistakes in the system (measurement accuracy). (In the case of certain European countries, the service provider measures water flow and not heat quantity: fees are calculated based on the temperature of the returning water (from the system), (the colder its gets, the lower the fee/tariff is)).
- In the case of the meters, a 2% error level can be taken into consideration (district heating benchmark).
- The cooperation with the other utilities is not of technological kind and it is hindered by transparency disputes (the core of the problem is uncertainty of reliability, the credibility of data provided to each other. Another reason for uncertainty is that there is no clear count regarding the number of meters).

Taking into consideration the above, our consortium's opinion is that the introduction of smart metering in the district heating service must be preceded by the two key events; first, introduction of smart metering into the other two utilities in question, and second, further developments to tackle the technological issues of metering district heating on a per household level.

This said, the potential to extend smart metering to district heating is real. Certain countries of Europe have solutions with smart metering logic in the heating sector. In these, for the last ten years, the measurement of district heating consumption is performed by measuring the temperature of the water used for heating, and meters with microprocessors and telecommunication solutions (data collectors, communication ports, etc.) are used for the transmission of data.

The above justifies the delayed implementation of smart metering in the field of heating compared to the other two utilities in the proposed Area SM Operator Model, as the heating sector can make use of the advantages of the smart metering system implemented in the case of electricity and gas. As a result, the technological solution mentioned above and existing in Europe can be implemented in a more cost effective way in Hungary.

3.4 Effects of the Ecological Environment

Hungary, as an EU member state, has committed itself to fulfill the ecological and environmental targets of the European Union.

The EU committed itself to reduce CO_2 emissions by 20% until 2020 and will increase the share of renewable energy to 20% within its energy consumption scheme.

The energy and climate package accepted in December 2007 by the European Commission (and approved by the European Parliament) defines a list of specific proposals for action and ambitious environmental protection goals (20-20-20 package). Based on this, Europe commits itself to:

- Reduce the total emission of green house gases to a level which is, at least, 20% lower than the 1990 levels.

In order to reach this, further goals were set:

- Reduce energy consumption by 20% compared to the level forecast for 2020 by improving energy efficiency
- Increase the share of renewable energy sources (wind energy, solar energy, biomass, etc.) to 20% in the total energy production/generation. (In case of renewable energy, the 20% limit is an average value that can be specified differently in the case of the different member countries. In case of Hungary the target value is 13% compared to the current 6% share.)

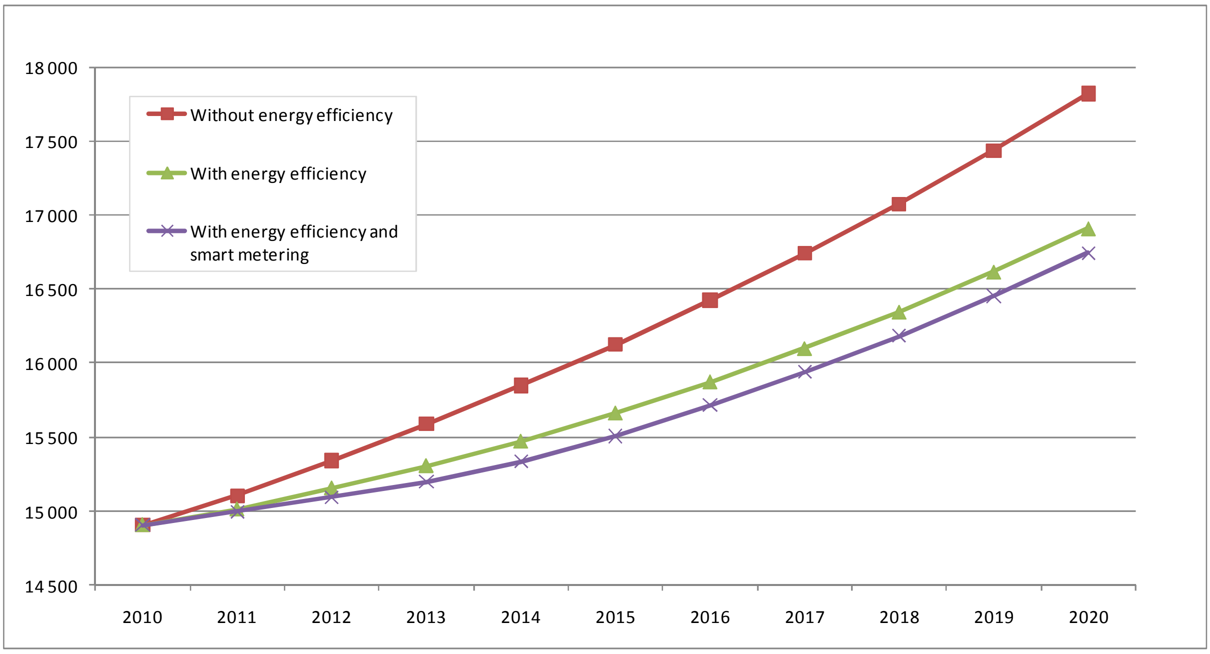
Our consulting consortium analyzed and quantified the fulfillment of the main target (the reduction of the emission level of green house gases) during the cost-benefit analysis.

The basics for the quantification were the result documents of the strategic project performed by the HEO in Spring 2010 on the expected changes in the national energy needs.

Based on the received documents, we quantified the reduction of consumption due to smart metering both in the case of electricity and gas sectors; then we defined the environmental benefits of the smart metering project by calculating with carbon-intensity factors (multipliers) specific to these sectors.

We would like to emphasize that smart metering, in case it *de facto* contributes to the reduction of consumer energy needs, can be a significant additional tool for the realization of the goals of energy efficiency programs, as it can be observed on the following chart in the case of electricity.

*Figure 8.: Expected electricity consumption of consumers with < 3*80A consumption level (Gwh)*



3.5 Effects of the Economic Environment

In a typical STEEP analysis, macroeconomic factors such as economic growth, interest rates, exchange rates and the inflation rate are reviewed. In the case of smart metering, it is more valuable to review the economic effects on some of the major industry players within the economy. Through these companies, there will be an impact on the overall economy, primarily through job creation and availability of funding.

3.5.1. Distribution Network Operators

Smart metering, when widely deployed, enables better information on the low voltage distribution network offering a range of potential savings to distribution operators. System-wide benefits derive from optimizing distribution operations, better reliability and the ways in which smart metering support outage detection and reduction of restoration times, thus improving quality of service. Improved information at distribution level further provides an opportunity for less network losses and better investment planning. This later effect can be the key benefit in Hungary, as the gas and electricity network losses are higher than the European average – up to 10%.

The benefits for distribution network operators:

- Identification of fault locations. Rather than the customer having to call to inform DSO/supplier when the power is out, with smart meters the utility automatically knows where the power is out and can dispatch crews to restore it immediately. Moreover, the distribution network operator can inform the concerned customers about the incident through internet/radio/SMS, thus improving customer satisfaction and avoiding typical situations of call center saturation.

- Faster restoration times provide an obvious benefit to consumers and savings to the distributor from reduced costs of more accurate dispatching of crews.
- Service quality improvements. The reward is potentially greater if the distribution network operator is subject to regulatory performance-based criteria such as number and duration of outages or is subject to penalties/incentives for compliance with standards such as restoration times or amount of non-delivered energy.
- Improved detection of network losses and theft. Smart meters provide more accurate information about the location of losses and theft. (For some companies in Sweden and Italy network losses were key factors in installing smart meters).
- Grid voltage and phase monitoring. This can lead to improvements in voltage stability and system reliability.
- Better network asset management and efficient infrastructure. The availability of real-time, accurate and comprehensive information (voltages, loads, stressing, losses) generated by smart metering on the whole low-voltage network enables optimization of distribution network operation. Accurate information (load data on grid connection, load profiles over time, maximum loads and load distribution and power quality) also helps to improve investment planning at the distribution level. Such information can be used both for new investments in infrastructure (helping to facilitate more distributed generation) as well as for network reinforcements.

3.5.2. Metering Companies

In most EU Member States meter reading is performed by distribution network operators. However, independent metering companies already exist or will be introduced in some Member States. Key operational savings for metering companies come from reduced meter reading costs and other way in which smart metering technology replaces labor costs, and facilitates contractual changes (e.g. meter activation/deactivation). Benefits also result from improved processes and fewer errors in meter management.

- **Efficient meter reading.** Operational savings derive from eliminating labor costs for manual meter reads. Smart meters also allow more frequent meter reads and improve meter reading accuracy, thus reducing meter disputes.
- **Remote activation/deactivation/maintenance.** Operational savings also derive from remote signals dispensing with the need for physical visits to premises to activate/deactivate and remote maintenance which does not require the customer’s presence. Some countries (e.g. Italy and The Netherlands) plan to use smart metering for the better management of bad debts through remote reduction of the available power, followed by remote disconnection if the customer does not pay.

3.5.3. Traders / Suppliers

In principle, where the metering market is liberalized and suppliers have the freedom to offer customers different metering solutions, the potential benefit for suppliers is higher since there is more scope for differentiation (e.g. meter design, specific tariffs, etc.). If meters are owned by the distribution network operator, the scope for differentiation between suppliers depends on the degree of flexibility provided by the metering technology adopted.

Smart meters offer suppliers several advantages, such as:

- Pricing options. The possibility of better knowing the consumption pattern of individual consumers
- Customers, with their permission, give suppliers the opportunity to target them with customized contracts. These contracts may offer different electricity prices that apply at different times of the day, contemplate demand response, etc.
- Potential for on-selling related energy management services. The increased knowledge about the end-customers consumption behavior presents an opportunity to develop new services aiming at helping the customer become more energy efficient.
- Easier change of supplier process as automation of meter reads naturally increases the speed of the process.
- Fewer invoice complaints due to more accurate invoicing, thus reducing back-office costs in terms of customer service centre and less reissuing of invoices.
- Fewer bad debts as there is no longer any need to gain access to premises (not just for meter reading but also for energizing/de-energizing, etc.).
- Better portfolio management. With smart meters, suppliers are charged according to the real consumption of their clients, instead of standard load profiles. This enables suppliers to optimize wholesale power purchases. On the other hand, aggregating a critical mass of demand responsive customers enables suppliers to further reduce wholesale energy costs and even, if they so wish, to participate in balancing and reserve markets, earning extra profits

3.5.4. Generation Companies / Producers

Although the generation companies are not in direct relation with smart metering, the wide-spread application of it has several benefits for these companies, as well:

- Continuous high utilization of generation capacity. As a result of cautious consumption the peak periods are softening, therefore the active altering of capacity is becoming less necessary. The energy consumption can be better forecast and at the same time the capacity alignment would be more precise.
- Better integration of small generation plants. Currently connecting the small generation plants to the domestic system may result in decreases of efficiency of larger plants. Leveraging the smart metering technologies the turning on and off of

these small plants can be done more appropriately matching the consumption curves.

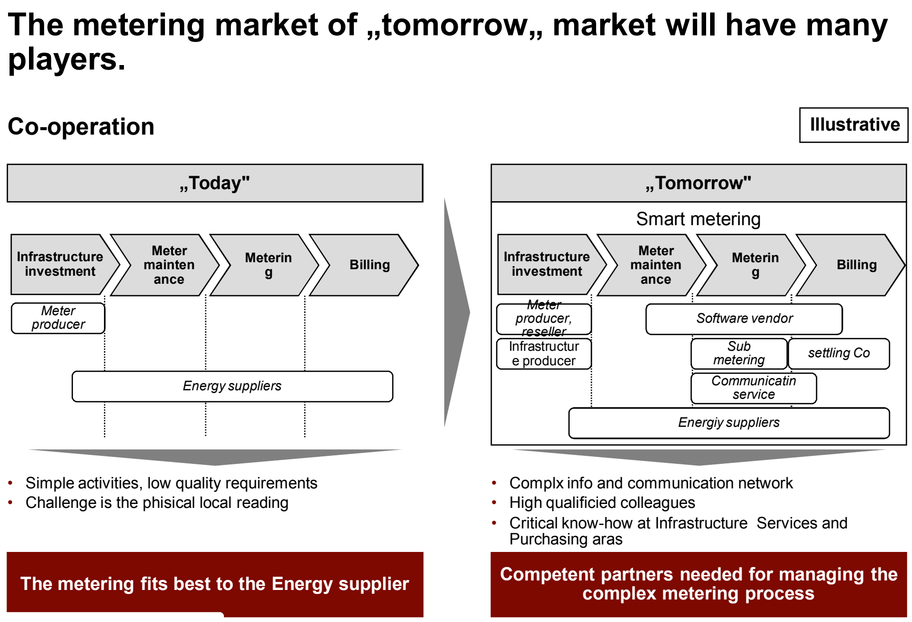
- Seasonal/periodic pricing. In Hungary, currently the power can be purchased on a predefined rate proportional to the consumption and regardless the intraday period. In the long-run, with adequate regulation, a real-time pricing is achievable. According to this the generators can sell their capacities based on their actual costs and the actual market environment.

3.5.5. New Players

Smart metering will bring significant change to the structure of the energy service market, especially by creating new functions and allowing for the introduction of new players. It is important to review the expected market changes. The new entrants to the metering market can be grouped into 3 categories:

1) The smart meter vendors, who will most probably be those delivering the infrastructure for the metering.
2) The vendors of communication technologies, producing and operating the communication tools.
3) The meter reading, certificate provider and billing processing service companies who will become part of the invoicing process.

The value chain will also change due to the new players.



Forrás: A.T. Kearney, Force Motrice

The economical equation of the multiplayer value chain is hard to define during the transition to smart meter markets. The advantages of the smart metering will most probably occur at all levels of the value chain.

3.6 Effects of Political and Legal Environment

In Hungary the legislation, directives and recommendations of the EU prevail in the field of political (professional policies, strategies) and legal environments. The development of directives

- 2006/32/EU and
- 2005/89/EU

sped up the implementation process of smart metering, as these directives specify the overall implementation of smart metering activities.

The specifications of these directives are general, without any technical detail. It is a frequent complaint that this makes the selection of the solution to be applied, as well as, the international and national harmonization very difficult. Based on an unoffical communication of ERGEG, such regulation at EU-level will not be performed; the specification of minimal requirements will be the task of the regulation bodies of the member states.

The regulation of the energy market and the current measurements, calculation and invoicing, that can be the basis for the implementation of smart metering in Hungary, is available. When introducing and detailing the proposed smart metering model later in this study, we will summarize, focusing to the implementation of smart metering, those laws and statutes that should be modified; and we will summarize which sections of the Data Protection Act must be taken into consideration regarding the data handling and processing activities.

Although the list of respective laws and statutes is contained by this document, the following is a summary of the stipulations regarding the measurement, calculation and invoicing activities:

3.6.1. Electricity

<u>Legal background of the measurement calculation and invoicing of electricity</u>

In Hungary the measurement, calculation and invoicing of electricity is regulated by chapter VI of Act LXXXVI of 2007 on Electrical energy. The measurement must be carried out regularly on calibrated meters as specified in the provision contracts.

The Act specifies the responsibility of the different parties regarding the measurement of electricity. The following chart contains the contractual relationship between the parties and the responsibility for measurement:

Parties (contracts)	Responsible
Contracts between licensees	System operator with the involvement of distribution licensees
Contracts between the connecting users and the licensees	Distributor network licensee
Contracts between users connected to the transportation system (grid) and licensees	Transportation system (grid) operator
Contracts with foreign partners (energy transportation through frontiers)	Transportation system (grid) operator
Contracts between power plants under 5 MW of performance and the distributor network licensee -	Distributor network licensee
Contracts between the licensee of private cable (needing permission) and users	Distributor network licensee (together with the user the owner of the private cable must take care of meter installation and measurement

Tasks related to metering devices

The installation, calibration and maintenance of the meters that make possible the connection to the distribution network and the invoicing of the provided energy must be performed by the distribution licensee. In case of power plants the installation, calibration and maintenance costs must be covered by the energy producer. In case of operators or users the cost must be covered by the grid operator or the distribution network licensees.

Reading of metering devices

The reading of meters (i.e.: the establishment of consumption) must be performed by grid operator or the distribution network licensee. The distribution network licensees transfer their data read to the grid operator.

The Act on Electrical Energy specifies the frequency of readings:

a) in case of devices with performance indicators and storing consumption meters: based on the method and deadlines stipulated in their provision regulation
b) other consumption meters: at least once per year (in case the network utilization contract does not specify it differently, it must be performed at least once per year.

3.6.2. Gas

Legal background of the measurement calculation and invoicing of gas service provision

In Hungary the trade and competitive market of natural gas is regulated by Act XL of 2008 on Gas provision. Chapter VIII deals with the measurement process and the calculations between the market players and consumers. (This is a summary of the chapter in English):

- The system operators must provide the data (regarding quality and quantity) for the calculation of consumption of consumers.
- The different system operators must set up measurement sites to be able to measure the buy-sell process among them. They must cooperate based on the Act and their Operations and Trading Regulations.
- The measurement and calibration of gas I the transportation pipeline is performed by the gas supplier.

Measurement costs are born by the gas suppliers, gas distributors and on-site suppliers at their own area of service at the consumers' premises. The measurements must be performed with the frequencies defined in their Operational regulation. Measurements must be performed at least once per year.

3.6.3. District heating

Legal background of the measurement and invoicing of district heating service provision

In Hungary the measurement and invoicing of the district heating service is regulated by Act XVIII. of 2005 in chapter Measurement and invoicing. The following is a summary of the chapter of this English language summary:

- The measurement of heat serviced must be measured by calibrated meters at sites defined by the local authorities. In case the conditions do not make this possible the measurement must be carried out at the heat receiving station with calibrated meters.
- District heating companies must specify their operational procedures (including measurement and invoicing) in their respective District heating Utility Regulation.
- The measurement of heat by building subsections (eg. individual apartments) can be performed only if the consumers cover the costs of installation of meters.
- The currently installed meters a owned by the service provider. Their calibration must be performed according to Act XLV of 1991 on measurements and calibration by the service provider. Consumers can request the calibration documentation of their meters from the service provider.
- New heating centers can only be built in case the amount of heat can be controlled and regulated and measured by consumer.
- In case of new heating centers the costs of investment regarding the following must be covered by investor:

a) heat regulation
b) conditions for the measurement of heat by setting up heat reception measurement

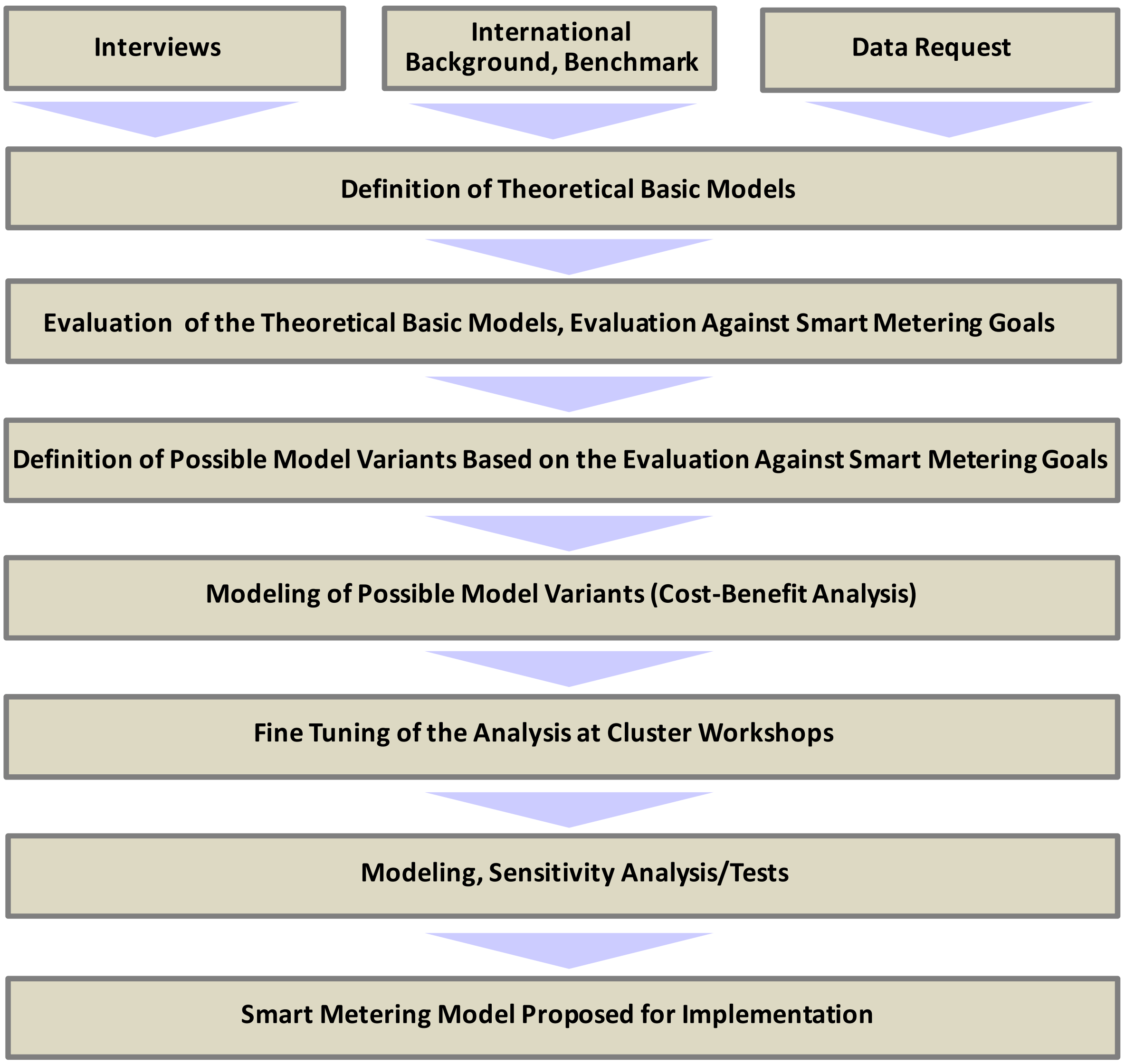
All cost must be covered by service provider in case the district heating system goes under reconstruction, enhancement (even the cost meters must be covered service provider).

The areas where legal or regulatory changes must be performed are listed and detailed in Chapter 6.3.

4. Smart Metering Models

The assessment of the possible models of the Hungarian smart metering system and the definition of the proposed smart metering solution were carried out according to the project plan and along the following logical and timing sequence:

Figure 9.: Selection process of the analyzed models



The project process was broken down to five main phases along the above project steps:

- **Data Collection and Foundation Phase**

During this phase, we conducted interviews with the representatives of all stakeholder groups, where expectations from the industry and the concepts from the industry regarding smart metering were defined.

Besides the interviews, we researched and analyzed in detail the public and available international smart metering concepts and, by evaluating the selected smart metering models, we collected the results, experiences and the necessary benchmark for the cost-benefit analysis. In order to provide more accurate and exact calculations, we developed a structured data requesting questionnaire that was sent to the DSOs, trading and telecommunication companies. Copy of the structure data requesting questionnaire is contained in Attachment 7. of this document.

- **Smart Metering Basic Model Phase**

The basic types of the possible smart metering model groups were defined in this phase of the project. We detailed the most important features in the case of each model type and the Pros and Cons of the given model group regarding the implementation in Hungary.

- **Evaluation of Basic Models, Model Variants Phase**

The smart metering basic models defined in the previous phase went through a comparative analysis against the goals defined together with the Hungarian Energy Office. Based on the results of the evaluation (and the international experiences and the remarks from the industry), we formulated proposals regarding the basic smart metering models and their model variants.

- **Cost-Benefit Analysis / Modeling Phase**

During this phase we performed the cost-benefit analysis of the three smart metering models, then, after discussing the models and the result of the CBA with the stakeholders at the cluster workshops, we increased the number of models to four. After this, the modeling and CBA of the four models were performed with the improved and supplemented data. During this phase we performed both quantitative (comparison of the different investment and operational costs of the different model variants) and qualitative (evaluation of non-quantified factors, e.g. transparency, effect on competition, possibility to influence consumer attitudes) analytical methods were applied. The data sources of the analysis were the following: international benchmark, publicly available data, data requesting questionnaire, information obtained at cluster workshops and consultants' estimation (primarily calculated according to benchmark). We performed sensitivity analysis/tests in the framework of the modeling process in order to assess the effects of certain selected model parameters.

- **Proposed Smart Metering Model Phase**

Based on the results of the CBA / modeling phase, we formulated our proposal regarding the Hungarian smart metering model and its implementation at national level.

In the following section of this study, we will detail the results of the consultants' analysis of the different project phases and the professional observations and recommendations.

4.1 Data Collection and Foundation Phase - Interviews

During this phase of the project (besides the investigation, collection and evaluation of the necessary knowledge and background material regarding smart metering), the interviews were important elements of the methodology. During these interviews, our senior consultants, based on agreement with the Principal on the topic, conducted interviews with the representatives of the stakeholder groups.

The detailed description of results of the interviews are shown in Attachment 4.

Based on the comments /questions regarding the operational features, the two main directions for implementation of smart metering, supported by the stakeholders, were defined.

- DSO-centered solutions managed by the current industry players
- Metering Company-centered solutions managed by a new independent player

4.2 Smart Metering Basic Models

The two theoretic smart metering models defined in the previous phase (Distributor/Network Licensee Model and Independent Metering Company Model) were discussed in detail

- at the Plenary Workshop with the participation of representatives of all stakeholder groups and,
- at consultations with the representatives of the Hungarian Energy Office.

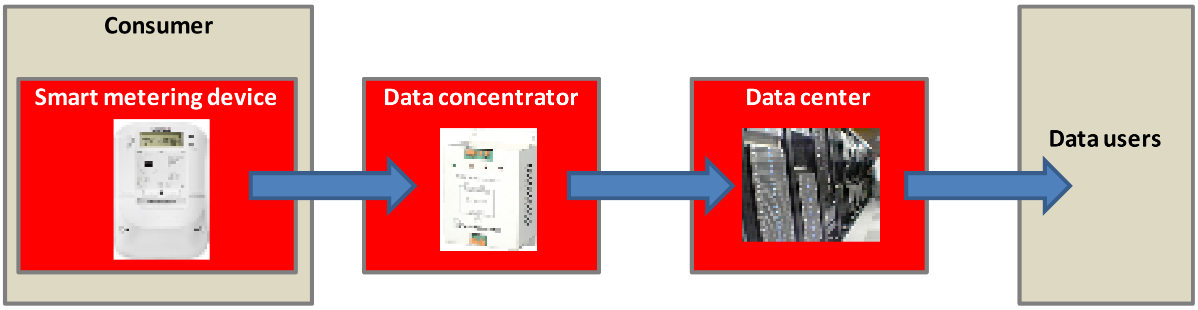
Based on these discussions and consultations and the international benchmark, the following three possible smart metering models were defined:

- DSO/Network licensee model
- Trading Company model
- Independent Metering Company model

The different basic models (as their definition suggests) are ’pure’, well separated ’sterile’, not intersecting with each other, and were not considered as models proposed for implementation in Hungary, but as the basic types of possible smart metering model groups.

During this project phase, the consulting consortium analyzed and evaluated all three basic models. The evaluation of the models followed the following smart metering process:

Figure 10:.Scheme of the smart metering value chain



After defining the process scheme we defined the elements of the entire value chain process as follows:

Table 1.: Definition of the elements of the measurement value chain

	Definition
Smart Metering Device	Electronic (digitally operating) consumption measuring appliance to be installed instead of the currently used metering devices by households that measure the consumption data of given households by utilities. Compared to the currently used meters, smart meters can forward data with optional frequency through a communication network. Minimal functionalities of such a meter are listed in Attachment 2.
Household Signal Forwarder	Collects the data sent by the smart meters (by utilities) of a given household through the communication channel and forwards them to the data concentrator. The household signal forwarder can be integrated into the smart metering device (regularly to the electricity meter) or can be installed as a separate unit in the household.
Data Concentrator	Data collection and systematizing device that forwards with given frequency the data arriving through a predefined communication channel from the household signal forwarders to the data center.
Data Center	Center responsible for the reception, systematization, processing and storage of the data packages (batches) incoming from data concentrators.
Entitled to Data	Entities defined by regulation or contracts that can periodically have access to, handle and use the individual or aggregated consumption data.

Smart meters consist of two well separated solutions: the electronic metering device and the communication device. The technological lifecycle of these two elements differ. The metering device can operate for 15 years without changes; meanwhile, the communication device can become obsolete in five years due to the rapid technological development.

As a result, it can be observed that the different companies are trying to develop common standards in the case of the metering devices and their interfaces while, in the field of communication, they are experimenting with several alternative and replaceable solutions.

The five most frequent technologies:

- Wireless – Public Network. The metering device has an interface connected to a public mobile network (mainly GSM/GPRS).
- Wireless – Dedicated Network. A dedicated mobile network that supports the communication of the meters. This network can also support other similar infrastructures. Possible technologies: Zigbee, Wi-Fi.
- Wireless – Local Connection. In case the Internet connection is at a reachable distance from the metering device, then it can be connected with wireless technologies as an Internet access point. Possible technologies: Wi-Fi, Bluetooth.
- Communication through the Grid (Power Line) (Power Line Communication, PLC). As the electric meters are connected to the grid (powerline), the communication through the powerline is a viable solution.
- Network Connection. The metering device is connected directly to the telecommunication network (e.g. phone), that can be the own network of a utility company. The smart meter operates as a modem that dials with certain frequency.

Among the technologies currently being developed, we have to mention the MUC (Multi Utility Controller) solution. MUC is a controller able to integrate the smart meters within a household and to simplify their operation through a customer-focused handling system.

It is important to emphasize that it is not the purpose of this study, therefore it is not dealing with it, to make any suggestions regarding the communication solution/technology to be applied during the smart metering process. In our opinion, the Regulator, after defining the communication expectations, has to delegate the selection of the communication solution that implements the expectation in the most effective way to the market players.

Based on the smart metering process shown on the figure above the basic models were analyzed, primarily, according to the following features:

- Responsible for the installation and operation of the meter
- Owner of the meter
- Financing
- Responsible for data collection, forwarding, processing, storage
- Cost-benefit sharing / cost-profit split
- Contractual relations, invoicing
- Acceptance by the industry
- Need for regulation
- Initiator of the installation of smart meters

During the analysis we mention as features the ownership, installation and operation of the smart metering devices. In our opinion these features are of secondary relevance in the decision regarding the selection from the possible smart metering concepts and the definition of the smart metering model proposed for implementation (i.e. the ownership is not the primary model creation criterion). Based on our consulting approach, during the preparation of this study, we focused on the process section of the smart metering value chain starting at the data concentrator and ending with the entitled to the data. The ERGEG report[3] establishes that in the case of the countries assessed in the report the installation, operation, inspection and ownership of the smart metering devices is among the competencies of the DSO in the case of both the electricity and the gas utilities. We believe that (based on other international (non-European) benchmark and the industry players' comments at the cluster workshops) it is recommended to follow such tendencies regarding the responsibilities of smart metering in the case of the smart metering model to be implemented in Hungary. Despite this, in the case of two of the three 'pure' theoretical basic models to be presented below and evaluated at high level we temporarily diverged from this basic assumption to enhance the focus of our assessment in this regard, as well.

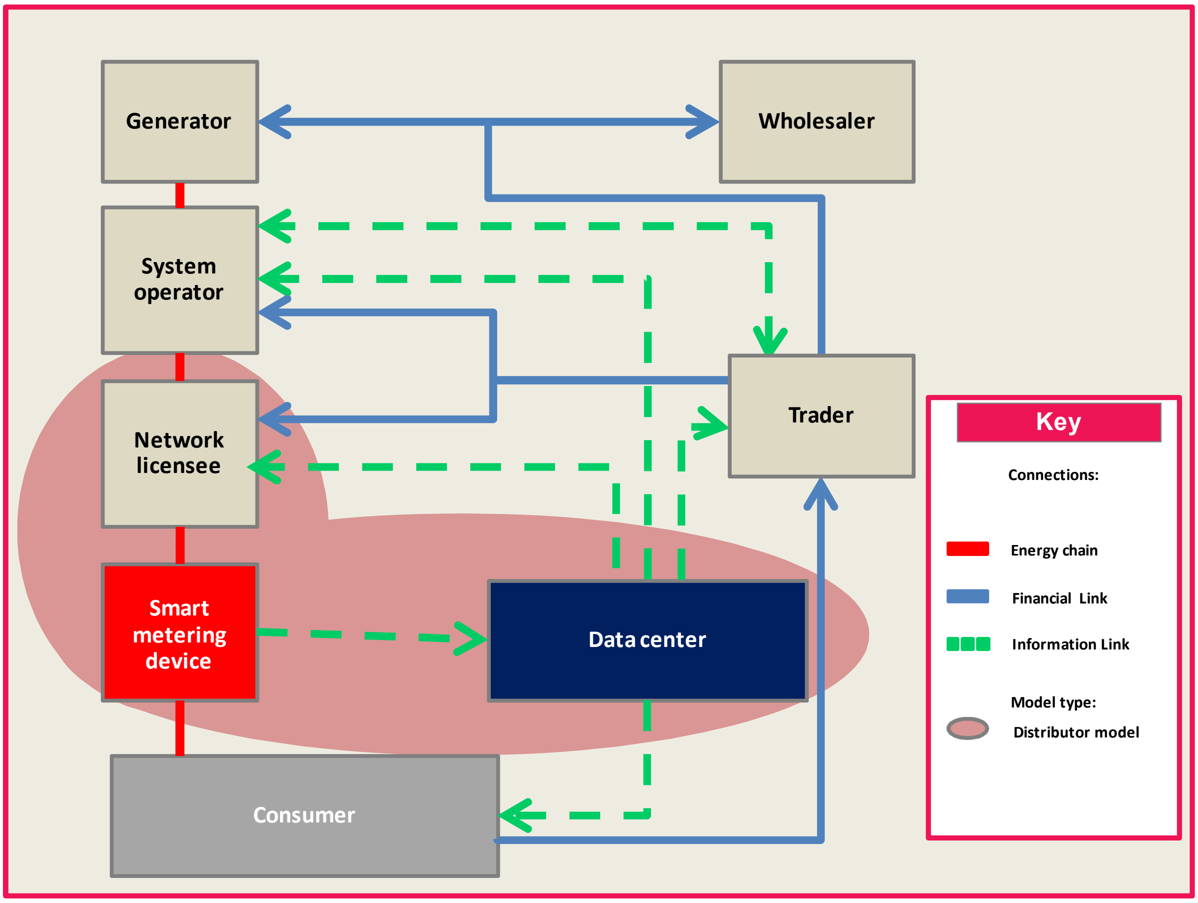
The results of the analysis and the consulting consortium's recommendations based on them are contained by the following chapters.

3.6.4. Introduction of the DSO/Network Licensee Basic Model

On the following figure we introduce the most important features of the DSO/Network Licensee basic model through the features of the electricity sector, and the different physical, financial and information links and connections among the different actors of the value chain. The scheme of the model is as follows:

[3] Status Review of Regulatory Aspects of Smart Metering (Electricity and Gas) as of May 2009 Ref: EO9-RMF-17-03, 19 October 2009

Figure 11.: Processes and links in the distributor basic model



The main features of the model are as follows:

- In the DSO model of smart metering, the metering device is owned by the DSO/Network licensee and, at the same time, is responsible for the installation and operations of the same.
- The initiator of the installation of smart meters is the Network licensee.
- The DSO, as a monopolistic service provider in its area, is responsible for collecting, forwarding and processing of data from the smart meters in its area.
- Possible ways of financing the investment:
    - The Network licensee performs the investment from own resources. This is included later, based on detailed regulation, in the Network Tariff.
- Those who have interest in the introduction of smart metering (e.g.: consumers, state or Trading Company) also contribute to the investment costs. The network licensee can only have his costs acknowledged through the Network Tariff (NT).
- The metering device remains part of the distribution network.

- The consumer remains in contractual relation with the Trading Company in the case of both electricity and gas (within the framework of network connection and network utilization contracts).
- The DSO, responsible for remote data reading, data processing, provides the Trading Company with data (based on contract and predefined data content and frequency), who prepares the invoice to the customer based on these.
- Invoicing and customer service activities towards the customer are performed by the Trading Company in the case of both electricity and gas for the consumers belonging to the universal service provision (in the case of consumers with a given profile the DSO is invoicing the system utilization fee).
- The consumer is in contractual relationship with the Trading Company, therefore all fee connected to smart metering are paid to the Trading Company but the entitled is the DSO (in case the DSO is invoicing directly the consumer, then the fees of smart metering can be invoiced by the DSO).
- The DSO can use its own assets or the ones of an external service provider (e.g.: telecommunication company) for the operation of the communication network.
- Possible ways of cost-benefit sharing:
    - The positive effects of efficiency improvement resulting from technological progress must be realized through the existing Network Tariff mechanism, under the Regulator's supervision
    - Through the NT mechanism, but the participants in the financing of smart metering can reserve rights for certain services of the smart meter (e.g.: Trading Company) – bearing in mind that certain players/actors can access data set by law regardless of financing.

Most important Pros and Cons regarding the DSO/Network Licensee Model:

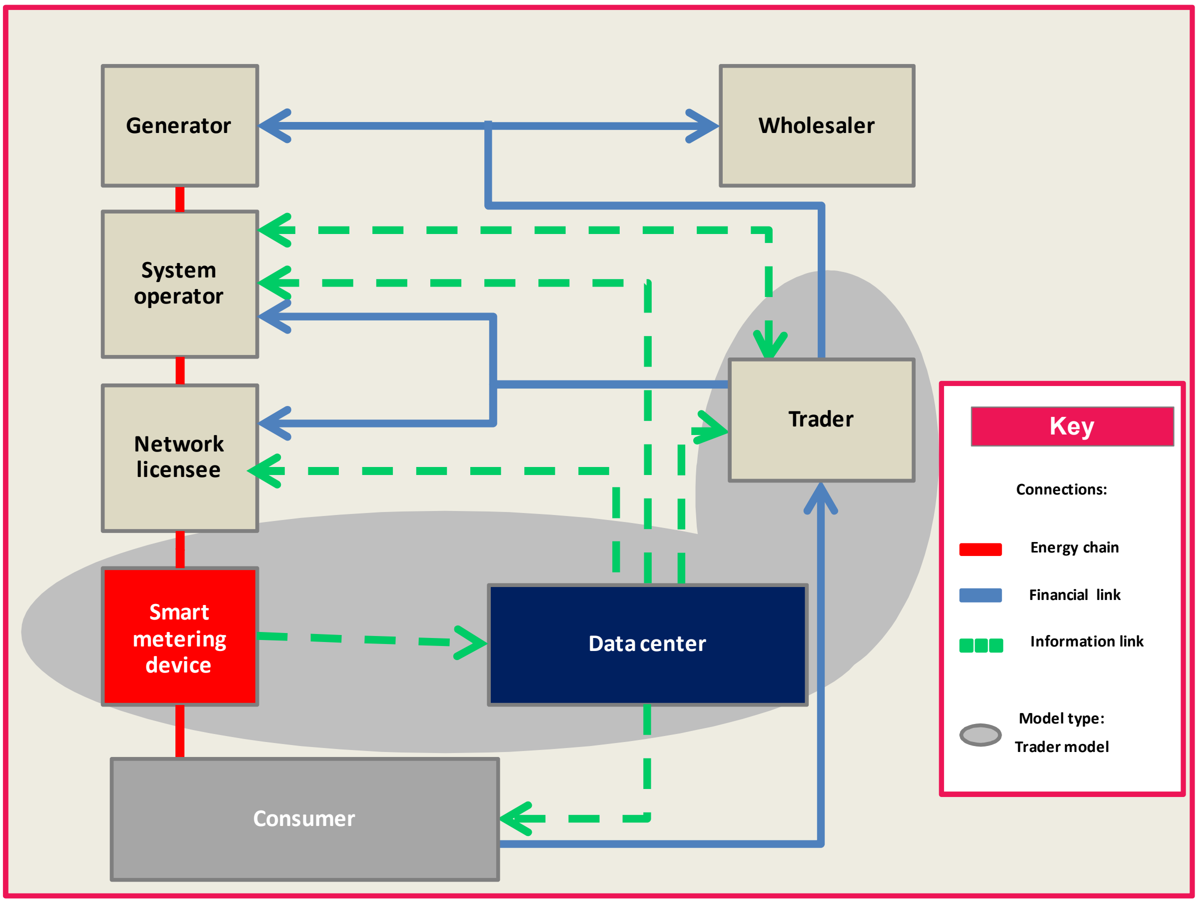
Pros	Cons
• Model mostly in synch with the current market structure • Lowest industry resistance towards the model (based on the results of interviews and Workshops) • The installation and maintenance can be performed with less resources and work processes • The telecommunication company can even connect to the system, its task can be forwarding the data to a central database • The technological solutions to be built in case smart metering is supervised by the DSO can mean the basis for smart grid, only in case the DSO is motivated by economic incentives	• Isolated solutions working in parallel can emerge for the different utilities and for the utility distributors of the same sector operating in the different regions of the country (that can cause compatibility problems when developing the system) • Leveraged counter-interests (e.g.: best commercial offer for the consumer, decrease in energy consumption), as both the DSO and the Trading Company usually belong to the same company group • In the case of its certain fees the DSO is interested in invoicing based on

• In the case of electricity (exclusively): the electricity DSO possesses a communication network (PLC or BPL) that is provided by the grid/network operated by the same DSO	turnover/consumption, fact that would decrease energy saving willingness. This effect can be further increased in case the group the DSO belongs to has commercial interests • In the case of gas: the DSO might have to develop a separate communication network and data storage solution, but they do not have experiences regarding this

3.6.5. Introduction of the Trading Company Basic Model

The scheme of the Trading Company Basic Model:

Figure 12.: Processes and links in the trading company basic model



The main features of the model are as follows:

- In the Trading Company model of smart metering, the metering device[4] is owned by the Trading Company
- The Trading Company is responsible for the installation of the metering device.
- The initiator of the installation of smart meters is the Consumer (in agreement with the Trading Company, according to the technical rules of the Network licensee).
- The investment is jointly-financed, with the dominant role of the Trading Company and the Consumer.
- The metering device is not part of the distribution network.
- The Trading Company (without monopolistic situation) is responsible for the data collection, forwarding and processing of its contracted consumers, on a competitive market.
- As the metering device is owned by the Trading Company (meters are kept on its account), therefore, in case of change of service providers, these meters must be uninstalled (and taken out of the books) or, the two service providers involved must agree on it.
- Cost-benefit sharing: compensation of the initial investment independently from the NT (possible metering, data provision and new energy trading services, other service fees).

Most important Pros and Cons regarding the Trading Company Basic Model:

Pros	Cons
• Utilization of the existing consumer-Trading Company contractual relationship • Trading Company can add new services to the functionality (placing displays, offering better fees to the consumers, energy saving consultancy) • The model defines smart metering as ’competition for households’ that result in the deeper knowledge of consumers on the advantages of metering	• Market competition weakening effect, that the ownership of the meters must be cleared when changing service provider • No significant support industry players (resulting from interviews and Workshops) • Significant need for regulation • Settlement with the System Operator is performed by the DSOs; the DSOs are responsible for the consumers’ consumption diagrams/graphs; network loss arises at the DSOs’ operations, therefore, in case consumer metering is performed by another entity it can reduce the interest of the DSO in the exact and timely settlement at system level.

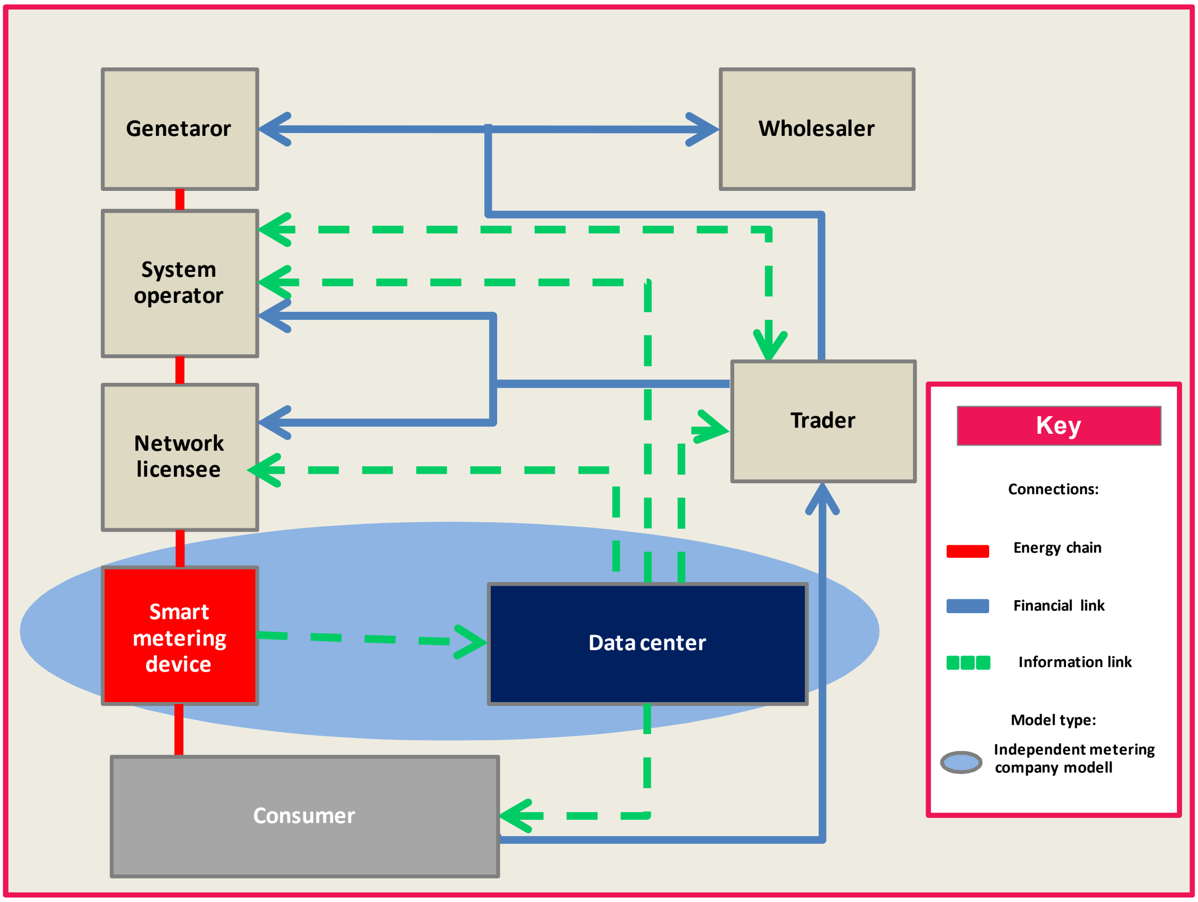
[4] As we recorded earlier in Chapter 4.2, the ownership of the meters is not a key factor when choosing from the different models. In the case of the basic models we only deal with the question of ownership of the meters as seen above due to the ’purity’ of the basic theoretic models.

	• Trading Companies can have counter-interests in the transparent communication of advantages consumption reduction due to their profit (margin) interest

3.6.6. Introduction of the Independent Metering Company Basic Model

The scheme of the Independent Metering Company Basic Model:

Figure 13.: Processes and links in the independent smart metering company basic model



The main features of the model are as follows:

- A new participant appears in the current supply chain (independent metering company) that owns the smart meters; the company keeps the meters on its accounts.
- The Independent Metering Company is responsible for the installation and inspection of the metering devices. These activities are performed by the DSO (based on a contract)
- Metering activities are performed by the Independent Metering Company (instead of the DSO)

- The Independent Metering Company, responsible for remote data reading, data processing, provides the DSO and Trading Company with data (based on contract and predefined data content and frequency).
- Trading Companies prepare their invoices to their customers using these data.
- The 'traditional' actors/players of the value chain are in contractual relationships with the Independent Metering Company regarding the following:
    - Use of metering device
    - Remote data reading
    - Data processing
    - Forwarding of data to the DSO, Trading Company
- During its operation, the Independent Metering Company can manage the data obtained i.e. can perform brokerage activities (consulting activities to customers on the most attractive commercial offers). These activities must be specified from data protection side and other considerations.
- Investment financing: joint-investment is recommended, although the role of the independent player is significant. Consumers and other service providers take part in the financing of the investment.
- Cost-benefit sharing: compensation of the initial investment independently from the NT (possible metering, data provision and new energy trading services, other service fees).

Most important Pros and Cons of the Independent Metering Company Basic Model:

Pros	Cons
• Currently the DSOs of the different utilities cover the territory of the country with different structures, while in the case of the metering company model there is the possibility to differ from this and apply a unified coverage principle. • The independent metering company has no direct turnover interests, therefore it can support effectively the energy efficiency goals. • Possibility for the application of multi-utility solutions and optimization of synergies (basically in the case of investment costs). • Higher 'degree of technological freedom' in case mixed telecommunication solution must be applied due to the different geographical circumstances.	• Significant regulation tasks; it is necessary the precise definition and separation of responsibilities and authorities. • More complicated contractual solutions. • As the model has more players than in the current operation scheme, longer lead times, higher load of administration tasks and more complicated processes can arise. • Special attention must be paid to the separation of physical network loss and theft (in case theft is performed at the meter the loss is burden of the metering company). • Service security to the consumer is guaranteed physically by the DSO, so in case of any break-downs, any other element guaranteed by an other market player can make the repair times longer

	(different service provider to contact by the consumer in the case of faults with the network, malfunction of meters, etc.).

4.3 Evaluation of the Basic Models, Model-Variant Phase

4.3.1. Comparative Analysis against the Goals of Smart Metering

The comparison and evaluation of the three basic theoretical models presented were performed against the goals (evaluation criteria) introduced in the Inception Report (taking into consideration the comments at the Workshops), using the following definition of the elements of the goals (evaluation criteria) set:

Figure 14.: Elements of the smart metering evaluation system

Goals of Smart Metering						
Cost of implementation	Time of implementation	Pricing and cost transparency	Improvement of competition within the industry	Lowering entry barriers for new technologies	Increasing energy consumption efficiency, lowering the impact on the environment	Improvement of service quality

During the analysis, the different elements of the goals were interpreted along the following definitions:

<u>Cost of implementation</u>

Defines the depth and speed of Smart Metering implementation. It is important from the system point of view, who bares higher costs (e.g.: consumer, service provider).

<u>Time of implementation</u>

Defines whether the given model has any direct influence on the schedule and time of the implementation. When the smart metering network reaches its critical mass, where, as a result of connecting an additional consumer through a smart meter to the network, the marginal profit exceeds the marginal cost of connection.

<u>Pricing and cost transparency</u>

Defines to what extent the given model supports the pricing transparency, as well as the cost transparency, of the market players.

<u>Improvement of competition within the industry</u>

It is an important factor the promotion of industry competition. The presence of more service providers promotes the decrease in fees, and if this is supported by the lowering entry barriers for new technologies, then the power of the consumers on the market will increase.

Lowering entry barriers for new technologies

The implementation of any of the smart metering models involves investment and can determine the characteristics of the national networks in this respect for years. Therefore it is important that the elements of the technology remain open for development. In this way the proposed investment can be protected from devaluation and, at the same time, the infrastructure of the industry remains open for technological development.

Increasing the energy consumption's efficiency, lowering the impact on the environment

The importance of energy efficiency is essential for the consumers, generators/producers and the environment.

Improvement of service quality

Evaluates whether the implementation of given smart metering model supports the continuous improvement of the service level; based on its specifics, the model provides possibility for/supports this purpose.

The evaluation of the basic models against the goals (evaluation criteria) is shown in the table below:

Table 2.: Comparative analysis of the basic models

	DSO Model	Trading Company Model	Independent Metering Company Model
Cost of Implementation	In the case of using existing communication infrastructure (own – PLC – or purchased) lower implementation costs at the electricity DSO. In the case of gas the communication solution to be applied is not obvious.	Highest cost level as an entirely new infrastructure or outside service provision is necessary.	Investment costs (mainly communication investment costs) can be significantly reduced depending on the ownership structure of the metering company.
Time of implementation	No significant differences among the different models		
Pricing transparency	No significant differences among the different models		
Cost transparency	(Even) Currently, the DSO is strictly regulated regarding cost transparency.	Expected transparency can be ensured based on proper regulation.	Expected transparency can be ensured based on proper regulation.
Improvement of competition within the industry	Nowadays, competition is hindered by the fact that prices are kept low in the universal service. The success of the DSO model in this respect strongly depends on the effect of the unbundling regulation.	The implementation of the model strongly supports it (competition), but raises questions when changing service provider at a later time: the issue of the meter must be solved.	The separated player does not possess industry self-interest; therefore this model supports industry competition at the highest level.

	(same owner groups).		
Lowering entry barriers for new technologies	Supports it, but given the capabilities of the DSO (in the case of electricity) the PLC solution has advantages compared to other current and future technologies.	Basically supports it, but has not explicit interest in involving new technologies besides PLC.	Probably the independent metering is the most open one to future technologies.
Increasing the energy consumption's efficiency, lowering the impact on the environment	On the short term, the DSO is interested in the sales of the highest volume possible of services, partly due to its tariffs linked to consumption.	Basically, the trader is interested in the sales of the highest volume possible of services (due to its margin interests).	The separated metering company has no counter-interests to the support of consumption reduction programs.
Improvement of service quality	Currently the HEO has strict prescriptions to the DSO regarding quality.	Currently the HEO has strict prescriptions to the Trading company regarding quality.	Can be ensured upon proper regulation.

Reasons taken into consideration when selecting the model to be evaluated during the next phases of the project:

- Based on the evaluation against the goals it is not recommended to keep the Trading Company model among the possible models for further assessment.
- Based on the international benchmark, it can be observed that none of the countries chose the implementation of a 'pure' Trading Company model.
- Based on the preferences of the industry players, the DSO model and another model supporting the appearance of the Independent Metering Company are supported to a higher extent.
- Market competition is significantly more supported by the DSO and Independent Metering Company models (mainly because the change of service provider is more difficult in the Trading Company model, as in given case either the meter must be uninstalled or the different service providers have to agree on the ownership and use of it.
- The DSO model fulfils to the highest the currently operating industry model scheme.
- The Independent Metering Company supports to the highest level the fulfillment of energy saving goals.

Apart from the 'pure' models, it is worth mentioning those additional model variants that were drawn based on the workshops and the consultants' activities / international benchmark analysis and in which, with the aim of implementing smart metering in the most efficient way, elements or parameters of the original 'pure' models were altered or mixed.

1. Mixed Independent Metering Company Model

   Installation and ownership of the meters is competence of the DSO, while reading, data transfer and information management are tasks and responsibilities of the

Independent Metering Company. In the case of this model the interests of the DSO are not harmed and, at the same time, a new participant with an existing infrastructure and communication and IT know-how can be integrated into the system with the involvement of the Independent Metering Company.

2. Distributors' Cooperation

   Motivation or direction of the responsible of the different utilities (electricity, gas, later district heating) with regulation and financial tools to harmonize in time the change of meters and, as a result, utilize the synergies of communication and operations.

3. Competing metering companies

   In case of the Independent Metering Company model there is an alternative model variant that is based on a principle supporting market competition (e.g.: concessions, or the model of competing metering companies on the open market).

In the case of all model-variants it is recommended to evaluate the following alternatives regarding implementation ad roll-out:

- Forced implementation schedule

  While taking into consideration that in case of the implementation of smart metering it is essential to reach the highest number of meters deployed in the shortest period of time, it is recommended that relatively new conventional meters are changed to smart meters later. This way the cost of these meters would be sunk costs in the accounts.

- Geographically organized implementation

  The Regulator, in agreement with the stakeholders, defines the implementation of smart metering according to a predefined schedule, pace and scale, by selected regions/areas of the country. In this way the deployment of data concentrators and the communication infrastructure can be harmonized, and the advantages arising from the operation of the smart metering system can be felt earlier in pockets.

- State support or consumer contribution during implementation

  In order to support the reaching of critical mass and/or the quickest implementation at the first phase of implementation, the State provides support for the installation of the first given number of smart meters by financing it from the central budget.

It is important to mention that, in this chapter, our target was the introduction of the above three model variants and the three alternatives of implementation; the assessment of these and their evaluation regarding their implementation in Hungary is presented in detail in the next modeling chapter.

4.3.2. Summary of the Proposed Smart Metering Models

Based on the consultants' analysis and the consultation sessions with the HEO, the following two model families were considered as starting points of the modeling and during the performance of the CBA:

- DSO basic model
- Metering Company model (with special regard to the so called mixed model variants, in case of which the installation and ownership of the meters is competence of the DSO, while reading, data traffic, information management are performed by the Metering Company).

Table 3.: Overview of the smart metering basic models recommended for quantitative analysis

	DSO Model	Metering Company Model
Roles and Responsibilities		
Responsibility for the smart metering system	Distributor	Metering company
Installation of meter	Distributor	Distributor
Ownership of meter	Distributor	Options: • Distributor • Metering company
Communication between smart meter and data concentrator	Distributor / external data owner (e.g.: within outsourced communication service)	Options: • Distributor • Metering company
Communication between data concentrator and data center	Distributor / external data owner (e.g.: within outsourced communication service)	Metering company
Responsible for local/unique metering data and communication	Distributor	Metering company
Focus of competition in the field of metering services for Trading Companies	Distributor is responsible for the following: have a proper meter provider and data owner/data center	Metering company is responsible for data collection, processing and forwarding to the respective industry players
Data processing infrastructure/storage	The Distributor must/should have its own data center or uses an external service provider for the processing and safe storage of data	Metering company must have its own infrastructure
Communication infrastructure	The Distributor must/should have its own data center or uses an external service provider	The Metering company must/should have its own data center or uses an external service provider

5. Cost-Benefit Analysis

(While the study was conducted in Hungarian Forint (HUF), all the results are presented in USD for ease of use internationally. The exchange rate used is 202,46 HUF/USD – the average of the official exchange rate of Central Bank of Hungary between January 2009 and June 2010.)

5.1 Framework of the Cost-Benefit Analysis

In the previous phase of the project we prepared a two-level comparison (qualitative and quantitative analysis) in order to make easier the choice among the selected models by demonstrating the costs and benefits. We quantified the direct and indirect costs, as well as the benefits and the estimated investment needs (quantitative analysis), furthermore, within the framework of a qualitative analysis, we introduced the effect of those factors that were to be analyzed at a later phase of the project when the selected models are known.

The CBA presented in the Preliminary Report was prepared, primarily, to support the selection from the different models, so it cannot be considered as an overall analysis. The model did not evaluate the following topics:

- External benefits of smart metering in the field of energy savings and reduction in the emission of green house effect gases (GHG)
- The distribution of costs and benefits among the different stakeholders
- Changes in the different models in case key parameters change (sensitivity analysis/tests)

The CBA presented in this study, the Final Report, has been significantly amended both in the case of the number of quantified parameters and in the case of the comparisons of the different models and model variants.

The model, taking into consideration the number of parameters used, is appropriate for performing sensitivity analysis/tests. Several of these tests will be presented in this study.

During model definition, we relied of five data sources:

1. Data from the Hungarian Energy Office;
2. Data provided by the industry players (distributors, trading licensees/universal service providers, telecommunication service providers) – data collection organized by the consultants[5];
3. Relevant information and data from international studies (benchmark)[6];
4. Remarks from the cluster workshops and written comments to the Preliminary Report;

[5] Example of the data requesting sheet sent to the DSOs is included in the attachments of this study

[6] The list of studies and conference material used for the analysis can be found in the attachments.

5. Information data obtained from the DSOs on the currently used 'traditional' meters regarding the aging of the meters and energy consumption of the examined consumer segment in relation with the number of meters installed.

During the introduction of the different model parameters we will mention the source of the given parameter and our remarks related to the relevance of it.

5.2 Model Basic Assumptions and Parameters

During modeling we had the following assumptions:[7]

5.2.1. Definition of the Assessment Framework

- The model uses two time horizons: an explicit forecasting period and a residual value. The explicit period refers to the first ten years of the implementation and roll-out, the period from 2011 to 2020. The model is a nominal model, expected inflation of the given year was taken into consideration in case of the different data. The period after the 10th year was modeled with residual value. The definition of the residual value was performed by the application of the annuity model, with the theoretic consideration of the operation of a 'standardized' t+1 year by using the following basic formula: $\{C/(r-g)\} / (1+r)^t$, where C is considered as a data characterizing the 'standard' year. In the annuity, r is a nominal discount rate split according to the description of parameters (11) and (12), g=0 i.e. we did not calculate with an increasing annuity. When defining the 'standard year', we took into consideration the data of the last year of operation (2020), except for those elements where the investments and the costs related show significant difference for the different years. Such items are the investment and replacement costs of the data center or the installed smart meters.
- When performing the CBA the following segments (mainly households - also the SMEs belong to this segment) were taken into consideration:
  - Electricity: under 3x80 A consumption segment
  - Gas: under $20m^3$/h consumption segment

  When defining the target group based on consumption, we took into consideration the available national data and, with our focus, we adapted ourselves to the typical target group definitions of the international studies.
- The model evaluates two utilities (electricity and gas). Partly due to methodological difficulties (and in harmony with the focus of the international projects) we did not

[7] The numbering of the parameters can be found on the 'Parameters' sheet of the model attached to the report

perform such a detailed CBA in case of the district heating utility sector also in the focus of the study. We do not assess the economic effects of the inclusion of other utilities, especially the water supply service, in the quantitative analysis, although, we are convinced that including this utility in the presented two-utility models, in case of appropriate implementation decision, can result in significant synergies.

5.2.2. Macroeconomic Factors

Macroeconomic factors are included in lines (1)-(12) of the parameter tables of the CBA. The assumptions of the model regarding the most important macroeconomic parameters are the following:

- Within the timeline of the model, inflation rate is decreasing from the starting 3.7% value to 3% in 2013 and stabilizes at this level [Parameter line (1)].
- The effect of inflation was taken into consideration in the case of all items, except in the case of the purchase of technological assets (data concentrator, smart metering device). We supposed that the due to the international penetration of smart metering technologies the global competition will result in price reduction in real terms. (The latter assumption was included in the model on Parameters lines (18) and (36), to be detailed later.)
- When defining the Net Present Value (NPV) of the costs and benefits we used two different discount rates:
    - 8% nominal discount rate for the analysis of sociological benefits and
    - 10 % nominal discount rate was used for modeling the capital cost of the industry.

  Remark: this latter is lower than the 7.1% real yield accepted for regulated activities in the sector supervised by the HEO projected to the stock of assets constituting the basis of regulation, but the difference between the model and the industry 'rule' (10 and 10.1%), practically disappears, considering long term inflation expectations, therefore we did not further fine tune the discount rate [Parameter lines (11) and (12)].

5.2.3. Scope and Schedule of Implementation

- While in the Preliminary Report we accepted, without any further assessment, the 80% rate of the EU Directive regarding smart meters, in the case of the Final Report this parameter became an important factor of the sensitivity analysis/tests for the evaluation. Parameter (13) contains the target number of smart meters in the ratio of the total number of meters of the target group [Parameters (15) and (16)]. The parameter value in the basic model was set to 70%, but in the study we present an analysis with 80% and 90% coverage, as well (see Chapter 5.5.2.).
- During the discussion of the Preliminary Report at the cluster workshops, several remarks were made claiming that the rate of the number of meters does not equal

the rate of them in the consumption; the relationship between these two factors can be represented with a parabola graph. On Parameter line (14), we present according to this the rate of consumption within the target group reached according to the coverage target number set based on Parameter (13). The connection between the number of meters and their rate in consumption is detailed by Parameter line (52). The values of Parameter (14) can be chosen from the value scale of Parameter (52), based on the number of appropriate rate of smart meters.

5.2.4. Number, Composition and Prices of Electricity and Gas Meters

- In order to define the number of electricity smart meters to be installed per year, we relied on the data provided by the network licensees and the HEO [Parameter (15)]. During data collection, the DSOs provided the number of meters installed in the under 80 A segment. These values were aggregated and constituted the basic value used for the calculation of the number of smart meters to be installed during the entire roll-out period, at national level. We did not calculate with the *a priori* organic change of the number of meters/consumers; the change in their consumption level and structure were taken into consideration in the case of the energy consumption forecasting by the HEO.

Table 4.: Number of installed meters per network licensees –electricity

(pieces)	ÉMÁSZ	ELMŰ	ÉDÁSZ	TITÁSZ	DÉDÁSZ	DÉMÁSZ	Total
Current number of meters	736 301	1 493 101	998 849	776 133	756 187	750 000	**5 510 571**

Remark: this number does not contain, on purpose, the number of B-tariff meters; adding this number (1.5 Million) to the above mentioned meters, the aggregated value of the parameter representing the distribution by age of the electricity meters can accurately be obtained. The reason for leaving out the B-tariff meters is that, based on our opinion, the physically separated B-tariff (night consumption) meters become unnecessary in the smart metering system. At the same time, this does not mean that radio and sound frequency control should be terminated, as this can be viable within the smart meter installed (two-tariff, partly remotely controlled meter), instead of using a separate meter. Based on the remarks at the workshops of the project, the enhancement of the expected functionalities of the smart meters presented in Attachment 2 does not generate significant price increase for the meters.

- When defining the number of gas meters, we relied on the data provided by the HEO from the yearly data provision of gas service providers from 2008 [Parameter (16)]. In the case of the network licensees, we summarized the values of 'Number of gas meters installed at consumers (< 20 m3/hr consumption category)' of the five DSO companies, giving 3 035 120 as a result. We did not calculate with the *a priori* organic change of the number of meters/consumers; similarly to the case of electricity, we took into consideration the change in the consumption level and structure at the forecasting of energy consumption.

Table 5.: Number of installed gas meters per network licensees – gas

(pieces)	category	Tigáz	DDGáz	Kögáz	Főgáz	GDF-SUEZ	Total
Current number of meters	< 20 m3/h	1 160 818	254 643	272 121	645 543	701 995	**3 035 120**

Based on the experiences of the cluster workshops and upon the DSOs' request, we took into consideration the effect of the fact that the aging of the meters is not homogeneous and different number of meters will be changed per year during the next ten years. The effect of this was considered in the case of the sunk costs of the meters and the saved reinvestment costs (24).

In the Final Report, opposite to the previous studies, the number of meters was not presented as a net value considering that this could cause misunderstandings in the interpretation of the data. In Parameter lines (19)-(22) and (26), we considered in detail the prices of traditional meters and smart meters per meter groups. We defined the purchasing price of smart meters with the comparison between the data from data request and the European benchmark (see below). Regarding the future prices of smart meters, we presume that due to the technological development and increasing market penetration the price of the meters will become more favorable. In order to quantify such an effect, we built in an inflation correction parameter resulting from technological development in the case of smart meters [Parameter (18)].

Table 6.: Sources of data and the initial smart meter prices used in the cost-benefit analysis

Data in USD	**Electricity**	**Gas**
Average of DSO data	193	300
Italian model[8]	93	-
UK model[9]	67	87
(Average) Price	**118**	**194**

- Despite the fact that during modeling we used the price obtained based on this average for calculation, we have to mention that there is significant difference between the data from international examples used and prices mentioned at the technological cluster workshop and the data provided by the DSOs. The reason for this can probably be that the costs of interrupters (cutouts) were included in the prices of the electricity meters. Considering the above and taking into consideration

[8] 70 EUR, Presentation by Ferruccio Villa at the HEO ERRA Training Course, Budapest, 2 February 2010

[9] 43 GMP, Baringa: Smart Meter Roll-out: Market Model Definition & Evaluation Project, United Kingdom, 8 April 2009

the key role of this parameter for the calculation of industry benefits, we also performed sensitivity analysis for the assessment of the effect of meter prices.

- We took into consideration in the Final Report, apart from the summarized number of meters, that the aging (age composition) of the meters is not homogeneous and different number of meters will be changed per year during the next ten years and that the meters used in case of electricity can be grouped in 1-phase, 3-phase and B-tariff meters [Parameter (24)]. The DSOs provided us with the data regarding electricity and gas meters to be changed under normal conditions in the next 10-12 years. These distributions presented the number of meters to be changed based on 1-3-phase or tariff categories. In order to have a unified view, the analysis uses the above three categories. Starting data (provided by the network licensees) were corrected based on the following information/assumptions:
    - The aging (age composition) provided by the DSOs corresponded to the entire stock of meters. Compared to the HEO data we came to the conclusion that the rate of the meters installed in the household consumer segment is 93.5 % compared to the total number of meters.
    - There are 1.5 million meters with B tariffs at national level and their depreciation equals the depreciation level of the service provider model used in our model.
- We estimated the price of the gas meters at USD 74, based on national retail benchmark [Parameter (26)].
- Based on the cluster workshops we took into consideration that the aging of the meters is not homogeneous and different number of gas meters will be changed per year during the next ten years. Regarding definition of the number of meters to be changed per year, the number of obsolete meters was defined by DSO. We divided the country into Tigáz, GdF-Suez, E.ON and Főgáz areas. In the case of the E.On area we relied on the data sent by E.ON regarding the meters of the E.ON area (for the period between 2012 and 2020); in case of the other DSOs we used the data provided by the HEO from the yearly data provision of gas service providers from 2008. These numbers are relevant in two areas of the model – these are significant figures in those cases where, instead of a balanced roll-out with normal depreciation, quicker or slower roll-outs can be expected:
    - As a sunk cost: because the meters changed before their lifetime, generate costs for the DSOs. In case the traditional meters are changed before their lifetime their book value would mean sunk cost [Parameter (25)].
    - As a saved reinvestment cost for traditional meter: in case the traditional meters are changed before the expiry of their lifetime.

5.2.5. Data Concentrators and Data Center

- From IT point of view, a data concentrator can serve several hundreds of (smart) meters; its theoretic capacity can even reach one thousand. Considering the geographic and demographic characteristics of the country, we estimated that, as an average, one data concentrator will serve 200 meters per utility (supposing independent utilities) [Parameters (28) and (29)].

- Based on the DSO Basic Model, in case the implementation of smart meters is performed according to the current industry sector, it is necessary in the case of both utilities that the different DSOs develop their own communication network for data management purposes. As the DSO Basic Model is not a multi-utility model, the DSOs develop their independent communication infrastructure for the different utilities. In case the DSOs cooperate or a SM Operator manages the data communication of both utilities in a given geographic area, then the same data concentrator can be used for both utilities [Parameters (30) and (31)].
- All DSOs uniformly specified the lifetime of the data concentrators in seven years [Parameter (33)]. (The explicit period of the model is ten years, so we calculate with the depreciation of the data concentrators and the reinvestments needs deriving from it even during the explicit period.) On the data requesting sheet, the DSOs, with one exception, specified the price of the data concentrators in HUF 300,000, (USD 1,482) therefore we used this value in the case of this parameter (38).
- It is necessary the development of a data processing and management center for the storage and management of the increased volume of consumption data (compared to the actual volume). The costs of this will probably arise in the first two years of the implementation and roll-out (i.e. not in proportion with the number of smart meters deployed). Based on our estimation, these costs will be split according to the following in the first three years, regardless of the implementation and roll-out schedule: 45%-45%-10%. The number of data centers depends on the model selected. Synergies are recorded by parameter lines (42)-(51).
- We specified the unit cost of communication between the data concentrator and the data center as HUF 10,000/year/meter (USD 49) based on the information provided by the telecommunication companies (52).

5.2.6. Operational Costs of Smart Meters – Electricity and Gas

- The direct operational costs of the smart meters were split into three items. The direct operational cost of the meter (69) and the cost of repair (70) were set in the model as the averages of the values specified in the data requesting sheets. As the cost of repair specified by the DSOs was related to total coverage, we included a cost increasing parameter (71) to be able to quantify the effect of the initial, less favorable territorial distribution. The value of this was estimated at 100% that can be interpreted as follows: its value is double (in present value) in case the coverage is minimal. Obviously, the value of this cost-premium factor will proportionally decrease with the increasing coverage. We specified the unit cost of communication between the data concentrator and the data center based on the information provided by the telecommunication companies. We would like to emphasize that the value of this parameter (72) does not contain any preferences regarding the communication solution to be applied.
- Besides the implementation of smart meters, the physical reading of the traditional meters will be necessary. The number of traditional meters will decrease in parallel with the spread of smart meters; therefore increase in their specific reading cost can be expected. As a result, we estimated the rate of this cost increase at 100% in case of maximum smart metering coverage [Parameter (73)]. We defined the specific reading costs in the case of electricity (74) and gas (75) as the fraction of the total reading costs (based on the data requesting sheet and HEO information) and the total number of meters [Parameters (15) and (16)].
- The DSOs informed the consulting consortium that they reserve the right for meter inspections, even in case of the smart meters. The unit cost of this was estimated at HUF 364 by them [Parameter (77)]. This means visits with inspection purposes and not reading or repairs. The frequency of these visits was estimated by the DSOs at 5% of the total number of consumers with smart meters [Parameter (76)].

5.2.7. Benefits of Implementation

- One of the most important benefits for the industry is the expected reduction in theft. This is the result of the increased volume of consumption data from the different meters available for the DSOs and theft can be detected from the comparison of the timeline data of consumption. (This was the main motivational reason for implementation in Italy.) The current value of theft was taken from the data provided by the DSOs on the data requesting sheets [Parameters (78) and (79)]. The losses related to theft calculated to energy fees gives 1% of the consumption of the universal service segment in the case of electricity and 2.4% in the case of gas. Based on our conservative expectations, the rate of theft can be reduced to the level of the ERGEG benchmark before the application of smart metering; therefore we modeled a 70% decrease of the current level [Parameter (80)].

Table 7.: Background for the calculation of reduction in theft

	Bencmark (ERGEG) - a priori	Benchmark (ERGEG) - reduction	Domstic data - a priori	Domestic decrease
Reduction of theft - electricity	0,20%	20-33%	1,00%	70%
Reduction of theft - gas	1,00%	50%	2,5%[1]	70%

1: Theft and Network Loss in Total

- Regarding the expectations related to reduction of the network loss, the DSOs expressed their concerns whether the targeted reduction can be fulfilled. As significantly different opinions were provided at the cluster workshops, we decided to keep, in the case of electricity, the 20% decrease rate in the model, while in the case of gas we reduced this rate to 40% [Parameters (58) and (59)]. According to the model, these reductions in loss reduce the total loss, provided by the DSOs - [Parameters (81) and (82)]. In chapter 5.5.3, we performed a sensitivity analysis/tests to assess the possible deviation of the parameter from the planned value, due to the discussions regarding the topic.
- The reduction in bad debt can mean additional industry benefit for the service providers: smart meters comprise such technologies that can make possible the remote management of the capacities used by the consumers. We are convinced that the application of such technologies makes possible the rationalization of the rules of switch-off/disconnection of customers (that currently limit the possibilities of service providers at a high extent). Based on this, we estimated that the bad debt over 30 days can be reduced by 90% in the case of electricity and by 40% in the case of gas [Parameters (85) and (86)]. As switch on and off of consumers cannot be remotely managed, due to technological reasons, as easily in the case of gas as in the case of electricity, we estimated the target number at a lower value. Based on the data from universal service providers, it can be established that bad debt over 30 days means the 35% of all customer A/R. The total universal service provider bad debt was considered with this rate [Parameters (83) and (84)].

Having performed the detailed introduction into the parameters, the following is a summary of those items we consider as the most important ones, mentioning the effects expected from smart metering.

Table 8.: Most important parameters affecting the industry

Item	Domestic data – a priori	Domestic decrease	Remark
Reduction in theft ELECTRICITY, %	1,0%	70%	Data request and consultants' estimation (in the basic model its effect is mentioned with the reduction in network loss)

Value of the reduction in theft (compared to a priori value) ELECTRICITY and GAS, %	2,5%[10]	70%	Data request and consultants' estimation (in the basic model its effect is mentioned with the reduction in network loss)
Rate of reduction in network loss ELECTRICITY, %	USD 365 Million	20%	Data request and consultants' estimation (including services at system level)
Rate of reduction in network loss GAS, %	USD 76,8 Million	40%	Data request and consultants' estimation (agreed with industry players)
Reduction in bad debt over 30 days ELECTRICITY, %	USD 133 Million * 35%	90%	Data request and consultants' estimation
Reduction in bad debt over 30 days GAS, %	USD 102 Billion * 35%	50%	Data request and consultants' estimation
Reduction in bad debt over 30 days ELECTRICITY, GAS, %	10%	-	Industry data (7,2% + inflation)

5.3 Introduction of the Smart Metering Models Evaluated During the CBA

We developed four models during the modeling activities. In one of these, similarly to the current industry solutions, the DSOs of the different utilities would separately operate the smart metering systems. The second model supposes a certain level of cooperation of the gas and electricity DSOs. We modeled separately in the two model variants whether a separate company or companies, so called SM Operators, are created to operate the smart metering system, and who perform this task as multi-utility service providers. There is no difference in the number of smart meters between the two models, as the installation (together with the ownership) is competence of the DSOs. The results of the models are discussed based on the quick implementation schedule, as

- based on the result of the sensitivity analysis/tests performed in case of the different implementation schedules, the quick implementation at national level (total coverage with smart meters of the targeted groups is performed within five years of the time of decision) shows the highest returns and benefits;

[10] Theft and network loss in total

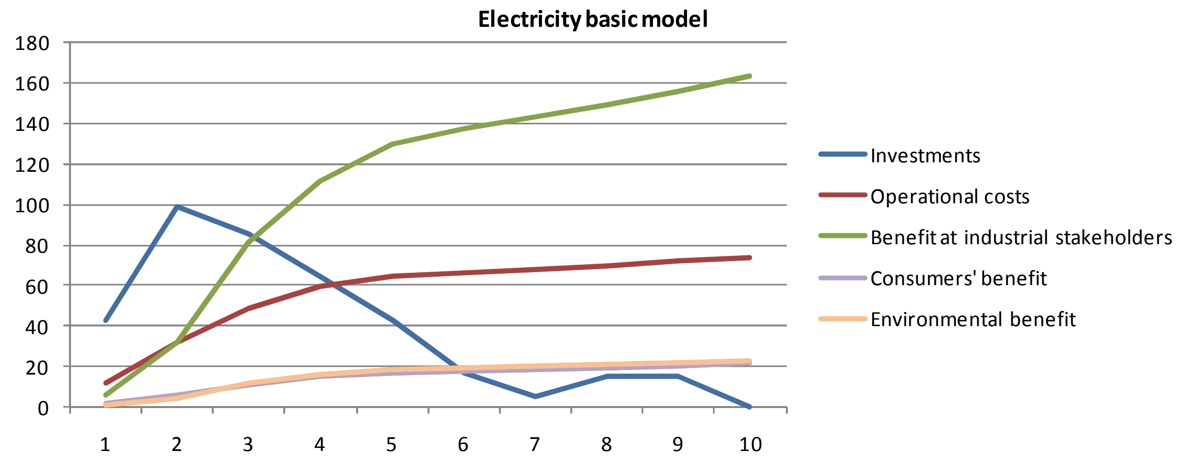
- the international examples evaluated show that where decision was made on the implementation of the system, the main goal was to reach the targeted coverage in the shortest period of time possible.

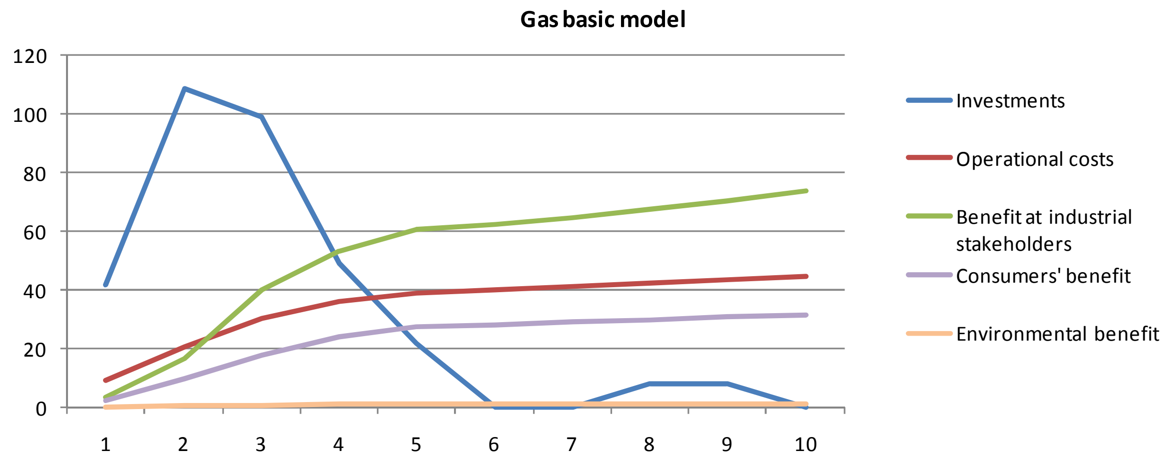
The following is an introduction of the models that were subject to the quantitative analysis.

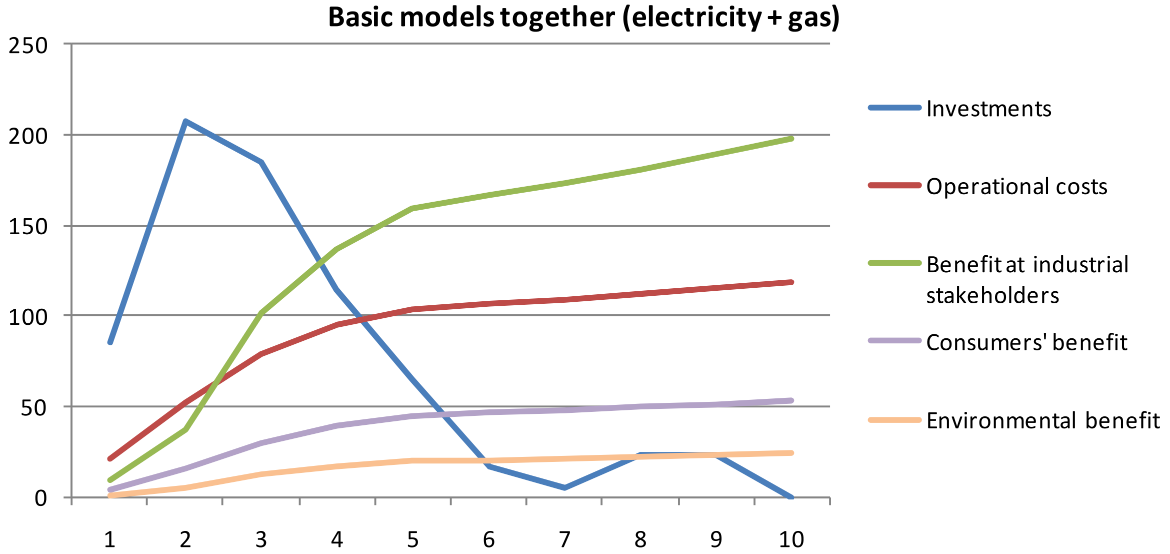
5.3.1. DSO Basic Model

Theoretically two independent systems are created in this model for electricity and gas utilities. This model does not provide the possibility to utilize significant synergies between the gas and electricity systems. From modeling point of view, we only calculated with one synergy: as a realistic assumption, the utility companies belonging to the same company group within the same utility sector will develop their data processing and management centers by company groups – see Parameters (42) and (43).

Figure 15. Annual level of cost and benefits in the distributor basic model during the first ten years of implementation and roll-out (quick implementation schedule, nominal value, USD Million)







It can be observed in the case of both sectors that the benefits can be exploited at an increasing pace, in parallel with the increasing coverage. The costs of implementation are the highest in the first three years, as the supporting infrastructure (data center, all data concentrators and smart meters) must be developed in this period and the sunk costs of the traditional meters arise in this period, as well. From the fourth year on, the investment need is significantly lower and raises again from the seventh year when the data concentrators installed in the first year must be replaced. Practically, the operational costs increase only with extent of the inflation after the entire system has been developed.

We performed sensitivity analysis/tests in case of the different roll-out scenarios. The results of these are summarized in Table 9.

Table 9.: Returns/benefits of the distributor basic model according to different implementation schedules

Electricity and Gas Basic Models (DSO) Without Synergies		Balanced Roll-Out			Fast Roll-Out			Delayed Roll-Out		
Net Present Values (Million USD)	Discount Factor	Explicit Period	Residual Value	Total NPV	Explicit Period	Residual Value	Total NPV	Explicit Period	Residual Value	Total NPV
Investments (-)	10%	358	189	547	592	279	871	270	174	444
Operational costs (-)	10%	422	456	877	566	456	1 021	242	456	698
Benefits at Industry Players (+)	10%	483	756	1 240	805	760	1 565	256	758	1 015
Consumer Benefits (+)	8%	172	309	481	259	309	568	91	309	400
Environmental Benefits (+)	8%	70	141	210	112	141	252	39	141	180
Balance		-54	561	507	18	475	493	-126	578	452
Balance at Industry Players		-296	112	-184	-353	26	-327	-256	129	-127

As it can be observed on Figure 15. (above), the investment and operational costs for both utilities during implementation and roll-out exceed the benefits generated by smart metering for the *industry players*. But even calculating with low level of consumption reduction, 1 and 1.5 % respectively in the model, taking into consideration the consumer savings in the case of electricity the costs of implementation and roll-out are cleared at national economy level within the 10-year explicit period with quick roll-out.

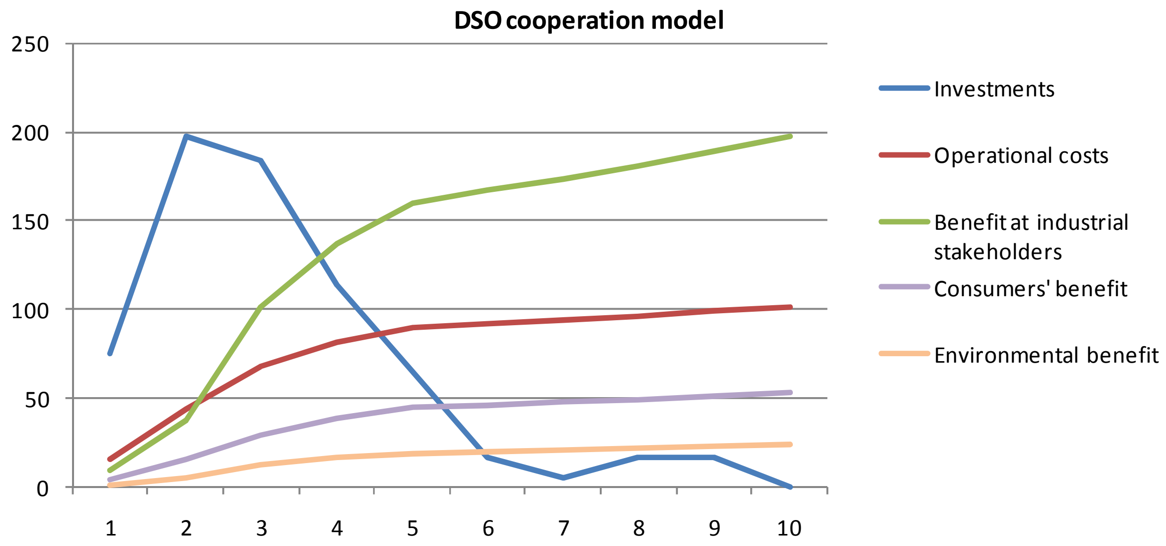
Taking into consideration the total lifetime (by supplementing the analysis with the residual value after the 10th year) it can be established that the 'pure' DSO model will not payback in the case of the industry players, even taking into consideration the residual value. The significant difference between the returns of electricity and the gas sector is that, while at national economy level (i.e. considering the consumer and environmental benefits), in the case of electricity, the implementation and roll-out of smart metering pays back during the first ten years of operation; in the case of gas implementation, even with residual value, is unprofitable. The reason for this is the higher price of meters and the lower extent of benefits (technological reasons: the remote switch-on and off technology of meters is not developed; the reduction rate of consumption and CO2 emission is significantly lower).

5.3.2. DSO Cooperation Model

The most important advantage of a multi-utility smart metering model arises from the reduction in investment costs and the better utilization of the deployed assets. Theoretically there is the possibility to realize these advantages in case electricity and gas DSOs cooperate regarding the development of the communication solutions and operate the smart metering system mutually. Based on our assumptions, this would result in the following benefits:

- The number of data forwarding devices (data concentrators) can be significantly reduced compared to the separate electricity/gas models (see Parameter 31)
- DSOs operating their smart metering systems cooperate regarding the costs related to the operation of smart metering (meter operation, repairs, cost of communication to the data concentrator), the (additional) costs related to the reading of traditional meters and the inspection and repair costs of the meters. Based on our opinion such level of synergy can be reached regarding these cost elements as if the entire system was operated by an independent metering company/SM Operator (see values corresponding to DSO cooperation of parameters (60)-(68)).
- Electricity and gas DSOs cooperate in the setup and operation of the data processing and management center (see parameters (46) and (51)). This results in lower number of data centers than in the case of separate DSO solutions by utilities, while the investment costs of the data centers can be significantly lower, considering that they can partly built on the existing IT background of the DSOs.

Figure 16 . Annual level of costs and benefits in the DSO cooperation model (quick implementation schedule, nominal value, USD Million)



As it can be observed from the theoretical assumptions and the estimated present values of the model, the DSO Cooperation Basic Model combines the advantages of the DSO Basic Model and the SM Operator Models, in case synergies can be exploited regarding investment and operational costs related to data transfer. Considering that in this case the harmonization of communication is not necessarily performed within one company, in the case of these synergies cost savings is not expected at such level as in the case of the SM Operator models, but the investment can produce profits even during the first year.

Due to the cooperation, the DSO Cooperation Model compared to the DSO Basic Model, shows a HUF 22 Billion, USD 110 Million return (or lower loss) in the explicit period (first ten years) from the industry players point of view.

Table 10.: Returns/benefits of the distributors' cooperation model according to different roll-out schedules

DSO Cooperation Model	Balanced Roll-Out				Fast Roll-Out			Delayed Roll-Out		
Net Present Values (Million USD)	Discount Factor	Explicit Period	Residual Value	Total NPV	Explicit Period	Residual Value	Total NPV	Explicit Period	Residual Value	Total NPV
Investments (-)	10%	331	176	507	566	266	831	244	161	405
Operational costs (-)	10%	355	393	748	484	393	876	193	393	586
Benefits at Industry Players (+)	10%	483	756	1 240	805	760	1 565	256	758	1 015
Consumer Benefits (+)	8%	172	309	481	259	309	568	91	309	400
Environmental Benefits (+)	8%	70	141	210	112	141	252	39	141	180
Balance		39	637	676	126	551	678	-50	655	604
Balance at Industry Players		-203	188	-15	-244	102	-142	-181	205	25

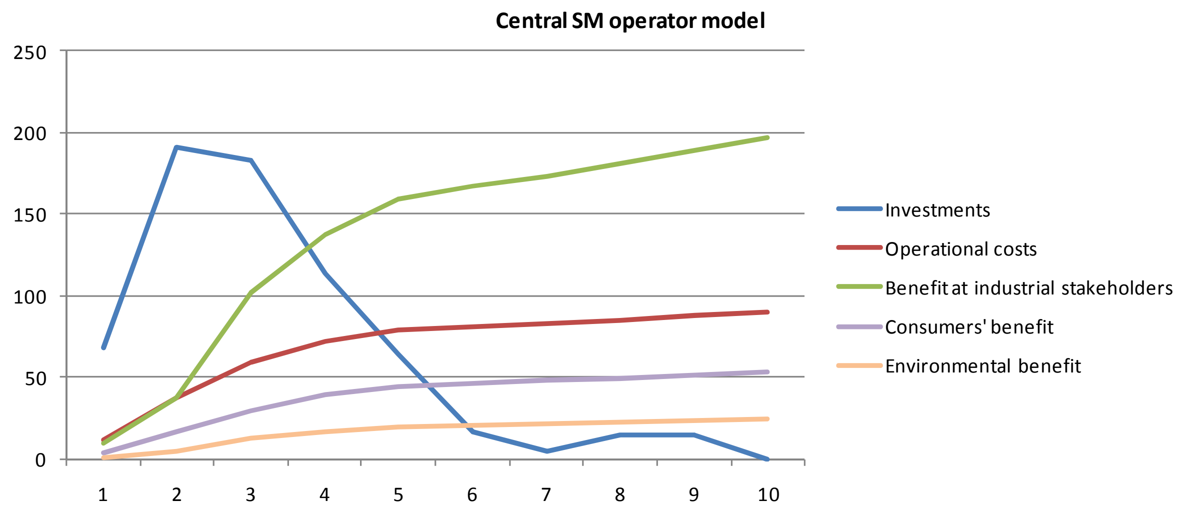
5.3.3. Central Smart Metering Data Acquisition and Service Company Model – Central SM Operator Model

We modeled the possibility of having only one SM Operator performing data communication on the entire territory of the country in case of both utilities. The basic advantages of this solution arise from the harmonization of the gas and electricity smart metering systems and the reduction of investment costs, as well as, the more efficient utilization of the assets.

These areas were modeled similarly to the DSO Cooperation Model. The following is a summary of the differences between the SM Operator and the DSO Cooperation Models. (The values of the parameters are described in the 'Parameters' chapter.)

- In the DSO Basic Model, the number of data concentrators in the case of electricity is sufficient to ensure the operation of both utilities in the territory of the country (see Parameter (30)).
- It is enough to operate only one data center in the country as only one company performs smart metering data acquisition and service activities.
- Considering the direct costs connected to the operation of the smart metering system (meter operation, repairs, costs of communication to the data concentrator), (additional) costs related to the reading of traditional meters and the inspection and repair costs of the smart meters, the possibility for synergies resulting from the harmonization of electricity and gas utilities is slightly higher than in the case of the DSO Basic Model [Relevant values of Parameters (60)-(68)].

Figure 17.: Annual level of costs and benefits in the central SM operator model (quick implementation schedule, nominal value, USD Million)



The Central SM Operator Model provides the highest return at both national economy and industry level. The reason for this: the value of synergies between the two utilities is the highest in this case.

Table 11.Returns/benefits of the central SM operator model according to different roll-out scenarios

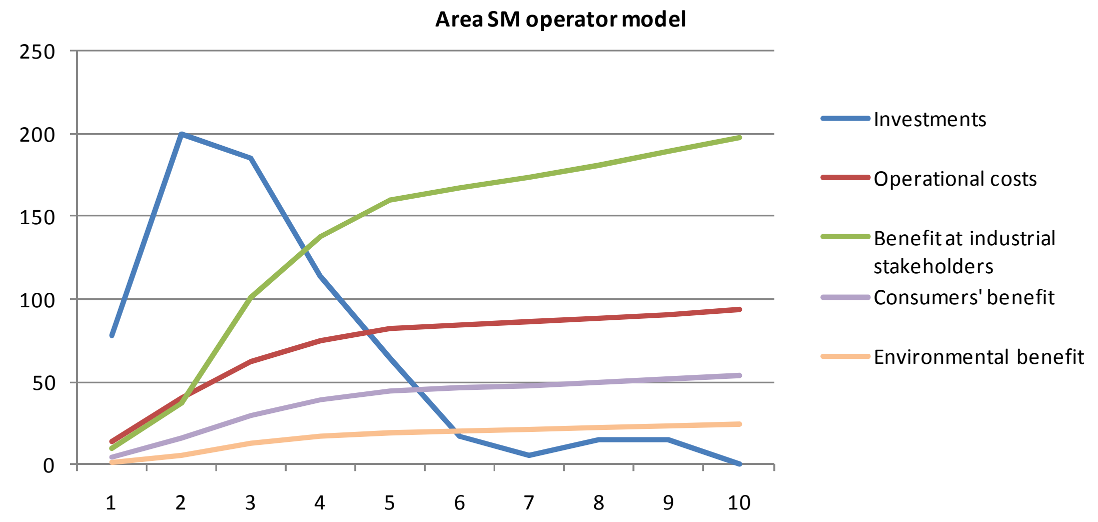
Central SM Operator	Balanced Roll-Out				Fast Roll-Out			Delayed Roll-Out		
Net Present Values (Million USD)	Discount Factor	Explicit Period	Residual Value	Total NPV	Explicit Period	Residual Value	Total NPV	Explicit Period	Residual Value	Total NPV
Investments (-)	10%	316	169	486	551	259	810	229	154	383
Operational costs (-)	10%	304	346	650	422	346	769	152	346	499
Benefits at Industry Players (+)	10%	483	756	1 240	805	760	1 565	256	758	1 015
Consumer Benefits (+)	8%	172	309	481	259	309	568	91	309	400
Environmental Benefits (+)	8%	70	141	210	112	141	252	39	141	180
Balance		105	690	795	202	604	806	5	707	712
Balance at Industry Players		-137	241	104	-168	155	-13	-125	258	133

It can be observed that, compared to the basic model, the return of the industry players is higher by HUF 30 - 40 Billion, USD 180-190 Million (depending on the selected implementation and roll-out schedule) even during the first ten years. It is a significant risk (disadvantage) of the model, although it cannot be quantified with the CBA, that it creates a national monopoly in the field of smart metering operation.

5.3.4. Area Smart Metering Data Acquisition and Service Company Model – Area SM Operator Model

We modeled the version of the SM Operator model in the case of which not one but several SM Operators operate in the territory of the country. Based on this the only modeled difference compared to the Central SM Operator model is that we calculated with the implementation and operational costs of not one but three[11] data processing centers.

Figure 18.: Level of costs and benefits in the area SM operator model (quick implementation schedule, nominal value, HUF Billion)



[11] As a matter of fact, the number of the three Area SM Operators was set deliberately, the model can have different number of operators but based on our assumptions the creation/development of more than five such companies is less probable and high number of operators would significantly worsen the possible synergies

It can be seen that, compared to the Central SM Operator Model, returns decrease due to the investment and operational costs of the additional data processing centers.

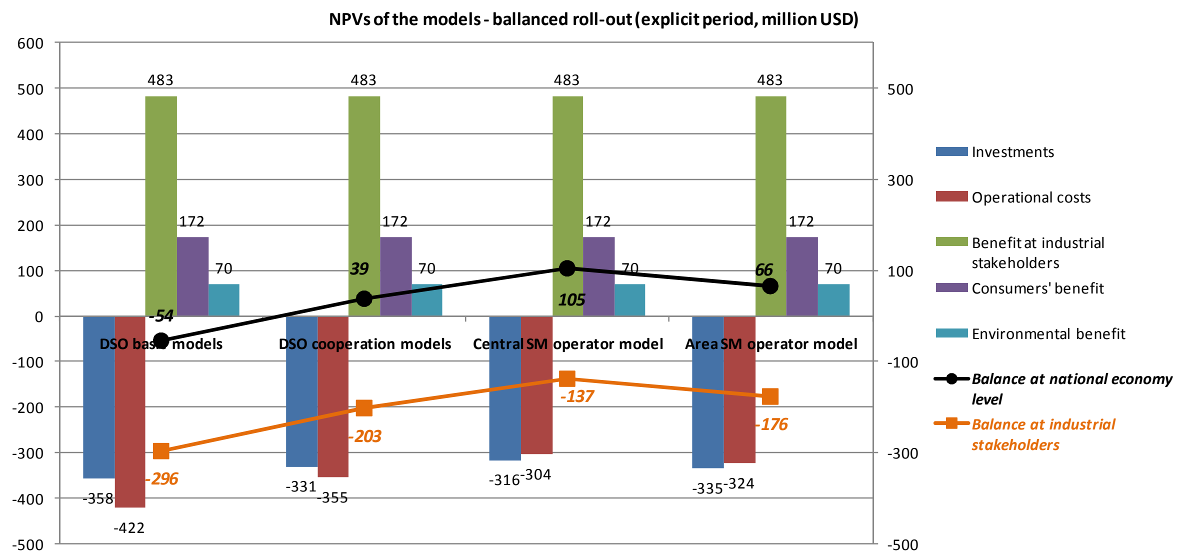
Table 12. Returns/benefits of the Area SM Operator Model according to different roll-out schedule

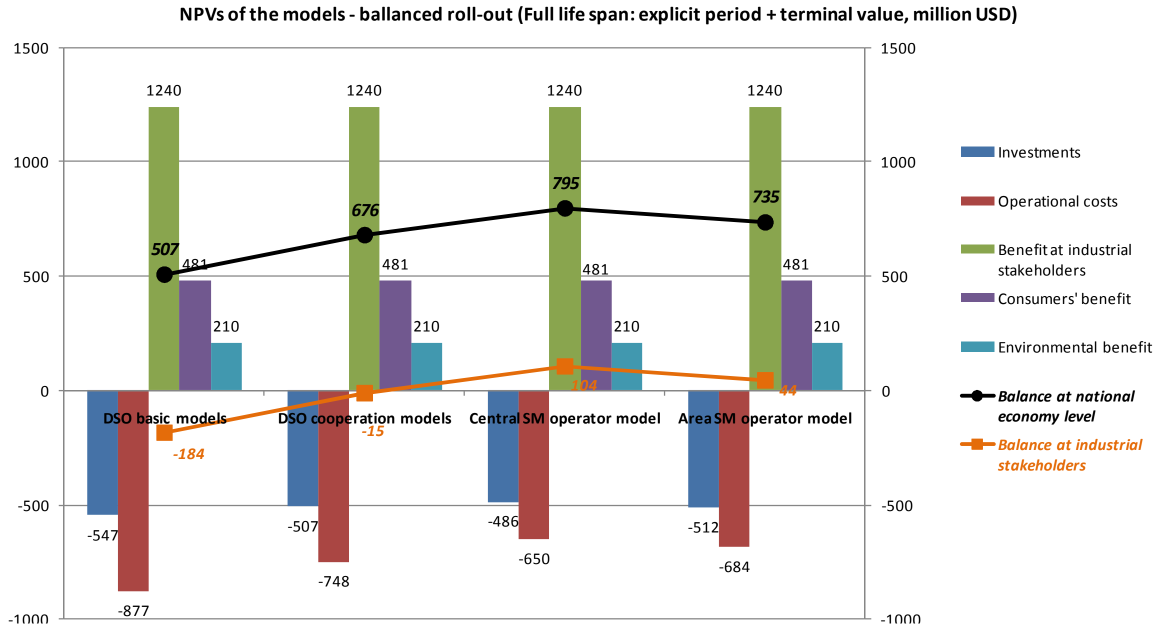
Area SM Operator Model	Balanced Roll-Out				Fast Roll-Out			Delayed Roll-Out		
Net Present Values (Million USD)	Discount Factor	Explicit Period	Residual Value	Total NPV	Explicit Period	Residual Value	Total NPV	Explicit Period	Residual Value	Total NPV
Investments (-)	10%	335	177	512	569	267	836	248	162	409
Operational costs (-)	10%	324	360	684	443	360	803	173	360	533
Benefits at Industry Players (+)	10%	483	756	1 240	805	760	1 565	256	758	1 015
Consumer Benefits (+)	8%	172	309	481	259	309	568	91	309	400
Environmental Benefits (+)	8%	70	141	210	112	141	252	39	141	180
Balance		66	669	735	163	583	746	-34	686	652
Balance at Industry Players		-176	219	44	-207	134	-74	-164	237	72

5.4 Summary of the Evaluation of the Models

In the following we will interpret the main returns of the four main models compared to each other. We will in introduce the returns of the balanced and quick implementation schedules for both the first ten years (explicit period) and the entire lifetime of the system (explicit period + residual value).

Figure 19.: Returns of the analyzed models in case of balanced roll-out



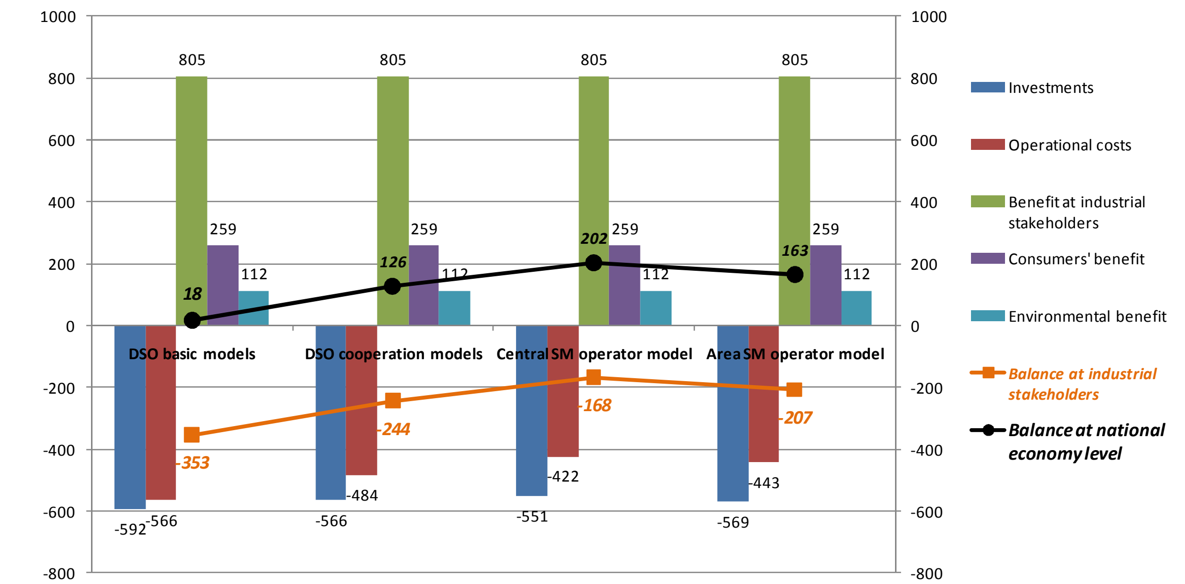


As a result of the modeling activity the following experiences can be obtained:

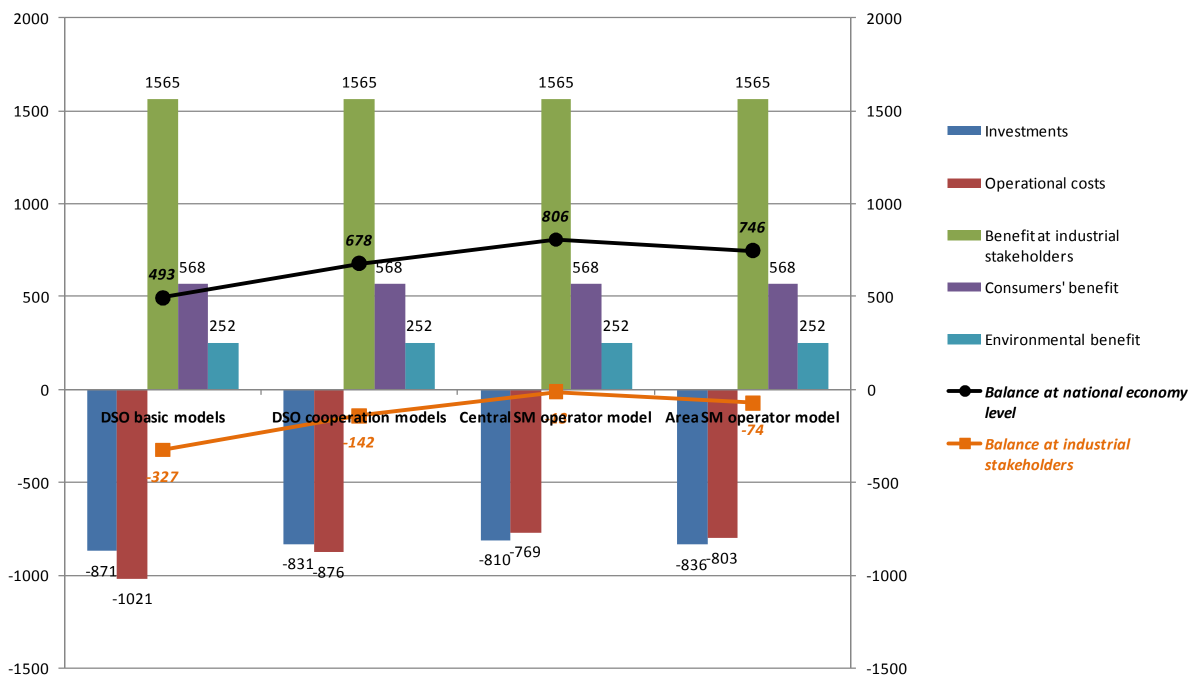
- Differences among the models are caused by the differences between the investment and operational costs.
- Any model with synergies applied provides benefits for the entire society within the first ten years of operation; however, the majority of benefits come forward as externalities in case of the industry players.
- Considering the entire lifetime, the Central and Area SM Operator models have positive benefits even at industry level.
- The benefits for the industry players do not calculate with a 'metering fee' of any other contributions from outside the industry.
- Both Operator models ensure higher returns than the DSO models; both in the case of comparing based on the same roll-out schedules and the explicit period/entire lifetime. The reason for this is that, although the investment needs of these models is higher regarding certain investments (development of data centers), these models exploit best the operational synergies between the two assessed utilities.
- It is recommended to choose from the models so, that the investment and operational synergies can be exploited to the highest extent in the case of the connected utilities. The comparison of the different SM Operator models shows that the SM Operator models provide the highest return as the exploitation of the synergies is the most efficient in these cases. Although the highest benefits are provided by the Central SM Operator model, we do not recommend its implementation. The reason for this is that the national monopoly created by it would weaken competition.

Figure 20.: Returns of the analyzed models – fast roll-out

NPVs of the models - fast roll-out (explicit period, million USD)

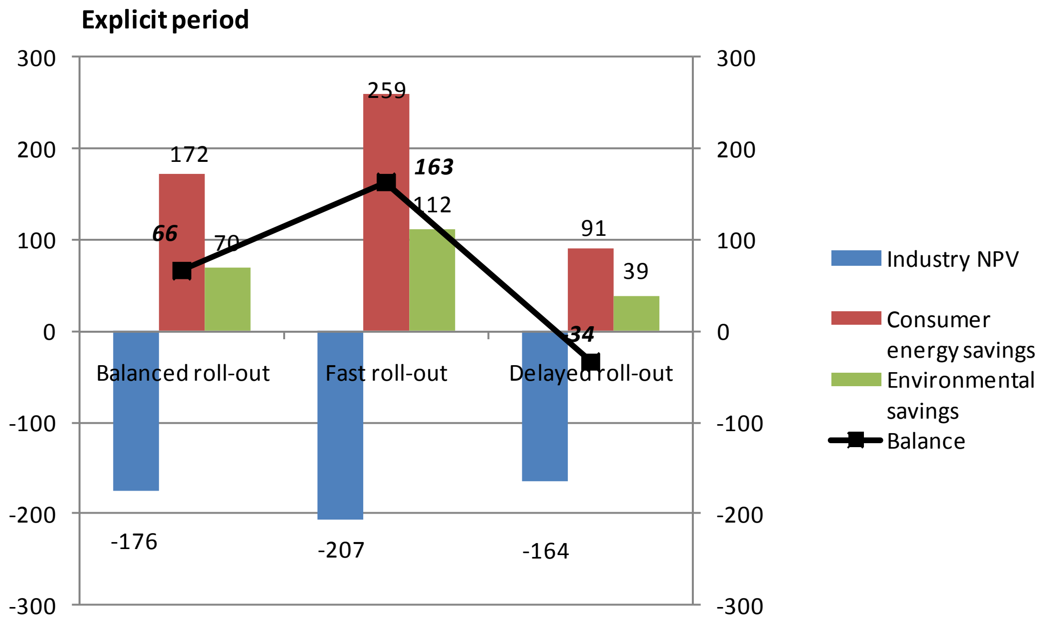


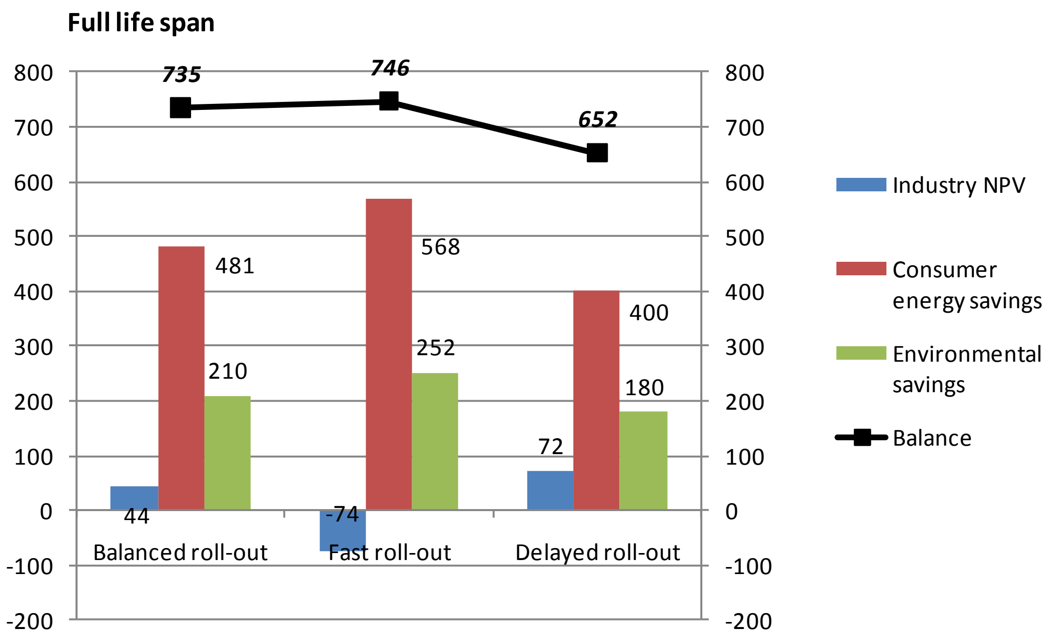
NPVs of the models - fast roll-out (Full life span: explicit period + terminal value, million USD)



Regarding schedule, we recommend the quick implementation schedule as this would provide higher benefits at national economy level than the balanced or slow roll-out schedules. However, this roll-out scenario is the less favorable for the industry players (see Figure 23). In order to reach that it provides benefits for the industry players even during the explicit period, it is necessary, with the use of certain techniques, the redistribution of benefits from the consumers/society to the industry players. The introduction of a, so called, 'smart metering fee' can be a means for this purpose.

Figure 21 : Returns of the area SM operator according to different roll-out schedules – in million USD





5.5 Sensitivity Analysis / Tests

The more than sixty parameters of the CBA carried out provide, practically, unlimited possibilities to test the sensitivity of the models to the changes in the calculated/estimated values of the key parameters. Sensitivity tests can focus our attention to the relevant risks that can significantly influence the success of the implementation of smart metering in Hungary.

5.5.1. Effects of the Different Implementation Schedules on Benefits/Returns

In the above sections we presented assessments regarding the different implementation schedules while assessing the models gone through quantitative analysis (see Table 9.: , Table 12. and Figure 21 on the analysis of the effects of the different implementation schedules).

Table 13.: Different assumptions used for the roll-out schedule details our assumptions recorded in the CBA regarding the number of years and the manner in which we simulated the schedules for the different scenarios.

Without reiterating our conclusions listed at the models evaluated by quantitative analysis, we would like to reemphasize that, although the total of the returns (at national economy level) can only be maximized, taking into consideration that the extent of their positive return is in proportion with the extent of the consumer energy savings, along the fastest schedule possible, it is recommended to decide on the application of a tight implementation schedule, inducing higher financing burden for the industry players and ensuring less favorable returns in the explicit period, in case it can be justified with high level of certainty that the implementation and roll-out can 'bring in' those benefits resulting from consumer energy savings and reduction of environmental damages that were quantified above.

Table 13.: Different assumptions used for the roll-out schedule

Balanced roll out					
Year	2011	2012	2013	2014	2015
%	10%	10%	10%	10%	10%
Year	2016	2017	2018	2019	2020
%	10%	10%	10%	10%	10%

Fast roll out					
Year	2011	2012	2013	2014	2015
%	10%	30%	30%	20%	10%
Year	2016	2017	2018	2019	2020
%	0%	0%	0%	0%	0%

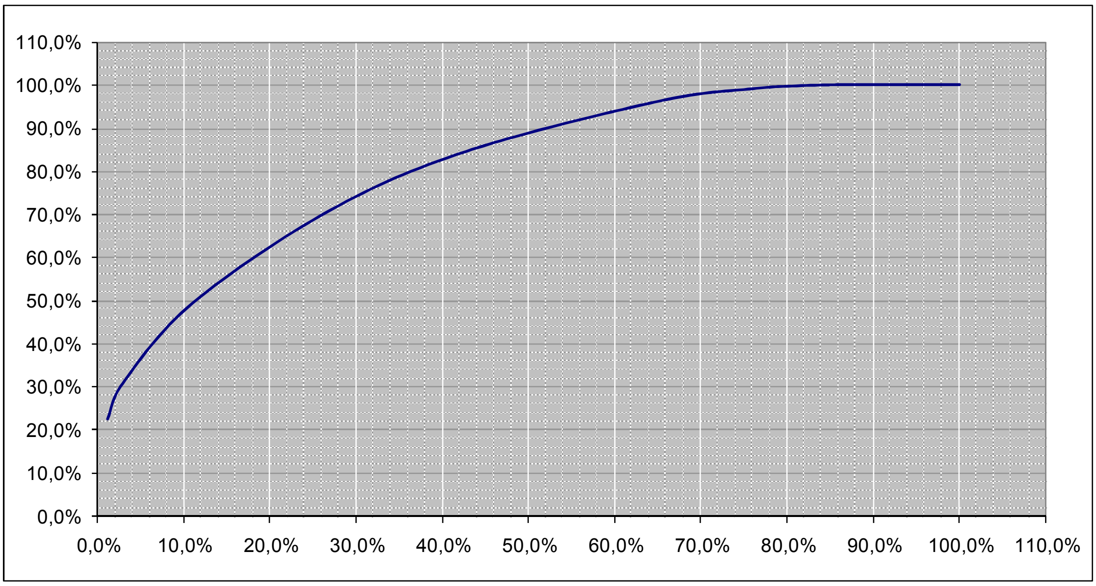
Delayed roll out					
Year	2011	2012	2013	2014	2015
%	0%	0%	0%	0%	0%
Year	2016	2017	2018	2019	2020
%	10%	30%	30%	20%	10%

The following is a summary of the effect of critical factors regarding implementation decision on the results that we consider important and were also raised by the remarks and questions from the industry players.

5.5.2. Different Coverage

When presenting parameters (13) and (14), we mentioned that consumption rate does not change in direct ratio with the rate of meters installed. Parameter line (52) records those values that, based on our expectations, approximate properly the consumption rate of the targeted consumer segment in relation with smart meter coverage.

*Figure 22.: Cumulated consumption data of the consumer segment under 3*80 A in relation with the number of meters connected*



Source: E.On

The rate of the traditional meters to be changed was calculated geared to the target number, taking into consideration the implementation schedule fixed in Parameter line (17). At the same time, we did not analyze in the model the option where the change of the meters is performed at the consumers with highest consumption level within the segment. Such an implementation can significantly improve the results presented by our consulting consortium. We recommend the further analysis of this scenario when decision is made on the actual implementation (geographically organized implementation).

The above Figure 22.: demonstrates that the results show high extent of sensitivity to that the targeted coverage, i.e. the rate of the target consumer group (consumptions under 3*80 A and under 20 m3/hr) we would like to involve in the smart metering system. Table 14.: Assessment of different smart meter coverage with quick roll-out clearly shows that coverage exceeding 70% is unfavorable regarding the returns and benefits for both the industry players and the entire project.

Table 14.: Assessment of different smart meter coverage with quick roll-out

DSO cooperation model	70% coverage (96% of consumption)			80% coverage (98% of consumption)			90% coverage (99% of consumption)		
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	126	551	678	7	498	505	-127	431	303
Balance at industrial stakeholders	-244	102	-142	-369	42	-327	-506	-28	-534
Central SM operator model									
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	4932	604	806	88	555	643	-41	492	450
Balance at industrial stakeholders	-168	155	-13	-288	99	-189	-419	33	-387
Territorial SM operator model									
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	163	583	746	49	533	582	-80	470	390
Balance at industrial stakeholders	-207	134	-74	-327	78	-249	-458	11	-447

Sensitivity tests regarding coverage unambiguously show that the change of all meters is not recommended in case the difference between the prices of traditional meters and smart meters is maintained at the modeled level. Taking this into consideration, we do not recommend that the implementation exceeds the 70% coverage, as the additional investment costs are not covered by the benefits resulting from the operation of reduced number of traditional meters, while the additional investments have strong adverse effect on the profitability of the industry players.

5.5.3. Extent of Network Loss

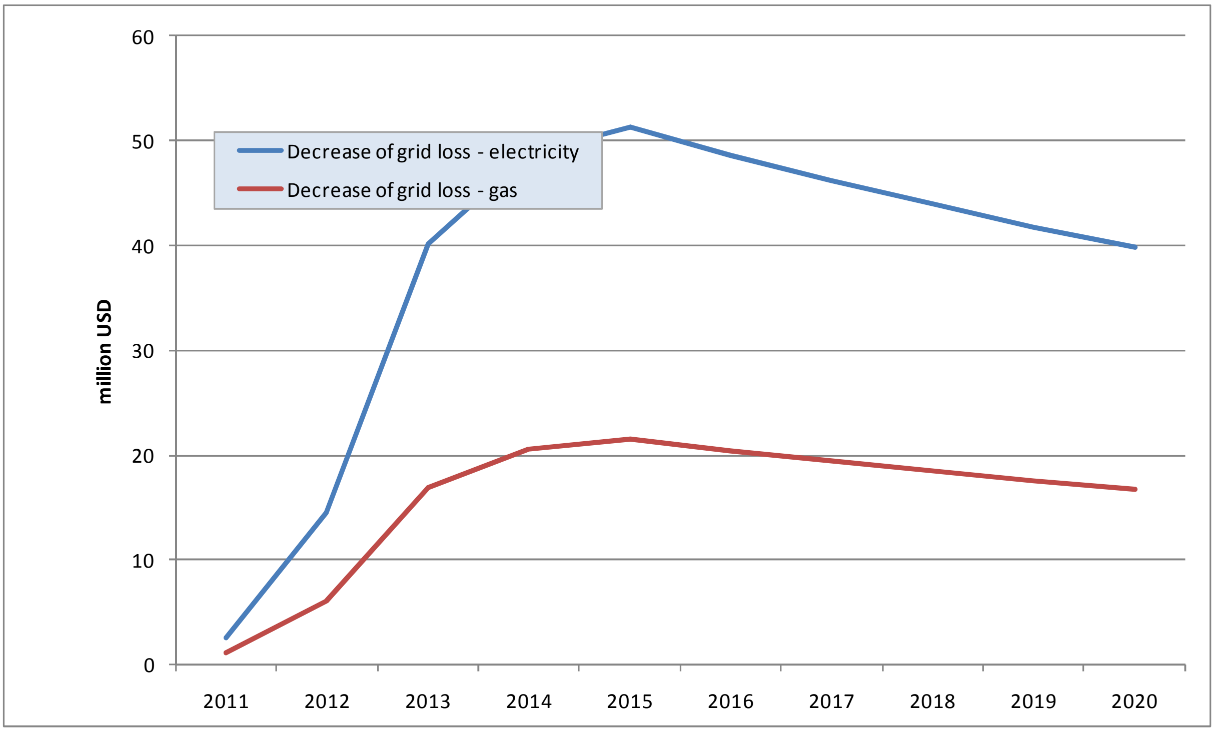
When describing the parameters, we briefly mentioned that out of the network loss the change in the technological and physical losses can be one of the most important positive factors for the industry players.

Based on the written and oral remarks from the cluster workshops, we performed several modifications in order to be able to demonstrate the effect of these factors in their complexity. At the same time, we have to mention that this study, taking into consideration its focus, cannot undertake the detailed discussion of all relationships and connections of smart metering with smart grids. Thus we did not evaluate the possibilities for quantification of the additional benefits of metering in the case of deferred investments in production and network development that are related to energy savings and we did not calculate either with the cost advantages of the DSOs that result from the network planning activities supported by the more accurate measurement capabilities.

In the framework of this study, we considered the remarks of the DSOs and, as an investment factor, we involved the, so called, segment meters connected to the smaller units of the distribution networks in our model and took into consideration the fact that the reduction in network losses can only be realized where the rate of smart meters deployed is high within the given network segment.

As shown in Figure 23, reduction in the losses increases in parallel with the development of the system, by reaching proper coverage. After reaching the targeted number of smart meters, savings increase due to the growth effects resulting from the changes in consumption trends, these show falling trend of the figures calculated based on real terms (2010 as basis).

Figure 23.: Rate of reduction of network loss as a result of smart metering implementation, in real terms on 2010 basis (price) – quick implementation schedule



Although, in case of electricity, the basic running parameter of the model was kept at the 20% level of the previous study, in case of the gas utility the parameter was changed from 50% to 40%. We are convinced that these values, although they are ambitious, can be reached through the effective and proper utilization of additional information from the meters by the DSOs. Industry benefits and returns will be strongly influenced by the level of savings reached by the DSOs in this respect. (According to data from Table 15.: in case of a lower reduction in network loss (10% less in the case of electricity and 20% less in the case of gas) the balance of the industry players is lower by approx. HUF 120 Billion – USD 580 Million).

Table 15.: Effect of the reduction in network loss on returns/benefits (quick roll-out schedule)

DSO cooperation model	10% (electricity) and 20% (gas) decrease			15% and 30% decrease			20% and 40% decrease		
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	-205	222	17	-39	387	347	126	551	678
Balance at industrial stakeholders	-539	-181	-721	-392	-40	-431	-244	102	-142
Central SM operator model									
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	-129	275	146	37	440	476	202	604	806
Balance at industrial stakeholders	-463	-128	-592	-316	13	-303	-168	155	-13
Territorial SM operator model									
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	-168	254	86	-2	418	416	163	583	746
Balance at industrial stakeholders	-502	-150	-652	-355	-8	-363	-207	134	-74

The actual network loss reducing effect of the smart metering project could only been taken into consideration on a limited information base, furthermore the different stakeholder groups had different opinions on the relating values presented in the Preliminary Report. Considering the fact that this factor significantly influences the return perspectives of the industry players, we recommend the consumer contribution to the development of the system during implementation (smart metering fee) is defined cautiously in order to reach that the interests of the industry players in supporting the implementation of the smart metering system are maintained.

5.5.4. Reduction in Bad Debt

The effect of the installation of smart meters on bad debt is strongly debated. The opinion of several stakeholders is that this item was unduly included in our study, considering that, based on their opinion, the reduction of bad debt is not hindered by inadequate technology but by the legal environment.

As mentioned at the description of the parameters, our opinion is that it is recommended to include the effect of this parameter considering that the expansion of technological opportunities will, in our opinion, change the approach of the decision makers to the modification of the legal environment. Due to the discussion on the matter, we performed some sensitivity tests presented below.

Table 16.: Effect of the reduction of bad debt over 30 days on returns/benefits (quick roll-out schedule)

DSO cooperation model	90% (electricity) és 40% (gas) decrease			45% and 20% decrease			0% and 0% decrease		
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	126	551	678	96	520	616	65	489	554
Balance at industrial stakeholders	-244	102	-142	-275	71	-204	-305	39	-266
Central SM operator model									
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	202	604	806	172	573	745	141	542	683
Balance at industrial stakeholders	-168	155	-13	-199	123	-75	-229	92	-137
Territorial SM operator model									
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	163	583	746	133	552	684	102	520	623
Balance at industrial stakeholders	-207	134	-74	-238	102	-135	-268	71	-197

Based on the Table, it can be seen that in case we did not consider the possibility for reduction in bad debt due to the implementation of smart metering, the returns would decrease by HUF 25 Billion – USD 123 Million , but this would not influence significantly the overall conclusions of the project.

5.5.5. Consumer Benefits (Energy Savings)

In the case of consumer energy savings the basic case of our calculation was that 1% of the households with electricity smart meters and 1.5% of the households with gas smart meters will consume less energy than the households with traditional meters.

We performed the modeling /test/ for the case where only the 50% of the expected consumption reduction is realized and for the case where no reduction occurs as a result of the installation of the smart meters.

Table 17.: Effect of the reduction in consumption due to smart metering on returns/benefits (quick roll-out schedule)

DSO cooperation model	1% (electricity) és 1,5% (gas) decrease			0,5% and 0,75% decrease			0% and 0% decrease		
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	126	551	678	-11	387	376	-148	222	74
Balance at industrial stakeholders	-244	102	-142	-241	105	-136	-238	108	-130
Central SM operator model									
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	202	604	806	65	440	505	-72	275	203
Balance at industrial stakeholders	-168	155	-13	-165	158	-7	-162	161	-1
Territorial SM operator model									
Net present value (million USD)	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV	Explicit period	Terminal value	Total NPV
Balance	163	583	746	26	419	445	-111	254	143
Balance at industrial stakeholders	-207	134	-74	-204	137	-67	-201	140	-61

It is critical for the implementation of smart metering what expectations we have regarding consumption reduction. In case consumption does not decrease as a result of the installation of the smart meters, then the majority of the societal benefits are lost and this could question the implementation of smart metering. At the same time, it is recommended to implement the smart metering system in case of low (1%) consumption reduction expectations.

5.6 Redistribution of Benefits among the Stakeholders – Measurement Fee for the First Period

The results of the CBA clearly show that the costs and benefits of smart metering are different in the case of the different stakeholder groups. It is recommended, for the successful implementation of the project, to assess the possibility of the introduction of the 'smart metering fee' for the financing of additional investment costs arising mainly during the explicit period. The smart metering fee would be paid by the consumers to the industry players interested in measurement/metering (DSOs, SM Operators).

It is beyond the framework of this study to perform the detailed analysis of the effects of the introduction of the smart metering fee and its distribution among the different industry players, as this highly depends on the implementation model selected. What we could do in this study is the assessment of how and to what extent the introduction of a 'smart metering fee' for the consumers with smart meters would improve the return/benefit expectations of the industry players (see Table 18.:).

Table 18.: Net present value effect of the smart metering fee on the return expectations of the industry players (million USD)

Monthly Metering Fee	Period of Time for Keeping the Metering Fee	
	5 years	10 years
USD 0.25	46	103
USD 0.50	92	205
USD 0.75	139	308

The table shows that a monthly 'extra fee' of USD 0,5 during the explicit period (first ten years) for the consumers with smart meters (or a higher fee for a shorter period of time) can provide, by the redistribution of cost and benefits, that the industry players support the implementation of the project, while the consumers can still have significant benefits through energy savings.

5.5.6. Summary of the Sensitivity Analysis / Tests

As a summary of the sensitivity analysis/tests, we demonstrate how the changes of the different factors affect the annual return figures. The following figure shows the comparison of four different scenarios demonstrating how these change the annual return expectations of the project and the industry players.

Apart from the basic models on the figures, the following additional scenarios were quantified:

1) Optimistic: which is higher (calculates with 2% consumption reduction for both utilities and with smart meters with lower purchasing prices by 25%)
2) Cautious: where the expectation regarding the reduction of network losses was reduced to half (10% for electricity and 20% for gas)
3) Pessimistic: further to the 'Cautious' scenario it calculates only with 0.5% consumption reduction in the case of consumers with smart meters

Figure 24.: Level of annual industry returns in the explicit period (quick roll-out schedule) (real terms, 2010 basis, million USD)

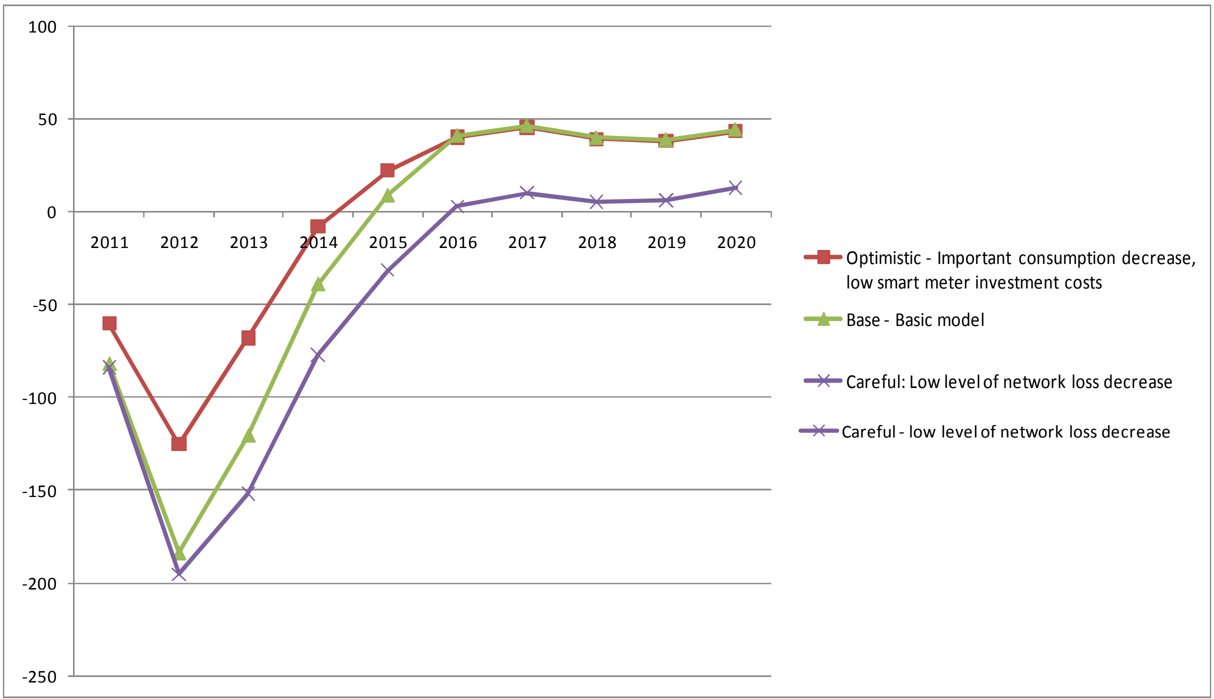
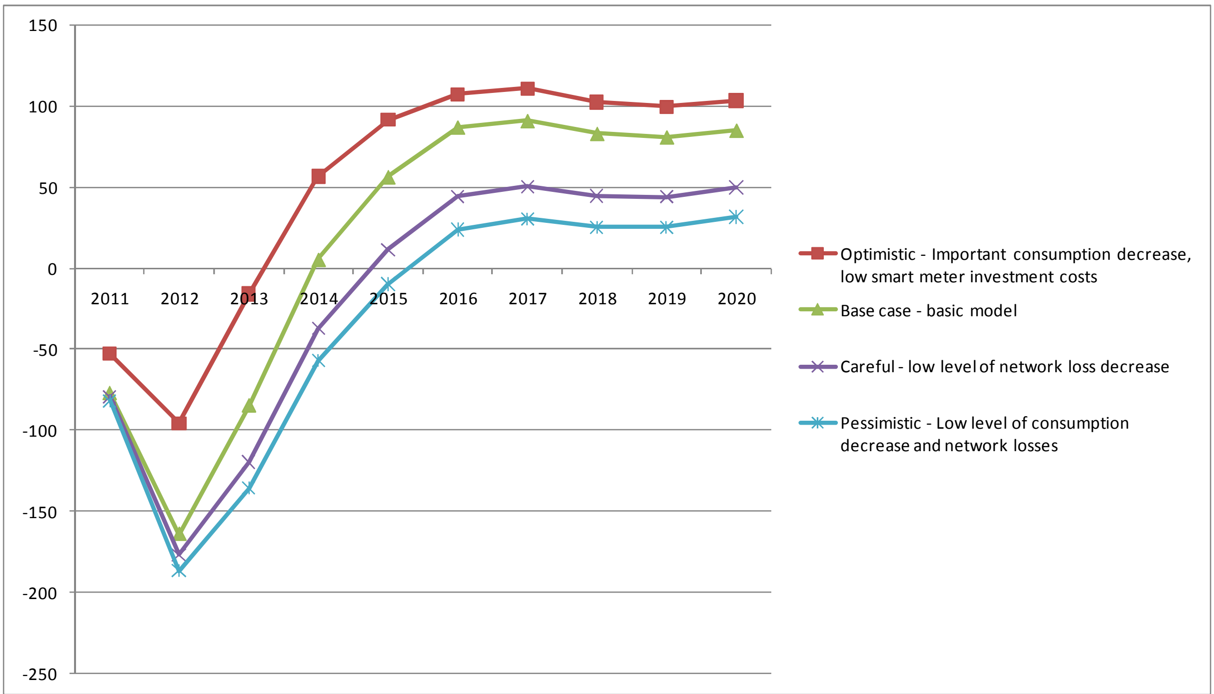


Figure 25.: Level of total returns of smart metering during the explicit period (quick roll-out schedule) (real terms, 2010 basis, million USD)



The figures demonstrate that the different scenarios show significant differences regarding the annual return expectations but make it clear that at national economy level the project has positive societal benefits even in the case of significantly less favorable values than the expectations set in the basic model.

5.7 Further Development Possibilities of the Cost-Benefit Analysis

We have already mentioned in our study that it is very difficult to draw the boundaries between smart metering and smart grids. Therefore, during the workshops, we discussed how the model could be enhanced by taking into consideration further effects. These effects are difficult to estimate and quantify, therefore we estimated in a conservative manner and evaluated these factors qualitatively and we did not involve them in the quantitative analysis. However, we would like to emphasize that all these advantages of such effects of smart metering can only be felt in case smart metering is implemented in parallel with smart grids and smart homes. The effects of the model partly quantified and partly quantifiable with further development are contained by the following table:

Table 19. Additional quantifiable benefit elements by the further enhancement of the cost-benefit analysis

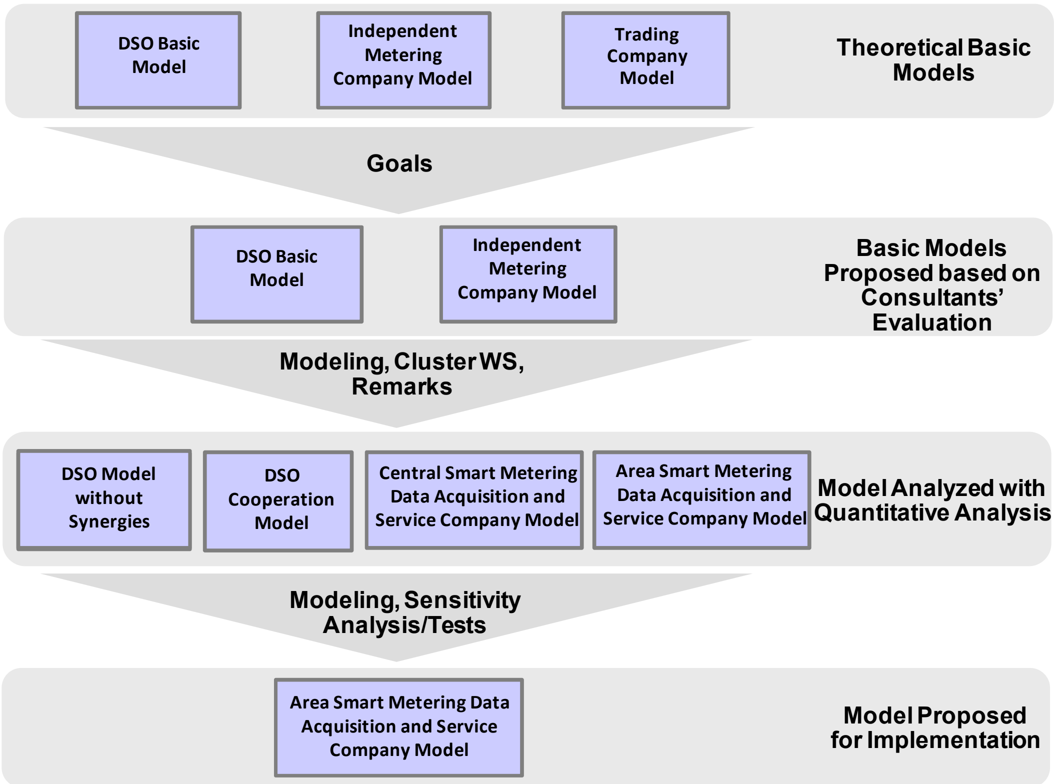
	Value	Source / Interpretation
Potential advantages for Consumer		
Consumer awareness and energy savings	1% - 4% (decreasing consumption per year)	UK benchmark (we quantified 1% and 1,5% effects respectively in the model
Better conditions for the protected consumers	-	Possibility for more detailed and careful legislation/regulation
More offers and flexibility	-	Any benefit for the customer means loss for other stakeholders
Increased competition among Trading Companies		
Potential advantages for Trading Companies		
Pricing possibility	0,2 – 0,5%	Better conditions for harmonizing demand and supply and to increase margins
Marketing possibilities, sale of additional products	Can increase sales by 1-3%	The so called value added services constitute portion of the total utility costs
Simpler change of Trading Company	Cost of changing Trading Company decreased by 50%	UK benchmark
Less complaints regarding invoices	2-5% reduction in customer service costs	Reduction in the number of invoice complaints
Potential advantages for DSOs and Network Licensees		
Detection of malfunctions	-	Included in the reduction of network loss
Faster restoration times	-	Does not generate benefits at household level but only at smart gid level
Consumption control	-	Included in the reduction of network loss
Advantages for Generators/Producers		
Continuously high power plant utilization	5-15% reduction in the peak consumption need	Based on UK and US benchmark
More effective integration of small power plants	2020-ig 0,2 – 0,5% increase regarding the ratio of the small power plants of households in the total energy production	Currently 6% share of renewables
Potential advantages at national economy level		
Increased energy supply security	-	Qualitative advantage/benefit
Power plant investments can be postponed or become unnecessary	-	Included in the reduction of peak consumption need

6. Proposed Smart Metering Model

Based on the consultants' assessment against the goals (evaluation criteria), the international benchmark, the conclusions of the pilot projects, the different consultation sessions with the Hungarian Energy Office and the industry players, the cost-benefit analysis and the sensitivity analysis/tests performed, our consulting consortium recommends the implementation of the Area Smart Metering Data Acquisition and Service Company Model (Area SM Operator Model) regarding the introduction of the smart metering concept in Hungary.

The final version of the model proposed was developed according to the following logical steps:

Figure 26.: Assessment logic regarding smart metering models



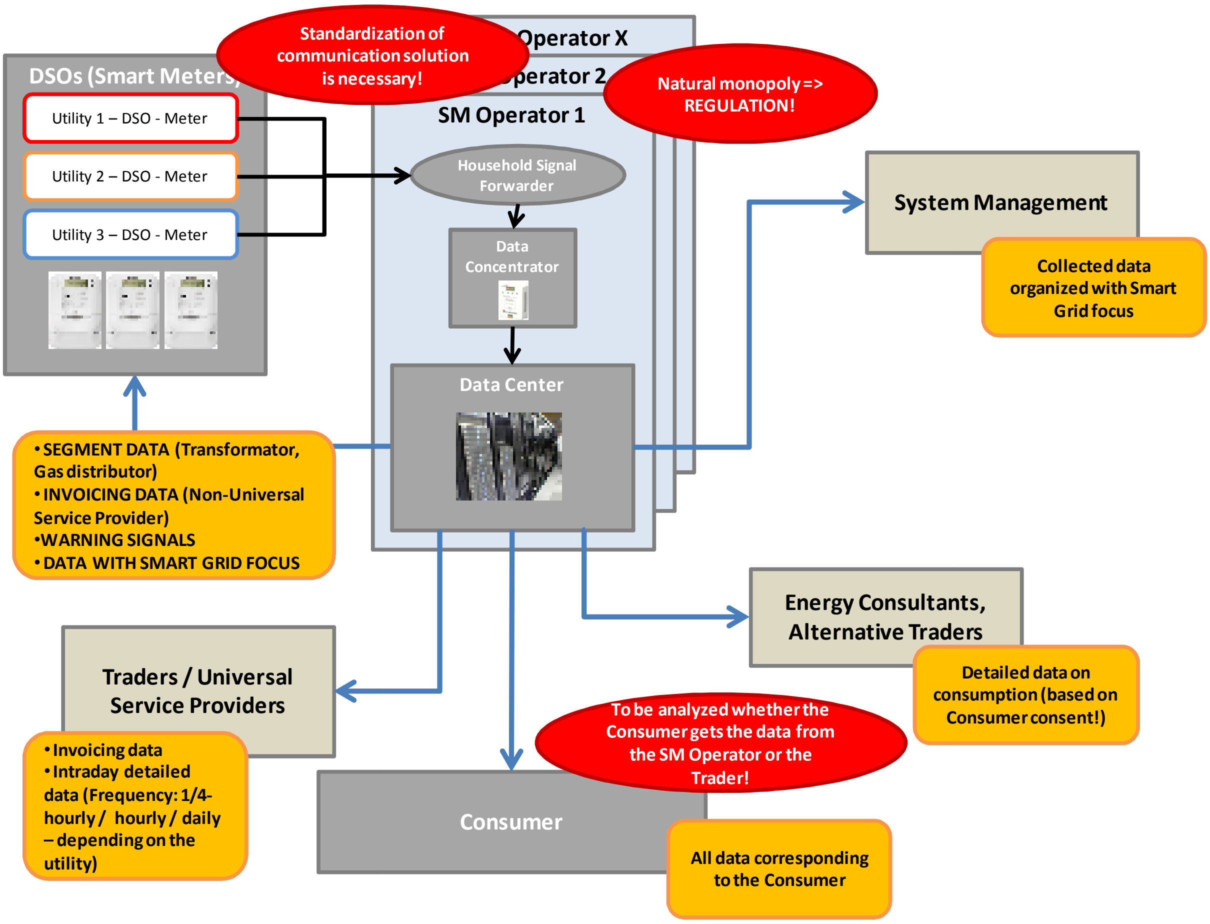
6.1 Definition of the Model

The possibility of competition and comparison of performance (benchmark) support the Area SM Operator Model. The Central SM Operator Model, with the best quantitative results, creates a new monopolistic service provider together with its risks and coordination tasks for the regulators. Meanwhile, in the case of the Area SM Operators, the performances of the (to be regulated) local monopolies can be compared and competition could be created for the concession rights every certain periods of time. As the Area SM Operator

Model ensures to a higher extent the possibility of both competition among the market players and appearance of fast developing technologies, the study recommends the detailed regulation preparation of this scheme to the regulation authorities.

The model recommended for implementation is shown on the following figure:

Figure 27: Tasks and data rights in the smart metering system recommended for implementation



Most important features of the model:

- Smart meters will be installed by utilities at the consumer premise according to pace of the chosen roll-out. The smart meter is owned by the DSO (kept on its accounts), and the DSO is responsible for the installation, maintenance and inspection of the meters.
- A new player appears on the market: the area smart metering data acquisition and service company (Area SM Operator). The SM Operator Company can be founded by any industry or non-industry player, but strictly in the framework of legal unbundling, i.e. it is a separate entity in legal, accounting, management and operational aspects. The Area SM Operator is under the regulation of the Hungarian Energy Office.

- Within the framework of the concession, the Area SM Operator is responsible for the remote collection and processing of data in the given region of the country. The Area SM Operator, possessing a natural monopoly, is responsible for forwarding the data collected by the household signal forwarders from the smart meters to the data concentrators and then to the data center (the household signal forwarders are owned by the SM Operator and the SM Operator is responsible for the maintenance, inspection and replacement of them). The definition of the signal forwarder, the data concentrator and the infrastructure between the data concentrators and the data center is the competence of the SM Operator.
- Smart meters are operated by the DSOs of the utilities. The DSO and the Area SM Operator are mutually responsible for the forwarding of data between the meters and the household signal forwarder. The in-house signal forwarding to the signal forwarder receiving and forwarding the data, in case of the utilities measured by smart meters at a given consumer, is the responsibility of the Area SM Operator. The reliability of the quality of the metering signal from the meter is the responsibility of the DSO.
- Network loss, regardless if it is arising from theft at the meter or from any other loss not related to the smart meter, is the burden of the DSO.
- Consumers remain in contractual relationship with the Trading company.
- The Area SM Operator provides the DSO and Trading Company with data (based on contract with predefined data content and frequency).
- The Area SM Operator, upon (regulated) contractual relationship, provides the DSO with data regarding to the following:
    - Section data (primarily data regarding transformation stations and gas distribution stations to support network maintenance and the detection and handling of network losses)
    - Consumption data in case of the consumers not belonging to the universal service provider
    - Warning signals regarding the network and the smart metering locations
    - Data with smart grid focus
- The Trading company in contractual relationship with the consumer obtains the following information from the Area SM Operator, by consumption sites:
    - Consumption data
    - Intraday detailed data with a frequency depending on the given utility (1/4-hourly, hourly, daily data)
- Trading Companies prepare their invoices to their customers using these data obtained from the Area SM Operator.

- During its operation, the Area SM Operator, upon consumer consent, can transfer the data obtained to energy consulting companies and alternative trading companies for further utilization (e.g. consulting activities to customers on the most attractive commercial offers) or can perform these activities itself (to generate extra income). These activities can only be performed while fulfilling the data protection requirements to the maximum level.

Open issues to be addressed:

- Standardization of the communication solution between the meter and the household signal forwarder of the Area SM Operator
- Information brokerage activity of the Area SM Operator (authorizations, data protection)
- The Area SM Operators possess a natural monopoly, therefore it is essential that they be regulated. The most important areas for regulation are the following:
    - Territorial coverage
    - Legal status of the Area SM Operator as a company, its market position, rights and responsibilities
    - Data format, data structure, frequency, content, etc.
    - Data entitlements
    - Ownership of meters (installation, calibration, maintenance)
    - Meter reading, establishment of consumption
    - Collection, calculation and forwarding of metering data
    - Deployment and operation of a standardized communication network to forward metering data
    - Security of metering data
    - Data security
    - Measurement/Metering fee
- In our opinion, it is recommended to consider the introduction and use of the metering fee during the first years of implementation. As a matter of fact, the 'smart metering fee' will only be invoiced to the consumers where the smart meter has already been installed. In the case of the introduction of the 'smart metering fee' it must decided whether the fee is in proportion with consumption or it is a fixed amount charged by smart metering devices. Taking into consideration that, based on our approach, there is no contractual relationship between the Area SM Operator and the consumers, the 'smart metering fee' will be paid to the Area SM Operator mainly through the DSO (and through the universal service provider in case of the universal service), therefore, it is a matter of decision whether it should appear as a new line on the invoice, as metering fee, or among the DSO's approved /recognized/

costs. It is also recommended to that when the DSO's benefits from smart metering have covered the costs, the metering fee be eliminated.

- The consumption data of the consumers can be provided by either the Area SM Operator or the Trading Company. The formal information transfer depends upon the decision of the Regulator. We suggest that it is favorable that the Area SM Operator not be in a contractual relationship with consumers, and that the Trading company be responsible for communicating the levels of consumption.

6.2 Implementation Schedule

There can be several implementation schedules considered for the introduction of the Area SM Data Acquisition and Service Company Model in Hungary. As we mentioned in Chapter 5 introducing the CBA, it is recommended, at national economy level, the rapid implementation of the solution with the appropriate coverage. It must be taken into consideration that favorable returns can be seriously altered in case:

1) Consumption does not decrease in according to the expected rate
2) Network losses do not decrease at the DSO according to the expected rate

Considering all these options, we recommend a structured and well designed implementation that supports the gathering of further experiences and, at the same time, systematically supports the final implementation, based on the following phases:

- **Smart Metering Regulation (Phase 1)**
  The objective of this phase is to create/modify the regulatory environment necessary for the launch of smart metering pilot projects. The rules need to be aligned with the final SM regulation to established later. We consider it important that the future SM Operators, due to their natural monopoly, be under authority (HEO) supervision.

- **Finite Number of domestic Smart Metering Pilot Projects (Phase 2)**
  The objective of this phase is to run domestic smart metering pilot projects .
  Any player within or outside the industry may participate in the given pilot, but a stand-alone (legally separated) company should be created even for the purpose of the pilot. Our recommendation for the minimum size of the pilot is 10,000 consumers / pilot, possibly in a multi-utility setup.

- **Evaluation of the Pilot Projects (Phase 3)**
  The objective of this phase is to become familiar with and evaluate the results of the smart metering pilot projects, discuss the experiences, fine tune the regulation and prepare area concession tenders.

- **Inviting tenders for non-overlapping territorial concessions that cover the entire area of the country (Phase 4)**

  Our recommendation is to establish concessional areas (territories) across the whole geographical territory of the country. Metering companies can obtain meter operator 'licenses' for the individual territorial concessions for a concession fee. The main condition for applying for a concession license: successful pilot project implementation in Phase 2.

- **Implementation of the meter operator model by the concession winner on each given territory (Phase 5)**

  The advantage of the introduction across several steps (relying on pilots) is that the assumptions presenting significant uncertainty factors can be tested in practice during the pilots, so that the final implementation will employ the best scheduling and content with high probability.

Regarding the deadline for introduction the following high-level time scheduling seems realistic in case of individual phases of implementation:

- 2010-2011: preparatory regulation
- 2011: launch of pilot projects
- 2013: closure and evaluation of pilot projects, invitation for concession tender
- 2014: domestic roll-out of smart metering / launch

These deadlines would suggest that, given significant time until a 2014 roll-out, we may assume with high probability that smart meters will be available at lower prices and EU standards will likely already be established.

It was defined, regarding the proposed model, that it must support multi-utility solutions and make use of its synergies. Therefore we recommend that the implementation of the smart metering concept in Hungary is performed in electricity and gas sectors in the first phase, while the second phase should involve (due to the specifics of water and district heating) other utilities.

6.3 Regulatory Issues Regarding Implementation

As we mentioned in the previous chapter, we consider the compliance of regulation an important success criterion of smart metering. In this chapter we compiled the areas to be regulated, and the form of regulation.

The following details related to the model, must be regulated by the modification or enhancement of the laws and statutes listed:

Electricity:

Table 20.: Laws and regulation to be modified (electricity)

Detail to be Regulated	Responsible	Form of Regulation
Status of the OM Operator as a company (regulation of natural monopoly), its market position, rights, responsibilities	Parliament, HEO	Act: - LXXXVI/2007 on Electric Energy - IV/2006 on Companies
Ownership of meters: - installation - calibration - maintenance	DSO	Act: - LXXXVI/2007 on Electric Energy, - XLV/1991 on Measurement / Statute 127/1991. (X. 9.) Statute: - 8/2006 (GKM) – on Metering Devices (compliance, quality, calibration) - 273/2007. (X. 19.) Government Statute on the Execution of Act LXXXVI/2007 on Electric Energy
Reading of meters, establishment of consumption	SM Operator	Act: - LXXXVI/2007 on Electric Energy
Metering Data: - collection - calculation - forwarding	SM Operator	Act: - LXXXVI/2007 on Electric Energy, - XLV/1991 on Measurement / Statute 127/1991. (X. 9.)
Development and operation of a standardized communication supporting the forwarding of metering data	SM Operator	Act: - LXXXVI/2007 on Electric Energy, - XL/2001 on Telecommunication - C/2003. on Electronic Communication
Security of metering data	SM Operator, DSO/Network Licensee, Trading Company, System Operator	Act: - LXXXVI/2007 on Electric Energy, - LXIII/1992 on the Protection of Personal Data and the Disclosure of Information of Public Interest
Security of data given to customers	SM Operator	Act: - LXXXVI/2007 on Electric Energy, - LXIII/1992 on the Protection of Personal Data and the Disclosure of Information of Public Interest
Security of data handed over to - energy consultants - alternative traders - other third parties	SM Operator	Act: - LXXXVI/2007 on Electric Energy, - LXIII/1992 on the Protection of Personal Data and the Disclosure of Information of Public Interest

Gas:

Table 21.: Laws and regulation to be modified (gas)

Detail to be Regulated	Responsible	Form of Regulation
Status of the OM Operator as a company (regulation of natural monopoly), its market position, rights, responsibilities	Parliament, HEO	Act: - XL/2008 on Natural Gas Provision and Service - IV/2006 on Companies
Ownership of meters: - installation - calibration - maintenance	DSO	Act: - XL/2008 on Natural Gas Provision and Service - XLV/1991 on Measurement / Statute 127/1991. (X. 9.) Statute: - 8/2006 (GKM) – on Metering devices (compliance, quality, calibration) - 19/2009. (I. 30.) Government Statute on the Execution of Act XL/2008 on Natural Gas Provision and Service
Reading of meters, establishment of consumption	SM Operator	Act: - XL/2008 on Natural Gas Provision and Service Statute: - 28/2009. (VI. 25.) (KHEM) Statute on the Price Setting of Universal Service in the Natural Gas Sector
Metering Data: - collection - calculation - forwarding	SM Operator	Act: - XL/2008 on Natural Gas Provision and Service
Development and operation of a standardized communication supporting the forwarding of metering data	SM Operator	Act: - XL/2008 on Natural Gas Provision and Service - XL/2001 on Telecommunication - C/2003. on Electronic Communication
Security of metering data	SM Operator, DSO/Network Licensee, Trading Company, System Operator	Act: - XL/2008 on Natural Gas Provision and Service - - LXIII/1992 on the Protection of Personal Data and the Disclosure of Information of Public Interest
Security of data given to customers	SM Operator	Act: - XL/2008 on Natural Gas Provision and Service - - LXIII/1992 on the Protection of Personal Data and the Disclosure of Information of Public Interest

Detail to be Regulated	Responsible	Form of Regulation
Security of data handed over to - energy consultants - alternative traders - other third parties	SM Operator	Act: - XL/2008 on Natural Gas Provision and Service - - LXIII/1992 on the Protection of Personal Data and the Disclosure of Information of Public Interest Statute: - 86/2003. (XII. 16.) (GKM) Statute on the Data Provision of Gas Service Companies

6.4 Data Protection Considerations Regarding the Model

The following is a summary of those sections of Act LXIII/1992 on the Protection of Personal Data and the Disclosure of Information of Public Interest that are relevant to the Area SM Operator Company Model. It contains those regulatory details that the SM Operator of the Area SM Operator Company Model must take into consideration during its activities regarding the management, processing, forwarding of data and making data transactions with other parties.

Act LIII/1992 on the Protection of Personal Data and the Disclosure of Information of Public Interest states that the purpose of the Act is to ensure the right to privacy regarding personal data and free access to information of public interest, notwithstanding any exemptions provided by legal regulation specified in the Act.

The Act applies to all data management and data processing operations performed in the territory of the Republic of Hungary that pertain to the data of natural persons or to public information or information of public interest. The Act must be applied to data management and data processing operations whether performed in full or in part by an automated process or by manual processing.

In our model the (legal) person of the data processor and data forwarder is not separated as these activities are performed by the newly established SM Operator companies.

Data Processing and Management

Personal data may be processed if the data subject has given his consent. The data subject may grant consent in a written agreement concluded with the controller for the performance of the contract. In this case, the contract shall contain all information that is to be made available to the data subject under the Act in connection with the processing of personal data, such as the description of the data involved, the duration of the proposed processing operation, the purpose of processing, the transmission of data and the use of a processor. The contract must clearly indicate the data subject’s signature and explicit consent for having his data processed as stipulated in the contract.

The rights and obligations of data processors arising in connection with the processing of personal data shall be determined by the data manager within the scope specified by the Act and other legislation on data management. The data manager shall be held liable for the legitimacy of instructions pertaining to data management operations.

The data processor shall be held liable within his sphere of competence and within the scope specified by the data manager for the processing, alteration, erasure and disclosure by transmission of personal data. The data processor shall not be permitted to subcontract any part of his operations to another data processor.

Personal data may - with the data subject’s consent or by virtue of legal regulation - be processed for the performance of a task carried out in the public interest or in the exercise of official authority, in the fulfillment of the official tasks of the controller or the recipient third party, for the protection of the data subject’s vital interest, for the performance of a contract between the data subject and the controller, in the legitimate interests of the controller or a third party, or in the legitimate operation of a charitable organization.

Automated Data Processing

Evaluation of certain personal aspects of any person by automated (computerized) processing of data may only be carried out if the data subject explicitly gives his consent or if such evaluation is permitted by law. The data subject must be given the opportunity to express his opinion.

Where personal data is processed by automated means, the data subject must, at his request, be informed of the mathematical method that is used and its essence.

Data Forwarding

Personal data may be transferred, whether in a single or in a set of operations, if the data subject has given his consent or if the transfer is legally permitted, and if the safeguards for data processing are satisfied with regard to each and every personal data.

Data Quality

The Act specifies the following regarding the quality of data:

Personal data collected for processing must be

a) processed fairly and lawfully;

b) accurate, complete and, where necessary, kept up-to-date;

c) kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the data were collected.

Data Security

Data managers, and within their sphere of competence, data processors must implement adequate safeguards and appropriate technical and organizational measures to protect personal data, as well as adequate procedural rules to enforce the provisions of the Act and other regulations concerning confidentiality and security of data processing.

Data must be protected against unauthorized access, alteration, transfer, disclosure by transmission or deletion as well as damage and accidental destruction. For the technical protection of personal data, the controller, the processor or the operator of the telecommunications or information technology equipment shall implement security measures in particular if the processing involves the transmission of data over a network or any other means of information technology.

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ERRA course 02Feb10 Smart Metering Italy Villa final bis

Attachment 2: Expected minimum functionalities of smart meters

Based on the smart metering basic models and the cost-benefit analysis/modeling we have the following assumptions regarding the expected minimum functionalities of smart meters:

- Two-way data communication
- Possibility for remote control
- Remote switch on/off function possibilities and the possibility for consumption limitation (electricity)
- Possibility for regular forwarding metering data upon request – possibility for quarter-hourly data forwarding (15-minute measuring intervals)
- Possibility for remote programming and update, controlling software can be remotely managed
- Possibility for recording and storage of data based on different parameters (e.g. consumption data and tariffs)
- Possibility for remote modification of tariffs and tariff periods
- Measurement accuracy: +/- 1% (low voltage, low capacity (current), single phase)
- Alarm messages (e.g. tampering)
- Remote display not necessary

Attachment 3: International Tendencies

The key drivers of the utility market on a global level are: prices of commodities, regulatory environment, incentives targeted at the energy efficiency and the changes on the demand side of the market.

The listed trends are incorporating the impacts of the financial crisis.

Key trends influencing the industry:

- The ever increasing prices for commodity goods require the market players to address the energy efficiency issues. This translates to stronger cooperation between the stakeholders.
- The EU regulations incentivize innovative technological solutions.
- The liberalization of the markets and steps taken to increase the level of competition on the utility markets force the market players to change their current practices.
- Europe's dependency on foreign supply of energy resources.
- Europe's increasing energy consumption and demand

Impacts of the financial crisis:

- Short-term decrease of the energy consumption
- Higher volatility and short-term decrease of the energy prices
- Increasing interest rates
- Postponed investments into new capacities
- Decreasing demand for the renewable energies

International regulatory background

The EU has two main directives that mention the smart metering concept (2004/22/EK and 2006/32/EK)

The first one deals with the certification and standardization of the meters within the EU's territory. This regulation allows a smart meter producer to get access to the markets of all EU states and facilitates a rapid penetration of new technologies.

The second directive addresses the topic of selling energy to consumers as a service. This allows the companies to include new services in their offering that should help the smart metering to become more profitable sold in a bundle.

The EU has the following expectations towards the implementation of the smart meters:

- Improvement of the energy efficiency within the EU
- Increase the share of renewable energies
- Improve the energy safety and stability of the EU
- Decrease CO2 emissions
- Meters should be separate for the different utilities, though data received from them should be available for processing by everyone with permissions

- Bills generated from smart metering should be user-friendly
- The consumers should at least see the following information on their bill:
  - Current price and consumption
  - Comparison of previous periods' consumption with the current one
  - Contact information to the respective customer services

Currently, most of the EU directives are being interpreted by the members' regulators and the legal aspects are under discussions. The level of details varies between the countries, but most are similarly to Hungary in the middle of the process for creating a regulatory framework.

International Situation of Smart Metering Implementation

The implementation of SM is compulsory in 4 countries today:

- In **Italy,** following a voluntary meter replacement program launched by the incumbent utility ENEL (with regulatory approval) in the 1990s, the regulatory authority (AEEG) has mandated full introduction of smart meters according to established minimum functional requirements in 2006. Replacement shall be completed by December 2011. Italy is a frontrunner in Europe in terms of smart meter installations with 86% of low-voltage customers already equipped with smart meters.

- In 2003 **Sweden** became the first EU country to mandate smart metering (indirectly) by legislating new national metering regulations requiring all residential customers to be read monthly by July 2009. Metering is done by the DSO. The main driver for remote meter reading was the difficulties due to the great distances one had to travel during meter reading.

- In March 2007 the governments of **Spain and Portugal** decided on the introduction of harmonized smart meters for all customers as a means to improve the functioning of the Iberian Electricity Market. Spain has already adopted legislation mandating full meter replacement by December 2018; Portugal has not yet adopted new legislation but the regulatory authority (ERSE) proposed that replacement should be concluded by December 2015. In Portugal, all medium, high and very-high voltage customers are equipped with AMR since 2005, following a previous decision by the regulatory authority

- **The Netherlands.** The NL Min of Economy plans overall roll-out till 2012, at 7m households, aiming for 2% energy savings. Today the usage of smart meters faces the difficulty of Data Protection until it is fixed the systems cannot be used.
  Strong cooperation with Telecommunication companies (KPN). Standard data Interface is defined. DSO owns and operates the meters; metering data processing is

the responsibility of Energy Supplier (retailer). Consumers have access to the metering data.

Other countries:

- **Finland.** The major consumers will be equipped with SM, no full roll out is planned.
- **Denmark.** Since 2005, automated reading is compulsory at the +100 MWh consumers. Regulation for full SM roll out is in progress.
- **Norway**. Since 2005, automated reading is compulsory at the +100 MWh consumers. Today the SM is optional for the households, but the government is aiming for compulsory full roll out by 2013.
- **UK.** Currently no specific regulation but regulation for compulsory use of SM is planned within 5 and 10 years for business and household consumers. Driver is the CO2 reduction. The metering market is liberalized and the consumers have strong data protection right.
- **Ireland.** Regulation is being planned, special focus on communication to Consumers (increase consciousness) and on micro power plants.
- **Estonia.** Compulsory for mid-sized consumers. 41% of total consumers penetration is expected by 2010
- **Cyprus.** Automated meter reading is compulsory at mid voltage consumers only. The regulator plans full roll-out of compulsory usage by 2014
- **Belgium.** The Energy office is examining the option of Smart Meter introduction.
- **Romania.** The Energy office is examining the option of Smart Meter introduction.
- **Germany.** The German regulation lets the market to drive the introduction of Smart Metering.
- **Croatia.** No liberalization and unbundling has happened yet.
- **Bulgaria**. No liberalization and unbundling has happened yet.

The following chart summarizes the status of smart metering introduction in the different EU countries based on the latest (December 2009), publically made available ERGEG/ESMA reports.

Country	Electricity	Gas
Austria	30,000 installed, no national obligation but this under review.	Roll out under discussion
Belgium	Trials underway – results will determine any national roll out.	
Cyprus	There is no smart metering deployed in Cyprus.	
Czech Republic	Trials underway – results will determine any national roll out.	
Denmark	Several electricity DSO's are deploying smart meters but there is	

	no national plan.	
Estonia	A major roll out is under discussion and a roll out may begin in 2011 that would conclude in 2013.	
Finland	In March 2009 new legislation that requires nearly full penetration of hourly metering and settlement by 1 January 2014 cane to effect.	
France	EDRF expected to commit to a full roll out in 2010 based on results of trial. Overall target of 96% smart meters installed by 2020.	Roll out under discussion
Germany	> 50 trials ranging from 10 to 100.000 electricity meters. A full national roll out is under discussion. Adopting a market based approach, allowing customers to opt in or out.	Similar situation with electricity metering but there is no planned roll out.
Great Britain	On 30th of October 2008 the Government decided on a national roll out of duel fuel smart metering for all 27 million households before 2020 1. On 2nd Dec 2009 the Government announced its planned approach to rolling out smart metering.	Same as for electricity
Greece	A roll out has been decided and will be carried out between 2010 and 2013.	
Ireland	A pilot study is underway and it is anticipated that this will lead to a full roll out, but the decision has not been made yet.	Same as for electricity
Italy	Currently have 33 million AMM meters and by 2011, all 36 million electricity customers will be equipped with a smart meter.	Has made decision to roll out of gas meters with a target of 80% installed by 2016
Luxembourg	A number of trials are being carried out by DSO's.	
Norway	New requirements regarding full scale establishment of smart metering were suggest autumn 2009 – through a discussion document, but the final decision is postponed until the spring 2010. The main reason for this postponement was to find out what happens within the European initiative for standardization	

	regarding smart metering.	
Portugal	The Regulator has made a preliminary study	
Poland	There is discussion of a roll out beginning in 2010 and completed by 2017.	Same as for electricity
Romania	There is no official national plan in Romania on smart metering.	Same s for electricity
Slovakia	Discussion of a roll out is underway.	
Slovenia		Roll out under discussion
Spain	A full roll out is underway, beginning in 2008 and planned for completion in 2018.	No economic case for roll out of smart gas meters for customers using <5.000.000 kWh/y.
Sweden	Will be the first one to achieve a 100% penetration in July 2009 when monthly collection of meter data becomes mandatory.	
The Netherlands	Dutch Senate rejected proposed legislation including a compulsory roll out of smart metering for reasons of privacy and security. Proposed legislation and smart meter standards are now being revised for new discussion in parliament in order to allow a voluntary roll out. New decisions are expected in autumn 2010. In the meantime, Dutch fourth largest energy supplier Oxxio has installed over 100.000 smart meters in the residential sector already.	Same as for electricity

Attachment 4: Interviews with stakeholders

The Experiences of the Interviews and Important Conclusions

SM experiences

- A little more than half of the interviewed companies/institutions has not dealt in depth with smart metering, their organization does not possess own experiences in the field. These include the following stakeholders: consumer, regulator, system management
- The respondents having own experiences, projects or professional initiative are from the distribution and trading companies from the electric energy, gas cluster and from the telecommunication companies (the latter mainly through their mother companies). These companies have shared their Western European (mainly Scandinavian, German and French) experiences.

Main Expectable Market Trends Regarding Smart Metering:

  - Influencing from the Smart Grid trends
  - Machine-to-Machine solutions
  - Passive house with remote management
  - Companies on the market are making more efforts to transform the structure of their energy consumption (even during the day), so that they can decrease their electricity bill with the packages offered by the traders. It is expected that this tendency will appear within the population.
  - The consumer habits are changing, the reasons for this are: higher gas prices, green energies are becoming more competitive, energy saving devices are appearing on the market, the insulation of the buildings are improving. As a consequence we can expect decrease in the specific consumption.
  - The development of the HSDPA technology is similar to the development of the electricity market (capacity must be planned based on public and market peaks of consumption; the target is to divert consumption from peak to low periods).
  - The possibilities offered by the pre-paid meters (like in telecommunications).
  - Participation in Smart Metering can be in the vision of telecommunication companies.
- The stakeholders estimated several 10 billions of HUF as the cost of the roll-out.
- Large part of the investment will arise on the distributors' side; therefore they have to finance it.

Advantages

- Advantages of smart metering at national economy level:
  - The development of demand-driven energy pricing schemes will promote competition (new market players, electric energy and gas become products of a more competitive market).

- Decrease in used energy.
    - Lower environment load level in case energy consumption decreases at system level.
    - Possibility to transform the price supporting system based on needs in a rational way.
- Advantages at consumer level:
    - Gets more precise information on the parameters of his consumption.
    - Possibility for personal pricing.
    - Increase in energy awareness.
- Advantages at service provider level:
    - Savings in operational costs at traders due to the decrease in the number of readings.
    - Decrease in outstanding debt.
    - Possibility to decrease grid loss.
    - Decrease of stealing due to the quicker and more effective localization.

Problems, Risks and Success Criteria

- The average energy-awareness of the consumers is low, therefore the public will not be interested in smart metering.
    - The most important advantage of smart metering at national economy level is the decrease in energy consumption, but the incumbent industry players are not
    - interested in it.
    - The price of smart meters is much higher than the price of currently used meters (furthermore their operational period is shorter).
    - The costs of data transfer will increase significantly both at traders' and distributors' level.
    - It is expected that in case of certain consumers the cost of installation arising from the change of meters will not payback (e.g.: rarely used weekend houses).
    - In the case of gas, due to physical features, the system balance is not so delicate as in the case of electric energy: the transformation of peak-low periods is not paying out.
    - In the case of heating: measurement is only possible between the producer and the service provider, in the case of consumers smart metering cannot be solved alongside the current technical conditions.
- The criteria of a successful roll-out: the most important expectations are regarding the quality of regulation, the professionalism and consistency of the roll-out period. Apart from this the expectations regarding the reliability and accuracy of the technical content of the solution were mentioned.

Most Important Answers Regarding Smart Metering Models and Their Features

  - The gas, electric energy and telecommunication companies agree that the responsibility for the installation of smart meters must be taken by the network licensee.
  - The consumers/regulators prefer similarly the independent metering company model and the distributor model, while the telecommunication companies choose the independent metering company model.
  - Financing of system setup: the majority prefers the solution where the network licensee finances the installation of the smart meters, the cost of investment will be paid back by the consumers with the recognized network fee.
  - Profit/costs split: significant differences in opinions. The consumers/regulators say the investment can be made self-financing, there is no need to increase service provider fees. Telecommunication companies prefer this scenario, but neither the electric companies nor the gas companies prefer it.
  - The incumbent electric and gas companies prefer slower introduction, while telecommunication companies prefer the solution where the regulator sets a close target date – closer than the planned changing pace of the meters.
- Regulation
  - The consumer/regulator cluster's strongest preference is a regulation solution which focuses on the regulation of the data model.
  - The gas/electric energy industry players would focus on the communication standards.
  - The telecommunication companies prefer the multi-utility model.
- In the case of operational models the strongest correlation is between the answers of the electric energy and gas companies and between the telecommunication and gas companies. Compared to this the opinion consumer/regulator cluster is at a lower but positive correlation with the opinion of the industry players. Besides this it can be noticed that there is no relation where the answers of the involved groups would entirely contradict, there are certain similarities in all cases.
- The relation between the answers of the groups is weaker in the case of the questions regarding solution principles. Significant correlation can only be noticed among the answers of the gas and electric companies. Furthermore the opinions of the regulators and the consumers entirely differ from the ones of the other stakeholders. The conclusion: there will be significant differences in the opinions regarding the solution principles to be implemented during the preparation phase.

Methodology

In this phase of the project (apart from investigating and evaluating the background material in order to obtain the necessary information on smart metering) the interviews conducted by our consultants with stakeholders of the matter were of high importance of our methodology.

The targets of the personal interviews were:

- obtain the knowledge of stakeholders on smart metering and their involvement in the same
- adaptability of smart metering models in Hungary
- define features of possible smart metering models and their evaluation
- identify the similarities and differences in the opinions of industry players on smart metering
- high level definition of smart metering models' scopes and focus areas

Our consultants conducted twenty-seven interviews during this phase:

Based on the interviews we have obtained a representative picture over the opinions of the stakeholders:

Summarized industry weight of the interviewed

	Distributor	Trader	System operator
Electric energy (based on MWh)	100%	75%	100%
Gas (based on m3)	98%	99%*	100%

Source: HEO, data of 2008
**only utility service providers' data*

At the same time we would like to highlight that the number of interviews differed among the different stakeholder groups, so their effect on the summarized answers can be different.

The opinions of only two representatives could be involved in the analysis (a significant service provider and a professional association. So thus the coverage of the sector (considering the number of flats serviced) is 36%. As the heating sector is highly proliferated and service is provided on isolated areas the assessment was carried out as follows:

- based on the above methodology, the opinion of heating service providers has been channeled, but during the assessment we did not create a separate assessment filter for them
- in order to provide all-round representation, the players of the heating market will be reached in the next project phase by our applied questionnaire tool.

During the interviews our consultants use a predefined, structured interview questionnaire that focused on the following:

- situation analysis regarding smart metering, experiences (unlimited (no. of words) answering)
- financial and financing aspects (unlimited answering)
- legal and regulatory issues (unlimited answering)

- expectations, success criteria (unlimited answering)
- features of smart metering models (weighted, point distribution). Areas involved:
    - operational model features
    - solution principle features

Smart metering models

The following chart shows the summary of the answers to the model features detailed above. The table shows the top 3 answers (shown with the total points) to the question.

Operational model features	Three most frequent answers (based on the points received)					
Responsible for meter installation	Network licensee	91	Independent metering company	22	Trader	13
Responsible for operation	Distribution licensee	70,5	Independent metering company	38,5	Trader	18
Financing	Network licensee (accepted network cost)	74	Central financing	16	Consumer	15
Cost/profit split	No new fee element, the investment is self-financing with new services	36	Paid by consumers through network fee	32	New fee element is introduced to cover the investment costs and service fees decrease	30
Rules of introduction	Installation is compulsory where there is a meter	40	Isolated solution	19	Close target date	15

Based on the answers given to the Operating model features those high level implementation directions can be set, based on which the most supported models by the stakeholders can be determined.

The following charts show the different models variants, with the following remarks:

- the aim of the charts is to show all the model alternatives that can be designed based on the answers of those involved in the interviews, so in the case of some model alternatives certain features can be inconsistent or contradictory. We intentionally included these in this phase, excluding the unambiguous inconsistencies;
- the model variants are shown along two totally different directions outlined during the interviews, the models are split by the main responsibility of the licensee or the independent metering company;
- the numbers below each model variant show the total of points assigned;
- the first two questions of the interview (the responsible for installation and responsible for operation) were amalgamated into one model feature, as the judgment of the two responsibilities show strong correlation;
- based on our opinion our fifth question regarding regulation cannot be considered as high level model definition feature (although its role will be highlighted in the final model definition period), therefore we did not involve its answers in the current phase of model definition;
- the internal weights of the survey differ due to the different number of interviews by the stakeholder groups (although the coverage of stakeholders can be considered as

representative), therefore in the case of the results/model variant the opinion of the stakeholders can appear stronger.

Distributor-centered model variants

Responsible for installation and operation	Network licensee/distributor								
Financing	Network licensee - accepted network cost			Central financing			Consumer		
Cost/profit split	No new fee element, the investment is self-financing	Consumers through network fee	New fee element, the other fees decrease	No new fee element, the investment is self-financing	Consumers through network fee	New fee element, the other fees decrease	No new fee element, the investment is self-financing	Consumers through network fee	New fee element, the other fees decrease
Total	271,5	267,5	265,5	213,5	209,5	207,5	212,5	208,5	206,5

Independent metering company centered model variants

Responsible for installation and operation	Independent metering company								
Financing	Network licensee - accepted network cost			Central financing			Consumer		
Cost/profit split	No new fee element, the investment is self-financing	Consumers through network fee	New fee element, the other fees decrease	No new fee element, the investment is self-financing	Consumers through network fee	New fee element, the other fees decrease	No new fee element, the investment is self-financing	Consumers through network fee	New fee element, the other fees decrease
Total	170,5	166,5	164,5	112,5	108,5	106,5	111,5	107,5	105,5

It is important to mention that the model variants on the charts are shown as ‘clean’ models (i.e. based on the model defining features some possibilities appear ambiguous), but all other models can be assessed that appear as the combination of answers given in the case of any definition feature. The identification and assessment of these ‘mixed’ models will be carried out at the first general workshop organized after the Inception Report is accepted.

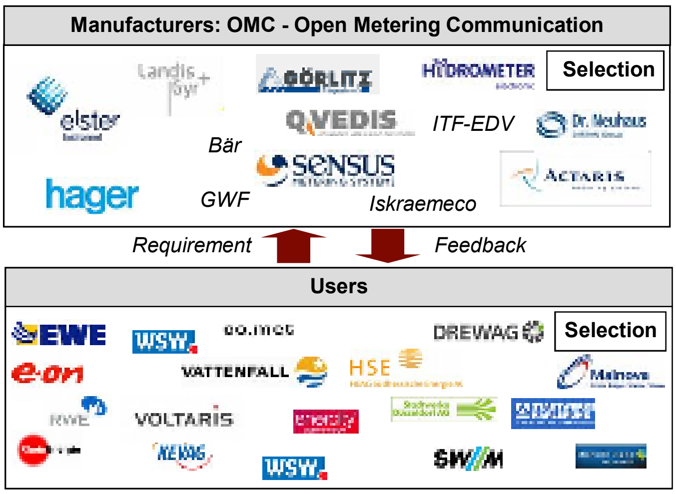
Attachment 5: Standards

International standards

The standards for Smart Meter play an important role at the penetration of the technology. The well defined European standards speed up the penetration because it decreases the risk and the cost.

Defining a common Smart Metering standard significantly reduces the risk of misguided investments

Development of a Smart Metering standard



Key parameters of Smart Meter standard

- The standard…
  - …describes the automated meter data collection and data processing
  - …is manufacturer-independent
  - …is multi-sector (electricity, gas, water, heat, heat cost allocators)
  - …enables an up to the hour billing (electricity, gas, heat) resp. up to the day billing (rest)
- Flexible: Integration of both, wire-based (e.g., electricity line) and wireless (e.g., area radio) meters
- Future-proof: Consideration of expected requirements resulting from the implementation of intelligent energy supply grids (Smart Grids)

Source: Hintergrundgespräche and Smart Metering-Konferenz Berlin and Nürnberg Mai 2008

The SM standards are reviewed by the smart meter solution layers. Its practical rational is the great difference in life cycles of the technologies applied. We differentiate standards at 4 technology layers:

- Front-end-systems: consumption meters (Smart Meters)
- Communication: Data transmission (Wireless, Cable, concentrator)
- Back-end-systems: Software (ZFA, billing)
- Overall: Data formats and Interfaces

While the first three layers standards are created – driven by the smart meter producers -, the fourth layer the standards are many times not defined or differ by country or by producer.

The EU plays an important role in SM standards setting. The final goal is to define an open architecture which consist the communication model as well and ensures the interoperability.

EGREG has also expressed its interest and view on the topic at its study on 2007. October 31. (Smart Metering with a Focus on Electricity Regulations):

> ….
>
> *Function expectation*
>
> *The service provider has to get its opportunity to choose from the technologies, solutions available.*
>
> *Key functions to analyze:*
> - *remote meter reading*
> - *consumer profiling*
> - *consumer data provisioning for Consumers*
> - *consumer data provisioning for authorized third party*
> - *Billing and consumption periods definition*
> - *remote meter controlling*
> - *remote regulation of meter: consumption reduction or switch off and on consumers*
> - *tariff information provision for the consumer*

Domestic Standards

The Hungarian utility companies use metering devices that fulfill the standards of the Hungarian Standards Body (MSZT). The Hungarian Standards are harmonized with the international standards regarding the same devices.

<u>Calibration of metering devices</u>

The legislation of utilities stipulates calibration as compulsory and defines the responsibilities for the calibration of meters. Act XLV. of 1991 on measurement deals with the calibration of meters.

The law details the devices to be calibrated by the National Measurement Office, and the calibration procedures.

Based on the law the metering devices that must be calibrated in case of utilities are:

- Electric consumption meters and built in supporting devices
  - one-phased electro mechanic meters
  - multi-phased electro mechanic meters
  - electronic meters
- Gas meters
  - lower than 6m3/h nominal metering limit

    - higher than 6m3/h nominal metering limit
- Heating consumption meters

Attachment 6: Relation Between Smart Grids and Smart Metering

The following[12] is a short summary of the relationship and connections between Smart Grids and Smart Metering, based on the findings of the European Technology Platform on Smart Grids.

"The term 'smart grids' has been used for many concepts, solutions and products for several years. Various stakeholders who refer to it often strongly drive the understanding and the use of the term, which often results in different understandings.

When looking at the output values expected from a smart grid (efficient electricity supply, low costs, satisfactory quality and security of supply, etc), this coincides with the output values we already expect from today's 'conventional' grid.

Though elements of smartness also exist in many parts of existing grids, the difference between today's grid and a smart grid of the future is mainly the grid's capability to handle more complexity than today in an efficient and effective way. This increased complexity is due to:

- Massive implementation of distributed generation at LV and MV level including the need for an efficient regulatory treatment of license applications;
- Implementation of large intermittent generation located geographically far away from the load centers;
- Changes in customers' behavior (i.e. an active demand side);
- Reduction of losses (e.g. through appropriate distributed generation which is located close to areas with high consumption);
- Increased use of self-healing technologies.

There is as yet no internationally unified definition of a smart grid. At a global level, definitions are normally given by standard organizations like the International Electrotechnical Commission (IEC), which recently circulated among its members a proposal for a smart grid definition. Additionally, several recent reports include a definition or an explanation of what a smart grid is:

'A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies.'

From a regulatory point of view, a definition or an understanding of the concept of smart grids should be based upon the needs for them, i.e. what they are intended to solve, and what kind of functions and output values they can provide for the users of the transmission and distribution grids.

[12] Excerpt from the document: ERGEG 2009 Report on Smart Grids. Document: E09-EQS-30-04_SmartGrids_10 Dec 2009

'Smart Grid is an electricity network that can cost efficiently integrate the behavior and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety.'

A smart grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies in order to:

- Better facilitate the connection and operation of generators of all sizes and technologies;
- Allow consumers to play a part in optimizing the operation of the system;
- Provide consumers with greater information and options for choice of supply;
- Significantly reduce the environmental impact of the whole electricity supply system;
- Maintain or even improve the existing high levels of system reliability, quality and security of supply;
- Maintain and improve the existing services efficiently;
- Foster market integration towards European integrated market.

Smart grid deployment should consider not only technology, market and commercial considerations, environmental impact, regulatory framework, standardization usage, ICT (Information & Communication Technology) but also societal requirements and governmental policies.

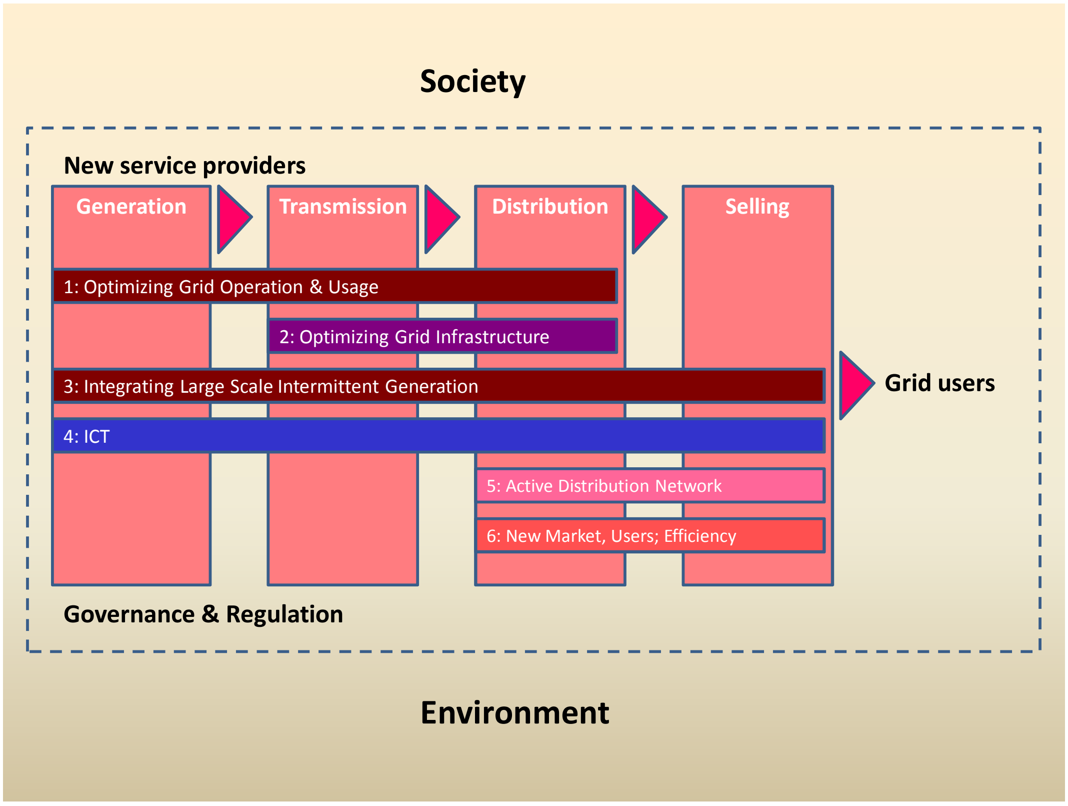


Figure 5: Scope and Priorities of Smart Grid Deployment

The scope and priorities for smart grid deployment are illustrated in the above figure[13] and consist of a number of features:

1. Optimizing grid operation & usage concerns decentralized, coordinated grid operation, operational security, optimization of losses and market based treatment of electric power flows;

2. Optimizing grid infrastructure concerns building new and improving and optimizing the existing grid facilities;

3. Integrating large-scale intermittent generation concerns integrating into the grid and the market large-scale generation (on/off-shore wind, large-scale solar, wave generation etc.);

4. Information & communication technology concerns the ICT tasks, standards and solutions;

5. Active distribution grids concerns "activating" the distribution grids towards (and beyond) the degree of automation and operation as is the case today with the transmission grids;

6. New market places, users and energy efficiency is finally about putting customer into focus.

Smart Metering supports the implementation of several of the above priorities, especially 1., 2., 5., and 6.

The terms smart grids and smart metering are often used together, sometimes even mistaken to have a similar or even the same meaning. Even though smart metering enables some features and functionalities of smart grids, the scope of smart grids is much larger than smart metering. This is illustrated in a simplified way in the following figure:

[13] Source: ERGEG 2009 Report on Smart Grids. Document: E09-EQS-30-04_SmartGrids_10 Dec 2009

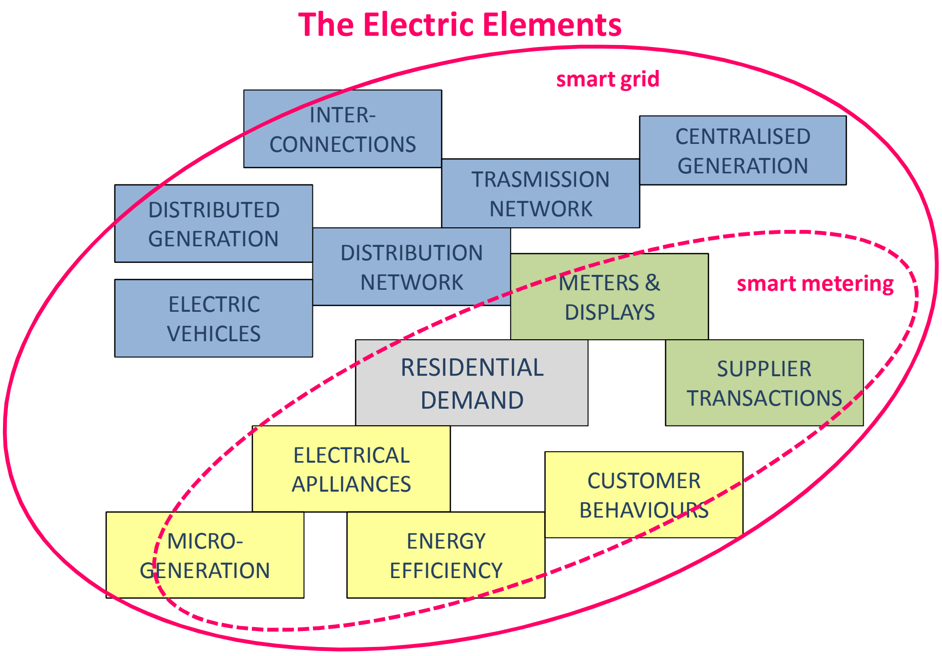


Figure 6: Smart Grid and Smart Metering Functionalities

Therefore, it is important to bear in mind that smart metering does not provide a smart grid, and on the other hand it is possible to have smarter distribution and transmission networks without smart metering."

Attachment 7: Industry Data Collection Sheet

Pilar	Content	Unit of Measure	Value
Costs of introduction			
	Data regarding meter		
	Price of meters available on the market	HUF/piece or EUR/piece	
	Installation cost of meters (installation/dismountling due to ageing of other reason for change, together with travelling costs)	HUF/time	
	Expected lifetime of meters on the market	year	
	Indicator regarding sunk costs		
	Average age of the meters in the territory of service provider	year	
	Expected lifetime of the meters used in the territory of service provider	year	
	Number of installed household meters per service provider	piece	
	Value of meters at the time of installation per service provider	HUF	
	In case it is necessary to install additional data forwarding unit		
	Cost of additional data forwarding unit	HUF	
	Expected lifetime of additional data forwarding unit	year	
	Cost of installation of installed data forwarding unit	HUF	
	In case it is necessary to install additional data concentrator unit		
	Cost of additional data concentrator unit	HUF	
	Expected lifetime of additional data concentrator unit	year	
	Cost of installation of installed data concentrator unit	HUF	
	Cost of communication network		
	Data traffic of an average smart meter per time unit	byte/unit of time	
	Development/set up costs of a data processing center	HUF	
	Cost of data access/management at the different actors authorized to information	HUF	
	Communication cost of service providedr/trader		
	Development of electronic communication towards service provider/trader	HUF	
	Operational costs of smart meters		
	Average number of field work regarding operation/maintenance of meters	field work/year/consumer	
	Cost of field work regarding operation/maintenance of metersMérőműszer üzemeltetésével/karbantartásával kapcsolatos kisz	HUF/time	
	Field work cost of annual meter visit/check of meters	HUF/time	
	Communication network costs		
	Market price of forwarding the above data through BPL infrastructure	HUF	
	Cost of data processing and storage		
	Data processing and storage costs of the above data	HUF/month	
	Cost of data processing center		
	Monthly cost of providing information terchnology background	HUF/month	
	Monthly cost of human resources	HUF/month	
	Material expenditure	HUF/month	
	Operation of other infrastructure	HUF/month	
	Cost associated with data access and handling		
	In case the distributor and trader are members of the same company group		
	Cost of data traffic and data processing regarding the own consumers of the service provider (distributor and trader)	HUF/month	
	In case the distributor and trader are independent companies (not members of the same company group)		
	Cost of data traffic and data processing regarding the own consumers of the distributor	HUF/month	
Benefits of introduction			
	Consumers		
	Current annual total cost of reading (physical reading, through email, through phone)	HUF/year	
	Cost incurred due to (invoice) complaints	HUF/year	
	Number of complaints		
	Complaints corresponding to distributor	piece/year	
	Distributor		
	Increase in metering accuracy		
	Income loss (commercial loss) due to current level of stealing	Ft	
	Network management (network infrastructure operation, development, maintenance necessary to cover the needs of total consumption of given network)		
	Current annual total cost of network management	HUF/year	
	Level of/change in network loss at substation level in proportion to the number of smart meters installed		
	Current level of network loss (physical loss)	GWh/m3/GJ, HUF	
	Necessary number of visits to consumer per year (due to reading/checking)	piece	
	Necessary number of visits to consumers with smart meters per year (due to checking)	db	
	Cost of one visit (reading/checking - not servicing/repair)	HUF	
Price and cost transparency			
	Cost of changing trader		
	Is it necessary to change the (smart) meter? In case yes, what is the cost of it?	HUF/change	
	Cost of meter reading and 'zero invoice' preparation	HUF	
	Other reasonable cost	HUF	
	Time of changing service provider	day	
Reduction of entry barriers of future technologies			
	Estimated cost of an additional service to the basic service		
	Cost of software update	HUF	
	Cost of harware development (at service provider)	HUF	
	Cost of meter change	HUF	
	Cost of the development of data processing system	HUF	
	Others	HUF	

Attachment 8: Broadband over Power Line (BPL)

In the last period, the broadband technology (broadband over power line – BPL) has undergone faster development in Europe than in the United States, typically because of the differences in the electrical grids. In the current networks the change of voltages is performed through transformers, and the data traffic isn't able to traverse through them completely. The solution is provided by bridging equipment that are able to smoothly transfer the data traffic between different voltages, so that it can continue its way in the network with changed voltage, too. The presence of transformers allocated to individual households is a common sight in the electrical grid built in the United States, while in Europe such equipment serves 10-100 households on average. This difference doesn't count as significant from the electricity provision point of view, but it extremely improves the data transfer capabilities of the European grid and the rates of return of investments necessary for this. At the same time, since the data transfer capacity of the network between transformers and households is low, the American-type grid is more suitable for providing faster data transfer possibilities compared to the European solutions. This explains the development trend according to which service providers don't use the BPL technology anymore for transmitting signals from the transformers to the end users; they use some kind of wireless solution (e.g. WiFi, WiMax, etc.) instead. This way in the near future it is expected that the BPL technology will be popular primarily in the core network, while on the so-called access level it will be mixed with other technologies.

On the level of the public, several technologies may come into discussion to fight the above – and several other – limitations, one of them is the so-called Power Line Communications, its development has undergone significant changes in the last 10 years.

PLC systems consist of terminal devices (e.g.: telephones, PCs, measuring equipment, etc.) that are connected or integrated into the electrical grid, and that enable the data traffic and communication to another device connected or integrated into the grid. Using the cables of the existing electrical grid for this purpose significantly decreases the costs and provides appropriate broadband connection between individual devices.

Usage areas for PLC could be:

- Control of the electrical grid
- Low bandwidth (24 – 500 kHz)
- A technology already in use for a long time now
- Home network (Broadband)
- Broadband access to internet (2-30 MHz)
- Broadband over Power Lines (BPL)

A new approach of PLC systems is the so-called Broadband Power Line System that serves the expansion of the internet on a larger scale by using a technology solution that enables the decrease of the limitations enumerated above to a minimum, with lower costs.

These new BPL systems transfer the data in the 2-30 MHz range compared to the operation of the earlier PLC systems in the 9-525 kHz frequency range that allowed a lower data traffic, this enables the undisturbed functioning of the broadband internet in the electrical grid.

Attachment 9: Key drivers of spreading smart metering

Once understanding the benefits of smart metering, it can be concluded that smart metering will play a key role in future of the energy industry. Nevertheless it is hard to estimate when a wide-spread application of this technology will be reached. Within the political and economic environment of smart metering it shall face several drivers which will help, and some obstacles which may hinder the wide-spread application.

We summarized the key drivers in five points:

- **Political intent to implement Smart Meters**. As of 2010 utilities have to offer Smart Meters resp. load variable tariffs as of 2011 – if technically feasible and economically reasonable
- **Increasing energy prices and transparent consumption**. Smart Meters are the technical basis to provide energy consumers with transparence on their actual consumption and to adjust their attitude correspondingly in a market environment with increasing prices
- **Network development in the energy industry**. Smart Meters are a key building block to link energy consumers with utilities and grid operators
- **Efficiency enhancement/sales-related potential**. Smart Meter are the basis to realize efficiency enhancement in the utilities' processes and to tap additional sales-related potentials
- **Standardization of Smart Metering protocols**. Defining a common Smart Metering standard significantly reduces the risk of misguided

The fast introduction of smart metering may also have some threats:

- **Unclear legal framework**. There are different obligations to implement Smart meters among European courtiers. Multiple business models arose from pilot implementation.
- **Unclear cost issue**. It is currently unclear who will bear the costs for the implementation and the initial investment. Both the domestic and the EU financial supports are available limitedly. The rapidly changing technology and the volatile economic and political environment make the P&L calculation of the model difficult.

Considering the drivers and obstacles one more factor should also be understood: the market competition. Due to the ownership unbundling the market competition fundamentally changed the business model of the industry. The effects of the market competition should be taken into account for the implementation of smart metering as well:

Summary: competition drives towards cost reduction and new products

Competition drives smart metering

Situation	Features	Implication / Solution
Network: cost pressure	• At Consumer Switching detailed settlement is needed with field visit • Consumer experiences long administrative process during Switching	**Process improvement** • Switching process can be automated by **smart meter** • Consumer comfort can increase

Retail: Margin increase and Customer retention	• Today only lower prices differentiate the services
	• Further price cut is difficult when the margin is already very low
		Innovative products
		• Intelligent, load and time dependent Tariffs would require Smart Meter
		  – Consumer: consumption modified towards more economical periods (i.e. night tariffs)
		  – Energy Sales: Electricity Sourcing (i.e. reduce Peak time usage)
		• Monthly billing
		• Due to physical differences, the innovative products are more expected at Energy than at Gas