How to overcome barriers for smart meter introduction?

A techno-economic analysis

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Abstract—**Intelligent metering devices are seen as the most important tool for improving the active participation of end consumers in the electricity market. However, the cost and benefit analyses carried out by the Flemish regulator have indicated different barriers arising with their implementation. Whereas the total payoff for the value chain is positive, the cost and benefits are unequally distributed between different parties. Especially for the distribution system operator (DSO), the costs largely outweigh the benefits. Decreasing his costs will be important to create the necessary public support, certainly when the DSO will bill these costs back to the end consumer. In this paper, a techno-economic analysis of different smart meter business models is made, indicating how these impact the total business case and the prices charged to the end consumer. The analysis shows that choosing the correct business model can both decrease the total costs for the DSO and maintain the benefits for the end consumers. This way, the economic viability of the total ecosystem is improved; bringing smart meters one step closer to the market.**

Keywords- smart meters; techno-economic analysis; business models

I. Smart Meter Policy in Europe and Flanders

The introduction of the third energy package by the European Parliament and the Council required the introduction of intelligent metering systems to assist the active participation of consumers in the electricity supply market [1]. Every nation has the opportunity to conduct an economic assessment of such a smart meter rollout. This analysis is required before September 2012, and should take into account all long term costs and benefits of these metering systems. If the assessment is positive, smart metering systems should be rolled out by 2018 to 80% of the population where such a smart metering system is economically viable.

In Belgium, the responsibility for the economic assessment was assigned to the regional regulators for the electricity and gas market. The Flemish regulator has performed two consecutive cost-benefit analyses, the first one in 2008 [2]. The outcome of this first analysis showed a negative net present value (NPV) for the total of actors in the electricity market. The major contributor is the large upfront investment cost, especially in the rollout of the smart meter devices. Other significant cost factors were the cost for communication and the database systems. Based on these results, a smart meter installation would not be economically interesting, and no rollout would be enforced by Europe in Flanders.

However, due to changing factors, like rising energy prices, changing technology and new insights in consumer electricity savings, a new cost benefit analysis was commissioned by the regulator in 2010. The first results have been made public in the beginning of 2012, and the impact of a smart meter rollout in Flanders is now assessed positively, with a NPV of around €140 million over 30 years [3]. The investment in meters still remains the largest cost, but the estimated benefits now result in a positive case. Based on these results, it could be concluded that a smart meter rollout is positive for Flanders.

II. Barriers for the Smart Meter Introduction

While this economic assessment returns a positive result, some issues and barriers still surround the introduction of smart meters in Flanders. The major barrier remains the high upfront investment in metering infrastructure and database systems required. In the classical view, these costs are solely borne by the distribution system operator (DSO), which results in a negative business case for this player [3]. When analyzing the results from the latest assessment in Flanders, a clear discrepancy between the distribution of costs and benefits can be observed. The DSO has a negative business case, whereas the benefits of his investment flow to the other actors in the energy value network [3]. These include the typical electricity value network actors, like the transmission system operator, the electricity producer, supplier and the end consumer, but the government and the society as a whole are also included. A typical cost for the government is tax income reduction, whereas society as a whole gains through the reduction of electricity consumption and its linked carbon footprint.

An additional issue with the DSO business case is the estimation of its different benefits. For example, the starting point in [3] is the obligation of monthly feedback of consumption to the end consumer. The smart metering devices allow the DSO to provide automatic feedback on consumption to the end consumers by using automatically gathered metering data. The cost of this automatic feedback is compared with the cost for manual on-site meter data recorded by DSO or metering companies' employees, resulting in large cost gains. This large benefit (€ 1 billion) improves the business case for the DSO, but is very sensitive to the meter reading frequency.

Finally, since the DSO has a negative business case, he will most likely charge the costs of his investments to the end consumers, as is typically done through changes in the distribution tariffs. Such spit incentives could largely impact the business case for these users. It can thus be questioned if his benefits are high enough to tackle this effect.

III. How to overcome these barriers?

Overcoming these barriers forms an important challenge for the successful installation of smart meters in Flanders. Several solutions were already indicated, e.g. a segmented rollout of smart meters to households where the benefits are high enough to result in a positive business case [3]. Households with solar panels or electric vehicles put extra stress on the distribution grid, and the returns for the DSO from smart grids is expected to be higher from these users. However, such a segmented rollout also results in the co-existence of different systems (manual meter reading and automatic reading), which increases the overhead costs for the different market parties.

Another possibility is looking for synergies in the smart meter business model. The typical model is the DSO centric business model, where the DSO is responsible for most of the operations linked to the meter. However, such an intelligent meter consists of different modules: metering, communication, steering intelligence, etc., which require different skills. For example, communication is not one of the core business activities of the DSO, so it could be outsourced to more designated parties.

In previous work, a generic value network for smart meter rollout was introduced, together with several possible business models [4] (Figure 1). Depending on the actors taking the leading role in the smart meter value network, a DSO centric model, a telecommunications operator centric and third party centric model were identified. The following section gives a short description of these business models, and evaluates how they can impact the total rollout cost for the DSO. Section 5 extends these models with a techno-economic analysis to estimate the required benefits for the end user. Finally, these savings are compared to real savings acquired by users in a Flemish field trial.

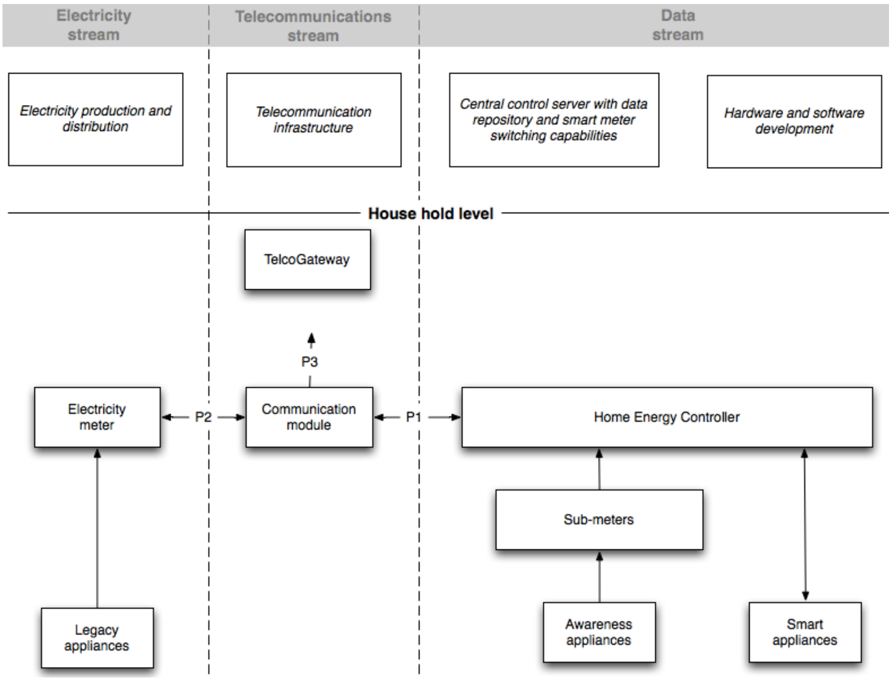

Figure 1: The consumer oriented smart meter business model [4]

IV. Smart meter business models

To indicate how the total costs for the DSO can be decreased by choosing an optimal business model, two business models introduced in [4] are of particular interest for this techno-economic study. The first one is the DSO centric fully integrated model, which is also used in the cost-benefit analyses in [2], [3]. In such a model, the DSO takes up all roles related to the smart meter, including metering, communication and home energy controller (HEC) functionality (Figure 2). The second model is also a DSO centric model, but now the operation of the communication module is outsourced to a telecom operator. Several variants of this model exist, where the DSO chooses for one or different telecom operators providing the necessary network connectivity. Cooperation models between DSOs and operators could emerge, but the consumer could also be free to choose his preferred operator, e.g. based on his current broadband connection. Or telecom operators could offer extra services to attract extra customers.

In this case, this business model could stimulate competition and innovation on the energy services market.

However, such a minor change in the chosen business model has significant impacts on the required meter design and the operational processes during the project lifetime. In case the DSO outsources the communication to a telecom operator, a modular smart meter design is designated. In such design, the communication module is installed on the mechanical meter component in a plug-and-play manner. This will most likely result in higher initial capital expenditures (CapEx) for the smart meter. However, these higher costs will be countered by lower operational expenditures (OpEx) during the lifetime of the smart meter. Indeed, the repair process of smart meters will be simplified. When an integrated meter would be installed, a failing communication module would require the installation of an entire new smart meter by a recognized electrician. In the modular design, this cost would decrease, since only the communication module would require replacement. Since existing mechanical meters typically have a lifetime of around 20 years, while communication modules have a significantly shorter lifetime, this impacts the total cost of ownership (TCO) of these meters.

It is important to make the trade-off between this higher initial investment and the lower OpEx. Will the business model where the communication component is outsourced to telecom operators result in a lower total cost for the DSO? And how does this lower total cost impact the required savings for end consumers?

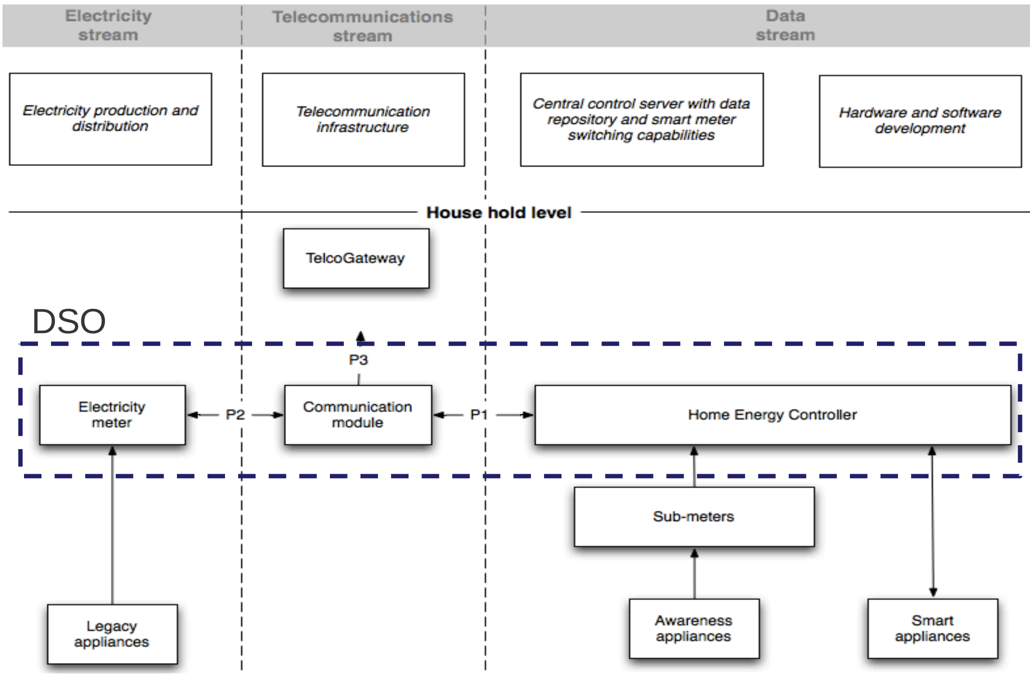

Figure 2: DSO centric model [4]

V. DOES OUTSOURCING DECREASE COST?

In this section, a techno-economic analysis will be conducted for the two business models introduced above: the DSO centric fully integrated model (further referred to as integrated model) and the DSO centric model with outsourced communication module (further referred to as modular model). Starting from an overview of the different cost categories, an assessment of the total cost incurred by the DSO will be given. This cost will also be benchmarked with results from previous studies.

A. Different cost parameters in the smart meter deployment

As was also indicated by [2], [3], the largest part of the DSO cost can be attributed to the initial investment in smart meter hardware. Within this meter hardware, the mechanical metering module and the communication module were identified. The cost of these two modules can be assumed to be equal for both an integrated and modular meter design. However, the modular design will come with a higher upfront cost, attributed to the design of plug-and-play interfaces. This extra cost is reflected in the category ‘other’, which also includes casing of the two components. An overview of the costs can be found in Table 1. Apart from the hardware costs, the cost for the installation procedure is also included. Based on [3], this amounts to €55 per metering device.

The added value of intelligent metering devices is the real-time data they can provide to different actors in the value network to improve their business processes (e.g. billing by the supplier). Communication between the different meters and the back-end is important, but also comes with an additional cost. Different communication technologies can be considered, fixed and wireless. In this analysis, IP based communication is taken as the most important technology, since about 70% of the 2.6 million households in Flanders already has an internet subscription [5]. Using the existing connection would come at no extra cost, and the small amount of data communicated between the meter and back-end is not expected to influence the connection speed of the user. With communication modules able to transmit wireless, a fixed Ethernet connection to the meter is not required. For the remainder of the users, wireless communication (GPRS, 3G) or power line carrier (PLC) are the selected options. In the current situation in Flanders, two DSOs are present, with the largest one preferring PLC communication. The exact distribution and monthly cost of the chosen communication technology is shown in Table 2.

Table 1: Smart meter hardware cost [3]

	Integrated meter	Modular meter
Metering module	€50	€50
Communication module	€80	€80
Other	€20	€40

Table 2: Available communication technologies and their related monthly cost [3]

	% of households (HH)	Monthly cost per HH	Server cost	Server capacity (in HHs)
IP	70%	€0.00	€2 500	75 000
PLC	24%	€0.13	€2 000	5 000
GPRS	6%	€0.75	€2 500	75 000

All these technologies also require additional installations in the back-end, e.g. servers for GPRS and IP or data concentrators for PLC. Servers for IP or GPRS are assumed to be able to manage the same amount of connections and have the same initial cost. Data concentrators for PLC manage a smaller number of households (Table 2).

B. *Repair process of smart meters*

In section 4, it was indicated that the different design of integrated and modular meters could significantly impact the costs linked to the repair process. A broken integrated meter requires a recognized electrician to replace the entire meter, independent of the broken component. In case of a broken communication module in the modular meter, the repair process can be executed by the consumer. This results in lower personnel costs, but is also reflected in the lower costs for meter hardware replacement. The different repair processes can be found in Figure 3 and Figure 4.

In case the metering module fails, the repair process is the same for both the integrated and modular meter. An electrician is required to drive to the meter location and replace the meter. The meter hardware cost can be found in Table 1. The personnel cost is estimated at €110 for the replacement and transport (= 2 hours). When the communication module fails, the advantage of the modular meter is the less expensive repair process. A recognized electrician is no longer required, since the plug-and-play design allows the replacement of the module by the consumer. However, it could be difficult for the end consumer to distinguish between a broken meter and a broken communication module. On the other hand, the DSO or telecom operator can more easily check which module is broken. The cost for checking the module and the fact that the consumer still needs to acquire this module results in a cost of €30 (Table 3).

Table 3: OpEx related to installation and repair procedures [6]

	Integrated meter	Modular meter
Installation	€55	€55
Repair metering module	€110	€110
Repair communication module	€110	€30

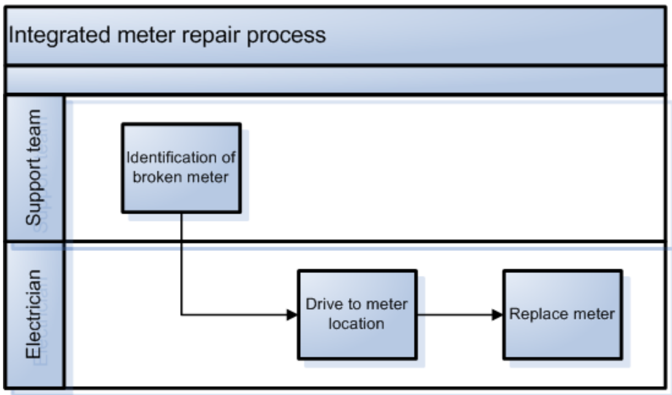

Figure 3: Simplified integrated meter repair process

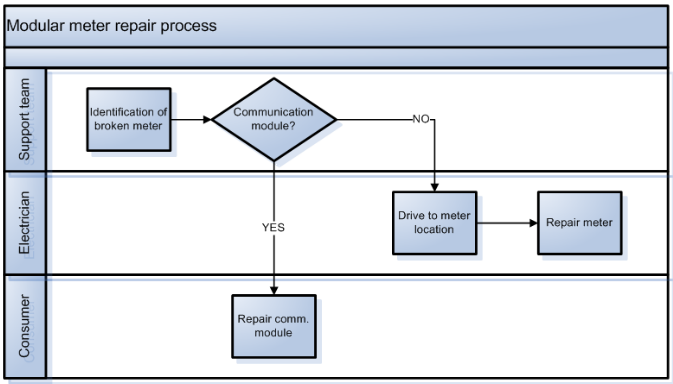

Figure 4: Simplified modular meter repair process

C. *Total smart meter cost for the DSO*

After the indication of the most important cost parameters in the smart meter business model, this section assesses the TCO of the meters for the DSO. To allow for a benchmark with the existing studies in Flanders, the same general parameters are used ([2], [3]). In Flanders, about 2.6 million households would require the installation of a smart meter [7]. The considered project lifetime is 30 years. With an estimated smart meter lifetime of 15 years, all meters will be replaced at least once. Consistent with [3], the same rollout period of 5 years is used. All costs are discounted with a factor of 5.5%.

Additional general parameters are the average lifetime of the communication module (5 years) and the failure rate of the meter. A conservative estimation of 1% per year was made, of which 75% is caused by a broken communication module.

Table 4: General parameters for techno-economic analysis [3], [7]

Parameter	Value
Number of HH	2 601 266
Project lifetime	30 years
Metering module lifetime	15 years
Communication module lifetime	5 years
Rollout period	5 years
Discount factor	5.5%
% of failing meters	1%
Communication module failure	75%

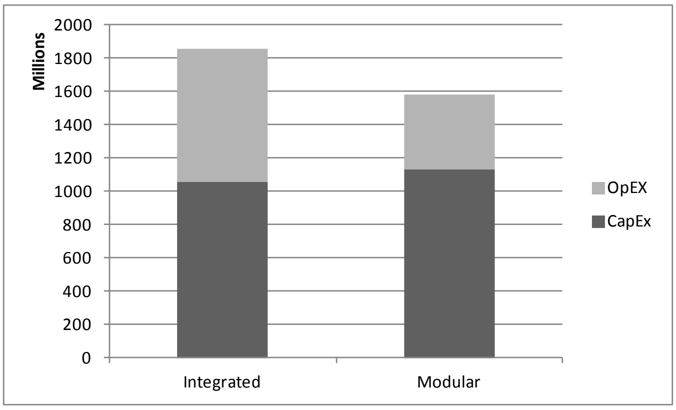

Figure 5: Total cost for smart meter installation and operation over 30 years

Comparing the total costs incurred by the DSO for the different meter designs indicates that a modular meter design is to be preferred. It decreases the total cost for the DSO with almost 14%, to just under €1.6 billion. The total CapEx for the integrated meter is lower than for the modular meter, but this is clearly countered by the significantly lower operational expenditures (Figure 5). When benchmarking the results of the integrated meter with previous studies conducted for the Flemish regulator, these previous studies indicate a higher cost for the DSO (+14%) in the integrated meter scenario. However, gas meters were not included in this study, explaining the difference in the results.

VI. Impact of the DSO costs on consumer benefits

It was already indicated that the costs and benefits in the smart meter business model are not equally divided between the different market parties. When the expected total benefits for the DSO of 950 million from [3] are added to the costs from the previous section, the DSO still has a deficit of €640 billion in the modular case (or €890 billion in the integrated case). In addition, it should be taken into account that in this analysis, the costs are underestimated by 12.5% compared to the studies of the Flemish regulator. Therefore, the corrected deficit of the DSO lies between €730 billion and €1.2 billion. It can also be expected that the DSO will charge these costs to the consumers through the distribution tariffs. What are the required benefits for end consumers to overcome these extra costs? These benefits include energy savings due to more continuous feedback, and a reduction in cost per kWh, since smart meters facilitate the switching process between suppliers and allow for Time of Use tariffs [3].

The extra cost per consumer over the project lifetime is €280 or €390. On annual basis, this comes down to €19.3 or €26.9 per household, calculated using constant payments and a constant discount factor. The total benefits for the users would thus sharply fall. However, based on the benefit analysis in [3], where the NPV for the households is estimated around 900 million, this would still result in a positive business case for the consumers in the modular meter design (€4.5). But in case of an integrated meter design, every household would in total lose €3.0 per year (Figure 6). Additionally, the smallest cost increase for the DSO would result in an even more negative business case for the end user. This could significantly decrease the public support for the smart meter in Flanders.

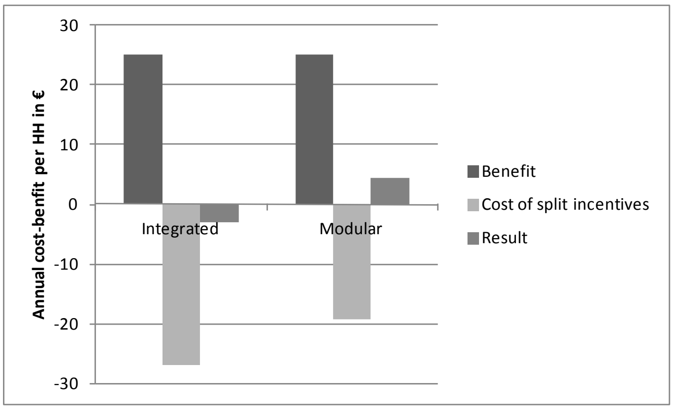

Figure 6: Consumer payoff for both meter designs - Impact of split incentives

VII. Conclusion

The Third energy package from the European Commission and the Council focused on intelligent meter systems as a tool to increase the active participation of end consumers in the electricity market. However, before proceeding with a large scale national rollout, Member States were allowed to conduct an economic assessment of such a smart meter rollout. In Flanders, two assessments were already carried out. The first one from 2008 indicated a negative outcome, but new improved technology and new insight in the effects of smart meters resulted in the need for a new analysis. In 2012, a positive assessment was given for the smart meter rollout in Flanders.

However, some barriers still exist. In the current view of smart meter rollout, the DSO is the sole responsible and incurs most of the costs, while acquiring insufficient benefits to come to a positive business case. Additionally, it can be expected that the DSO will compensate these losses by increasing the charges for end consumers through increased distribution tariffs. In turn, this significantly impacts the outcome for the consumers, and could decrease the public support for the smart meter rollout.

This paper has given an indication on how to overcome these barriers. Choosing for another business model for the smart meter rollout decreases the total rollout costs. In the fully integrated model, the DSO takes care of both metering and communication. Since the latter is not part of its core business activities, a modular model was proposed, where telecom operators take over this role.

As a consequence of this modular model, changes in the smart meter design are required. Moving towards a modular meter design is advised, since this allows for different communication technologies to be used and could stimulate competition and innovation. However, such a design comes at a higher initial investment, but decreases operational expenses in the repair process. The techno-economic analysis indicated that these savings greatly impact the total cost for the DSO, by decreasing it with about 14%.

Since the business case for the DSO is negative for both models, he will be forced to charge extra distribution tariffs to the end consumer. In the integrated model, so-called split incentives between the DSO and the end user results in a negative case for the end user. When choosing for the modular concept, the end user still has a positive business case.

Based on these results, it is already clear that choosing the correct business model for smart meters significantly impacts the business case for different players in the value network. However, the benefits for the end user are mainly reflected by a lower energy consumption, which makes the business case for the end consumer only marginally positive. Since the use of smart meters also entails the opportunity to introduce new products and services, like Time of Use tariffs, automatic steering of flexible loads or energy efficiency programs, future research should definitely take the impact of these products and services into account when evaluating the total benefits for the end consumer, based on actual field trial results.

VIII. ACKNOWLEDGEMENT

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IX. REFERENCES

[1] European Parliament, “Directive 2009/72/EC of the European Parliament and of the Council,” *Directives*, 2009.

[2] M. Schrijner and J. Burgers, “Energiemeters worden mondiger-Resultaten van een kosten-batenanalyse naar de invoering van ‘slimme meters’ in Vlaanderen,” *KEMA Nederland BV*, 2008.

[3] M. Schrijner, W. Mulder, and F. Koenis, “Financiële haalbaarheid slimme energiemeters in Vlaanderen Een kosten-batenanalyse in maatschappelijk perspectief,” *KEMA Nederland BV*, 2012.

[4] J. Van Ooteghem et al., “Evaluation of the techno-economic viability of smart metering value network configurations based on a consumer oriented approach,” in *Competition and Regulation in Network Industries, 4th Annual conference, Proceedings*, 2011, p. 17.

[5] BIPT, CSA, Medienrat.be, and VRM, “Beslissing van de regulatoren voor de elektronische communicatiesector (CRC) van 1 juli 2011 met betrekking tot de analyse van de breedbandmarkten,” 2011.

[6] ACV, “National minimum wages electricians,” 2012. [Online]. Available: http://acv-csc-metea.acv-online.be/sectorinformatie/loonbarema.asp.

[7] FOD Economy - Statistics Belgium, “Households in Flanders,” *Population structure in households*, 2010. [Online]. Available: http://statbel.fgov.be/nl/statistieken/cijfers/bevolking/structuur/huishoudens/. [Accessed: 01-Apr-2012].