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INNOVATIVE INSTRUMENTS FOR ENERGY SAVING POLICIES : WHITE CERTIFICATES AND COMPLEMENTARY CURRENCIES

"INESPO"

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ENERGY

FINAL REPORT

INNOVATIVE INSTRUMENTS FOR ENERGY SAVING POLICIES: WHITE CERTIFICATES AND COMPLEMENTARY CURRENCIES

"INESPO"

SD/EN/09

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D/2012/1191/32
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TABLE OF FIGURES

TABLE OF CONTENTS

SUMMARY

The growing energy consumption in Belgium and Europe raises many concerns about security of supply, environment, climate change, volatility of prices and energy poverty. To bend this trend, the efficient use of energy in the household sector is of great importance bearing in mind the European objectives of reducing greenhouse gases emissions by 20% for 2020 and by 80 to 95 % for 2050.

A decrease in energy consumption for the household sector can be achieved in two ways:

- investing in energy efficiency for housing (e.g. double glazing) and domestic appliances (e.g. A++ fridge);
- changing the behaviour of energy consumers

Up to now, policy-makers seem to have focused on increasing energy efficiency of domestic appliances and housing. However, the final electricity consumption in the household sector (for EU-27) has increased by 8% between 1990 and 2007 and this despite 16% effective gains in energy efficiency for household appliances over the same period of time.

Behavioural factors play an important part in this unsustainable trend of household energy consumption and it is thus necessary to develop policies that do not only tackle energy efficiency but also consumer behaviours.

Smart meters and motivation for energy savings: filling the gap

At the time the INESPO project was conceived, the discussions around smart meters were essentially technology-driven and there were important forces at play for a massive deployment in the EU. Front-runners in the deployment of smart meters (i.e. Italy, Sweden, to some extent The Netherlands) had mostly considerations relative to logistics, field operations, customer service, fraud protection, accurate billing or monitoring the distribution grid for instance.

Focusing more on the human behaviours behind the smart meter technology is a first objective of the INESPO project. Besides, as recent studies show that the link between smart meters and energy savings for households is not undisputable it becomes more and more obvious that there is a gap on the issue of motivating households for energy savings in the researches carried out on smart meters. The INESPO project is seeking to design innovative instruments to fill this gap by adding incentives to the smart meter technology.

In order to do so, the project is exploring the possibility of coupling non-financial incentives (complementary currencies) to smart meters. This is building on the emerging trend to use complementary currencies as policy instruments for sustainability (e.g. projects such as E-portemonnee, Torekes or the former NU-Spaarpas project).

The coupling with a form of market-based financial incentive inspired from the concept of white certificates with households as obliged actors is also explored.

Designing new policy instruments

The central objective of the INESPO project is the design (including the technical aspects) of system architectures that integrate complementary currencies or "white certificates for households" and smart meters.

The designed systems are intended to be used as instruments for energy policies and therefore developed and financed by public authorities. Beyond the core phase of designing INESPO, it is intended to provide first insights on the social acceptability, as well as the potential energy savings and economic aspects of the designed systems. It is however beyond the scope of this study to actually test the effects of the designed instruments in pilot experiments, or to deal with the many aspects (e.g. legal, political, privacy, etc.) that would go along with an implementation of the designed instruments by public authorities.

Positioning INESPO

Before embarking in the design of the systems, the first work package is dedicated to positioning INESPO regarding policies and measures, complementary currency projects, white certificate schemes and smart metering infrastructure in the EU. Insights from this research are fed in the system design phase.

Determinants of energy savings

With a similar objective, research is carried out on the determinants and barriers to energy savings for the household sector. The results of this research are used to see on which grounds complementary currencies and smart meters can promote the desired changes.

Taxonomy and system designs

As the research regarding the system design progressed, it became evident that a specific instrument was necessary in order to achieve successfully the core phase of designing the systems. A key step in this process was to develop a taxonomy of constitutive parameters of CC systems which allows reducing complexity and lays the foundation for the design of the INESPO systems and their subsequent evaluation.

The work carried out on the taxonomy sheds light on the importance of the choice of the ***model*** in the design of the systems. Indeed, the research on the possible rationale for the model reveals a polarity between what we have called a ***rewarding*** and a ***regulatory*** architecture. This is used as a fundamental distinction between the two systems designed in the INESPO project.

System designs (in a nutshell)

System design 1 (S1) based on a rewarding architecture

In S1, households participate to the system on a voluntary basis and are "rewarded" by public authorities for their energy savings. This occurs in two major ways:

- Households can obtain complementary currency (CC) units through their ***relative consumption reduction*** over a given period of time (Δ in consumption)
- Households can obtain CC units for some specific actions related to increasing a dwelling's energy performance, buying basic energy efficient appliances / products, energy audit, maintenance, as well as energy education.

How households can use their CC units is a key parameter to bring participants on board in a rewarding system which has deserved particular attention in the system design.

Among the key strengths of S1 is the potential to promote energy savings by the households who are consuming the most and have made little to no effort yet to reduce their consumption. Besides, such a rewarding system is likely to be more attractive and socially acceptable than a regulatory system.

Conversely, a key weakness of S1 is that it over-rewards households who are consuming the most and have made little to no effort yet to reduce their consumption. Besides, it is not self-sustaining financially and is thus dependent on public funding.

System design 2 (S2) based on a regulatory architecture

In the architecture of S2, the system is based on a model with mandatory participation of every household. Such a ***regulatory*** system allows working on the ***total energy consumption*** and setting ***quota*** or ***targets*** for household energy consumption.

S2 requires realistic targets which are calculated for households taking some elements of their profile into account. Each household obtains a number of CC units that corresponds to their energy targets.

As a household consumes energy, it also uses CC units accordingly. At the end of the period for which the target was set, a given household energy consumption can

- meet the energy target: all CC units have been used
- be more than the energy target: the missing CC units are to be bought at a penalty rate fixed by public authorities
- be less than their energy target: the remaining CC units can be sold to public authorities at a discounted rate.

The price paid for energy itself remains unaffected in the INESPO S2 system and since the target is given in CC units, it does not physically limit the energy consumption as a quota would do. However, the fact that households earn or pay some extra Euros for CC units according to their consumption has a global effect on their energy budget. A variant with a market-based "white certificates for households" is also developed where households can trade their CC units.

One of the key strengths of S2 is that every household has to participate. Targets can be set for energy consumption, in line with energy policies. Besides, S2 can be financially sustainable if targets and penalties are properly set.

However, households whose consumption is high above their energy targets are likely to have major problems to comply. Since the mandatory participation, as well as the penalty bring S2 close to a tax-mechanism, it is likely that S2 is perceived in a negative way, and even rejected. The way the targets are calculated (and the parameters chosen for household profiles) is very sensitive, both for the equilibrium of the system itself and for its perceived fairness.

Technical aspects

The objective of this part of the research is to investigate the technical feasibility of the coupling of complementary currencies and smart meters, and to provide first insights on how this could be achieved.

Regarding technical options for the smart meters, two options are considered:

- a base scenario where neither the metering infrastructure nor the meter itself are designed specifically for the INESPO system.

- an advanced scenario where smart meters can be extended to incorporate INESPO specific functions.

The research carried out on the use cases mainly comprises consumer as well as back-office use cases. First insights for the underlying database are derived from those use-cases. Besides, architecture outlines are also developed for the base and the advanced scenarios.

Social acceptability of the designed systems

Once the two systems are designed, it is of great importance to investigate their social acceptability. Focus groups were organised to investigate this question.

The focus groups provide insights on the social acceptability of the designed systems (S1 and S2). As could be expected, the rewarding system (S1) is preferred to the regulatory system (S2). Besides, participants in general are very favorable to the idea of using complementary currencies as non-financial incentives.

However, the system S2 is not completely rejected and is seen as a potentially effective system to reduce households' energy consumption. It is considered that, if announced in time and backed by sufficient transitional measures, the core of the system could be generally valuable in the long run.

Modeling S1 and S2

A model is built for S1 and S2 with the aim of providing first qualitative insights regarding the potential energy and CO2 savings of the systems, as well as their economic evaluation.

Estimates for total energy savings and costs of S1 and S2

Figure 1 shows how, according to the model, the total energy savings and costs of S1 and S2 evolve in function of the rewarding rate (for S1) and the penalty rate (for S2). The modeling of S1 and S2 tends to show that S2 is a more efficient system both regarding energy / CO2 savings and economic aspects. This is mostly to be explained by the much higher participation rate that is expected in S2 compared to S1. Besides, S2 seems to be promoting behavioural changes which lead to lower costs for households to achieve energy savings. Finally, the penalty applied in S2 brings the system to an economic equilibrium.

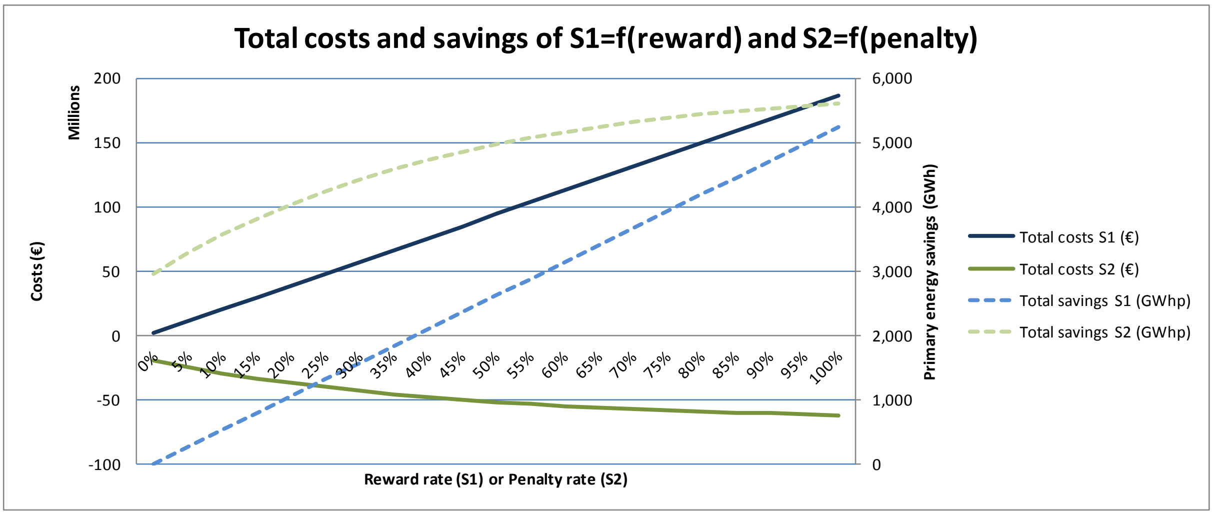

Figure 1: Costs and savings of S1 and S2 as a function of the rewarding and penalty rates

Conclusions

The hybrid solution

The S1 and S2 systems have been designed to explore the polarity between a rewarding vs. a regulatory architecture. It was thus purposely decided not to develop mechanisms to try to "fix" the problems inherent to the design of S1 and S2.

It was rather decided to explore the possibility to design a "hybrid solution" (S3) to the problems raised by S1 and S2. In S3, some features of the rewarding model are integrated into the regulatory model to provide extra flexibility to the system.

Further development and Policy implications

The INESPO project has pioneered the way for using complementary currencies (with a market-based variant for "white certificates for households") as an incentive scheme coupled to the smart meter infrastructure. It can be argued that the designed instruments present similarities with existing ones. Indeed, S1 is close in essence to a subsidy and S2 to a progressive tariff. However, the specificities of using complementary currencies make them different in many respects such as the rebound effect or the social network aspect for instance.

Choosing between a rewarding and a regulatory architecture for policy making is a vast debate that touches on many issues. In the INESPO project, the aim is limited to exploring the possibility of designing systems based on both types of architecture, as well as providing first insights on their social acceptability and the modeling of some of their impacts. Besides, many aspects of the designed instruments deserve further research, and trials with households should be made to investigate their impact on behaviours.

However, as exposed in the Position Paper, the possibility to effectively develop those instruments lead to practical recommendations regarding the roll-out of smart meters.

Most importantly, it implies defining prior to deploying smart meters the necessary standards and requirements for

- free accessible communication port for in-house use
- consumption data manageable by consumer independently of the SM-DSO connection
- optional feed-back systems (displays, websites, etc.)
- optional transfer of data to chosen third-party (ESCos, energy services such as those that could be built around the INESPO concept, etc.)

Indeed, if those choices are not made prior to the deployment of smart meters, it could hamper for decades the possibility to develop instruments designed to motivate households for energy savings.

1. INTRODUCTION

The growing energy consumption in Belgium and Europe raises many concerns: security of supply, environment, climate change, volatility of prices, energy poverty, etc. To bend this trend, some directives have been adopted at the EU level, regarding energy production and consumption.

Regarding energy production, directives have already been implemented / voted, among others to promote renewable energy (e.g. Renewable Energy Directive, 2009/28). But, although renewable energy production is likely to significantly increase in the next decades, energy consumption will have to go down considerably at the same time to match the objective of reducing the greenhouses gases emission by 80 to 95 % by 2050 (European Commission COM(2009) 039).

Energy saving is therefore one of the most essential topics to address in the coming years. Indeed, energy conservation and efficiency policies have great potentials in terms of emission reduction (IPCC, 2007).

All sectors are concerned, but with its 25% share of final energy consumption and its considerable energy savings potential (EEA, 2010), there is a growing emphasis on the household sector. The efficient use of energy in the household sector is thus of great importance to achieve the European objective of reducing greenhouse gases emissions by 20% by the year 2020. Moreover, it can contribute to improve security of supply and fight energy poverty.

A decrease in energy consumption for the household sector can be achieved in two ways:

- investing in energy efficiency (EE) for housing (e.g. double glazing) and domestic appliances (e.g. an A++ fridge);
- changing the behaviour of energy consumers

Up to now, policy-makers seem to have focused on increasing energy efficiency of domestic appliances (with, for instance, Dir. 2005/32 on the eco-design of Energy using Products), and on improving the energy efficiency for housing (with, for instance, the recast of the Energy Performance of Building Directive).

However, increased energy efficiency does not automatically lead to energy savings in the household sector. The so-called rebound effect implies that people may respond to the introduction of more energy efficient technologies with behaviours that partly offset the potential energy savings offered by those new technologies. Such behavioural responses like, for instance, increased use of an energy efficient appliance, together with an increased number of appliances may lead to a paradoxical increase in energy consumption, despite the achieved progresses in energy efficiency (this topic is developed, among others, in the research work of Steve Sorrell, Sussex Energy Group, SPRU, University of Sussex). This is confirmed, for example by the EEA indicators regarding final electricity consumption. Those indicators show an increase of 8% between 1990 and 2007 of the final electricity consumption in the household sector (for EU-27) and this despite 16% effective gains in energy efficiency for household appliances over the same period of time (EEA, 2010 and 2011).

Many studies have shown that behavioural factors play an important part in energy consumption. More specifically, the role of habits, and the lock-in of consumers in existing (carbon-based) socio-technical systems, as well as the study of social practices provide insightful explanatory factors for the current unsustainable trend of household energy consumption (see, for instance, Shove and Walker 2010; Gram-Hansen, 2009; Anker-Nilssen, 2003 or Røpke 2001).

1.1. Smart meters and energy savings for the household sector

At the time the INESPO project was conceived, the discussions around smart meters were essentially technology-driven and there were important forces at play for a massive deployment of smart meters in the EU. Indeed, the Energy Service Directive (2006/32/CE) stated that "(b)illing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption".

At that time, the expectations for energy savings that users could make due to smart meters were rather optimistic. In case of direct feedback to the users, those savings were even estimated around 5-15% (Darby, 2006).

A few years later, it was requested by the 3rd Energy Package (Directive 2009/72/CE) that Member States make a cost-benefit analysis for the deployment of smart meters, with the obligation of a 80% roll-out in case of a positive result.

1.2. Motivating for energy savings: the INESPO project

Focusing more on the human behaviours behind the smart meter technology was a first objective of the INESPO project. Besides, as more recent studies show that the link between smart meters and energy savings for households is not undisputable (e.g. PWC, 2012; Klopfert and Wallenborn, 2011; Hargreaves et al., 2010) it became more and more obvious that there was a gap on the issue of motivating households for energy savings in the researches carried out on smart meters. The INESPO project is seeking to design innovative instruments to fill this gap by adding incentives to the smart meter technology.

The new policy instruments designed in the INESPO project are exploring the possibility of coupling non-financial incentives (complementary currencies) to smart meters. This is building on the emerging trend to use complementary currencies as policy instruments for sustainability policies (e.g. projects such as E-portemonnee, Torekes or the former NU-Spaarpas project).

The coupling with a form of market-based financial incentive inspired from the concept of white certificates with households as obliged actors is also explored. However, as the research on constitutive elements of complementary currency and white certificate schemes progressed, two main conclusions were drawn:

- constitutive elements of both types of instruments showed similarities
- the obligatory aspect of white certificates schemes, as well as the possibility to sell and trade were seen as a distinctive feature of white certificate schemes

Consequently, extending the concept of white certificates to the household sector as obliged party translates, in the framework of the INESPO project, into designing a system of complementary currencies based on an obligatory architecture with a marked-based system of exchange.

1.3. Designing the new instruments

At the core of the INESPO project is the design (including the technical aspects) of system architectures that integrate complementary currencies or 'white certificates for households' and smart meters. Those innovative instruments based on the use of smart metering aim at motivating households for energy savings both through behavioural changes and investments in energy efficiency. The designed systems are intended to be used as instruments for energy policies and therefore developed and financed by public authorities.

The first attempts to design the systems and integrate them with smart meter technology revealed, however, that too many parameters had to be taken into account, some of them having a decisive impact on the architecture of the systems. It was thus necessary to reduce complexity by carrying further the analysis of the constitutive parameters of CC systems which was initiated in the task dedicated to positioning INESPO. This led to a taxonomy (new task compared to initial planning) of constitutive elements of those systems which lays the foundation for the design of the INESPO systems.

This taxonomy is indeed central for the design phase and is also used in further work packages dedicated to providing first elements on the social acceptability as well as energy saving potential and economic aspects of the designed systems.

1.4. Smart meters roll-out, a burning actuality context

However, as the INESPO project is exploring the possibility to design new instruments to motivate households for energy savings, the smart meter roll-out is becoming a subject of burning actuality. Indeed, the deadline of 3 September 2012 when Member States have to deliver their cost-benefits analysis on smart meter roll-out is coming closer. Discussions regarding technological, legal and cost-bearing aspects of the roll-out (as well as how and when to do it) mobilize different stakeholders and points of views. But INESPO is focusing on another aspect which seems currently under researched: can a SM roll-out also be used to motivate households for energy savings?

Besides, the compromise on a proposal for a Directive on Energy Efficiency that would repeal Directives 2004/8/EC and 2006/32/EC reached by the European Parliament and the Council on June 14th 2012 shows that the issues of informing and empowering consumers regarding their energy use has come up the policy agenda.

It was thus strongly felt during the follow-up committees of the project that INESPO brings new arguments and points of views that should be known to policy-makers. To take this into account, the new task of developing a Position Paper was added to the initial planning. This Position Paper was presented to important stakeholders of the smart meter roll-out in Belgium during an extended follow-up committee meeting.

1.5. Structure of the report

The report is structured in the following manner:

After this introduction, **section 2** is dedicated to presenting the methodology and results of the research carried out in the INESPO project. This covers **Positioning INESPO** (**section 2.1**) by providing an overview of the relevant policies and measures, complementary currencies projects, white certificates schemes and smart metering infrastructure in the EU. **Section 2.2** is dedicated to the methodology and results for **Designing INESPO**. This covers linking the determinants of energy saving behaviours to the incentives used in the project, developing a taxonomy of constitutive parameters, and applying the preliminary steps for the design of the systems. The following **section 2.3** describes the **Designed Systems** which include S1 based on a rewarding architecture, S2 based on a regulatory architecture and S3 based on a hybrid architecture. The technical aspects of the designed systems are also covered in this section. **Section 2.4** is then dedicated to the **Social Acceptability** of the designed systems (S1 and S2) and includes methodology and results. In **section 2.5**, first elements are provided for the **Evaluation** of the designed systems (S1 and S2) regarding potential energy and CO_2 savings as well as economic aspects, which includes modelling S1 and S2. **Section 2.6** and **2.7** are dedicated to **Policy Support** : a **Position Paper** developed more specifically for policy-makers in the field of smart meters roll-out is presented in **section 2.6** and **Further policy recommendations and conclusions** follow in **section 2.7**.

Section 3 summarises the **Dissemination and Valorisation** activities and **Section 4** the **Publications** of the Partners to the project. **Acknowledgments** are made in **Section 5** and the list of **References** is provided in **Section 6**.

2. METHODOLOGY AND RESULTS

2.1. Positioning INESPO

The question of motivating households for energy savings is at the heart of the INESPO project. With this objective in mind, the project explores the possibility to add incentives (complementary currencies / white certificates) to the smart meter technology. The core task of the INESPO project is thus to design new energy saving instruments based on the innovative coupling of smart meters and complementary currencies / white certificates. Those innovative policy instruments are intended to be used and financed by public authorities.

Before embarking into the design of those policy instruments, it is however necessary to position INESPO within the actual context of policies and measures, as well as regarding the most promising aspects of complementary currencies, white certificates and smart meters that can be used for the design of the new systems.

2.1.1. Overview of EU directives and Belgian policies and measures regarding energy savings

Should everything else remain equal, increasing energy efficiency results in energy savings. In reality, however, energy savings resulting from efficiency improvements at the household level have to an important extent been offset by behavioural factors like an increased use of electric appliances, changes in comfort standards, etc. As pointed out by McLaren et al. (1998) the real question is thus not so much 'how can we be that much more efficient', but 'how can we ensure the gains from our efficiency strategies are used to deliver real environmental improvements'. The latter question opens up the discussion to include sufficiency, which implies changing our behaviour in order to realise energy savings (Herring, 2006) and, in turn, on the instruments that can promote the desired behavioural changes.

Rulemaking and division of powers in the field of energy

The objectives of the energy saving policies in Belgium are largely inspired by European commitments. European regulatory action addressing energy consumption by households sets the scene for the way in which domestic energy use is tackled in Belgium. Just like the European energy policy, energy policies in Belgium are particularly influenced by the need to mitigate climate change. This is because there is an important synergy between reducing the emissions of green house gasses and energy production and consumption as the latter accounts for about 80 % of the total greenhouse gas emissions in the EU-27 (EEA, 2008). Climate policy, however, affects many other policy fields. The federal government and the regions, which in the framework of the Kyoto Protocol are responsible for reducing the Belgian greenhouse gas emissions over the period 2008-2012 by 7,5% compared to 1990, seek to achieve this target in a way which is most appropriate given the specificities of the Belgian economy and development path. In this respect the federal government disposes of competences in the field of taxing (setting taxes on energy), product policy (implementing minimum standards for the energy performance of energy using products) and energy (nuclear energy, planning of major infrastructures for the production and storage of energy, energy tariffs and offshore energy policy). The regions, on the other hand, are responsible for rational energy use, renewable energy, transport and local distribution of gas and electricity, environmental policy, mobility, housing, industry and agriculture. (Federal Climate Change Service, 2010; National Climate Commission, 2009)

European regulatory action aimed at reducing energy consumption at the household level largely focuses on making buildings and (household) products more energy efficient. The former is facilitated by directives on the promotion of energy end-use efficiency (Directive 2006/32/EC) and on the energy performance of buildings (Directives 2002/91/EC and 2010/31/EU). The latter is shaped by a directive on energy labelling of domestic appliances (Directive 92/75/EEC and Directive 2010/30/EU) and a directive which establishes a framework for the setting of eco-design requirements for energy-using products (Directive 2005/32/EC). The first three regulatory initiatives are part of the theme 'rational energy use in Buildings', one of the 11 strategic axes of the Belgian climate plan 2009-2012. The last initiative on eco-design requirements of energy-using products is integrated in the Belgian law on product standards, but is not explicitly referred to in the National climate plan. (National Climate Commission, 2008)

Whereas Member States actively promote the energy end-use efficiency and energy performance of buildings they, apart from the enforcement and inspection of the specific regulations, do not have to intervene much with respect to the energy labelling of domestic appliances nor with the eco-design requirements of products. Products that do not comply with the requirements are simply removed from the market. Eco-design may be stimulated by various programmes, but the link to energy savings at the household level is, at least, very indirect.

Policies and measures stimulating rational energy use in buildings

The Belgian policies and measures all relate to stimulating rational energy use in buildings, facilitating the implementation of Directives 2006/32/EC, 2002/91/EC, 2010/31/EU, 92/75/EEC and 2010/30/EU. The following sources have been used to develop the overview of relevant Belgian policies and measures:

- The National Climate Plan of Belgium 2009 -2012 (National Climate Commission, 2008);
- Belgium's fifth national communication on climate change under the United Nations Framework Convention on Climate Change (National Climate Commission, 2009);
- the Flemish (Flemish administration, 2006), Walloon (Walloon administration, 2007a) and Brussels (Brussels Institute for Management of the Environment IBGE-BIM, 2002) plan addressing climate change;
- the contribution of the federal government (Federal administration, 2007), as well as the contributions of the Flemish (Flemish administration, 2007), Walloon (Walloon administration, 2007b) and Brussels (Brussels Institute for Management of the Environment IBGE-BIM, 2007) regions to the first Belgian energy efficiency action plan (2008-2010) within the framework of Directive 2006/32/EC;
- the publication 'Premies voor energiebesparing in Vlaanderen' (Vlaams Energie Agentschap, 2010);
- information on the websites of the competent regional administrations http://www.energiesparen.be/ (Flemish region), http://energie.wallonie.be/ (Walloon region) and http://www.ibgebim.be/ (Brussels region).

The instruments policy makers dispose of for influencing the behaviour of specific target groups typically can be divided into three groups: obligation (legal instruments like orders and prohibitions, permissions, standards, etc.), exchange (economic stimuli like taxes, subsidies, tradable permits, etc.) and persuasion (social instruments like information, education, promotion of good practices, etc.) (Verbruggen, 1994). The initiatives that deal with stimulating rational energy use in buildings make use of obligation, exchange as well as well as persuasion:

- minimum energy performance standards are imposed to new buildings and existing buildings that are subject to major renovations. Therefore, methodologies have been developed for calculating the integrated energy performance of buildings. The standards in the different regions vary in terms of their stringency as well as the way they are determined;
- systems have been developed for the energy performance certification of new and existing buildings. An energy performance certificate informs owners, users and potential tenants and buyers of a building's energy performance and possible energy efficiency improvement measures. This certification system has been developed to make the housing market more transparent with respect to the energy performance of buildings;
- financial stimuli, principally tax deductions and grants, are used for stimulating rational energy use in buildings. Other financial incentives are loans. These financial stimuli are provided by a variety of actors;
- strategies for realizing the targeted energy savings by the promotion of rational energy use in buildings are made up of a great variety of communication initiatives. The objectives of these initiatives range from raising awareness, about the need to save energy and the relatively important benefits that some relatively minor investments or behavioral changes may bring, to providing tailor made advice;
- schemes have been set up for creating, training and recognising energy specialists who can then perform energy audits. The objective of these schemes is to develop a market for energy services;
- public centers offer disadvantaged people assistance and targeted technical advice as well as information on financial aid;
- urban planning and building regulations that obstruct energy efficient building and renovation are relaxed;
- obligation to conduct a regular maintenance and control of boilers fired by means of a non renewable fuel;
- informative billing requirements of energy consumption in order to provide final customers with a comprehensive account of their energy consumption and related costs;
- promotion of the uptake of energy efficient household appliances;
- financial incentives for the promotion of plug-in electric vehicles.

Conclusions

Policies and measures concerning lowering energy consumption at the household level heavily rely on promoting energy efficiency. It can be concluded that people's energy behaviour is only marginally addressed by current policies and measures. Relevant initiatives in this respect are the exemplary role of the public sector, product labelling, information provision and informative billing of energy consumption. Although there are some initiatives that seek to change people's 'everyday life' actions most only target people's energy behaviour through influencing their investment decisions. Besides the aforementioned government led initiatives, there are a number of actions initiated by the environmental movement. An interesting type of initiative is an 'energy challenge' like 'energiejacht' (formerly known as 'klimaatwijken').

Today, there is not a structural system that promotes people to change their energy behaviour. The communication or persuasion initiatives are free of obligation. In our view there is room for a system that rewards energy saving behaviour and/or sets standards which require people to change their energy behaviour on a structural basis.

2.1.2. Overview of complementary currencies for sustainability in the EU

As argued in the preceding section, existing policies and measures are not sufficiently oriented at motivating households to change their behaviours towards energy savings. The types of behaviours at hand are complex: investment behaviours, as well as everyday life behaviours. Although public authorities actively promote investments in energy efficiency through direct subsidies, their actions (e.g. communication, information) to bend everyday life behaviours towards energy savings do not seem sufficient. Bearing those elements in mind, it felt necessary to investigate innovative ways to motivate households for energy savings.

Complementary Currencies, also referred to as 'alternative', 'local', 'social', 'parallel' or 'community' currencies in the literature (see, for instance, Glover, 1995; Solomon, 1996; Moers, 1998; Blanc, 1998; De Meulenaere, 1998) encompass a great diversity of systems in the EU. Indeed, ranging from grass-roots Local Exchange and Trading Systems (LETS) to more top-down, sustainability-oriented schemes, complementary currencies have the common trait of using another standardised unit than the Euro to mediate exchanges. According to the definition provided by Bernard Lietaer et al. (2010, p.99), "(t)hese different types of currencies are called 'complementary' because they are designed to operate in parallel with, as complements to, conventional national moneys."

Complementary currencies in the EU

A first striking element when exploring the history of complementary currencies (CC) in Europe is that there is a long tradition of diversity regarding currencies, with a variety of coins issued at the local level and attested forms of dual monetary systems prior to the establishment of the metallic standard in the eighteen century currencies (Cohen, 2004; Lietaer, 2000; Fantacci, 2006). The setting up of the Swiss Wirtschaftsring, or 'Economic Circle' in 1934 can be seen as a revival of this phenomenon. Indeed, in the midst of the Great Depression, a handful of short of cash Swiss businessmen decided to create this CC system to escape from bankruptcy. More than 75 years later, the Wirtschaftsring (WIR) is the "world's largest and oldest exchange based solely on a private or 'club' form of money, with more than 77,000 small firm and household members in 2003" (Stodder, 2009, p. 80).

But it is really as from the late 1980's that CC systems with social or local economic aims started blossoming in Europe. Local Exchange and Trading Systems (LETS) are probably the best-known form of those grass-roots CC systems with social aims. The rationale that prevails in most of the LETS systems can best be encapsulated in the concept that "one hour equals one hour" which serves as a basis for mutual exchange of services between participants. By 1999, the number of LETS was estimated to be around three hundred in the United Kingdom, as well as in France, and about a hundred in Italy, in The Netherlands and in Germany (Williams, 2006).

Time Banks are quite close in essence to LETS, with the principle that one hour equals one 'time credit'. In turn, 'time credits' are deposited in the Time bank, and withdrawn when necessary. Some Time Banking projects received support from public authorities, notably in Italy, where they were initiated in a perspective of equal opportunities and balancing between work and family times, mostly for women (Lenzi, 2006).

Other landmarks in the landscape of CC projects are projects of regional / local currencies. It is in Germany that this type of CC has developed in the most impressive manner. They can be characterised as being private monetary systems that want to benefit the local economy by retaining purchasing power at the local level (Thiel, 2011). Sometimes, those local currencies lose value over time through a mechanism of negative interest rate known as 'demurrage'. This is thought to promote a more rapid circulation of the money which should, in turn, benefit the local economy.

Selecting CC projects used for sustainability policies

For the INESPO project, the research is focused on CC systems used for sustainability policies that include an environmental dimension. However, in comparison to CC systems with local socio-economic aims that have developed sometimes to a considerable extent in a number of EU Member-States (Seyfang and Longhurst, 2012), environmental sustainability is a new and emerging motivation to create CC systems. Indeed, in their identification of existing types of CC systems, Lietaer and Kennedy (2008) could only spot one project with environmental sustainability aims.

NU-Spaarpas

This project called NU-Spaarpas has been developed in the City of Rotterdam (NL) and ran from May 2002 to end 2003 (van Sambeek and Kampers, 2004). It mainly consists of a loyalty scheme that rewards purchasing 'green' products with more points than buying regular products. Rewarding some environmental-friendly behaviours (mostly linked to recycling) is also foreseen in the project. Though the private sector was very active in this project, public authorities also played a key-roll and it can be considered that, to a certain extent, NU-Spaarpas was used by public authorities as an instrument for sustainability objectives (Joachain et al., 2009 and Joachain and Klopfert, 2012).

Through the research carried out in the framework of the INESPO project it was possible to identify, besides NU-Spaarpas, two other pilot projects that use CC systems as policy instruments for sustainability and have an environmental dimension.

E-portemonnee

The pilot project E-portemonnee was initiated in 2005 in Overpelt, a municipality of the Province of Limburg (BE) and is a leading experiment to use CC as policy instrument for environmental sustainability. Participants obtain points by performing some sustainable actions from a list established by the local municipality such as switching to green electricity or following a composting course (Bond Beter Leefmilieu, 2005). They can then exchange their points against products or services proposed in a list of rewards (e.g. entrance tickets for the municipal swimming pool or energy saving lamp bulbs). Contrary to NU-Spaarpas, the role of the private sector is very limited in E-portemonnee: it is a project where the Intercommunale for waste management (Limburg.net) as well as the municipal authorities have the leading role (Joachain et al., 2009 and Joachain and Klopfert, 2012). This project is still running and has grown to include 6 other municipalities.

Torekes

The environment around CC is rapidly evolving and it proved a successful approach to extend the timeframe devoted to the research on CC with sustainability objectives. This allowed including in the research the Torekes project that was launched at the end of 2010 in a deprived area of Ghent (BE). The aim of the project is to reinforce social links but also to create a better living environment. In this view, actions like painting the front of one's house or participating to 'clean-up days' are rewarded with 'Torekes' (i.e. in this project, the CC unit is called 'Torekes'). But caring for the environment at a more global scale is also rewarded through actions like switching to green electricity or placing a "no junk mail" sign on the letterbox. In this project, CC is also used as policy instrument by public authorities (Joachain et al., 2009 and Joachain and Klopfert, 2012). However, one of the specificities of this project is the important role devoted to local non-profit organisations. Indeed, they are responsible for organising some of the activities of the project (for obtaining as well as using Torekes). A very interesting example of this is the "community gardens" action. Participants to the project can rent a plot of land in community gardens. But this plot of land can only be paid using Torekes. The first results show this is a powerful motivation for residents of the area to get on board the project (Torekes, Verslag, 2011 and Bienstman, 2011). Besides, participants can also spend their Torekes in local shops (groceries, bakeries, etc.), which also contributes to make the project attractive.

Biwa Kippu and Tradable Energy Quotas

Besides those three projects, two proposals were also selected for further analysis: Biwa Kippu (Lietaer and Takada, 2010) and Tradable Energy Quotas "TEQs" (Fleming and Chamberlin, 2011). Indeed, in the Biwa Kippu proposal (Shiga Prefecture, Japan) participation to the system is conceived not on a voluntary basis but as a sort of civil service in CC (Joachain and Klopfert, 2012). This introduces very innovative elements regarding the model of the CC system that could not be overlooked in the INESPO project (even if it is a Japanese proposal). The same holds true for TEQs proposal (United Kingdom) which also works with mandatory participation. However, in this proposal, it is the idea of a 'carbon budget' and allotted quotas that is explored. Therefore, even if TEQs is not *per se* a CC proposal, it was taken into consideration for the relevance of the system itself.

Insights for the system design of INESPO

The analysis of the selected projects was carried out on the basis of available data (including grey literature and websites). The data gathered on those systems mainly touch upon descriptions of how the systems function, as well as statistics about the number of participants and the CC units in circulation (Joachain et al., 2009). They are often presented in activity reports of the projects and are not collected for research purposes. Besides those available data, interviews of key actors were also carried out. This resulted in the identification of three main categories of constitutive elements for those systems:

- History and objectives
- Functioning and currency
- Interface with users / merchants and database
- Leadership, human resources, costs and financing

This research also provided first quantitative and qualitative results on the selected projects. Figure 2 shows a summary of those results for two of the selected systems: NU-Spaarpas and E-portemonnee (for more details, see Joachain, 2012, INESPO Internal Report on CC Schemes for sustainability in the EU).

Benchmarking so few and diverse systems had little added-value to offer for the core phase of designing the new systems of the INESPO projects. Besides, a systematic understanding of the constitutive parameters of those systems was lacking. This lack was even felt more accurately when the research on the methodology to design the new systems of the INESPO project started. It was thus crucial to develop a new analysis instrument that could not only be used to analyse existing systems but, most importantly, to design new ones. This instrument – a taxonomy of constitutive parameters for those systems – is exposed in section 2.2. Designing INESPO, page 37.

	NU-Spaarpas	**E-portemonnee**
Objectives	Influencing the circulation of goods by promoting "greener" consumption and behaviours. Targeting the "grey mass" of consumers	Using CC as a policy instrument to promote sustainable behaviours. Anchored at the municipality level
Functioning	Participants receive NU points when purchasing in participating stores (4X more for "greener" products, than for "regular" products) and for specific sustainable behaviours (like recycling). The NU points can be used to obtain "green" presents amongst participating shops, daily passes for public transportation, tickets for events, etc	System based on two lists: 1) a list of actions set up by each municipality to obtain points. Typical items: switching to/using green electricity, following composting course/composting, etc. 2) a list of rewards set up by each municipality to use points. Typical items: tickets for municipal swimming pool/sport centers/ movies, public transportation, etc.
Type of currency	Electronic - points - stored on chip card	Electronic - points - remote
Interface	Users: Web access to accounts / Merchants: Terminal - scanner - barcode (card) - chip (card) / Database: central DB	Users: Human interfaces (Municipal clerck, etc.) - web access to accounts / Merchants: I.D. card reader + web access / Database: central DB
Leadership/partners	Public / private partnership between the City of Rotterdam, Rabobank en Stichting Points	Limburg.net (leading the project) + Bond Beter Leefmilieu (support) + municipalities (design their own version of E-port.)
Human resources	At peak time: 20 persons (17 FTP) employed mostly for promotion	Staff from Limburg.net + 4/5 ETP Bond Beter Leefmilieu + municipal clerks (environment dpt, etc.)
Costs/Financing	Setting up costs and operational costs (HR costs + Technical costs: 10,000 cards - 100 terminals) with total budget > 3 million euros. Financing: subsidies EU and Dutch authorities	Limburg.net (project + software costs) + Subsidy from Flemish Region. Total budget < 100,000 EUR. Municipalities finance their E-port system: average budget 3,000 -5,000 EUR + sponsoring
Results quantitative	Participating households: 10,000 (peak time) - Points obtained: >1,500,000 (Most pop: recycling) - Points used: <150,000 (Most pop : cultural events)	For the pilot phase : Participating households: 15-20% - Points obtained: >350,000 (Most pop: recycling - composting) - Points used: < 130,000 (Most popular: lottery tickets)

Figure 2: Summary of NU-Spaarpas and E-portemonnee

2.1.3. Overview of white certificates schemes in the EU

White Certificate schemes aim at achieving energy savings in end-use sectors, such as the residential or commercial sectors. In order to achieve this energy saving objective, public authorities, often through energy market regulators, give to "obliged actors" (i.e. generally energy suppliers or distributors) mandatory saving targets. In turn, the obliged actors have to propose energy saving measures applicable to the "beneficiary sectors"(i.e. the eligible end-use sectors). Obliged actors carry out the measures directly or through partnerships. Once the savings are measured and verified, according to a predefined measurement and verifying protocol, the regulator issues the corresponding quantity of certificates. At the end of the compliance period, each obliged actor must give to the regulator the necessary number of certificates to comply with its target. If not, a penalty system is often foreseen. In some schemes, it is foreseen that "eligible actors" might also carry out energy saving projects and receive certificates which they can later trade to obliged actors. The general functioning of a WC scheme is summarised in Figure 3.

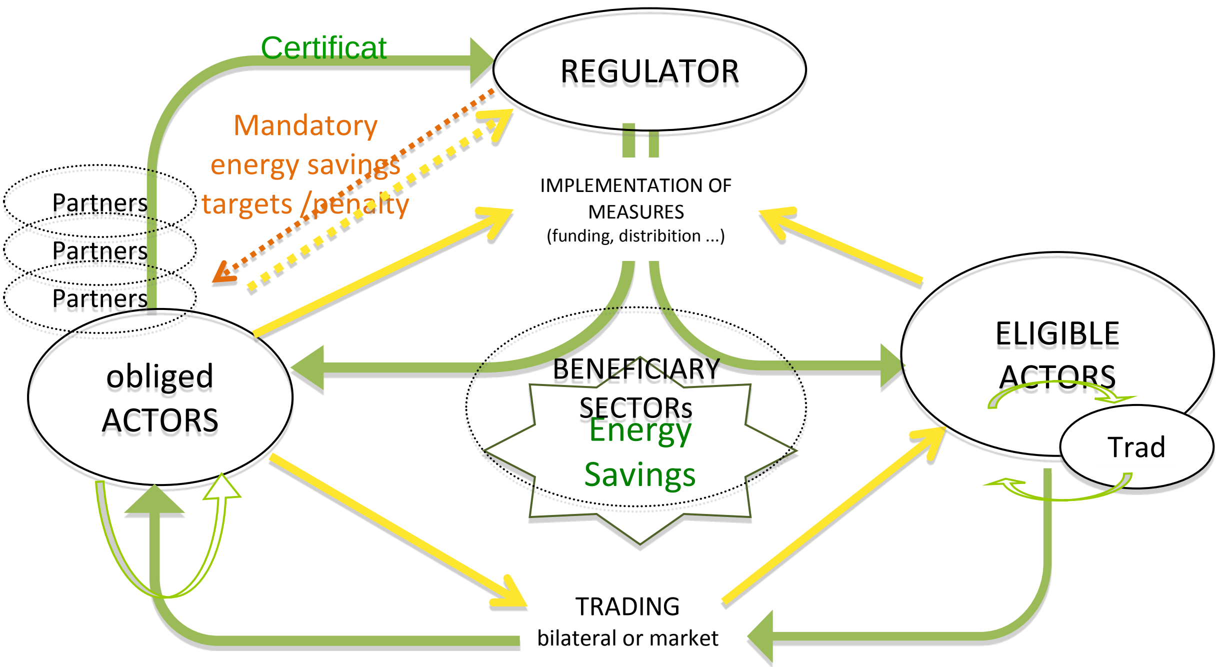

Figure 3: General functioning of white certificates with full options (trading and certification)

Systems developed in the EU

In Europe, 5 countries[1] have introduced a system of obligations on some categories of energy market operators to stimulate investment and to deliver energy savings. When these obligations are coupled with the possibility of selling and buying certificates of saved energy, they are generally called White Certificates Schemes such as in Italy or France. In Italy, the "Tivoli di Efficienza Energetica" (tee) entered into force in 2005, putting an obligation on the distributors[2]. The scheme largely promotes 'hard' measures. It allows eligible actors[3], including esco's[4], to trade certificates with obliged actors. The Italian scheme promotes

[1] Ireland has also a scheme, but no or very few information is available.
[2] In most of the schemes, the energy suppliers are obliged.
[3] those are other actors than obliged ones, allowed to get WC for achieved savings
[4] ESCO: Energy Service Company

bilateral as well as market trading. The crediting lifetime, that is to say the period during which a measure is considered as delivering savings (and thus certificates), is limited to 5 or 8 years.

As the certification of the savings and the possibility to trade are not systematically foreseen in all interesting similar schemes in the EU, the scope of the research was extended to include scheme developed in the UK for instance. The UK "Carbon Emission Reduction Trading » (CERT) scheme is indeed particularly interesting for the INESPO project, as the suppliers can only achieve savings for the residential sector. Moreover, the CERT includes behavioural and demonstration actions and its target must be partly achieved in priority groups. The UK scheme does not issue certificates for the savings but the absence of certificates does not preclude the trading under other forms such as the trading of savings and of obligations.

Besides the Italian, French and UK schemes, the Flemish and Danish schemes where also selected even if no trading possibilities exist in those schemes.

Analysis

All 5 systems were analysed on the basis of system descriptions and data available in the literature (amongst which: Pavan M. 2008; Bertoldi et al. 2010; Lees 2007; Togeby M et al. 2007; Baudry & Osso 2011; EuroWhiteCert team 2006; for more details, see Holzemer, 2010, INESPO Internal report on White Certificates Schemes in the EU).

This shed light on main constitutive parameters of such systems (see Figure 3):

- Targets
- Obliged parties
- Scope of the scheme
- Certification and Trading
- Governance issues (e.g. baseline and additionnality rules, measurement and verification methods)

	Italy (TEE)	France (CEE)	UK (EEC, CERT)	Flanders	Denmark
Since...	2005	2006	2002	2003	2006
OBLIGATIONS Target	Annual Target & compliance Annual Primary energy (Toe) 2010: 4,3 MToe	Pluriannual target & compliance Final en. (TWh cumac) 2006-09: 54 TWh cumac 2010-: at least 100 TWh*	Pluriannual target & compliance EES: final en. (TWh) CERT: carbon content (MTCO2) EEC1: 62 TWh EEC2: 130 TWh CERT:185 MtCO2 (+/- Half of the target = in the priority group)	Annual target & compliance Primary energy 0.58 TWh/y (A part of the target in a low income households group + complementary obligations)	Annual target & compliance Final energy 2006:2,95 Pj/y 2008:5,4Pj/y
Obliged actors Threshold:	Electricity and gas distributors More than 10000 customers, since 2009 more than 50000 in y-2.	Energy suppliers (electricity, natural gas, GPL, heat and cooling for stationary applic. domestic fuel) + transport fuel* GPL: 0,1 TWh/y Domestic fuel: no / yes * Others: 0,4 TWh/y	Electricity and gas suppliers EEC1:15 000 customers EEC2:50 000 customers	Electricity distributors No	Electricity, gas and heat distributors Oil distributors (voluntary basis) ?
SCOPE Eligible types of energy	All fuel savings	Electricity, natural gas, GPL, heat and cooling, domestic fuel (transport fuel since 2010)	Gas, electricity, oil, LPG	All fuel savings	All (except transport fuel)
Eligible actors	Energy service providers, obligated actors and their controlled cies. Since 2007 other cies (if they reduce their own energy and have an energy manager)	Any public or economic actor (under some conditions →ESCOS excluded) From 2010 local authorities, housing agencies, ANAH	Electricity and gas suppliers and daughter cies	Obliged	Obliged (& daughter cies)
End-use sectors eligible	All (including transport)	All (except EU ETS)	Residential only	Residential, non-energy intensive and services	All (except transport)

Figure 4: Comparison of white certificate schemes

All EU existing scheme function on a mandatory basis, that is to say they have fixed mandatory targets to some energy market actors. However, the schemes are usually also flexible in the sense that they offer different possibilities for obliged actors to comply. This allows for obliged actors to choose the most cost-effective options. Indeed, it is only the achieved savings which are taken into account and not the amount of money invested by the obliged actors.

The INESPO project is seeking ways to extend the concept of white certificates to households as obliged actors for the residential sector.

However, as the research on constitutive elements of complementary currency and white certificate schemes progressed, two main conclusions were drawn:

- constitutive elements of both types of instruments showed similarities
- the obligatory aspect of white certificates schemes, as well as the possibility to sell and trade were seen as a distinctive feature of white certificate schemes

Consequently, extending the concept of white certificates to the household sector translates, in the framework of the INESPO project, into designing a system of complementary currencies based on an obligatory architecture with a marked-based system of exchange.

2.1.4. Overview of smart metering infrastructure in the EU

Before explaining the infrastructure envisioned in INESPO, a short overview of SM in Italy, Sweden is presented, as these two countries currently have the most widely deployed SM infrastructure in Europe. The cases of The Netherlands and Belgium are then exposed.

Italy

The smart metering system in Italy (called "Telegestore") was developed in the 90's by the largest distribution company, ENEL. Technologically it can be considered as a second-generation smart meter deployment (with simple PLC "one-way systems" being first generation). ENEL's metering system is currently exploited commercially by IBM.

When liberalization of the energy market started in 1999 the Italian Regulator AEEG issued a resolution made the use of an Automatic Metering Infrastructure mandatory. The new meters were to be installed and owned by the distributors and furthermore customers are not allowed to buy their own meter.

ENEL started a full rollout around 2000 which concluded in 2005 after the installation of about 30 million meters (Deconinck et al., 2010; De Craemer et al., 2010). Important reasons for the switch were the expected savings or revenues regarding logistics, field operations, customer service and, to a high degree, fraud detection. The regulator, government or other market parties had no or only marginal influence on requirements ENEL had to fulfill. During the peak of deployment, more than 40.000 meters were installed a day by about 4.000 workers.

Figure 5: ENEL smart meters (single phase & triple phase)

It has to be mentioned that ENELs system is a very basic form smart metering, in that sense that it is mostly intended for remote meter reading, tariff switching and (dis)connection. However, the impact of ENELs deployment (and subsequent marketing campaign) on smart metering developments in other countries should not be underestimated, particularly among politicians and regulators in Europe.

Sweden

In contrast to Italy, smart metering in Sweden took off due to legislative decisions. Following a debate on inaccurate billing, the Swedish parliament passed a regulation in 2003 requiring all electricity meters (more than 5 million customers) to be read on a monthly basis by 1 July 2009. If a meter reading is missing, extrapolation is not allowed (forward estimation) but intrapolation must be used (which means a later meter reading must exist). Only then, a meter reading will get the status ”calculated” and can be used for invoicing and settlement. The purpose of the new regulations was to give customers a better understanding of their invoice based on real instead of, up to then typical, estimated meter values.

The Netherlands

In the beginning of 2006 an effort was started by the Dutch Standardization Institute NEN to define a draft standard for smart meters in the Netherlands. This work resulted in a report called NTA 8130 released on 30 April 2007, defining a minimal set of functions and legal conditions a smart meter has to conform to. For example, the meter has to be remotely readable, offer remote (dis)connection for electricity and gas and facilitate the implementation of current-limits and load shedding. Meters would also have to be usable for monitoring the distribution grid.

After finishing the project, a lot of discussion arose on the outcome of the standard. Some parties complained about the lack of functionality to facilitate a transition to a smart grid.

Originally, the Dutch government proposed that all seven million households of the country should have a smart meter by 2013, as part of a national energy reduction plan. In August 2008 the roll out of these seven million meters was delayed for several reasons, mainly because there was limited possibility to track small scale local energy production (e.g. by PV panels), and that there was uncertainty in the parliament on future developments in smart meters. More importantly, some consumer organisations tried to boycott the proposals to make smart meters mandatory (proposals 31320 and 31374) with petitions, out of fear that not enough measures were in place to guarantee the privacy.

Eventually, the ministry of Economic Affairs decided that every customer should be able to have a smart meter installed, but only voluntarily. However, this was already possible before. Additionally, the maximum read-out frequency is limited to bi-monthly.

Smart metering in Belgium

Flanders

In Flanders, the biggest players on the distribution market are Eandis and Infrax. Both are cooperating to implement a smart metering solution in Flanders, with Eandis taking the lead.

During the period 2009-2010, a proof-of-concept (PoC) was realized using Infrax's cable network (Infrax, 2009). The goal was to test communication (reading measurements, determining energy efficiency, link to gas meter) using a limited number of meters. Because this was purely a PoC, the cost of the hardware plus installation cost for single home was about €1000.

A second proof of concept by Eandis studied the possibility of using PLC (Power Line Communication) to communicate with the MUC (Multi Utility Controller, to be able to read not only electricity meter but also gas and/or water meters). The increased reliability and bandwidth of Eandis' implementation could enable near real-time communication between meters, which is essential to realize the potential of smart grids. Typically, meters will be read out on an hourly or quarterly time base. A larger-scale test is currently going on, involving up to 61000 new smart meters.

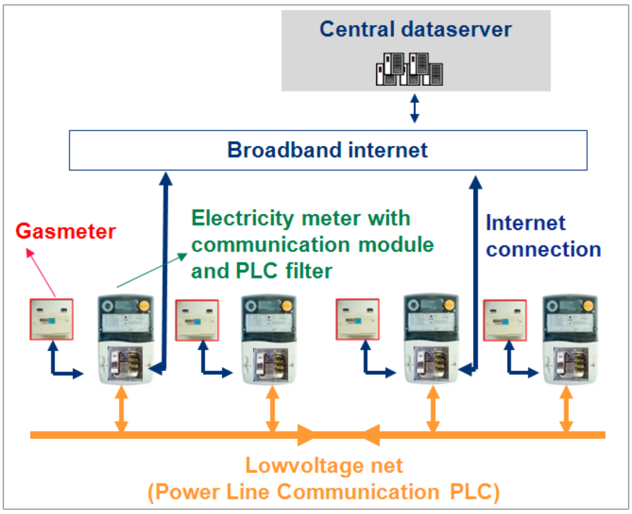

Figure 6: Eandis' PLC based smart meter communication concept

The VREG (Vlaamse Regulator voor de Electriciteits- en Gasmarkt) has also expressed its interest to prepare a so-called central Clearing House (CH) before a full smart meter rollout has begun (post-2012) (VREG, 2009a and 2010). This Clearing House could be considered as a "crossroad database" that regulates the information data flow between all energy market parties (related to billing, changing supplier, moving, etc…) (VREG, 2009b).

Wallonia

At the end of 2008 the Walloon regulator, CWaPE, published an outline for the introduction of smart meters (CWAPE, 2008). In the first phase, the functionality required for a smart meter infrastructure will be defined. The second and third phases should deal with the preparation and realization of a pilot project and in the fourth phase a decision will be made about a large-scale rollout in Wallonia. However, no timeline was provided.

Brussels

In April 2009, the regulatory commission for the electricity market in Brussels (BRUGEL) presented its stance on the introduction of smart metering the region of Brussels (Quicheron, 2009). A few scenarios were considered but the general idea conveyed is that the need for smart metering is not high enough to offset the costs for the involved parties. BRUGEL further notes that a coherent approach on the national level is necessary and that additional studies should be performed to determine the required functions of the meters.

2.2. Designing INESPO

Designing innovative policy instruments based on the integration of complementary currencies / white certificates and smart meters is the core task of the INESPO project. The research carried out to position INESPO provides an initial set of useful insights to ground the design of the systems. Complementary insights are found through gaining knowledge on some key determinants of energy saving behaviours. All this research material is intended to feed the reflection for the crucial phase of designing the systems.

However, the first attempts to design the systems and integrate them with smart meter technology revealed that too many parameters had to be taken into account, some of them having a decisive impact on the architecture of the systems. Since benchmarking was not optimal to carry on with the design phase, it was thus necessary to reduce complexity by deepening the analysis of the constitutive parameters of complementary currency systems. This led to a taxonomy of constitutive elements of those systems which lays the foundation for the design of the INESPO systems.

The methodology for designing the systems is thus based on the taxonomy and includes the following steps before embarking in the core design phase:

1. Selection of the architectural models
2. Selection of the technical options
3. Baseline and profile computation
4. Defining the system boundaries, actors and functions

In the next section, insights about key determinants of energy saving behaviours are first presented. The taxonomy is then exposed and followed by the 4 preliminary steps of the system designs.

2.2.1. Determinants of energy saving behaviours

Although energy saving is primarily considered as an environmental issue, personal motivation factors to save energy can be manifold. Next to the desire to improve the environment or mitigate climate change, people could also change their behaviour for other reasons, like saving money, the desire to decrease dependence to (sometimes politically unstable) energy producing countries or regions, or others. All motivations are relevant.

A non-exhaustive overview of the literature is presented. A broad focus is first adopted, as the motivations, incentives and determinants of a shift towards more sustainable behaviour might be partly the same for specific energy behaviour. The focus of the analysis then gradually shifts to energy use by households, and mainly to the behaviours determining their energy use.

Theories explaining behaviour and behavioural change

Energy use and the social dilemma: the rationalistic approach

Policy makers and scientists, mainly neo-classical economists, consider the individual consumer as a rational human being, who makes his consumption choices based on a kind of personal cost benefit analysis (de Bakker et al., 2008). The model of 'reasoned action' by Ajzen (1991) fits into this school. He states that intentional environmentally friendly behaviour is a function of a motivational and a normative component. The first refers to the consequences the consumer expects from his behaviour and his evaluation of these consequences. The latter refers to the (perceived) social norms and the consumer's willingness to comply with these norms (Beckers et al., 1999).

In this perspective, government campaigns to make citizen behaviour more sustainable often rely on information campaigns, aiming to convince the consumer that he or she should care about the environment and think about the future generations. In practice, however, these sensitising campaigns often have little effect. This is sometimes explained by the consumer's social dilemma: on the one hand, the citizen is aware of the problems of the environment, and he is in favour of tackling these problems, but on the other hand he thinks that he has no personal benefit from it, and others will take advantage from it and just continue their old behaviour (Milieu en Natuur Planbureau, 2007). The result of this dilemma is inconsistent behaviour (Beckers et al., 1999).

Critique on the rationalistic approach

According to Ester (1999), the rationalistic perspective on environmentally relevant behaviour has three weak points:

- it ignores that (environmental) behaviour is a complex matter and more than the sum of the individual behaviours;
- it does not provide a satisfactory explanation on how consumers make appraisals and how they are influenced by social and cultural trends;
- it does not include the supply side of the alternatives for the consumer's behaviour: even if a consumer has a positive attitude and an intention for environmentally friendly behaviour, there might still be obstacles related to the availability of these benign alternatives and his capability to opt for them. Next to the availability, the price and the credibility of the producer as a provider of environmentally friendly products are equally important.

Some authors, like Janssen and Jager (2002, p. 284), think the rationalistic assumption on consumer decisions is wrong: "when people decide, they do not engage in economic optimising (rational actor type behaviour), but rather use more simple heuristics or engage in biased information processing in their evaluation of the relative advantage."

The Social Practices Model

The authors of the Social Practices Model (SPM) see the above described vision on consumption decisions as too one-sided. They argue a broader perspective is required (de Bakker et al., 2008). Social dilemmas will probably play a role, but other things should be brought in the analysis. They claim that social routines and daily habits have an influence on a lower level of consciousness; information campaigns cannot get through to this level. We do actions like brushing our teeth, going to work, etc. without really thinking about it. This under consciousness is not taken into account in the behavioural models applied by those adhering to the rationalistic approach.

These actions (social practices) are related to day-to-day-life knowledge. Everyone knows how, why and when to do them. It is only when they are questioned, often by others, that we start thinking about them at a more conscious level (Spaargaren, 1999).

In Spaargaren's SPM, it is not the individual attitude nor the norms or structure that are put at the centre, but rather the actual behavioural practices that an individual shares with other human agents. In this respect we could e.g. refer to Bartiaux (2008) who illustrates the importance of supportive interaction within people's social networks in order to be able to effectively change behaviour.

The social practices are in the middle between the human agent, with his lifestyle, and the structure, containing the so-called systems of provision. The latter term encompasses the availability of green behavioural alternatives: the higher the levels and modes of green provisioning, the higher the chances that people will be brought into a position in which the greening of their lifestyle segment becomes a feasible option (Spaargaren, 2003). The lack of the supply of green alternatives can hinder a person in his social change, even if he or she really wants to realise this change.

Behavioural change for energy savings

The EU's energy saving policy has been largely based on increasing energy efficiency. Energy saving by behaviour changes has hardly been the object of real policy making. One of the reasons for this development is that it is not clear if, and which, significant energy saving can be expected from the behaviour of citizens. (de Bakker et al., 2008)

A study by McKinsey&Company (2009), however, finds that the energy saving potential of behavioural measures is about one fourth of the potential of investment related (or technological) measures. At the same time, energy savings resulting from efficiency improvements are offset by behavioural factors like an increased use of electric appliances, changes in comfort standards, etc. Changing energy behaviour is thus crucial to ensure the gains from our efficiency strategies are effectively realized. (McLaren et al., 1998)

On a conceptual level, a distinction is made between on the one hand people's motivation to change behaviour, and on the other hand their ability to change their behaviour. Motivating forces (as awareness, knowledge, attitudes, norms, habits, etc.) are necessary to bring about change, but they are not sufficient. What is needed at the same time are enabling factors (financial, technical, organizational, etc.). Next to motivation and enabling factors there is also a need for a reinforcing factor (peers, friends, authorities, customers, etc.) if we want the individual behavioural changes to become permanent. From a purely theoretical point of view such a proposal follows the classical pattern of describing human behaviour as following some intrinsic (personal and internal) motivations, but being restricted by external constraints, be it financial, technical or social. (Intelligent Energy Europe, 2009)

Possible triggers of behaviour change towards more energy saving

Attitude

There is no guarantee that people with a higher environmental awareness and motivation to save energy will effectively change their energy behaviour. The following quote may still summarize the literature: "Although there is little evidence in this study to support the attitude-behaviour assumption, this does not mean that such a link does not exist, or that there is no causal relationship between attitudes and behaviours. What this study does do, however, is to demonstrate that when attitudes are measured as they commonly are, their predictive ability is unlikely to be higher than about 30%, and could be much lower." (Hini et al., 1995, p. 28) Also, in more recent research by Vringer et al. (2007, p. 553), the conclusion remains that "a self-regulating energy policy, solely based on a strategy of internalising environmental responsibility will not be effective in saving energy. There are indications that a social dilemma is one of the reasons why people's consumption patterns do not conform to their value patterns, problem perception or motivation to save energy". Vringer et al. (2007) found no significant differences in the energy requirement of groups of households with different value patterns, taking into account the differences in the socio-economic situation of households, except for a small difference in the 'motivation to energy saving': people described as 'motivated to save energy' appeared to have a slightly lower energy requirement. A very similar conclusion was reached by Bartiaux (2008) and Gaterleben et al. (2002). The research by Gatersleben et al. (2008) showed that self-reported proenvironmental behaviour is only marginally related to household energy use. The latter rather seems to be related to household size and income. A final confirmation of this conclusion can be found in MNP (2007, p. 77): "Household energy use shows no correlation with the prioritisation of the climate problem or with the motivation to save energy".

These examples show there is not one driving force behind environmentally beneficial behaviour. The lack of a relation between household energy consumption and value patterns of consumers, their problem perception of climate change as well as their motivation to save energy means that a self-regulating energy policy, solely based on a strategy of internalizing environmental responsibility will not be effective in saving energy.

Household income

Household income is an important determinant of energy use, but the relation is complex. According to Anker-Nilssen (2003) this complexity requires greater incentives for households to reduce energy use.

Whereas low income households are more likely to adopt energy saving practices like switching off the lights or waiting for a full-loaded washing machine the dwellings of high income households, however, are likely to have more energy saving features. High income households, however, consume more energy as they seek to save time (e.g. increased private car use) and maintain their high comfort level. An examination of Norwegian households by Anker-Nilssen (2003) also shows that when the energy price increases gradually, low income households save energy while high income households do not react much. An unprecedented price hike, on the other hand, rather has the opposite result. (Anker-Nilssen, 2003; O'Doherty et al., 2008)

Prices

Research shows that prices do matter for household (energy) behaviour, but it is suggested that they are not the main determinant of energy behaviour (Killian, 2007; Proost et al., 2010; Jeeninga et al., 2001). The effect of the price of energy becomes relatively more important with decreasing income (Anker-Nilssen, 2003).

Knowledge

The criticized rational actor approach presents people as individual agents acting 'rationally' in response to information made available to them. Ignorance about environmental issues can be rectified by the provision of information: information will engender concern; and concern will translate into behaviour change. This assumption is, however, not supported by empirical evidence with respect to energy savings. The SEREC research project on residential energy consumption in Belgium found that the more energy saving advices are customized the more individuals appreciate them. More general advices are not really used, but also more customized advice is often not sufficient to trigger behaviour change. Previously unquestioned practices need to become questioned. Besides, there is also a need for consistent information through social interaction as well as support from the environment of the individuals in order to effectively trigger energy saving behaviour. (Bartiaux, 2008)

Other determinants

Other factors that also have an impact on household energy use are: people's age and socio-economic situation, household size and its composition and the age and architectural characteristics of a dwelling as well as the installed energy using equipment.

Barriers to energy saving behaviour

The most important conclusion of this paper is that energy use, and energy saving behaviour, cannot be empirically explained by studying one single determining factor, whether it be attitude, income, prices, culture, information or other.

According to Spaargaren (2003), a lifestyle is defined as a set of social practices that an individual embraces, together with the storytelling that goes along with it. It is clear that a sustainable lifestyle cannot be explained by just one parameter. Many barriers are present, each of them explaining in part why sustainable behaviour is so hard to put in practice.

We now provide a list of potential barriers to energy saving behaviour by households. It is based on the available theoretical and empirical knowledge that is available in literature:

- being stuck in habits and old routines, making it difficult to switch to more energy friendly behaviour;
- many policy instruments aim at making the citizen's attitude greener, but (1) these policies have very limited effectiveness in actually greening them and (2) to the extent that they indeed make attitudes greener, the impact of a green attitude on behaviour is fairly small;
- the behaviour and opinions of those belonging to people's social network (family, reference groups, like neighbours, friends, etc.) is an important determining factor (also linked to the social dilemma). This is sometimes called a 'lock-in' effect;
- culture may play a role: come measures can be felt as an attack to people's freedom of choice, privacy or other fundamental values in a certain culture;

- particularly in countries where many consumers are shifting to the middle class, a rising energy use can be observed;
- although taxes are one of the most popular policy instruments, their use as an instrument to actively steer behaviour in a more sustainable direction is still very limited. Many scientist, mainly economists, regard taxation as the most effective type of policy instrument to realise behaviour change. However, many barriers remain for their implementation, the most important being the general un-popularity of any kind of taxation with both business and the general public. Other barriers are the alleged existence of negative side effects, both economic (e.g. loss of competitiveness) and social (e.g. negative distributional impacts);
- in cases where economic instruments exist, the tariffs are often too modest to realise the desired behavioural shift, or too many exemptions or rebates are granted, which erodes their effectiveness;
- much information on energy saving options is available for citizens, but the information is not tailored enough;
- people may oppose energy savings because they believe this would undermine their quality of life. The message accompanying energy saving programmes should, therefore, ensure that their effectiveness is not undermined by misconceptions;
- especially with respect to indirect energy use people may doubt their efforts can effectively reduce energy use. People cannot check the actual amount of energy saved. A lack of credibility should be prevented by promoting transparency and preventing inconsistent messages.
- the promotion of innovative technologies at an early stage may be risky as these technologies may still encounter growing pains. This could hamper the general uptake of these technologies at a later stage.

Identifying these barriers is a first step to overcoming them. However, the difficulty remains to find out how strong these barriers are, and when, under what conditions, they play a role.

2.2.2. Creating new instruments to promote energy savings

The innovative instruments designed in the INESPO project aim at overcoming some of those barriers and promoting energy savings for households. In order to do so, those new instruments integrate complementary currencies (or marked-based "white certificates for households") to smart meters. Since the INESPO project is limited to the design phase of those new instruments, it is only possible at this stage to highlight potential effect they might have on energy savings for households. Further research and trials with the instruments will have to be carried out in the future to validate (or not) those effects. Besides, those potential effects depend on the choices made for the design of the systems. In the next sections, general insights are provided on those potential effects, without differentiating between the possible architectures for the system (see Joachain and Klopfert, 2012, for a further discussion on the subject).

Personal benefit and social networks

The incentive part of the new instruments (complementary currencies or "white certificates") can be seen as relevant in both the rationalistic and the social practices approaches. Indeed, a participant can derive personal benefit if he obtains complementary currency units, for instance, but he is also participating to a scheme that could be setting new standards at the social level. Besides, the innovative coupling of complementary currencies with smart meters provides not only an incentive but also more accurate information to the participants on energy consumption. If, as it is recommended in the technical part, the participant has an in-house display and provided the meter reading frequency is high enough, he could even get an immediate feed-back on his consumption. Appropriate attention should be given on using this new instrument to provide, whenever possible, information tailored to the needs of the participants. Besides, the instruments should be conceived as dynamic systems that keep participants alerted on different energy saving actions, on various rewards offered, etc. in order to sustain motivation over time. The new instruments could then act as motivating, enabling and reinforcing factor, removing obstacles typical to the invisibility of energy consumption and the lack of reward for energy saving efforts. However, there is more to it than the effect such a system could have on separate individuals. Indeed, participating to such a collective system could lead to the development of social networks where experiences and tips are exchanged, for instance, which could, in turn, bend some social practices towards a more sustainable direction.

Specific features of the new instruments

Using complementary currencies (CC) offers specific features that are highly relevant in the case of energy savings (see Joachain and Klopfert 2012).

Symbolic value

As it is often the case for commercial loyalty schemes of major players in the food retail industries, the actual value of the points / CC units can be very low (e.g. 0.5% of each Euro spent). However, customers can be satisfied with the reward scheme and store loyalty increases (Demoulin and Zidda, 2008).

Since some of the proposed CC systems share similarities regarding their functioning with commercial loyalty schemes, this could be extended to the new instruments. In the case of the innovative instruments designed in the INESPO project, collecting CC units could even have a symbolic value, especially as it is related to a sort of proof of "green behaviour". This differentiates this type of instruments from direct subsidies which are calculated in Euro. The use of a CC as units of account allows thus to decouple to some extent motivation from the financial system.

Games and challenges

Depending on how the new instruments are presented to the public, they could also be perceived as a kind of "green challenge" for families. The literature on games used for learning (see, for instance, Malone and Lepper, 1987) or for entertainment (see, for instance, Hainey et al, 2011) has explored the various reasons to spend time playing. Based on an extensive literature review, Hainey et al. state that challenge comes as the first reason to play. Besides, they argue that challenge, as well as other factors among which control contribute to building intrinsic motivation.

It can thus be argued that, depending on the way the new instruments are presented to the public, they could bring this sense of "green challenge" and control (due to the smart meter) which are required to build intrinsic motivation.

Rebound effect

Because the CC system allows deciding how to use the CC units obtained, such systems have the potential to limit the rebound effect due to incentive part of the scheme. Indeed, if proper attention is given to building the using list, only items which have a limited negative impact on the environment can be proposed. Since the CC units are not useable outside of the perimeter defined by public authorities, this can limit the rebound effect. This differentiates CC systems from Euro-based incentive systems. Indeed, since Euro are accepted for any kind of purchase, it is very difficult for public authorities to ensure that the subsidies granted do not contribute to a negative impact on the environment in the long run.

Perspectives for policy making

Using CC also offers new perspectives for policy making. Indeed, such systems offer the possibility for public authorities to design the system in a way that serves their policy objectives. In order to do so, they have more parameters (see taxonomy, page 39) than when using the Euro. Besides, those parameters can also play on the cost efficiency of CC systems compared to direct subsidies, for instance. An example of this is provided when the CC system foresees environmental-friendly actions both to obtain and when using the CC units. In the E-portemonnee project, for instance, participants can obtain points by following a composting course and use them for free public transportation tickets. The positive impact of the system on environment-friendly actions is then doubled: It is also frequently observed that participants do not use all the CC units they have obtained, thereby lowering the impact of the incentive scheme on public budget. Most interestingly, by using a CC unit instead of a Euro, policy-makers also have the opportunity to de-couple their policies from the financial markets.

Possible drawbacks

The issue of privacy is a sensible one regarding the proposed new policy instruments designed in the INESPO project. People might reject the system as being too intrusive. Moreover the fact that public authorities are trying to set new standards for energy savings might also be rejected. Proper attention should thus be given to ensuring privacy (a question that has not been touched upon in this project) and to presenting the scheme in a non-intrusive and non-moralising manner.

The complexity of the designed instruments is another potential drawback which has been explored in the focus groups dedicated to social acceptability. Besides, the architectures on which the different system designs are built have also different degrees of social acceptability (see 2.4. INESPO - Social acceptability, page 64)

2.2.3. Objectives and taxonomy

The analysis of the selected CC systems which was performed in the first work package of the INESPO project (see section 2.1.Positioning INESPO, page 20) shed light on the importance of carrying on with the study of the constitutive parameters of those systems. Therefore, a new task (Task 2.0) was added to the tasks initially planned for the second work package. In this new task 2.0, a taxonomy of constitutive parameters for the selected CC systems is developed taking into account the coupling with smart metering technology, and integrating the insights from the study of white certificates. The resulting hierarchical classification of parameters was used as a building tool for the design phase.

Given the contribution of this taxonomy to the research on CC, the results were presented at the 1st International Conference on Community and Complementary Currencies, University of Lyon in February 2011 and published in the International Journal of Community Currency Research (Joachain and Klopfert, 2012).

Before embarking into the taxonomy itself, it is first necessary to define the objectives of the project at hand, which are categorised as shown in Figure 7. In the case of the INESPO project, those objectives can be defined in the following manner:

Objectives

As shown in Figure 7, the objectives of complementary currency systems for sustainability can be manifold. However, in the case of the INESPO project, the objective is focusing on lowering energy consumption in the household sector. This objective translates into targets of energy savings (e.g. 2% for electricity, 4% for gas).

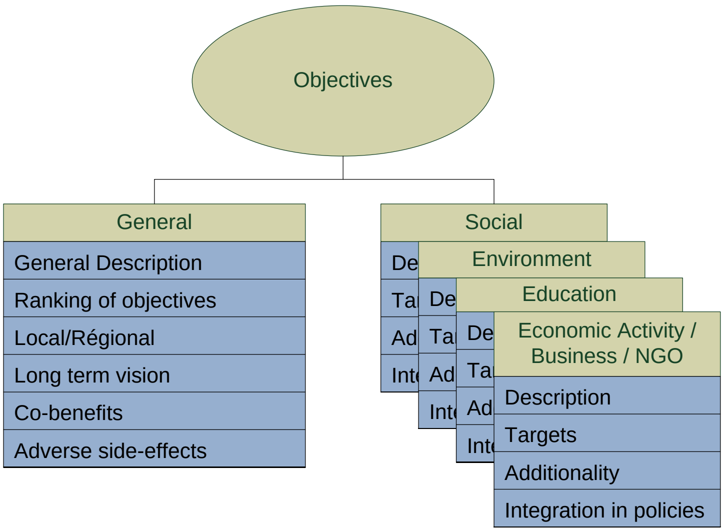

Figure 7: Objectives of complementary currencies

Taxonomy

The taxonomy for the system architecture is organized in three major blocs: the ***rules***, the ***user access point*** and the ***management*** (see Figure 8). Bearing in mind the core objective of the INESPO project (i.e. system design), the emphasize is put on the ***rules*** from which the perception of the system by the participants derives, as well as on the ***user access point***, which comprise the technical elements of the design. Regarding the ***management***, general advices is given, since the INESPO project only covers the design phase. Should an implementation project take place in the future, however, it would be highly recommended to carry further the research on management and governance issues, as they could be key factors for the success of such a pilot project.

The rules

The ***rules*** comprise parameters related to the ***motivation to participate***, the ***operations*** and the ***currency*** (see Figure 8). A is detailed in Joachain and Klopfert (2012, p. 160), "(…) in the phase of designing a CC system, the first logical step, once the objective(s) are set, is to decide how to motivate people to get on-board. The next step in then to design the functioning of the system accordingly, and then to choose the parameters for the currency itself. All those choices are interrelated in the sense that they create dependencies, and should all contribute to build a consistent CC system."

The definition of the different parameters of the ***rules***, as well as the choices made for those parameters in the INESPO system design are given in section 2.3. INESPO - System designs

The ***user access point*** comprises technical features of the system such as ***device type***, ***data***, ***capabilities***, ***feedback***, etc. (see Figure 8). This part of the taxonomy deals with how the actors identified in the INESPO system interact (e.g. how do households view their account or how the back-office assigns CC units to households). Such use cases, as well as architecture outline and first approximation of underlying database are described in section 2.3.5. System design: Technical aspects.

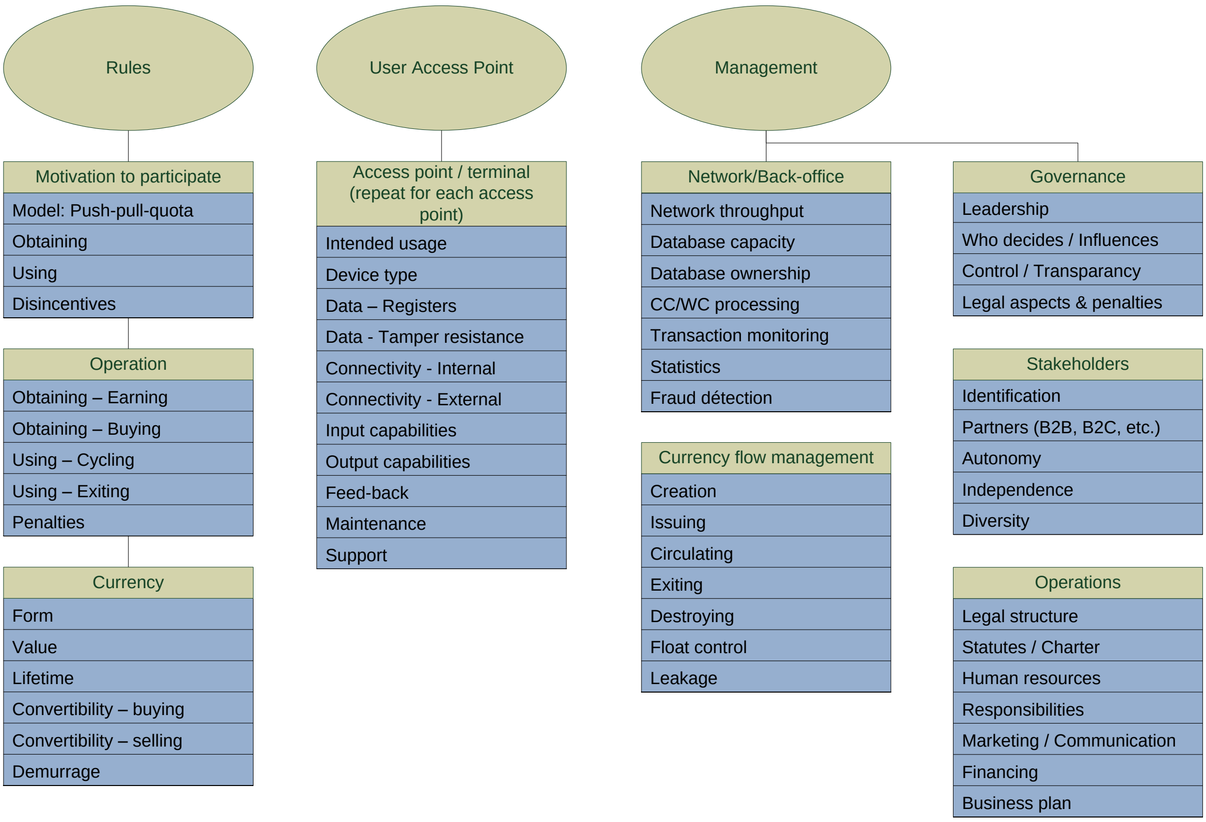

Figure 8: Hierarchical classification of parameters for the CC systems (from Joachain and Klopfert, 2012, p. 161)

2.2.4. The 4 preliminary steps of the system design

Selection of the architectural models

The work carried out on the taxonomy sheds light on the importance of the choice of the ***model*** in the design of the systems. Indeed, the research on the possible rationale for the model reveals a polarity between what we have called a ***rewarding*** and a ***regulatory*** architecture. The project E-portemonnee in Limburg is a perfect example of a ***rewarding*** model: CC units are given for specific sustainable behaviours detailed in a list set forth by each participating municipality. The actions are thus "rewarded" by public authorities in the CC system. In the framework of the INESPO project, using such a rewarding model implies to use ***relative consumption reduction*** to reward changes in behaviours and investments in energy efficiency, each household making their "best effort" to reduce their energy demand.

Using a ***regulatory*** model is an option which has not been implemented yet but has been proposed for CC systems (see Lietaer and Takada, 2010). This type of model is radically different as it based on mandatory participation and the willingness to comply with regulations put in place by public authorities. Such a ***regulatory*** system allows working on the ***total energy consumption*** and setting ***quota*** or ***targets*** for household energy consumption.

It follows that the choice between a ***rewarding*** and a ***regulatory*** model orients the systems on radically different paths. For designing the INESPO systems, it was thus decided to build:

A rewarding system (S1) where households participate to the system on a voluntary basis and are "rewarded" by public authorities for their energy savings. This occurs in two major ways:

- Households can obtain complementary currency (CC) units through their ***relative consumption reduction*** over a given period of time (Δ in consumption)
- Households can obtain CC units for some specific actions related to increasing a dwellings' energy performance, buying basic energy efficient appliances / products, energy audit, maintenance, as well as energy education.

A regulatory system (S2) with mandatory participation of every household and the setting up of ***quota*** or ***targets*** for household energy consumption.

S2 requires realistic targets which are calculated for households taking some elements of their profile into account. Each household obtains a number of CC units that corresponds to their energy targets.

As a household consumes energy, it also uses CC units accordingly. At the end of the period for which the target was set, a given household energy consumption can

- meet their energy target: all CC units have been used
- be more than their energy target: they have to buy the missing CC units at a penalty rate fixed by public authorities
- be less than their energy target: they have remaining CC units which they can sell to public authorities at a discounted rate.

However, carrying on with the design of **S1** and **S2**, two major drawbacks for those systems were identified:

- the **rewarding system (S1)** could be perceived as unfair for over-rewarding the households which had done the least efforts yet (and penalising the households which had done the most efforts),
- the **regulatory system (S2)** was most likely to cause major problems for households with high above-average consumption to comply with the energy consumption targets.

Faced with this problem, a first methodological choice was not to try to develop mechanisms to "fix" S1 and S2 (e.g. by setting a cap system for S1 for example), but rather to conceive them as two extreme systems, each at one end of the spectrum of possible architecture designs. The second methodological choice that derived from this initial choice was to develop a third system, called a **hybrid system (S3)** that would combine "the best from both worlds".

Selection of the technical options

A working implementation of the INESPO schemes mainly rests on the availability of good user profiles, thus making valid energy consumption measurements necessary. This is where smart metering is essential, as it is the only way of effectively collecting and managing consumption data on a regular basis. In Belgium, there is no political decision yet regarding smart meter roll-out, but the main actors in the (electricity) market are involved in pilot tests. Besides, as requested by the European Commission, cost-benefit analyses for smart meter deployment have been carried out in the three Regions, Brussels, Flanders and Wallonia (e.g. PWC for Brussels, 2012).

The INESPO project is aiming at building new opportunities for energy savings in the household sector, should a smart meter deployment take place. As argued in section "

2.6. Position Paper", the forces at play (e.g. push from the industry, smart grid management) make it likely that smart meters will enter households anyway in the future, however, there is still great uncertainty on how, when and what kind of smart metering infrastructure will be deployed. Therefore, it was decided to work with two technical options:

- A **base scenario**: The base scenario is realizable on short/medium term. In this scenario, neither the metering infrastructure nor the meter itself can be accessed directly by the INESPO system. It provides remote reading of the measurement indexes without any further processing. The typical user interface will be using a browser on a personal computer.
- An **advanced scenario**: The advanced scenario is defined by extending the base scenario and, although it is a preferred scenario in the framework of the INESPO project, it would require a strong political support to be implemented. In this scenario, smart meters can be extended to incorporate INESPO specific functions. It foresees in-home displays, recharging/redeeming at home, driven by an extendable smart meter platform (possibility to add/change services to smart meters remotely).

Baseline and profile computation

Since **S2** and **S3** are based on a ***regulatory model***, with the obligation for households to participate, it is of uppermost importance to define which parameters have to be taken into consideration for computing the energy targets households will have to comply with. Both architectures require thus to determine which parameters will be used to define households profiles, taking into account their diversity. Based on their profile, baselines are then set for households, as well as saving objectives. This computation results in energy target that are realistic for each household taking into account some of their specificities. Besides, it is important to be able to process the measured data to be able to differentiate energy savings due to changed behaviour from energy saving due to changes in the context of the consumer (such as new or less family members at home, change of appliances, etc.). Setting the targets right is considered as a responsibility of the INESPO governance.

The focus of this task is thus put on studying which parameters are most important to take into account. The following diagram (Figure 9) shows possible parameters for the baseline (profile) computation in order to set the energy targets. The information required, as well as the entity where the information would have to be retrieved (i.e. Supplier, Local Administration or Social Security) is also shown on the graph. Some parameters, which had been initially listed as potentially impacting the energy consumption, have not been taken into account (marked with a red dot). This recommendation for the choice of parameters is mostly done bearing in mind the necessity to operate a trade-off between being fair in the choices of parameters that reflect the differences between households, and keeping the system workable and relatively simple to implement.

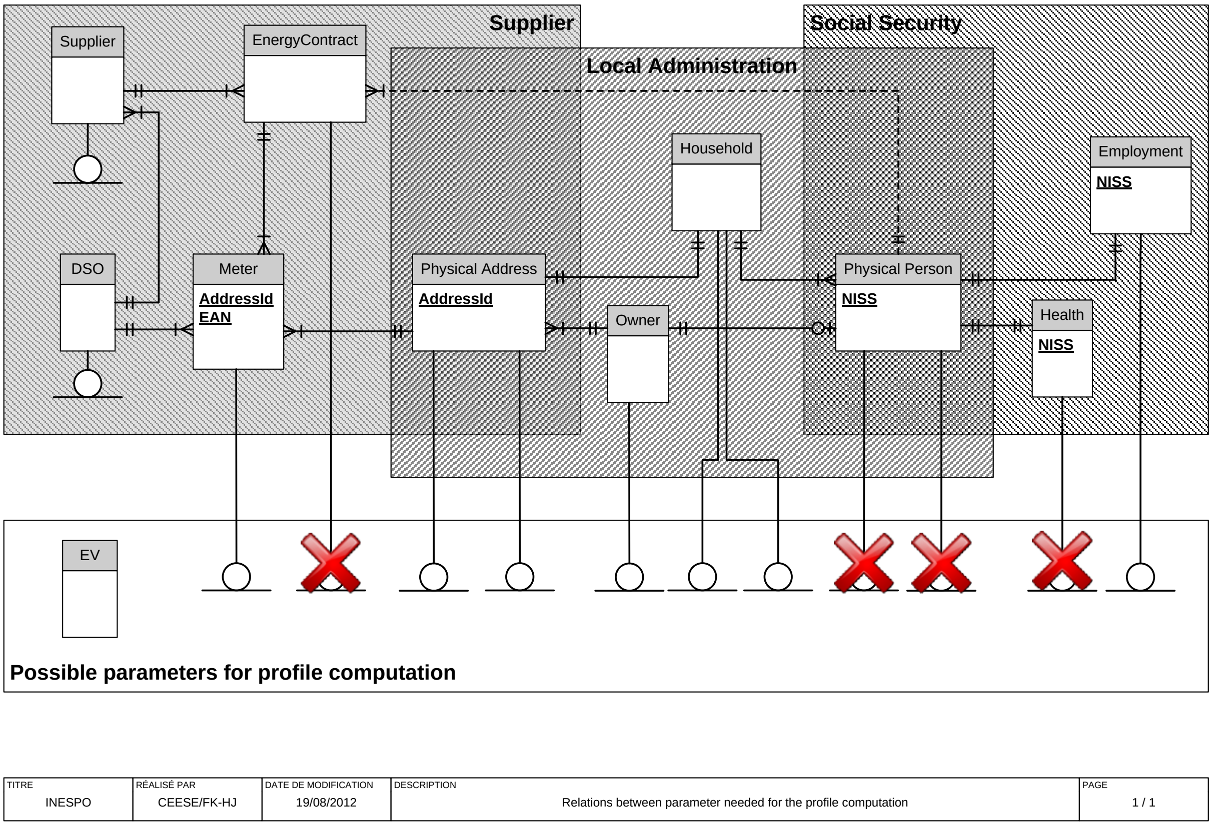

Figure 9: Parameters necessary for profile computation and their sources

Regarding the computation of the baseline and the targets themselves, a methodology based on Principal Component Analysis (PCA) could serve as a reference for public authorities, bearing in mind that the final decision will rest on other considerations as well (targets set by the EU, etc.). Indeed, PCA allows to extract a "typical behavior" out of a collection of power profiles. This way, a single profile can be compared to the "average" to evaluate how good or bad this specific household's behavior is. Of course, some clustering or segmentation has to be done first to differentiate between e.g. household size, inhabitant's income, … so that the comparison is fair.

Additionally, the confidence on the number needs to be determined in order to derive its statistical significance when applied to different consumer groups. This could lay the foundation to define the "energy targets" that would be set for households in S2 and S3.

INESPO System boundaries, actors and functions

Applying the UML diagram methodology, the boundaries, actors and functions of the INESPO system are determined as shown in Figure 10. The INESPO system boundaries includes participants (households), partners (merchants), the whole INESPO structure (back and front office), as well as the meter data manager (MDM). Other actors with whom interactions are foreseen (i.e. mostly for data transfer) are outside of the system boundaries, such as Energy Suppliers or Administration.

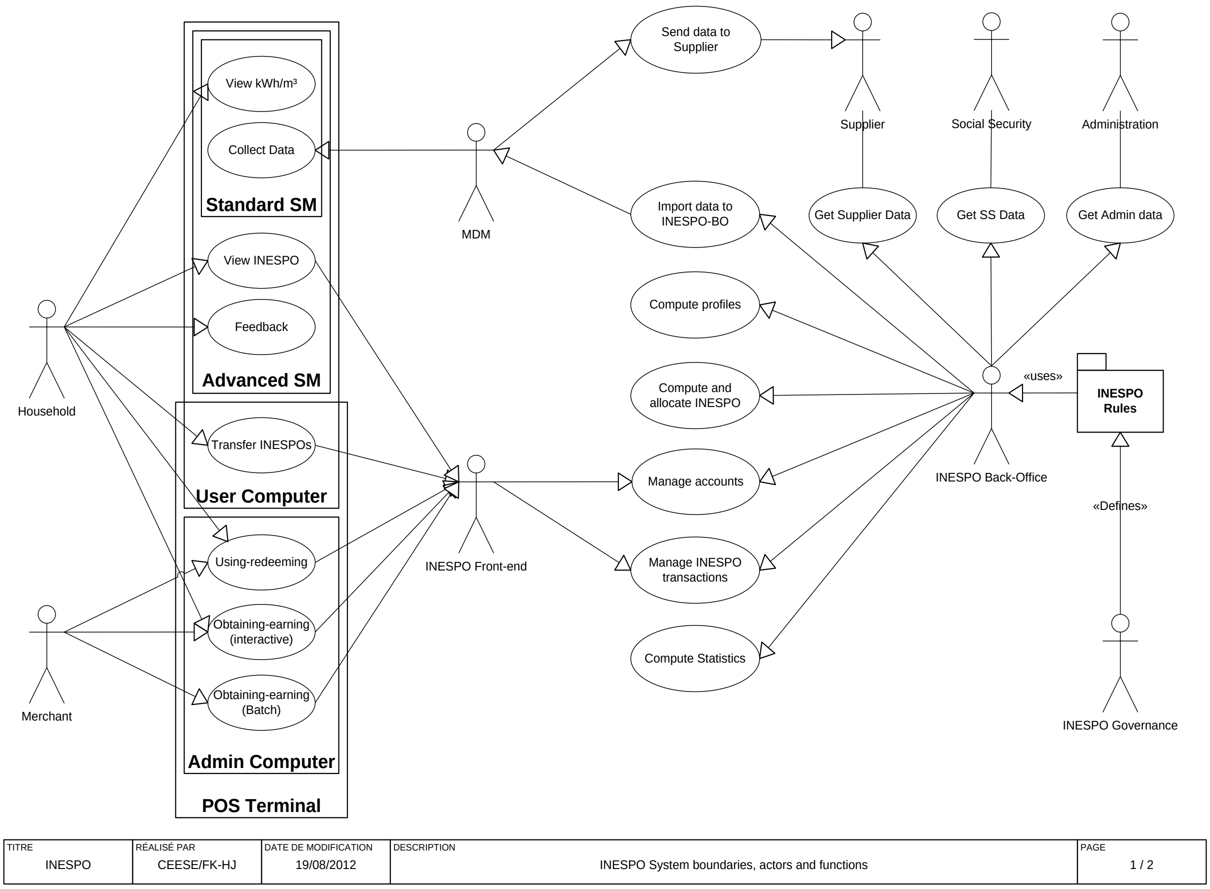

Figure 10: Boundaries of the INESPO system

The INESPO system comprises the following actors, with their main functions:

Household: A single household that is participating in the INESPO system

INESPO Back Office (Database, Processing, Interaction)

Main functions:

- Getting the necessary data (from the MDM / Supplier, Social Security, Administration)
- Tracking the INESPO side (versus MDM data) of the energy consumption history.
- Computing and allocating INESPO's
- Managing accounts in INESPO's
- Computing statistics
- Storing consumer account status (monetary system, management of Complementary Currencies (CCs)). This is further referred to as the account database.
- CC or points calculation service.

INESPO Front-end: Responsible for user interaction.

Main functions:

- Managing the obtaining – using and transfer of INESPO's

MDM of the DSO: The Meter Data Management system of the DSO.

Merchant: The owner of shop that has a terminal for INESPO's.

Supplier, Social Security & Administration: The databases from external parties needed for profile, baseline and target computation.

2.3. INESPO - System designs

The three systems designed for the INESPO project (**S1**, **S2** and **S3**) which are presented in this section are based on the taxonomy (see page 39). A definition of each parameter is given prior to the description of the choices made for the parameters within a given architecture.

The logical order for designing the systems is also derived from the taxonomy and comprises three steps. Once the objective(s) for the system are set, the first logical step is to decide how to **motivate** households to get on board. Three main parameters are impacting the motivation to participate to CC systems: the model chosen, as well as the way to obtain and use the CC units.

The second step is then to design the functioning of the system. Those parameters are detailed in the **operation** sub-section, which comprises ***obtaining*** (***earning*** / ***buying***) and ***using*** (***using-exiting***) the CC units.

The third and last step of this phase is to design the **currency** itself. The parameters that have to be defined relate to the ***form*** and *value* of the currency, as well as its ***lifetime*** and ***convertibility***. A last parameter that has to be covered is whether or not the currency bears (negative) interest with the ***demurrage*** / ***interest*** parameter.

Those three steps (**motivation** – **operation** – **currency**) belong to the same rationale of setting the '***rules***' for the CC system.

The following paragraphs describe the ***rules*** for the 3 different systems designs:

- **S1** : built on a **rewarding** architecture
- **S2** : built on a **regulatory** architecture
- **S3** : built on a **hybrid** architecture mixing regulatory and rewarding aspects

The last section is dedicated to the technical aspects of the systems.

2.3.1. System design 1 (S1): Rewarding architecture

The Rules - Motivation to participate

Model [The 'model' describes what kind of rationale is used for the system as a whole to motivate households to participate]

In the architecture of S1, CC units are given (using a "push" mechanism) to households when they perform specific sustainable actions according to the rules defined in the 'obtaining' parameter. The terminology 'rewarding' is preferred to the terminology 'voluntary'. Indeed, 'voluntary' does allow differentiating this type of systems from grassroots CC systems based on reciprocity (i.e. LETS, Time Banks). Both types of systems can be voluntary, but the term 'rewarding' is consistent with the fact that the INESPO system is intending to create a policy instrument which promotes and rewards energy savings in the household sector.

Obtaining [This parameter describes the rationale to build the rules for households to obtain CC units in such a way that it motivates them to participate]

In S1, the model chosen is a rewarding model, and obtaining rules should be built in a way to make sense to participants, notwithstanding the fact that they have to be in line with the objectives of the INESPO project and take into account the need for objective measurement.

Since S1 is a rewarding system, the obtaining – earning rules are based on the behaviours that the project wants to promote, keeping in mind the central objective of the INESPO project which is the reduction of energy consumption by households. It follows logically that the difference in energy consumption for each participating household (Δ in consumption) should serve as a basis for earning CC units. For example, on a yearly basis, this reduction is defined as

ΔC = Cy – Cy-1 (where Cy stands for the energy consumption of a household during year y).

A very important remark at this stage is that, although capping the initial energy consumption would have been a possibility to avoid over-rewarding the households which have done the least efforts yet, it was decided not to do this within this exploratory study, in order to bring the system S1 to its limits (see positive and negative aspects of S1 summarized at the end of the system description).

On top of this central way of earning CC units, some specific actions are also rewarded. The rationale used to select those actions is the following:

- Providing coherence by strictly sticking to the objective of reducing energy consumption in the dwelling of the households (target group)
- Targeting behavioural changes through modifying the external and internal context in which the selected behaviours have to take place.
- Targeting behavioural changes through providing information / education

This has many implications. A first major implication is that the perimeter of the actions that are rewarded is limited to the dwellings of the households (target group of the INESPO project). Other 'eco-friendly' behaviours related to transport for instance, are thus not selected. A second major implication is that actions that do not, strictu senso, reduce energy consumption are also not selected. For instance, actions like switching to green electricity or producing electricity in the home are not rewarded (no reduction of energy consumption), whereas placing a solar boiler for instance can be rewarded because it reduces the total energy consumed from sources external to the dwelling. A third implication which is more related to changing the external and internal context and avoiding the rebound effect is that only a limited number of energy efficient domestic appliances (related to basic needs) are eligible for reward (based on best energy label on the market). Besides, in order to avoid that older and less efficient appliances are kept, bringing used appliances to recycling parks (or asking the seller of the new appliance to take it back) is also rewarded. A fourth implication in relation to information / education is that actions related to energy education are also rewarded (e.g. energy audit, energy education courses).

Using [This parameter describes the rationale to build the rules for households to use the CC units they have obtained in such a way that it motivates them to participate. Different choices are possible, which include the possibility to use CC units in shops (merchants). In this case, a possible rationale might then be to establish mechanisms to help CC units being exchanged as much as possible between merchants before they exit the system.]

Since S1 is a rewarding system, this is a key parameter to bring participants on board. Therefore, the following rationale was chosen:

- Increasing the motivation to participate and making the system more attractive by enlarging the scope vis-à-vis the core objective of reducing household energy consumption

- However, ensuring coherence both for the users and as a system
- Targeting behavioural changes through modifying the external and internal context in which the selected behaviours have to take place.

Those choices have, as it was the case for the obtaining rationale, clear implications. Obviously, a balance has to be achieved between enlarging the scope and ensuring coherence. In order to do so, the following guidelines are used: the actions that entitle to earn CC units are all eligible for using. For example, if a household invests in double glazing, they get rewarded with CC units. Those CC units can be used for all the actions of the obtaining list which the household wants to perform later (as in a loyalty scheme). However, in order to make the using list more attractive, other actions like investing in photovoltaic installation or switching to green electricity are also eligible to use the CC units (this will of course depend on the agreements with the installers, energy suppliers, etc.). Using the CC units in shops (merchants) also seemed a very interesting option. However, this option drives even further the problem of coherence, an especially in terms of systemic coherence. Indeed, INESPO has no commercial objectives and it is not intended to run a whole system which includes pay-back to merchants. To overcome this problem, it seems best to seek ways to convert CC units from the INESPO system into other existing systems. This option has two major advantages: the first one is to use existing systems instead of duplicating them (e.g. Ecochèques, for instance), and the second one is that it also makes possible to link this system with existing or forthcoming CC systems that have compatible objectives (e.g. E-portemonnee, for instance). Once again, this will depend on the agreements made with those other systems, as well as on technical feasibility.

The Rules - Operation

Obtaining - Earning [Describes the rules vis-à-vis households on how to earn CC units]

A central way to earn CC units is based on Δ C as measured from one period to another by the smart meter infrastructure.

Besides, a list of actions also enables households to earn CC units. This obtaining-earning list is built taking into account the guidelines developed for the motivation – obtaining parameter. A complete list has been proposed, which comprises:

- Investments for increasing a dwellings' energy performance (such as investing in high efficiency glazing, replacing single or double glazing, in a dwelling's air tightness, placing a condensing gas fired boiler, thermal solar energy installations, etc.)
- Buying services that may benefit a dwelling's energy performance (such as energy audit, maintenance and control, etc.)
- Buying basic energy efficient appliances / products (such as fridge, washing machine with the best Energy label on the market: A, A+, A++, plus returning the old appliance that is replaced, etc.)
- Energy education (such as following a formation de 'Guides énergie' http://www.walhain.be/services-aux-citoyens/environnement/energie/formation-de-guides-energie or on URE http://www.formation-construform.be/formations/utilisation-rationnelle-de-lenergie-ure/)

Obtaining – Buying [Describes the rules vis-à-vis households on how to buy CC units]

Considering the fact that S1 is a rewarding system, buying CC units is not foreseen.

Using [Describes the mechanisms put in place to allow the circulation of the obtained CC units between participants to the system]

In S1, a using list is built for households to use their obtained CC units. This list is taking into account the guidelines developed for the motivation-using parameter.

This using list mainly comprises further investments in all the actions from the obtaining-earning list (such as investing in high efficiency glazing, performing an energy audit, buying a fridge with the best Energy label on the market or following an energy education course).

Some complementary items are taken into consideration for the using list, in order to make the system more attractive for households, such as:

- Investing in the dwellings' risk of overheating (Sun screens, Shadowing)
- Investing in renewable heat production (Photovoltaic installations, Wind mills)

Besides, other possibilities should be explored such as:

- Paying green electricity bills (provided agreements are concluded with suppliers)
- Converting into CC units from other existing systems that have compatible objectives (provided proper agreements and infrastructure are put in place). Conversion to the following schemes may potentially be considered:

  Ecochèques

  E-portemonnee

  Eco-Iris

Since INESPO's objective is focused on energy savings and not on creating a commercial network, no mechanism is put in place to help CC units being exchanged between merchants. However, a mechanism is foreseen for merchants (commercial partners to the projects such as double glazing installers or shops selling energy efficient appliances) who want to convert their CC units back into Euro.

Using – Exiting [Describes the mechanisms put in place for the use of CC-units that involves their exiting of the system]

Typically this occurs when merchants that have accepted CC units as means of payment for their goods and services, want to convert their CC units back into Euro. A convertibility-exchanging rate is then foreseen for them.

Besides, in order to provide an "exit gate" to participating households, it is foreseen that they can convert their CC units into Euros. However, a major discount (e.g. 50% discounted value compared to value in the using list) is then applied to promote using CC units according to the using list.

The Rules - Currency

Form [Describes the vehicle chosen for circulation of the CC units. Several choices are possible for the vehicle, but a first basic choice is whether to use a paper or electronic form. In the case of an electronic form, a second choice has to be made between electronic local or remote. Finally, in case of an electronic remote vehicle, the need arises to define the database server as well as the identification means.]

Using an electronic form with remote storage is highly recommended for the INESPO system, considering the smart meter infrastructure it is based on. A first overview of the database server is provided in the technical description of the system (see 2.3.5. System design: Technical aspects).

Value [Describes the unit of account chosen for the CC as well as the standard(s) in relation to which the CC-units are evaluated. Those standards can be multiple, anchored in official currencies or not.]

For S1, the unit of account is “1 INESPO”. For the S1 architecture, the value of 1 INESPO is anchored in multiple standards:

- 1 INESPO is equal to 1 kWh of primary energy saved
- equivalence in INESPO’s for each item of the obtaining – earning list (e.g. 100 INESPO’s per m2 of high efficiency glazing replacing single or double glazing, 500 INESPO’s for an energy audit, etc.)
- equivalence in INESPO’s for each item in the using list (e.g. 1 INESPO is worth 0,10 Euro for investing in high efficiency glazing or buying a fridge with the best Energy label on the market; 1 INESPO is worth 0,5 kWh green electricity, 250 INESPO’s are needed for an energy education course, etc.)

Informal value [This parameter is used when it is not a formal relation but rather an informal relation to a given standard that is used to evaluate the CC-units]

In the case of S1, an informal value could be used to determine the equivalence in INESPO’s for some items of the obtaining-earning and the using list (e.g. rule of thumb is that 1 INESPO is more or less equivalent to 0,10 Euro)

Lifetime [This parameter describes the validity period of the CC unit]

For the S1 system, the lifetime of the CC units is less critical than in S2, but should take into account two facts. On the one hand, the lifetime of the CC units should not exceed the period for which the necessary budget has been assigned. On the other hand, the lifetime should be long enough to enable households to use the CC units they have obtained. A period between 2 and 5 years seems optimal.

Convertibility – Buying [This parameter defines a formal convertibility rate for buying CC units]

Since S1 is a rewarding model, it is not expected that households will buy CC units and, as a consequence, no convertibility-buying rate is foreseen.

Convertibility – Exchanging [This parameter defines a formal convertibility rate for exchanging CC units]

In the case of S1, a convertibility rate is foreseen for merchants that have accepted CC units as means of payment for their goods and services, and exchange those CC units back against Euros.

Convertibility – Selling [This parameter defines a formal convertibility rate for selling CC units]

As an exit gate for the households who do not want to use their CC units according to what is offered in the using list, a convertibility rate is also foreseen for them to sell their CC units at a discounted value (e.g. 50% of the average value of a CC unit from the using list)

Demurrage - Interest [This parameter indicates whether the CC unit is losing (demurrage) or gaining (interest) value with time]

In the case of S1, no demurrage/interest is foreseen.

Strengths and weaknesses – S1

Strengths:

- S1 has the potential to promote energy savings among those who are consuming the most, and have made little to no effort yet to reduce their consumption. Indeed, it will be the easiest for them to make the necessary investments and be rewarded by the system.
- S1 is more attractive (rewarding) and socially acceptable (voluntary participation).
- In its mechanism, S1 is close to a subsidy, although in CC.
- Through the obtaining-earning and using lists, S1 allows for public authorities to focus on specific aspects of their energy saving policies.

Weaknesses:

- This system over-rewards households which are consuming the most and have made no efforts yet to reduce their consumption. On the contrary, households which have already made all necessary investments and efforts to change their behaviours are penalised. Indeed, it is more difficult for those who have already made the necessary investments to continue reducing their energy consumption. In this sense, this system can be seen as over-rewarding those who have made the least efforts yet and penalising those who have made the most efforts towards reducing their energy consumption.
- Because S1 is based on a voluntary participation, its impact is reduced in comparison to a regulatory system.
- There is a risk of free-riding in S1.
- This system needs public subsidies to function. It is not self-sustaining, and is costly to public authorities.
- This system has a tendency to "kill itself over time". Indeed, as households perform the actions that the system promotes, they have less and less opportunity to earn CC units over time.

2.3.2. System design 2 (S2): Regulatory architecture

The Rules - Motivation to participate

Model [The 'model' describes what kind of rationale is used for the system as a whole to motivate households to participate]

In the architecture of S2, the system is based on a model with mandatory participation of every household. The terminology 'regulatory' was preferred to the terminology mandatory for this model because it implies that the energy saving objectives are regulated by public authorities.

According to the two proposals with regulatory models that were described previously (i.e. Biwa Kippu and TEQs, page 22), two main options are possible for a regulatory model.

The first option is close to the mechanism of a civil service or 'tax-like' system using CC (see Biwa Kippu proposal, Lietaer and Takada, 2010). According to this rationale, households have to provide a certain number of CC-units on a defined time basis (ex: 100 INESPO per year for each household). Applying this rationale to INESPO, those CC-units would be earned through reducing energy consumption. This option was, however, considered unfair. Indeed, considering the energy reduction objective of INESPO, this would have implied that all households should have to reduce their energy consumption to provide the requested number of CC units at the end of a given period, regardless of the efforts they had already made in the past to reduce their consumption. As it is commonly accepted that the most cost-effective and straightforward actions are most likely to be taken first, using such a rationale would penalise households which have already made the most efforts towards energy savings. Besides, since S2 is, unlike S1, based on a regulatory model, those households would not have the choice to opt out of the system. Therefore, using such a rationale to build S2 was rejected.

The second option, which is selected for S2 is based on energy targets. This type of model is close to a quota system using CC units (see TEQ's proposal, Fleming and Chamberlin, 2011). Indeed, energy targets are calculated for households taking some elements of their profile into account. In this sense, the system can be considered as "fair" (households with similar profiles get similar targets) provided the parameters for profile computation are properly chosen. Each household receives a number of CC units that corresponds to their energy targets. As a household consumes energy, it also consumes CC units accordingly. At the end of the period for which the target was set, a given household can either break even (energy targets are met, all CC units have been used) or have consumed more or less than its target. In the case it has consumed more, it has to buy extra CC units (penalty). If, on the contrary, it has consumed less than its target, it can sell back its remaining CC units (reward). The price paid for energy itself remains unaffected in the INESPO S2 system. However, the fact that households earn or pay some extra Euros for CC units according to their consumption has a global effect that can be close to a progressive tariff if the price paid for energy and the gains/penalties for CC units are both taken into account.

Obtaining [This parameter describes the rationale to build the rules for households to obtain CC units in such a way that it motivates them to participate]

Since there is an obligation for each household to participate to the system in the S2 design, the focus is not on motivating households through attractive obtaining and using rules. The motivation for households to participate comes from their willingness to comply with regulation put in place by public authorities. However, much attention must be dedicated to determining the energy targets for households in a way that makes sense to them and is socially acceptable. In this sense, the selection of parameters for profile computation is a very sensitive point. Obviously, a trade-off has to be done between taking the particulars of household's situations into account and keeping the system fair, simple and manageable (see page 39 for a proposal of parameters for profile computation). Those energy targets must also be in line with public authorities' objectives in terms of energy consumption reduction.

Using [This parameter describes the rationale to build the rules for households to use the CC units they have obtained in such a way that it motivates them to participate]

In S2, the using rules will be defined in relation to the absolute consumption of the households. This overlaps the remark made above regarding the importance of setting the energy targets properly. The rationale for the using parameter must also take into account the fact that if the energy targets were not properly set, it would be most detrimental to the durability of the system (i.e. if most of the households would be in excess of CC units at the end of a period). Indeed, this would pose a problem in terms of setting the energy targets properly for the next period if households are allowed to use the CC units they have spared for the next period. If, on the contrary CC units in excess cannot be used for the next period and are to be sold at a heavy discount, this would be a major disincentive.

The Rules - Operation

Obtaining - Earning [Describes the rules vis-à-vis households on how to earn CC units]

Since S2 is a regulatory model based on energy targets, this parameter describes the principles / formula for computing the energy targets, which translate into the number of CC units allotted to each household. Those targets are based on households' profiles that take into account a few selected parameters. At this stage, it is too soon to envisage an actual formula. Indeed, selecting the relevant parameters and deciding about their respective weight in the formula results from choices made at the governance level. In the INESPO project the aim is limited to designing innovative policy instruments. If, in the future, public authorities decide to test and use those instruments, a proper governance structure will have to be put in place which will have to decide, amongst others, about those issues. Proper attention should be given to making this information clear and understandable to all households. In this system design phase, research was carried out to provide some general recommendations on parameters that could be selected for profile computation. The following parameters –Energy Performance Certificate of the building (EPC), heating type, rent / owner, number of persons in households, usage (first of second residence, etc.), employed/ unemployed- were singled out as having potentially an important impact on household energy consumption. An overview of the data bases from which the needed information could be retrieved is provided in Figure 9.

Obtaining – Buying [Describes the rules vis-à-vis households on how to buy CC units]

In S2, households which consume more energy than their energy targets are in shortage of CC units. They have the obligation to buy from public authorities the CC units that are missing. The convertibility-buying rate for CC units is set in Euro by public authorities. Ultimately, this drills down to paying a penalty in Euro for consuming more than the energy target. To keep in line with the energy saving objective of the system, it is recommended that the Euro collected as penalty are centralised in a fund that will be used to promote investments in energy efficiency (e.g. insulation work, etc.) by households. The amount of Euro which a given household has paid should be recorded in the database of this fund. If, within a given period (e.g. 3 year) this household invests in energy efficiency, the fund would reimburse part of what has been paid. However, a percentage (e.g. 50%) of the amount would be retained by public authorities to cover the costs of the system (e.g. 10% for running costs and 40% to buy CC units back from households with energy consumption below target). A recommendation would be to match those investments with those eligible for subsidies. In this way, a single file could be entered by households to ask for the subsidy and to get an extra financial support under the form of the Euro the household had paid to the INESPO fund.

Except for the obligation of buying CC units from public authorities when a household has consumed more energy than its target, there is no other possibility foreseen to buy CC units in the S2 system.

It must be noted that using an electronic form for the CC units allows traceability, and that thereby exchanges between households participating to the system can be avoided.

A variant of this system design has been developed with a market-based "white certificates for households" scenario that allows exchanges between participants (see below).

Using [Describes the mechanisms put in place to allow the circulation of the obtained CC units between participants to the system]

In the S2 design, there is no circulation of CC units. The only way of using CC units which is foreseen is related to energy consumption and is described in using-exiting.

Using – Exiting [Describes the mechanisms put in place for the use of CC-units that involves their exiting of the system]

In the S2 design, which is based on energy targets, the CC-units a given household receives at the start of a period are used simultaneously with the energy consumption. For example, regarding electricity consumption measured by the smart meter technology, let's suppose a given household receives 10,000 CC units (equivalent to a target of 10,000 kWhp of primary energy = 4.000 kWh of electricity consumption) for a year. With every kWh electricity consumed (equivalent to 2.5 kWhp), 2.5 unit of CC units are used by the household. Those 2.5 CC units exit the system. The total electricity consumption of the household for the year is either equal to 4,000 kWh (break-even) or above 4,000 kWh (obligation to buy CC units), or below 4,000 kWh (possibility to sell CC units).

Convertibility rates are fixed by public authorities for buying and selling CC units.

The Rules - Currency

Form [Describes the vehicle chosen for circulation of the CC units]

Using an electronic form with remote storage is mandatory for the S2 design to allow traceability.

Value [Describes the unit of account chosen for the CC as well as the standard(s) in relation to which the CC-units are evaluated]

For the S2 architecture, the value of 1 INESPO is equal to 1 kWh primary energy (= 0.4 kWh of electricity).

Informal value [This parameter is used when it is not a formal relation but rather an informal relation to a given standard that is used to evaluate the CC-units]

No informal value is foreseen in the S2 design, since the public authorities define the convertibility rate.

Lifetime [This parameter describes the validity period of the CC unit]

For the S2 system, the lifetime of INESPO should not exceed the period for which the targets are given, in order to be able to restart with new energy targets and new CC units for the next period.

Convertibility – Buying [This parameter defines a formal convertibility rate for buying CC units]

A convertibility – buying rate is fixed by public authorities at the beginning of each period. This convertibility-buying rate only applies to the case when households are in the obligation to buy CC units from public authorities because they have consumed more energy than their target.

Convertibility – Exchanging [This parameter defines a formal convertibility rate for exchanging CC units]

In the case of the S2 design, no exchange of CC units is foreseen and therefore no convertibility – exchanging rate fixed.

Convertibility – Selling [This parameter defines a formal convertibility rate for selling CC units]

A convertibility – selling rate is fixed by public authorities at the beginning of each period. This convertibility – selling rate only applies to the case when households have the possibility to sell CC units to public authorities because they have consumed less energy than their targets. However, the convertibility – selling rate is lower than the convertibility – buying rate. Indeed, the rationale of the S2 design is that households achieve their energy targets and not so much that they outperform their targets (not a rewarding system).

Demurrage - Interest [This parameter indicates whether the CC unit is losing (demurrage) or gaining (interest) value with time]

In the case of the S2 design, this is not foreseen.

Strengths and weaknesses - S2

Strengths

- Every household has to participate to the system
- Targets can be set for energy consumption (energy policy)
- Financial sustainability of the system (once installed) if targets are properly set
- Depending on the choices made for the parameters of the calculation of energy targets, the rationale of the system can be relatively easy to understand ("everyone gets an energy target")

Weaknesses

- Households that are high above the energy targets when the system is put in place will have major problems to comply
- Setting targets which are too difficult to reach is not acceptable.
- The S2 architecture is vulnerable to an excess of CC units (too much CC units allotted = energy targets too easy to reach). Special attention should be given to establishing the energy targets in this respect.
- Setting the targets properly is also a very sensitive issue for the perceived fairness of S2 by households (including the parameters for profile computation)
- Setting the penalties right is also sensitive
- There is a risk of energy consumption shift in S2 (to other sector or to other energy sources such as wood pellets or coal for instance)
- The fact that CC units in excess are convertible at a discounted rate is not giving a high incentive to outperform the energy targets set and might be perceived as unfair.
- S2 is close to a tax/ tariff system for those exceeding their energy targets, and is most likely to be perceived in a negative way. This has to be compared with other options to reach the same energy savings objectives. A key parameter for social acceptability is the way the energy targets are calculated.
- Households might need an adaptation period in order to understand the functioning of the system (how to buy/exchange CC units, etc.)

Further considerations

Fairness

The way to calculate the energy targets is crucial for the perceived fairness of the S2 system.

Tenant / Owner

The S2 architecture might be more relevant for owners who have the possibility to do some energy efficient investments when needed. However, since the PEB of rented housing is becoming mandatory, this could be used as a corrective factor for tenants. It is recommended to seek further mechanisms to promote investments from owners in rented housing. However, the behavioural part of the system is equally valid for tenants and owners.

2.3.3. Variant of S2 with market-based "white certificates for households"

Considering the similarities of the constitutive parameters of white certificates and complementary currency schemes, extending the concept of white certificates to the household sector as obliged party translates, in the framework of the INESPO project, into designing a system of complementary currencies based on an obligatory architecture with a marked-based system of exchange. This variant of the S2 system is described in the following sections with the specification for all the parameters which are not identical to those described for S2.

The Rules - Motivation to participate

Using [This parameter describes the rationale to build the rules for households to use the CC units they have obtained in such a way that it motivates them to participate]

On top of the rationale for obtaining and using CC units according to their energy targets (such as described in S2), households have the possibility to trade their CC units. Households having CC units in excess (i.e. whose energy consumption is lower than their energy target) and those having a shortage of CC units (i.e. whose energy consumption is above their energy target) are thus entitled to exchange their CC units, in an eBay type virtual market.

The Rules - Operation

Obtaining – Buying [Describes the rules vis-à-vis households on how to buy CC units]

In this variant of S2, the obligation to buy from public authorities the CC units that are missing is still valid. However, households that are missing CC units due to their consumption being higher than their targets have the opportunity to try to buy CC units on the market of "white certificates for households". Those exchanges should be traceable and limited to a maximum number of CC units per household to avoid that it becomes a commercial operation.

Using [Describes the mechanisms put in place to allow the circulation of the obtained CC units between participants to the system]

In this variant of S2, circulation is allowed between participants who can use their extra CC units to sell them on the market of "white certificates for households".

The Rules - Currency

Convertibility – Buying [This parameter defines a formal convertibility rate for buying CC units]

Convertibility – Selling [This parameter defines a formal convertibility rate for selling CC units]

On top of the fixed rate determined by public authorities, convertibility –buying and selling rates are fluctuating according to market mechanisms for CC units on the "white certificates for households" market.

Strengths and weaknesses - Variant of S2 with market-based mechanism

Strengths

- Efficient way of reaching targets according to mainstream economic theories
- Potentially less expensive for households that are high above targets
- Could create extra motivation to consume less than targets (limited stream of extra revenues at potentially higher rates than the convertibility – selling rate fixed by public authorities)

Weaknesses

Lower autonomy of the system as it is linked to the Euro and the fluctuations of the financial sphere.

Public authorities lose control to some extent on the target / penalty equilibrium of the system

Could lower motivation for households that are high above targets to take appropriate measures for energy savings (as extra CC units are available at potentially lower rates that the convertibility – buying rate fixed by public authorities).

Could make the system less sustainable on a financial basis for public authorities

Especially sensitive to an excess of CC units (too much CC units allotted = energy targets set too generously).

2.3.4. System design 3 (S3): Hybrid architecture

The Rules - Motivation to participate

Model [The 'model' describes what kind of rationale is used for the system as a whole to motivate households to participate]

Taking the strengths and weaknesses of S1 and S2 into account, S3 is designed as a hybrid system integrating elements of a rewarding architecture into a regulatory model.

Obtaining [This parameter describes the rationale to build the rules for households to obtain CC units in such a way that it motivates them to participate]

In S3, the main motivation is as in the S2 design, the willingness to comply with what is requested by public authorities (limiting energy consumption at the level determined by the energy target). However, households which have not performed actions to reduce their consumption yet have an extra motivation to do so in S3, since a list of those actions allows them to obtain-earn extra CC units. Obtaining CC units is thus mainly related to energy targets, as in S2 but, on top of that, complementary actions are rewarded, as is the case in the S1 design.

Using [This parameter describes the rationale to build the rules for households to use the CC units they have obtained in such a way that it motivates them to participate]

In S3, the central way to use CC units is linked to household energy consumption, as in S2. However S3, just like S1, provides extra ways to use the CC units. The convertibility rates are a key instrument to differentiate the ways to use the CC units.

The Rules - Operation

Obtaining - Earning [Describes the rules vis-à-vis households on how to earn CC units]

S3 is a hybrid system with, at its core, a system of energy targets identical to the one described in S2. However, the list of actions such as described in S1 also allows households to earn extra CC units.

Obtaining – Buying [Describes the rules vis-à-vis households on how to buy CC units]

As in S2, the only case in which this is foreseen is when a participant has used all his CC units (the allotted CC units and those earned through the obtaining-earning list), and has the obligation to buy extra CC units from public authorities. However, in the S3 design, households have complementary ways of obtaining-earning CC units (list of actions) which they might favour over paying a form of penalty.

Using [Describes the mechanisms put in place to allow the circulation of the obtained CC units between participants to the system]

As described in S2, but CC units can also be used for items on a using list similar to the one described in S1.

Using – Exiting [Describes the mechanisms put in place for the use of CC-units that involves their exiting of the system]

S3 has the same main functioning as S2 (CC units are "consumed" and thus "exit" the system in parallel with the effective energy consumption of the households). However, for those households which have consumed less energy than their targets, the using list offers complementary possibilities to use their CC units before they exit the system. As an exit gate, a convertibility-selling rate is foreseen, but at a discounted value.

The Rules - Currency

Form [Describes the vehicle chosen for circulation of the CC units]

As in S1 and S2.

Value [Describes the unit of account chosen for the CC as well as the standard(s) in relation to which the CC-units are evaluated]

As in S2 plus value for items on the obtaining-earning list and the using list as in S1.

Informal value [This parameter is used when it is not a formal relation but rather an informal relation to a given standard that is used to evaluate the CC-units]

As in S1

Lifetime [This parameter describes the validity period of the CC unit]

As in S2.

Convertibility – Buying [This parameter defines a formal convertibility rate for buying CC units]

As in S2, for households which have to buy extra CC units from public authorities. They have the choice of either:

- Paying a 110% of the convertibility-exchanging value and use their CC units for paying their penalty for being above target.
- Paying a 120% of the convertibility-exchanging value and keep those CC units in a fund for investing within a given period of time (e.g. 3 years) in the list of investments foreseen (see S2)

Convertibility – Exchanging [This parameter defines a formal convertibility rate for exchanging CC units]

As is the case in S1, a convertibility rate is foreseen for partners that have accepted CC units as means of payment, and exchange those CC units back against Euros. This convertibility rate is used as the baseline (100%) for other convertibility rates (buying and selling)

Convertibility – Selling [This parameter defines a formal convertibility rate for selling CC units]

In the case of S3 as in S2, a conversion rate from CC units to Euros is foreseen for households in excess of CC units, but with a discount (e.g. 50% of the convertibility-exchanging value).

Demurrage - Interest [This parameter indicates whether the CC unit is losing (demurrage) or gaining (interest) value with time]

Not foreseen

Strengths and weaknesses – S3

Strengths

- Every household has to participate in the system.
- The system does not over-reward the households which have done the least efforts yet (as was the case in S1). Households that are high above the energy targets when the system is put in place are, however, are not over-penalised either (as in S2) since they have the possibility to gradually adapt using the "obtaining-earning" mechanism of the system.
- Targets can still be set for energy consumption, even if the rewarding part of the system diminished their accuracy.
- The system offers a wider use for CC units in excess.
- Households who are lacking CC units are encouraged to invest in energy efficiency
- The system requires subsidies for the rewarding part; however, the penalty foreseen could still bring it near to financial equilibrium.

Weaknesses

- The system is more complicated to understand.
- Social acceptability is key

- The S3 architecture still has some of the problems inherent to a regulatory architecture (e.g. perceived fairness, sensible parameters: targets, penalty, etc.). Further considerations

Tenant / Owner issue

S3 architecture is particularly relevant for owners who have the possibility to do some energy efficient investments when needed. However, since the PEB of the rented housing is becoming mandatory, this could be used as a corrective factor for tenants. It is recommended to seek further mechanisms to promote investments from owners in rented housing. However, the behavioural part of the system is equally valid for tenants and owners.

Links to other projects

It is recommended to link this project with other existing CC systems with sustainability aims by creating "exchange rates" for using the CC units in excess. This would be a way to create a more unified network of CC systems (which would make more sense to users) and would also create a new sink for INESPO CC units.

2.3.5. System design: Technical aspects

Use cases

Consumer centric use cases

These use cases can be performed through any of the interfaces provided (web site, in-home display, shop-terminal, …).

Consumer account view

- The consumer logs in to the INESPO BO (e.g. using in-home display or web browser).
- The system authenticates the consumer.
- The system looks up and summarizes the account status (statistics) in the database. Optionally, a benchmark is calculated (to position the consumer's behaviour within his classification group).
- The system displays account information, such as current CC status and predicted status.

Consumer buys additional CCs

This use case is only applicable to a S2 (regulatory) or S3 (hybrid) a system for the obligation of buying extra CC units when a household has consumed more energy than its target. Besides, the specific case of a market-based WC system is also taken into consideration

In the case of a S2 or S3 system:

- The consumer logs in to the INESPO BO
- The system authenticates the consumer
- The consumer specifies the amount of CCs he has to buy
- The system looks up sources for the CCs (in the case of S2 and S3 this is from public authorities)
- The system verifies payment.
- The system transfers CCs from the source to the consumer's account and compensates the source.

In the case of a market-based WC system

After the four initial steps described in Consumer account view:

- The consumer logs in to the INESPO BO
- The system authenticates the consumer
- The consumer specifies the amount of CCs he wants to buy, or the price he is willing to pay, or who he is willing to buy CCs from.
- The system looks up sources for the CCs (in a CC market system this would be from other consumers that are selling their spare CCs) in the account and market database.
- The system displays the possible sources and price. Step 3 and 4 can be repeated.
- The system verifies payment.
- The system transfers CCs from the source(s) to the consumer's account and compensates the source(s).

Consumer sells spare CCs

In the three system designs, a convertibility-selling rate is foreseen for households which want to sell their CC units. In the case of a market-based WC system, the same mechanism will apply

- The consumer logs in to the INESPO BO
- The system authenticates the consumer
- The consumer specifies the amount of CCs he is willing to sell and optionally specifies a minimum price.
- The system registers the intention and puts a hold on the consumer's CCs being sold. This prevents consuming CCs that are being sold.

Consumer uses CCs

This use case will be typically performed inside a shop (redeeming for real objects), or with an installer (double glazing, insulation, etc.).

- The consumer asks the shop owner/installer to pay using his CCs.
- Using the shop/installer terminal, the owner requests the INESPO BO to process payment.
- The system verifies both the shop owner's/installer's and the consumer's account status and transfers the appropriate number of CCs.
- The system notifies the shop owner/installer that payment has completed.

Back-office use cases

Authenticate user

The system identifies the user based on predefined credentials. Access to certain options (is the user allowed to sell CCs, execute payments, etc…) is determined.

Manage User CCs and quota's

Whenever CCs need to be manipulated, this use case will be involved.

Verify payment

The systems checks if CCs that are being bought are paid for (e.g. by internet banking).

Update CCs

Periodically, the INESPO BO system will integrate new meter data into the accounts. This could be by importing from a DSO's MDM or by querying the meters or "energy boxes" directly. Based on this data and baseline information, CCs will be assigned (or removed) from consumers.

Manage database

Adding/updating new measurement data that arrives from "energy boxes".

Retrieve user statistics

User statistics can be of quantitative or qualitative nature (total consumption this month, benchmarks against other consumers or groups, …) and are updated or generated on request.

Other use cases

Shop owner: Collect payment

This use case is already incorporated in Consumer uses CCs.

Energy box: Send measurement data

The "energy box" mentioned earlier can monitor the households' meter directly (thus sidestepping the DSO's MDM completely) and upload data frequently to the INESPO BO.

Architecture outlines

Base scenario

In the base scenario, neither the metering infrastructure nor the meter itself can be accessed directly by the INESPO system, meaning that the DSO (Distribution System Operator, such as Eandis) will be the middle-man to access meter readings or settings. This will most likely severely limit the minimum time interval between successive readings and make it impossible to adapt the meter (software) to specific INESPO needs. Meter data is very much a single-way affair (meter to MDM to INESPO).

However, it may still be possible to read out the meter from inside the premises themselves (using an auxiliary port on the meter) so that e.g. an in-home display or terminal can still be used.

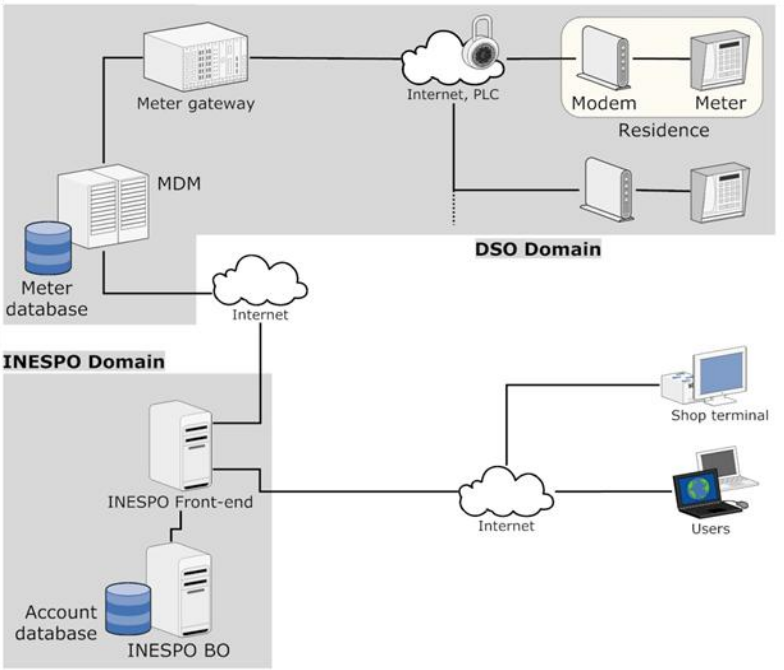

Figure 11 INESPO standard smart meter architecture outline

Advanced scenario

In the advanced scenario, smart meters can be extended to incorporate INESPO specific functions. Meters can be directly read out by the INESPO BO server (but most likely still through a gateway of the DSO), instead of receiving data through the MDM. This will improve the CC calculation flow. Thus, communication with the meters is fully two-directional.

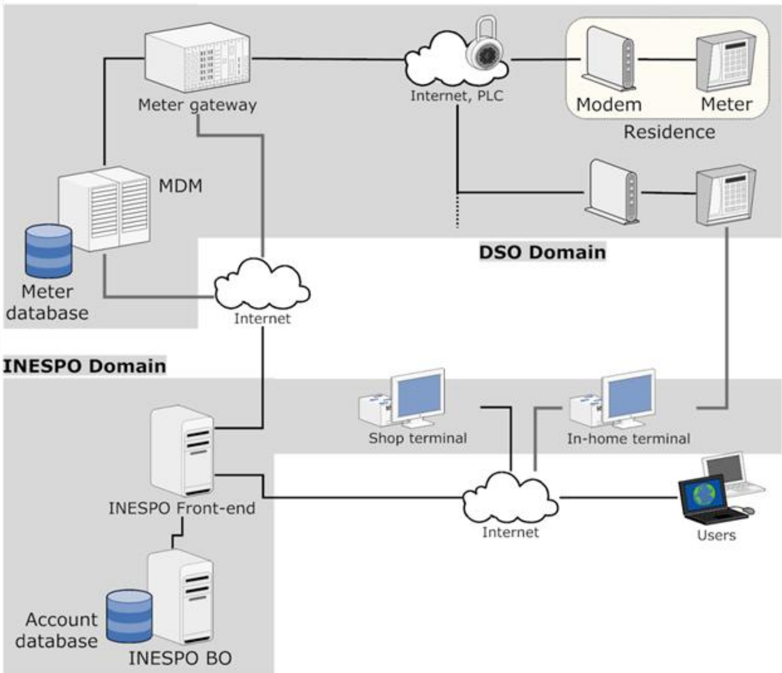

Figure 12 INESPO advanced smart meter architecture outline

Database system

Based on the derived use cases, it is possible to derive a "first approximation" of the underlying database of the INESPO back-office.

Using only a basic set of attributes, an UML use case diagram has been designed. Additional attributes will be necessary in an implementation but are omitted in this approximation.

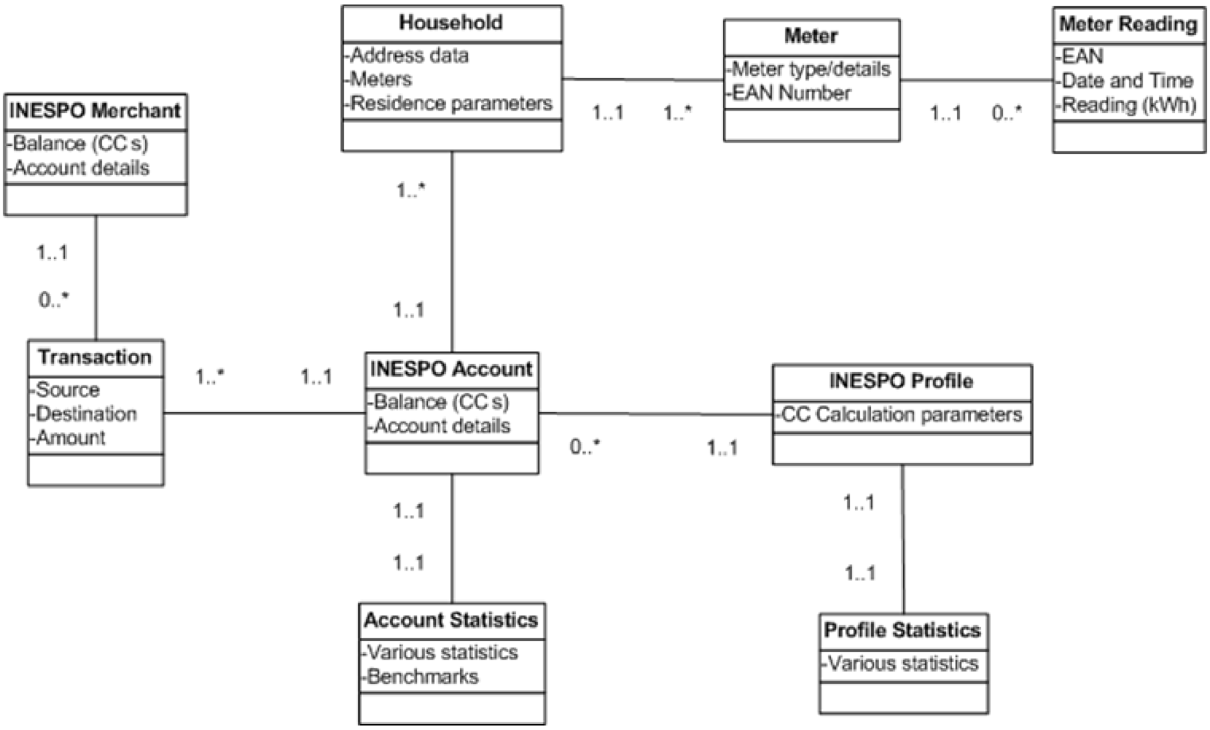

Figure 13 Back-office database class diagram

The UML classes are then used to draw a relational schema of the resulting tables and keys (with the exception of the account statistics table).

Implications & issues

As the proposed systems are very much a one-way affair, one of the main issues is scalability. In a scalable architecture, resource usage should increase linearly (or better) with load, where load is measured in user traffic, data volume, etc.

A good illustration is the French DSO ERDF. If it were to install smart meters for its 35 million connections, reporting a value every 30 minutes would result in about 84GB of measurements every day (at only 50 bytes/measurement). This would also generate a lot of database queries per second (not only writing values, but also lookup queries, etc…). One or more adequately sized dedicated datacentres (cloud based) would be needed to sustain such traffic, running a well-designed application.

Possible bottlenecks

If a central back-office is used in the INESPO system, the following bottlenecks would require special attention:

- Computation of CCs
- User statistics
- Transaction management (buying/selling)

The front-end can play a major role in the offloading of the back-office because it is in an ideal position to act as both a caching and load-balancing system. More on this subject is found in the next section on scalability considerations.

Scalability considerations

Because the INESPO architecture potentially has to serve millions of users, scalability is a major concern. But just as in any other high availability business application, two methods can be used to increase the service capacity: scaling up (adding more resources to a system, such as more memory, disks or CPUs) and scaling out (adding more computer systems).

Furthermore, several general design considerations can be taken into account when a more concrete implementation is built:

- Splitting: to make scaling possible, splitting is essential, and typically possible on multiple levels:
- Service-oriented-architecture (SOA) or Functional partitioning
- Application-level splitting
- Data partitioning
- Limiting distributed transactions
- Asynchronous handling of requests
- Virtualization: Adding another layer of abstraction to an interface
- Caching: The goal of a caching system is to keep the most requested data in memory so it can be immediately retrieved without taxing any other systems.

Privacy considerations

A topic still left untouched in the architecture design is the implications on privacy. Privacy can be defined as the right to respect for private life, to secure for the individual a sphere within which he can freely pursue the development and fulfilment of his personality.

Considering that smart meters can technically be used to track a household's behaviour (Labeeuw and Deconinck, 2011) adequate measures must be put in place to avoid abuse. Potential interested parties of such meter data include not only malicious hackers but also creative marketing departments willing to go the extra step to supply third parties with e.g. optimized advertising targets.

2.4. INESPO - Social acceptability

An important precondition for the successful implementation of energy policies is their social acceptability. The reason for this is simple: politicians are reluctant to implement policies lacking public support. This reluctance has both to do with the fear of opposing the general public as well as with effectiveness considerations. Studying social acceptability also helps in identifying elements that could and/or should be improved.

According to Steg et al. (2006 a) social acceptance of energy policies mainly depends on two factors: individual attitudes and preferences on the one hand and features of energy policies on the other hand. The individual factors influencing social acceptance have to do with people's awareness of the need to reduce our energy consumption as well as the extent to which people feel responsible and are prepared to assume responsibility for the problems our energy intensive lifestyle causes (Steg et al., 2006 b). The policy features influencing social acceptability are diverse. First, public support for a policy correlates positively with its perceived fairness (Jagers et al. 2010). Fairness may have several dimensions, but in this context the distributional impact is considered particularly important.

Second, acceptability of a policy is higher when it is likely to be effective in reaching its objectives. Third, policies that do not impact people's freedom of choice are also more acceptable. A fourth element is that households find energy savings through energy efficiency improvements more acceptable than behavioural changes (Poortinga et al., 2003). Fifth, people are more in favour of the use of incentives than disincentives. A final point is that also the way incentives are financed or revenues from disincentives are used matters. Disincentives are deemed more acceptable if the revenues they generate are allocated within the same domain rather than to the general funds of the government. Likewise are incentives considered to be more acceptable when they are financed from within the energy domain rather than from general public funds. (Steg et al., 2006 a)

2.4.1. Methodology

Research methods

The social acceptability of the innovative instruments for energy saving has been assessed by means of five focus groups with five to fifteen participants each lasting about two hours and a half. A total of 43 participants attended the focus groups. Each focus group addressed a different group of people: greens, people with a low income or social tenants, young people, settled people with children and people aged over 55.

A focus group is a carefully planned, relatively in-depth discussion during which the participants can build on each other's ideas. The 5 discussions all followed the same format:

- Warm up and introductions: Introduction to the INESPO project and the objectives of the focus group. Participants are informed about the format of the focus group and are put at ease. Finally, the rules of game are also explained.
- Current knowledge about energy use and options for energy savings by households: Participants engaged in an exercise in which they inventoried which activities require (most) energy at home. Next, they were asked to indicate which options are available to them for lowering their energy use. To conclude participants were asked what the government is offering households to stimulate energy savings at home.
- The discussion about every single question was followed by a wrap-up by the discussion leader. At the point in the discussion where the options for lowering the energy use were being discussed it was explicitly pointed out that there are two broad options for saving energy: changing our energy behavior or investing in energy efficiency improvements.
- Willingness to reduce one's energy use: This discussion explored the extent to which individuals are prepared to take action to lower their domestic energy use. The reasons underlying people's prepared to save energy were also discussed.
- Presentation and evaluation of the innovative instruments: The instruments were introduced to the participants and spontaneous responses were aired. After that specific questions were raised to find out how the participants feel about the systems.

The smart metering component of the instrument or system was marginally covered during the focus group discussions. A literature and document review was carried out to find out about the most important acceptability issues pertaining to smart meters.

Rationale and limitations of the approach

A qualitative approach was chosen for this research as it allows exploring people's initial ideas and views people about the acceptability of the innovative systems for stimulating energy savings. A focus group is an ideal tool for facilitating such an initial stocktaking on acceptability issues as is allows collecting a wealth of information from different people in an interactive, structured and relatively in-depth manner. This technique is deemed very useful for testing public support for new measures, or parts thereof, at an early stage.

Given the approach taken, the findings that are presented on the systems are the views of a small number of people. These views were formed over a relatively short period of time and on the basis of limited information. It should also be recognised that people may have been influenced by the way discussions were structured as well as by the group dynamics. For this reason it would be incorrect to refer to the results in terms of minority / majority views or percentage figures. The results give an indication of the views held by the people that participated in the focus groups and caution should be applied in extrapolating the findings.

The discussions during the focus groups did not focus on the smart metering component of the innovative instruments. The reason for this is twofold. First, the added value of doings so would have not been very high given the wealth of information that exists on the acceptability of smart metering technology. Second, in order to ensure the quality and the depth of the discussions it was decided not to bother the participants with a quite different topic.

2.4.2. Results

Observations and views on current energy saving policies and people's preparedness to reduce energy use

Although not the primary objective of the current research, the discussions during the focus groups revealed a number of useful complementary insights. A brief overview of the most import issues with respect to people's views on current energy saving policies, people's preparedness to reduce their energy use as well as people's ideas on what would be the best way forward to make households save energy are provided here. The idea is that these issues also matter with respect to the acceptability of the innovative instruments.

Observations and views on current energy saving policies

People generally find the current system of energy saving policies, and especially the different financial incentives, complex. The problem is that they lack overview of what is exactly offered by whom: there is a proliferation of actors and initiatives. Partly because of this people also find that initiatives are not well-coordinated and might even give wrong and conflicting signals.

There are a number of issues concerning the financial incentives for promoting energy savings. There is a general concern over the tenability of a subsidy based system in the long run. Related to this is the fact that people planning to invest in energy saving measures fear the fact that financial incentives can suddenly be removed or lowered. Another issue that matters to people is the fact that households have to pre-finance their energy saving investments. Even more important is the fact that people with no or a low income cannot benefit from tax reductions for energy saving investments.

However a lot is being done already some people find there is still a lack of emphasis on promoting the soundness of the structure of the houses from an energetic point of view.

People also find that energy bills should be send much faster and more frequently. At the moment the link between the energy bill and energy use / behavior is too loose.

People's preparedness to reduce their energy use

The single most important observation is that comfort matters to people. People also prefer to save energy through investing in the energy efficiency of their houses rather than by changing their behavior. The young people stated it this in the following way 'we rather like to care about energy at certain moments in time e.g. when buying a house or electrical appliances instead of having to adapt our behaviour'. People aged over 55, however, wonder whether investing in the energy efficiency of their houses it is still worth the effort and the investment.

A side condition put forward by some people is that everybody has to assume responsibility in accordance with one's means. Others, however, expressed their doubts about whether individual efforts really can make a difference. Young people admitted they are not losing any sleep over limiting their energy use as most of them do not have to pay the energy bill themselves.

What is the best way to make households save energy?

There is a general agreement that increasing the price of energy would be very effective to realise energy savings at the household level. Some participants in the focus group further elaborated the idea and suggested there should be a variation in prices depending on the amount of energy consumed.

Getting prices right is not the only issue. The provision of 'more and better information' was also highlighted as a working point. Information should be correct, consistent and trustworthy; accessible; provided at the right time as well as at the right place; and, targeted (simple enough, etc.). People need to know what they can best do in their situation; they want to know what a good investment is and what not. Some participants suggested making courses in energy conscious behaviour compulsory.

Others suggested that the government should make sure that all electrical appliances on the market – and by extension also investment goods like houses – are very energy efficient so people do not need to worry about this when purchasing. Younger people noted the introduction of a sort of competition element in order to stimulate people to save energy.

Insights on the social acceptability of the innovative instruments

In general, many participants in the focus groups liked the logic behind the idea of using complementary currencies. They themselves see the lack of information on their energy use as an obstacle to saving energy and acknowledge smart metering might offer some interesting applications.

Both systems gave reason for concern with respect to the position of tenants and people who do not have the monies to invest in energy saving measures.

Before entering into a selection of comments on the two systems reference is made to a number of outstanding issues:

- How to deal with people working at home, living partly abroad, sharing a collective heating system, etc.?

- Do these systems replace parts of existing energy policies or to they come on top of it?
- Who will manage the system and determine the different factors?
- Will the system only cover the use electricity and natural gas?

While some people find it all right to talk about relatively general principles others rather prefer to have all rules fixed and impacts quantified. Especially the latter group of people might have found it difficult to talk about the systems as there are still a number of outstanding issues and undefined parameters.

Rewarding system (S1)

People like the idea of being rewarded for energy friendly behaviour. In general, the participants in the focus groups very much liked the logic behind the idea of using complementary currencies (INESPOs) as it allows policy makers to realise more energy savings with fewer resources.

People that are retired and/or have a low income liked the idea of having the tax reductions for energy saving measures replaced by INESPOs as they cannot reap the benefits of tax reductions.

It was raised in all but one focus group that households that already have a low energy consumption cannot fully take advantage of the rewarding system. These households might actually loose in this system as they might help to sustain the system financially, but cannot themselves reap the benefits of it. A solution put forward for remediating this situation would consist of also rewarding households that consistently have a low energy use. The question one should ask here is whether the government should spend money on supporting those that can hardly lower their energy use even more while there are still many other households with more cost effective energy saving options.

Not everyone can fully take advantages of this system. Both tenants as people that do not have the necessary monies to invest might not be able to benefit from the system.

Regulatory system with quotas (energy target) (S2)

In various focus group discussions it was raised that this system can potentially be very effective in reducing households' energy use. This is a reason for some people to prefer the regulatory system with quota instead of the rewarding system. While some state the system still needs some refinement there is are many people that oppose the system. It is questioned whether people are ready for such a system. The concerns about the readiness of the people for this kind of system especially concerns the short and medium term. When announced in time and backed by sufficient transitional measures the core of the system is generally seen as valuable in the long run.

The reasons why people are not fond of the system are manifold. The complexity, as well as the administrative burden the system may generate, of the system has been cited in almost all focus group discussion as an issue of concern. Particularly people aged over 55 and people with a low income see the complexity of the system as problematic. It is said that people will oppose this regulatory system because they simply find it too difficult to understand it. Especially the definition of the household specific baselines is deemed to be too complex as it depends on a – still undefined – function encompassing various parameters.

It is not only the complexity that matters, but also the perceived fairness of the system. People doubt whether the quota or energy targets can really be allocated in a fair way. Both the complexity and fairness of the system renders the participants in the focus groups quite sceptical about the acceptability of the system as they tend to believe it will be impossible to arrive at a system that is considered fair by everybody.

Next to the perceived fairness it is a fact that those people that are not able to invest in the energy efficiency of their homes might find themselves trapped by the system. These households will find themselves worse of year after year when the targets are becoming stricter. The solution is that either the system is adapted to account for the situation of these people or complementary mechanisms are set up to address this kind of situations.

Some people have problems with the regulatory system as it might be perceived as a sort of hidden taxation.

Another drawback of the regulatory system is that it will be possible for people to escape from this 'mandatory' system. Households that are using electricity and natural gas for heating their house could switch to heating oil, pellets, coal, etc. which are not included in the system. The idea is that the system will simply not work because of this. It was also highlighted that this might even lead to a situation that is inferior in terms of energy efficiency and the overall environmental impact.

The management of this system is also challenged by specific realities. The focus group discussion with the group of people with a low income revealed that social tenants change homes very often. It is e.g. not uncommon for those people to move up to 3 or 4 times year.

Complementary insights from the online survey

As the social acceptability of the systems is correlated with their effectiveness we can also refer to the insights of the evaluation of the INESPO architecture, and more specifically the online questionnaire that has been carried out. The questionnaire enquired households about their opinion on various characteristics – among which the energy saving potential – of both the rewarding and the regulatory system.

Not surprisingly, the majority (73.33) of the respondents prefer the rewarding system. However, about a quarter of the respondents are rather in favour of the regulatory system, which can be considered as a relatively high score for this type of system.

It is very likely that this preference reflects in the fact that the majority (59.44%) of the respondents to the questionnaire believe that the rewarding system will generate more energy savings than the regulatory system (17.22%). It should also be noted that nearly one fifth (18.89%) of the respondents doubt whether the systems can really reduce household energy consumption. With respect to the rewarding system households believe that rewarding investments in energy savings is slightly more effective than rewarding behavioural change. Critical for the effectiveness of both systems is the fact whether households will exit the systems or not. The answers to the questionnaire indicate that the incentives in the rewarding system and the disincentives in the regulatory system might have the desired effect, which is critical for the effectiveness of both systems to generate energy savings.

Use of smart meters

With respect to the use of smart meters a number of different issues are touched upon: people's knowledge about smart meters; idea's on the energy saving potential of smart meters; people's preference for the kind of information provided as well as the information channel used; people's ideas about privacy considerations, the introduction of tariff periods, and the acceptability of cutting of electricity at peak periods.

Knowledge

The knowledge about smart meters among the households is low. Only a quarter of the respondents to the VREG (2011) questionnaire stated that they know what a smart meter is. People with a higher education level are better informed about smart meters. During the focus group discussions no one could explain the principle of a smart meter.

Usefulness and energy saving potential

The VREG (2008) questionnaire asked people whether they would be able to save energy when they would receive more information on their energy consumption (not specifying what this information would be like). Slightly over three-quarter of the households thought they would be able to save electricity with this additional information, while a little less than two third of the households consuming natural gas judged they can make savings on their gas consumption.

After having received a brief introduction about smart maters two thirds of the respondents to the VREG (2011) questionnaire believe that a smart meter can be helpful in reducing their energy use. People aged below 55 as well as tenants are most convinced of the usefulness of smart meters. A quite striking observation is that those people with prior knowledge about smart meters are more sceptical with respect to the energy saving potential of smart meters.

Within the group of people that believes the use of smart meters might be useful for saving electricity 10% of the people state the use of smart meters could save them up to 7%, 36% beliefs savings between 2 and 5% are feasible, while 32% even thinks to save between 5 and 10% and 9% believes that savings of more than 10% can be realised (VREG, 2011). The expected energy saving potential of smart meters for gas consumption are quite similar: 11% expects to save up to 2%, 36% between 2 and 5%, 21% between 5 and 10% and 12% of the people think savings over 10% will be achieved VREG (2010).

Young people and people with small children are generally more optimistic about the energy saving potential of smart meters (VREG, 2010 and 2011)

Provision of information on actual energy use

The VREG (2011) questionnaire revealed that the most popular channels for receiving feedback on one's energy use is via the internet (57%), as an annex to the invoice (57%) or via the smart meter (44%). A bit more than a quarter of all respondents would like to receive the information via a separate screen on a well-accessible place.

The younger the people the more they like to receive the information via the internet. The same is true for high skilled people. People aged over 55 prefer an annex to their invoice. Also low skilled persons prefer to receive information on paper or via the mobile phone. (VREG, 2011)

The results of the VREG (2010) questionnaire reveal that nearly two third of the respondents likes to receive the feedback in euro's and not in kWh. From the remainder about two third would like to get feedback in euro and one third both in euro and kWh. People that have a higher education and/or earn more generally have a higher preference for receiving feedback in kWh.

Households are mostly interested in comparing their year to year energy consumption. Less than half the households want to be able to compare their energy use to comparable families. Younger people are generally more interested in benchmarking their energy use with families of a comparable size. (VREG, 2010)

Privacy

The VREG (2010) questionnaire revealed that most households (86%) have no problems with the fact that smart meters allow energy companies to track their energy consumption at quasi every moment of the day. People aged over 55 are slightly more concerned about their privacy than younger families. People with the lowest and the highest education are generally more concerned about privacy related issues.

Tariff periods

Smart meter technology allows working with tariff periods. This means that electricity will be cheaper / more expensive at certain parts of the day. Two third of the households stated in the VREG (2011) questionnaire that they would adapt their electricity consumption in order take advantage of the lower electricity tariffs at certain parts of the day. Younger people are much more open of tariff periods than people aged over 55. Also tenants are clearly more in favour of tariff periods than owners.

A bit less than half of the respondents states they might want to buy smart appliances, which can automatically be activated when tariffs are low, after smart meters have been installed. One third is not interested in smart appliance and about 17% even considers buying smart appliances in the near future. People aged over 55 are less interested in buying smart appliances than younger people. (VREG, 2011)

Cut of electricity at peak periods

About 55% of the respondents are against limiting electricity use at peak periods in exchange for a compensation. Tenants are generally less opposed to the idea than owners. People with the highest incomes are significantly more opposed to the idea. Those respondents that find smart meter technology useful are relatively more open to temporary limits in the electricity provision than others. (VREG, 2011)

2.5. INESPO - Architecture evaluation

The previous sections provide first insights on the social acceptability of two of the designed systems (S1 and S2). But other aspects have to be investigated for those systems as well: on the one hand, the potential energy savings, green shifts and CO_2 savings such new instruments could bring and, on the other hand, some elements about their economic aspects.

Obviously, as INESPO is a pioneering project of theoretical elaboration and design of the systems, it is impossible to come up with accurate quantitative figures for any of the here above mentioned points. Further experiments, trials and pilot projects based on the designed systems are needed to assess the potential and costs of those innovative instruments. Besides, the expected results would still be subject to changes, depending on the political will to implement those instruments, and the many governance decisions that need to be taken.

However, the object of the next sections is to come up with first qualitative evaluations on the one hand of the energy saving potential of the designed rewarding and regulatory systems and, on the other hand, of economic aspects. The potential of these systems to promote a green shift (i.e. an increase in the consumption of renewable energy as compared to the use of 'grey energy' from fossil fuel fired or nuclear power plants) is also touched upon. The point of analysis is, again, the household level.

2.5.1. Energy savings, green shifts and CO_2 savings

Research method

The methodology to carry out this task is resting on a three-step process:

- the identification of parameters that enable to differentiate between S1and S2
- the building of a questionnaire on this basis for an online survey (specific groups of respondents)
- the building of a model for S1 and S2

Since the results of modelling S1 and S2 for energy and CO_2 savings are also used for the economic evaluating, the last step of modelling is explained in a separate section, page 81.

Identification of differentiating parameters

The parameters shown in Figure 14 are differentiating S1 and S2 regarding the potential energy and CO2 savings that could be achieved. An important parameter which is outside the boundaries of the system designs is the number of smart meters installed. S1 promotes specifically investments in energy efficiency (although a limited number of them, as defined in the obtaining and using lists). S2 only promotes investments indirectly via the energy targets and the possibility to use the INESPO fund. Both systems are built to promote energy savings obtained through behavioural change, but S1 is working with relative changes in consumption and S2 with absolute energy consumption targets. The timeframe is also different, since targets in S2 are set for a well-defined period (1 year in this design).

	S1	S2
Participation	Voluntary	Regulatory
Roll-out	Open (participants equipped)	Minimum required 80%
Investments in EE	Specific rewards Obtaining list (for a limited number of investments) Using list (for a limited number of investments)	No specification on investments Possibility to use the INESPO fund to recover Euro for investments
Behav. change	Δ consumption	Energy targets
Time frame	Open	1 year

Figure 14: S1-S2 differentiating parameters

The online survey

An online questionnaire has been developed and then carried out to enquire households about their opinion on various characteristics – among which the energy saving potential – of both the rewarding and the regulatory system. In total, 180 completed questionnaires have been received. In order to receive feedback on the systems from a broad spectrum of households – as in the focus groups that were organised for assessing the social acceptability of the systems – specific groups of people were addressed: greens, people with a low income or social tenants, young people, settled people with children and people aged over 55.

For clarity reasons, only the principles of S1 and S2 were exposed in a few lines on the questionnaire, without mentioning concepts like complementary currencies or smart metering for instance. For the same reason, the hybrid system (S3) was not presented in the questionnaire.

In order to try to avoid strategic answers, the questionnaire not only enquired households about the energy saving potential of the key characteristics of both systems, but also about their own preferences for specific features of these systems.

The insights gathered through the questionnaire are also combined with insights from the social acceptability analysis, as the effectiveness of measures of the systems is correlated with their acceptability. The questionnaire consists of a number of key questions about the system, a control question and a number of questions about the socio-economic background of the respondents.

The questionnaire

Key questions about the system relate to:

1. preferences for either a rewarding or a regulatory (energy target based) system;
2. appreciation of the likely effectiveness of either a rewarding or an energy target based system;
3. preferences for either changing behaviour or making energy saving investments;
4. appreciation of the likely effectiveness of changing behaviour or making energy saving investments;
5. preference for the different options on both the obtaining-earning and using lists;
6. likely reaction when they are confronted with a situation in which their allocated energy target turns out to be too limited compared to their regular energy use;
7. appreciation of the different options on the using list versus the possibility to exchange INESPOs for Euros.

Rationale and limitations of the approach

The method chosen allows exploring the energy saving potential of the designed systems as well as the potential of these systems to promote a green shift. Although 180 people completed the online questionnaire the findings are not representative. Most respondents to the questionnaire are male (61%). The age of the respondents varies, but older age groups tend to be overrepresented (11% up to 29 years old; 16% between 30 and 39 years old; 25% between 40 and 54 years old; 21% between 55 and 64 years old; 27% of 65 and older). Most respondents (89%) own the house or apartment they live in, which is higher than average. The monthly disposable household income of the respondents follow the following distribution: 2% up to 999 euro; 25% between 1000 and 1999 euro; 35% between 2000 and 2999 euro; 25% between 3000 and 3999 euro; 13% dispose of 4000 euro or more. Most respondents stated they are (relatively) economical with energy (15% very economical; 32% economical; relatively economical 48%; not economical 5%). To conclude, we like to refer to the fact that a relatively large number of people think the energy efficiency of their dwellings can either not be improved (13%) or only very little (25%).

Also, the answers to the questionnaire do not provide evidence of households' behaviour, but only a statement by household representatives. Moreover, the respondents have not been introduced to the entire systems, but only to their basic characteristics.

Some results are presented in terms of minority/majority views or percentage figures. However, for the reasons mentioned above, caution should be applied in extrapolating the findings.

A few times reference is made to the results from the focus groups. As the collection of ideas on the basis of focus groups is a purely qualitative approach, the resulting insights can only be used as exploratory.

Results from the online survey

As could be expected, the results of Q1 show a marked preference (73.33%) for the rewarding system (S1), although the regulatory-target based system (S2) reaches a surprisingly high score (23.33%) considering its mandatory – tax-like rationale. Only a limited number of respondents (3.33%) had no clear answer on the matter.

Q2 covers the appreciation of the respondent on which system could help public authorities reaching the greatest energy savings for the household sector. Even if a vast majority of respondents' answers (76.66%) indicate they believe those systems will promote energy savings, still 18.89% of the respondents are doubtful about the fact that either system will have a significant impact on households energy consumption. This tends to indicate that respondents are aware of the difficulty of behavioural change.

Amongst those who believe the systems have an impact, the relative percentages between tenants of a rewarding (3/4) and a target-based system (1/4) are more or less maintained. The fact that the majority of the respondents thinks the rewarding system has the greatest potential to realise energy savings is somewhat surprising as, in general, evidence suggests that regulatory (obligatory) systems are more effective than rewarding (voluntary) systems, because of higher participation rates. Evidence is supported by the discussions during the focus groups which indicated that the regulatory system can potentially be very effective in reducing households' energy use. However, the discussions during the focus groups also raised questions about the acceptability of such a regulatory system which could negatively impact the answer related to its perceived effectiveness.

The rewarding system (S1)

With respect to the rewarding system, most households (52%) think that rewarding the investment in energy savings is likely to generate most energy savings, while a smaller percentage of the participating households (43%) believe rewarding energy savings is the more effective strategy. Irrespective of the kind of action/behaviour that is rewarded, a critical issue with respect to the effectiveness of the system is what households actually do with the reward, which is a number of INESPO CC units, they obtain. Do households chose to use this reward for (co-)financing investments in energy savings, energy courses, paying their green electricity bills, etc., or will they exchange the INESPOs they obtained for Euros and thus opt out of the system? A large majority of the households that participated in the questionnaire (84%) indicated they would use the reward to (co-)finance investments in energy savings, energy courses, paying their green electricity bills, etc. About one tenth of the responding households indicated they would either do nothing with the reward they receive (1%) or exit the system and exchange their reward for Euro(s) (9%). The answers to this question indicate that the rewarding system might be effective as the majority of the people choose to use the INESPOs they receive.

The regulatory system (S2)

With respect to the regulatory system, it is key to know that households can consume more energy than the target that is attributed to them. Households that consume more than their target, however, have to pay extra for each unit of energy they consume more. Being asked what they will do when they are informed that they are about to consume more than their target, and that beyond this point each unit of energy will cost more, households stated they will do the following: both invest within one year in energy savings and immediately adapt their energy behaviour (41%), immediately adapt their energy behaviour (40%), invest within one year in energy savings (3%), invest later on in energy savings (5%), nothing and thus pay extra for each unit of energy they consume more than their target (7%). The answers to this question illustrate that households believe the regulatory system will mostly impact their energy behaviour, as well as to a much lower degree, their investment decisions. As only a minority of the people indicate they will not do anything to lower their energy use the system might be potentially effective.

Green shifts

On the basis of the questionnaire it is only possible to extend on the potential of the rewarding system to promote a green shift. In the rewarding system households can obtain a number of INESPOs as a reward, which they can use for (co-)financing investments in energy savings or expenditures that promote a green shift. The latter expenditures can be the payment of green electricity bills as well as the purchase of installations for the generation of green electricity (like photovoltaic installations or heat pumps) and hot water (solar boiler). Households were asked what they would use their INESPOs CC units for. About one third of the households that responded to the questionnaire opted of an option that would support a green shift (payment of green electricity bills (13%), installation of photovoltaic panels (7%) and installation of a solar boiler (10%) rather than for energy saving investments.

With respect to the regulatory system it can be stated that this system is primarily designed to generate energy savings. The system does not provide any specific incentive to switch from the use of 'grey energy' to the use of energy from green or renewable sources.

Limitations of the results

As stated before, what households state they think they will do still does not provide evidence of their actual behaviour. The results should therefore be interpreted with caution. Probably, much depends on the strength of the incentive (value of the reward in the rewarding system) or disincentive (extra cost of a unit of energy for a household that is above target as well as the level of ambition of the target in the regulatory system). Also, the energy saving potential of the systems considered will depend on a number of critical issues that have been identified during the focus group discussions. What information and assistance will be provided to the households with respect to their energy use? Will it be possible to escape from the system or not? Will there be a board that supervises the system and has the capacity to manage the system and adapt the different parameters in order to increase the effectiveness of the system?

2.5.2. Economic evaluation

In order to provide elements on the economic evaluation of S1 and S2, the methodology includes a first step dedicated to the setting up of the systems, and a second step which uses the modelling of S1 and S2:

- setting up of S1 and S2: research of differentiating parameters and elements of costs
- running costs of S1 and S2 (maintenance and specific costs)
- modelling S1 and S2 (jointly with energy and CO_2 savings in page 81)

Elements of cost (including differentiating parameters)

In this part, an initial and general estimate of costs is presented relative to the implementation of the INESPO scheme.

Figure 15 below shows the number of households considered in the cost calculation:

Number of connections/households	4.612.914	hh
Number of connections/households in Flanders	*2.604.786*	*hh*
Number of connections/households in Belgium	*4.612.914*	*hh*
Factor Flanders/Belgium	*1,7709*	

Figure 15: Number of households considered in the cost calculation

The project related costs are divided into several parts. Each part is further detailed below. Some costs only apply to specific implementations of the INESPO system (differentiating parameters), which are marked as such.

- Smart meters
- Back-office
- Front-end
- Daily management
- Set-up & maintenance of S2 household profiles
- Calculating INESPO's
- Validation & anti-fraud
- Privacy measures
- Set-up of terminals & kiosks

Smart meters

In 2008, KEMA made a report for the VREG on the cost-benefits of a smart meter rollout in Flanders. While INESPO merely makes use of a smart meter infrastructure, it is interesting to have an estimate of the total costs involved in such an operation (see Figure 16). The results have been extrapolated to the whole of Belgium based on the number of households.

Installation of smart electricity meters (KEMA)				
DSO	430.770.000	EUR		
DSO	102.170.000	EUR		
DSO	-151.190.000	EUR		
Total for DSO's in Flanders	381.750.000	EUR		
Extrapolation for Belgium	676.055.507	EUR		
			676.055.507	EUR
Installation of smart gas meters (KEMA)				
DSO	309.400.000	EUR		
DSO	65.770.000	EUR		
DSO	-124.670.000	EUR		
Total for DSO's in Flanders	250.500.000	EUR		
Extrapolation for Belgium	443.619.920	EUR		
			443.619.920	EUR
Set-up of data-systems for smart meters				
DSO	360.540.000	EUR		
DSO	-62.680.000	EUR		
Total for DSO's in Flanders	297.860.000	EUR		
Extrapolation for Belgium	527.491.534	EUR		
			527.491.534	EUR
DSO	151.090.000	EUR		
DSO	90.680.000	EUR		
Total for DSO's in Flanders	241.770.000	EUR		
Extrapolation for Belgium	428.159.633	EUR		
			428.159.633	EUR
Total cost of installing smart electricity and gas meters (without indirect benefits)			**2.075.326.594**	**EUR**

Figure 16: Total costs involved in deploying smart meters

The initial set up of the back-office is a crucial task. Apart from buying and setting up server hardware, a database framework will have to be created and its initial structures filled. This has to be right from the start; fundamentally changing it during prime time could be very costly. In both the voluntary and the regulatory system, data from the social security service and suppliers will need to be inserted and updated on a regular basis (see Figure 17). Additionally, a validated and secure market-backend has to be created where the INESPO credits can be traded or bought through payment systems (variant of S2 with "white certificate" tradable market).

We expect this task to take about 220 man-months. Maintenance is taken to be 20% of total initial cost.

Set-up and maintenance of back-office		
Integration of databases federal government		
S1 (No full profiles)	1.000.000	EUR
S2 (Full profiles)	1.500.000	EUR
Set-up of databasesystem	1.000.000	EUR
Development of market-backend (marketplace for INESPOs)		
S1 (No conversion possible)	N/A	
S2 (INESPOs to items)	800.000	EUR
Maintenance percentage	20%	
Maintenance costs		
S1 (Subsidized system)	200.000	EUR
S2 (Regulatory system)	360.000	EUR/jaar

Figure 17: Set-up and maintenance costs of back-office

Front-end set-up and maintenance

The front-end is the part that allows direct interaction with end-users and terminals. The development includes not only the software but also interaction studies and end-user documentation, such as the typical "help" sections (see Figure 18).

Additionally, maintenance includes adding new features, applying fixes and patches and basically ensuring the front-end stays operational.

Set-up and maintenance of front-end		
Development of end-user software		
S1 (Advanced requirements)	1.000.000	EUR
S2 (Simple consultation site for end-users)	100.000	EUR
Maintenance percentage	20%	
Maintenance and upgrading of application software		
S1 (Subsidized system)	200.000	EUR/year
S2 (Regulatory system)	20.000	EUR/year

Figure 18: Set-up and maintenance costs of front-end

Daily management

For a contact point to ask question, report problems or complaints, a continuously operating team is required (see Figure 19). They should be able to quickly intervene and assist in day-to-day affairs. About 5 FTE seems sufficient for this task. Cost of location is not included.

Daily operational management		
Initial organisational set-up	30.000	EUR
Cost of 1 FTE	75.000	EUR/FTE
Number of persons in operational management	5	FTE
Cost of operational management	375.000	EUR/year

Figure 19: Daily operational management costs

Household profiles set-up and maintenance (S2 only)

For S2, initially a set of rules will be applied to the database information on the households participating in INESPO to divide them into the necessary consumption profiles (see Figure 20). For most households, the data imported in the INESPO database will be sufficient to reliably classify them. There will still be a number of cases that need manual intervention, which costs time and thus a lot more money.

Set-up of household profiles (S2 only)		
Automatic generation of a profile	0,1	EUR/hh
Profile generation requiring manual intervention	5	EUR/hh
Part of profiles that can be built automatically	80%	
Total cost of generation of profiles	4.981.947	EUR/year

Maintenance of household profiles (S2 only)		
Part of the profiles that changes during a year	8%	
Total cost of regeneration of profiles due to changes	398.556	EUR/year

Figure 20: Profile-related costs (S2)

Calculating INESPO's

Calculating INESPO's		
Generation and allocation of INESPOs		
S1 (points by consumption and saving measures)	0,005	EUR/hh
S2 (points determined by use of kWh)	0,0025	EUR/hh
Total cost of generation and allocation		
S1 (Subsidized system)	23.065	EUR/time
S2 (Regulatory system)	11.532	EUR/time
Number of re-generations per year		
S1 (Subsidized system)	12	times/year
S2 (Regulatory system)	12	times/year
Additional generation cost per market-transactions (S1 only)	0,00025	EUR/hh*year
Estimated market-transactions (S1 only)	12	trns/hh*year
Total additional costs (S1 only)	13.839	EUR/year
Total INESPO generation cost per year		
S1 (Subsidized system)	290.614	EUR/year
S2 (Regulatory system)	138.387	EUR/year

Figure 21: Costs for calculating INESPOs

Security

Validation and anti-fraud		
Separate validation system		
S1 (market + credit system)	25.000	EUR
S2 (simple points system)	5.000	EUR
Maintenance percentage	20%	
Maintenance cost of validation system		
S1 (Subsidized system)	5.000	EUR/year
S2 (Regulatory system)	1.000	EUR/year

Privacy measures		
Evaluation privacy by external party	50.000	EUR
Number of evaluations per year	2	times/year
Cost for implementing changes to the system	8.000	EUR/time
Total cost of privacy measures	116.000	EUR/year

Figure 22: Security related costs

Terminals and kiosks set-up (S1 only)

Setting up terminals/kiosks (S1 only)		
Cost of hardware/software of a terminal	600	EUR/term
Installation of hardware	30	EUR/install
Number of terminals to install	500	stuks
Total cost of terminals	315.000	EUR
Training installers	2000	EUR/pers
Number of installers	5	persons
Installateurs kosten	250	EUR/install.
Total cost of installers	135.000	EUR

Figure 23: Terminal related costs

2.5.3. Modelling S1 and S2

In the following section, the modelling of S1 and S2 is presented. This modelling is aiming at providing first qualitative evaluations of the two system designs regarding their potential in terms of energy and CO2 savings, as well as in terms of economic evaluation. It is based on a model developed by Klopfert and Joachain, 2012c.

Modelling S1 and S2 is resting on hypothesis regarding external data which are used for both systems (Figure 24). In the model, it is considered that heating comes from gas with an average consumption per household of 25,000 kWh per year. This is a limitation of this model as it supposes that other heating methods (fioul, biomass) can also be monitored through SM-type or related methods which is not the case for the moment.

Hypothesis		
Number of households in Belgium	4,612,914	
Average electricity consuption	3,500	kWh élec
Average gaz consuption	25,000	kWh gas
Electricity to primary energy factor	2.5	
Gas to primary energy factor	1.1	
CO2 saving per kWh elec	456.0	gr / kWh
CO2 saving per kWh gas	251.0	gr / kWh
End-user price electricity	0.17	€ / kWh
End-user price gas	0.05	€ / kWh
Installed SM at INESPO roll-out	80%	
Installation rate of SM	5%	
Value of CO2	10	€ / ton

Figure 24: External data

If further quantitative research were to be drawn from those models, this would imply, in the first place, to validate the hypothesis and figures adopted in the models.

Figure 25 shows how the participation rates vary in S1 and S2 in function of the reward rate for S1 and the penalty rate for S2 according to the hypotheses of the model.

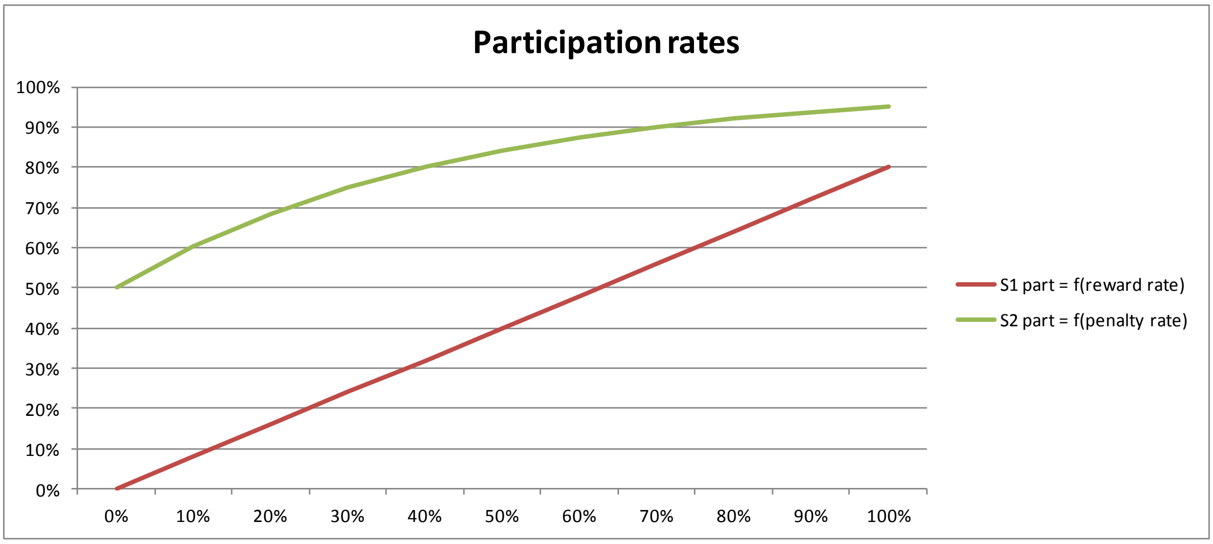

Figure 25: Participation rates for various rewarding (S1) and penalty (S2) rates

Results of modelling S1

A summary of the result obtained by this modelling of S1 for households is provided in Figure 26.

The costs for the public authorities are estimated based on the costs for the INESPO S1 system (set-up, maintenance and cost per household for rewarding system). On top of those costs are the costs of rewarding households. The benefits from CO2 savings are attributed to public authorities.

S1 System			
Parameters			
SM Deployment	80%		
Rewarding budget rate	10%		
Saving factor relative to reference	100%		
Reference electricity savings	1.25%	see Impact S1	
Reference gas savings	6.39%	see Impact S1	
Summary			
Electricity saving	1.19%	12.30	GWh
Gas saving	6.07%	448	GWh
Primary energy savings		523	GWh
CO2 savings		0.12	Mt
Cost of system for government (€/year)		4,668,477	€
Costs for participating households		15,278,065	€
Total costs of the system		19,946,541	€

Figure 26: Evaluation of costs and savings of S1 system

Results of modelling S2

For the modelling of S2, all calculation are computed on yearly costs taking into account an amortisation period. This implies that financial barriers and cash-flows problems are not taken into account in this model.

A summary of the result obtained by this modelling of S2 for households is provided in Figure 27.

The costs for the public authorities are estimated based on the costs for the INESPO S2 system (set-up, maintenance and cost per household for regulatory system). The 10% tax on the penalties as well as the benefits from CO2 savings are attributed to public authorities.

S2 System			
Parameters			
SM Deployment	80%		
Imputation of SM cost on INESPO	100%		
Penalty (Obliged contribution to fund)	0.10	€/kWhp	
Penalty rate	50%		
Effective penalty	0.05	€/kWhp	
Tax on fund	10%		
Target factor relative to reference	100%		
Target electricity savings	1.25%		
Target gas savings	6.39%		
Summary			
Electricity saving	1.15%	125.3	GWh
Gas saving	5.45%	4,232	GWh
Primary energy savings		4,968	GWh
CO2 savings		1.12	Mt
Cost of system for government (€/year)		11,349,832	€
Costs for participating households		-63,732,302	€
Total costs of the system		-52,382,470	€

Figure 27: Evaluation of costs and savings of S2 system

Conclusions:

Participation and energy savings

The participation rate is a crucial parameter of the model. In the first place, it impacts dramatically the estimation of the total energy and CO_2 savings that can be delivered by S1 and S2 respectively.

In the model, the participation rate (P) is a function of respectively:

- S1: Participation =f(reward rate)
- S2: Participation =f(penalty rate)

The shape and hypothesis chosen for the functions reflects the fact that:

- Only a limited percentage of the population participate to voluntary systems (S1)
- Only a limited percentage of the population is not willing to comply with the regulation, and this percentage falls when the penalty increases (S2).

As expected with using a rewarding vs. regulatory architecture, the estimated participation rate is much lower for S1 compared to S2.

It follows that, even if the realisation of the savings (R) per household is slightly higher in S1, the total savings generated by S2 in the model is of another order of magnitude (ten times higher) than those enabled by S1. This is also shown in the potential CO_2 savings which are also estimated about ten times higher in S2 than in S1. Those results reflect the fact that households actively participating in S1 might be considered as having a higher success factor in the realization of their savings; however, this is completely offset at the global level of the system by the difference in participating rate (P) between S1 and S2.

In the model run for S1, the value chosen for the rewarding rate is 10% of the total investment budget, which leads to a participation rate (P) of 5%. Those figures, which seem realistic for a system based on voluntary participation, can be modified to check the implications this has on the global energy savings and costs of S1.

It is however very unlikely for the participation rate (P) of S1 to come close to the 80% participation rate (P) which is estimated for the regulatory system S2. Indeed, according to the hypothesis of the model for S1, an extravagant 100% rewarding rate would be necessary to reach such a participation rate (P= 80%), which is not realistic and would lead to rocketing costs (households / public authorities) of S1. It seems thus not realistic for S1 to be able to deliver the same global energy and CO2 savings as S2. Figure 28 shows how those costs for S1 rise when trying to achieve higher savings with S1.

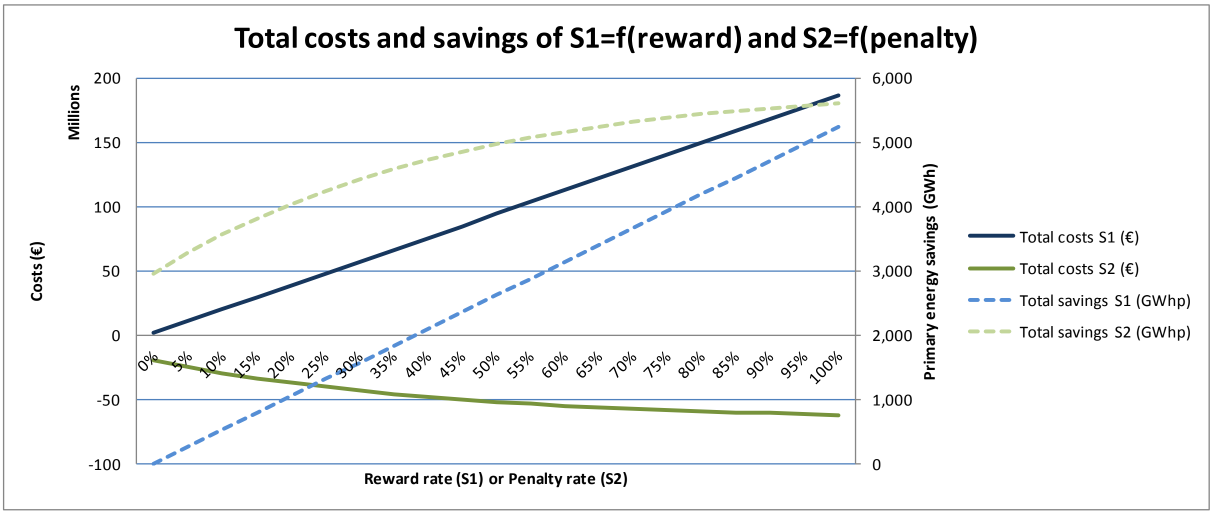

Figure 28: Costs and savings of S1 and S2 as a function of the rewarding and penalty rates

Investments in energy efficiency and behavioural changes

As the online survey shows (page 73), S1 seems to be promoting more investments in energy efficiency and S2 more behavioural changes. Since this involves more investments in the case of S1, it results in higher estimated costs for households to achieve energy savings in S1 than in S2.

The potential secondary effects, such as an increase of economic activity are not considered in the model.

The rewarding rate applied in S1 influences the total budget for both households and public authorities in opposite ways: the higher this rate is, the best it is for households and conversely. In the model for S1 a value of 10% has been given to the rewarding rate, which seems a rather generous hypothesis. However, this 10% rewarding rate does not allow compensating the higher costs for the households in S1 compared to S2. Indeed, a 50% rewarding rate would have to be applied for the costs of the households to be more or less equivalent for the two systems. Once again, applying such a rewarding rate is not realistic and would very much inflate the budget of public authorities.

For the system S2, the penalty is a very important parameter which influences both the participation rate and the results of the economic evaluation. In the model, a penalty of 0.05

€ per kWhp above target is applied. This would be roughly equivalent to the price of a kWh gas and means that households which have consumed more energy than their targets would have to pay a penalty roughly equivalent to the price of 1 kWh gas per kWh primary energy above their target. The average cost of this penalty estimated in the model is 13.34 € per household. Of course, it has to be taken into account that only those who fail their target would have to pay, which concentrates the penalty on fewer households. However, in S2, penalties are kept in an INESPO fund and households can later recuperate part of it provided they do investments in energy efficiency. This could thus constitute a sort of forced saving fund for those households that consume more than their targets with an important motivation to recuperate their euro through investments. The average cost of penalty would then only be around 6.65 € per household. This INESPO fund would also strongly reinforce the potential of S2 to promote investments in a medium term.

Free-riding, shifts of consumption and coherence

It can also be argued that S1 could be used for free-riding by households which planned to do the investments anyway. This could be tempered with the using list of S1, if the CC units obtained by participating households can only be used for further investments in energy efficiency. However, as explained in section 2.3.1, the using list has to be sufficiently attractive for households to get on board the system. A trade-off has thus to be made between staying in line with the energy saving objectives of the system on the one hand; and offering a rewarding system attractive enough for households to participate on the other hand. If it becomes possible for households to use their CC units to pay their green electricity bills, for instance, this could be a very powerful incentive for households to participate but it could also lead to increased free-riding.

Regarding S2, it can be argued that targets set for households could lead to a risk of energy consumption shifts to other sectors (e.g. systematically showering at the sports club, etc.). Further research would have to investigate, however, to which extent such a consumption shift is conceivable and practicable for households, how many of them would be ready to change their practices accordingly and which influence it would have on consumption. Another potential risk of S2 is that households switch to other types of energy sources than electricity and gas to escape the system (e.g. wood pellets, coal, etc.). The only way to limit those shifts is to develop mechanisms to monitor those energy sources as well.

Regarding the coherence of the actions taken by households to lower their energy consumption, it can be argued that the obtaining-earning list in S1 is a generic list which does not provide indication to households on what is the most relevant in their specific case. This could lead to incoherence in energy saving investment strategies (e.g. replacing boiler before isolating the envelope of the building), which can be inefficient in a number of cases.

In S2, since there is a form of obligation of result, the actions taken might be more tailored to the needs of each household.

Costs / benefits of the S1 and S2 systems for public authorities

The costs for public authorities cover the setting up and the maintenance of the systems themselves as well as the costs / benefits due to running of the systems (reward and penalty).

Regarding the costs related to the setting up and maintenance of the systems, the estimated costs on a period of 10 years are much higher for S2 than S1, due to the extra cost in S2 of taking households' profiles into account. However, the costs / benefits estimated for the running of the system completely offset this trend. Indeed, for S1, even if the costs due to setting up and maintenance are considerably lower than in S2, the budget needed for rewarding the households brings the global budget in deficit.

Regarding S2, even if the costs related to the setting up and maintenance are much higher, the benefits from the 10% tax rate on penalty nearly brings the system back to an economic equilibrium.

The economic value of the CO2 savings is attributed to public authorities in the model. This does not compensate for the costs of S1, which does still depend on public funding. But it reinforces Regarding S2 in its economic sustainability. However, the hypothesis of a 100% attribution of CO2 savings to public authorities should be refined in further research.

Figure 28 shows how the total costs of S1 and S2 evolve when the rewarding (for S1) or the penalty (for S2) rates increase from 0% to 100%. The graph also shows how the total savings increase for S1 and S2 together with increasing rewarding / penalty rates. As previously argued, very high rewarding rates (40%-50%) for S1 are necessary before total energy savings obtained by S1 come near those of S2. The effect of those very high rewarding rates on the costs of S1 for public authorities is also shown in the graph with rocketing public budgets. In the model presented for S1, a more realistic rewarding rate of 10% is adopted, which leads to a total of 327 GWh primary energy savings and a cost for the public authorities around 3.5 million euro per year. The cost per participating household (taking into account the benefits they have from the rewarding, as well as the economic value of their energy savings in electricity and gas) is around 120 € per year.

In the S1 model, the estimated reference rate for the savings realised by households are based on the energy saving potential and the results of the online survey relative to the investment proposed in the obtaining-earning list and behavioural change. However, it is possible to take those realised energy savings per household as a variable of the system as shown in Figure 29. It could indeed be argued that the rewarding system S1 is most appealing to the households which have done the least efforts in the past and have high energy consumptions. The energy saving rate for those specific households could thus be higher than the average 1.19% and 6.07% used in the model for S1. In Figure 29, the x-axis shows the multiplying factor for the estimated reference rate of realized savings (saving factor). The y-axis shows the increase in costs for public authorities. However, the highest values of realised savings are unrealistic, even for those households with the highest potential. Besides, costs for public authorities also become prohibitive.

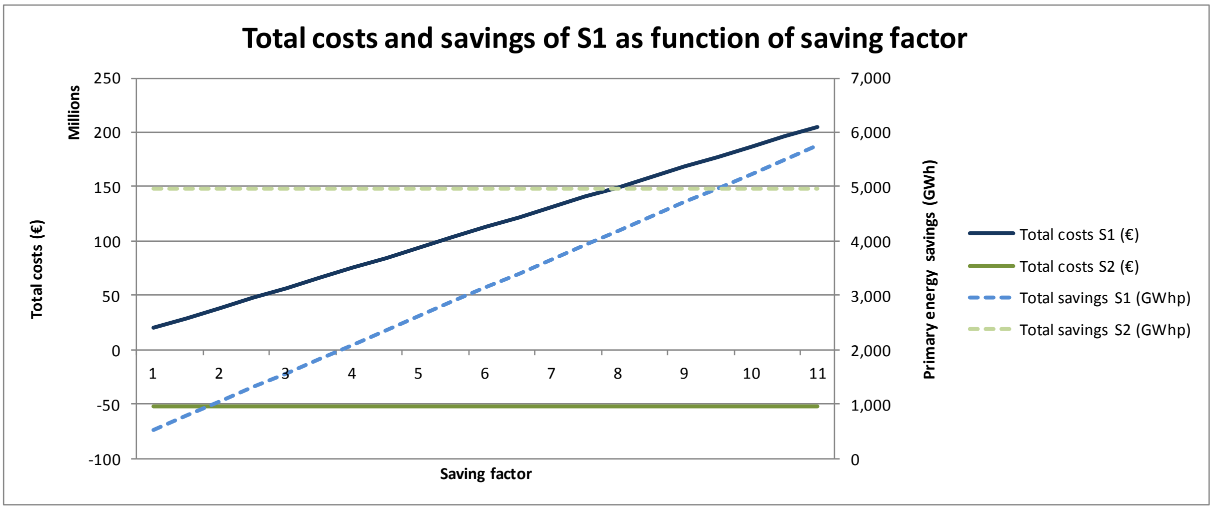

Figure 29: Costs and savings of S1 as function of a multiplying factor

In the S2 model, the penalty rate considered in Figure 28 is comprised between 0% and 100% of a basic penalty of 0.10 € per kWhp which is equivalent to two times the price of a kWh gas. Figure 28 shows how total savings for S2 increase with higher penalties while the total benefits of the system for public authorities increase accordingly. This can be seen as a new form of tax on energy. In the modelling of S2, a 50% rate was applied which leads to a penalty of 0.05€ per kWhp for energy consumption above target.

Smart meter deployment

The modelling of S1 and S2 which is presented in the previous paragraphs tends to show that S2 is a much more efficient system both regarding energy / CO2 savings and economic aspects. This is mostly to be explained by the much higher participation rate that is expected in S2 compared to S1. Besides, S2 seems to be promoting behavioural changes more which lead to lower costs for households to achieve energy savings. Finally, the penalty applied in S2 brings the system to an economic equilibrium.

As shown in Figure 28 and Figure 29 with total savings and costs are estimated in function of the rewarding rate and saving factor, this gap between S1 and S2 is not likely to be overcome. However those modelling are based on the hypothesis of 80% smart meter deployment prior to INESPO. Although for S1, this hypothesis is not critical, S2 cannot be implemented otherwise. Figure 30 shows the total costs of S1 and S2 when the extra costs of installing smart meters in all households are allocated to S2 (only). For S2, a theoretical rate of 100% of installed smart meter for electricity and gas is considered, and the costs have been calculated accordingly. For S1, only the costs of the extra percentage of smart meter installed have been taken into account. As can be seen, an installation rate of around 50% marks the limit where S2 becomes more interesting on the basis of the total costs of the systems.

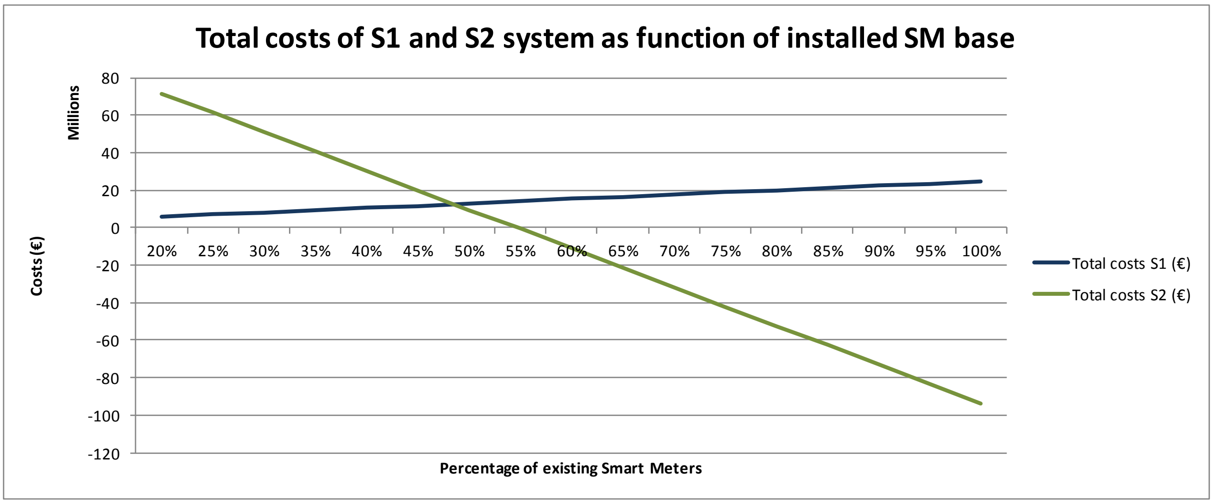

Figure 30: Costs of S1 and S2 taking into account a partial deployment of Smart Meters

2.6. Position Paper

As the INESPO project is exploring the possibility to design new instruments to motivate households for energy savings, the smart meter roll-out is becoming a subject of burning actuality. Indeed, the deadline of 3 September 2012 when Member States have to deliver their cost-benefits analysis on smart meter roll-out is coming closer. Discussions regarding technological, legal and cost-bearing aspects of the roll-out (as well as how and when to do it) mobilize different stakeholders and points of views. But INESPO is focusing on another aspect which is under researched: how could a SM roll-out also be used to motivate households for energy savings? It was strongly felt during follow-up committee meetings that INESPO brings new arguments to the debate about SM roll-out that should be known to decision-makers in this field. It was therefore decided to produce a Position Paper (new Task 5.0 added to the initial planning). This Position Paper, which is presented in the next section, is dedicated to policy-makers and stakeholders involved in the discussions around the smart meter roll-out. It was presented during an extended follow-up committee meeting of the INESPO project.

Adding motivation to smart metering technology: the Innovative Instruments for Energy Saving Policies project

On June 14th, the European Parliament and the Council have reached a compromise on a proposal for a Directive on Energy Efficiency that would repeal Directives 2004/8/EC and 2006/32/EC. This text shows that the issues of informing and empowering consumers regarding their energy use has come up the policy agenda:

> "Member States shall take appropriate measures to promote and facilitate an efficient use of energy by small energy customers, including domestic customers. These measures may be part of a national strategy. (…) (T)hese measures shall include one or more of the elements listed below:
>
> (a) a range of instruments and policies to promote behavioural change" (Art. 8a)

The question of motivating households for energy savings is at the heart of the Innovative Instruments for Energy Saving Policies (INESPO) research project funded by Belgian Science Policy that started in 2010. This project is willing to give more attention to users of SM, especially to their behaviours and motivation for energy savings, an aspect that is insufficiently tackled when the focus in primarily on technological, legal and cost-bearing aspects of the SM roll-out.

Indeed, energy savings is one of the few positive consequences that a user might expect from the replacement of his old analogue meter by a SM. But, as research confirms, it is far from obvious that placing a SM will lead to any saving at all, if users are not motivated. The INESPO project is precisely aiming at coming up with innovative ideas to motivate users for energy savings, should a significant roll-out occur.

The research carried out in the INESPO project focuses on the innovative concept of coupling non-financial incentives to smart meters in order to increase motivation for behavioural changes towards energy savings. At the core of the project is the **design of system architectures** that integrate non-financial incentives and smart meters, as well as the **technical feasibility** and **social acceptability** of the designed systems.

This Position Paper results from the research carried out in the INESPO project and summarizes the starting points, as well as the recommendations that stems from it.

2.6.1. Context

Smart Meters roll-out: a rapidly evolving context in the EU

Back in 2006, the Energy Service Directive (2006/32/CE) stated that "(b)illing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption". At that time, the expectations for energy savings that users could make due to smart meters were rather optimistic. In case of direct feedback to the users, those savings were even estimated around 5-15% (Darby, 2006). A few years later, it was requested by the 3rd Energy Package (Directive 2009/72/CE) that Member States make a cost-benefit analysis for the deployment of smart meters, with the obligation of a 80% roll-out in case of a positive result.

But the context around smart meters is rapidly evolving in the EU. Cost-benefit analysis (CBA) performed by Member States are not all positive (e.g. PWC, 2012 for Brussels Region, which makes Belgium's final position unclear). Besides, consumer opposition to smart meters has also risen in some countries (e.g. The Netherlands).

Billing, direct feed-back and motivation

The context has also evolved around what could be expected from the smart meter technology in terms of energy savings for households.

If the added-value of the smart meter for the customer is limited to obtaining frequent enough billing on the basis of actual consumption, there is not much in recent studies to be optimistic on the energy savings potential for households. A next step is then to provide direct feed-back to customers via an in-house display. However, even in the case of direct feed-back, recent studies show modest energy-saving potential (see EDRP, 2011 in Klopfert and Wallenborn, 2011) and even sometimes forms of lock-in once some energy savings have been achieved (Hargreaves et al., 2010).

The INESPO project builds on the conviction that users' motivation deserves more attention than is currently bestowed to it. Indeed, recent studies show growing evidence that a SM deployment without informing and motivating users has but little potential for behavioural changes. Through the systems designed in the INESPO project, public authorities could find a proper channel to add information and motivation to the smart meter technology. In this sense, if and when a SM roll-out occurs, it should be seen by public authorities also as an opportunity not to be missed to care for information and motivation of users.

2.6.2. The INESPO project

At the time the INESPO project was conceived, the discussions around smart meters were essentially technology-driven and there were important forces at play for a massive deployment of smart meters in the EU. Focusing more on the human beings behind the smart meter technology was a first objective of the INESPO project. Besides, as the literature review showed that the link between smart meters and energy savings for households was not undisputable, it became more and more obvious that there was a gap on the issue of motivating households for energy savings in the researches carried out around smart meters. The INESPO project is seeking innovative instruments to fill in this gap by adding incentives to the smart meter technology.

The INESPO project has led to the design of three instruments to motivate households for energy savings. The designed systems are based on the innovative idea of coupling a non-financial incentive (complementary currencies) to smart meters. A variant with a market based financial incentive (white certificates) has also been explored.

Those instruments can adapt to different types of roll-outs but require some common standards regarding connectivity and modularity of smart meters. The objective of this Position Paper is to inform policy-makers about the new instruments designed in the INESPO project and the technical requirements developing this type of instruments involves. It is important that the new elements brought by the INESPO project are taken into account before decisions are made for the roll-out of smart meters. Indeed, those technical requirements have to be taken into account before the roll-out takes place and, since technology choices once deployed are not easily bent, this is an opportunity not to be missed.

INESPO in a nutshell

The INESPO project is seeking to design new instruments to motivate households in order to achieve significant energy savings

The new instruments are based on the innovative idea of coupling a non-financial incentive (complementary currencies) to smart meter. A variant with a market-based financial incentive (white certificates) has also been investigated.

Three system designs were developed that can adapt to different roll-out schemes

Minimum technical requirements should be defined before roll-out to avoid missing the opportunity

2.6.3. Starting Point of the Position Paper

Smart meters roll-out

The context around smart meters has evolved in Belgium. Questions have arisen on whether or not a roll-out will take place in Belgium, and on the form it should eventually take. Answering those questions is beyond the scope of the INESPO study. However, the starting point of this position paper is that a smart meter roll-out is likely to occur anyway. Indeed, in case of negative cost-benefit analysis (Belgium would then not be bound to equip 80% of consumers with smart meters), the roll-out of SM could then be driven by other forces, such as a pull-effect due to smart-grid management, or should a legal obligation for monthly billing on basis of actual consumption be decided, or via a push from the SM industry for instance.

According to the analysis of the forces at play, it seems thus likely that, whether through the Directive or else, the SM technology will enter households in a medium term. A major difference is that:

- in case of a positive CBA, the Directive states that "at least 80% of consumers should be equipped with intelligent metering systems by 2020."
- in case of a negative cost-benefit analysis, there is no clear view on the timing and mode of roll-out.

Irrespective of the way a potential roll-out takes place, there are still key questions to be answered including the question of what will be foreseen as feed-back system, for instance.

Defining functionalities of smart meters

Functionalities of smart meters must be defined taking into account multiple interests. As developed in Klopfert and Wallenborn (2011, p. 11 and 12), mostly feed-back and energy services are important for household energy savings, whereas from the smart grid point of view, data collection and remote control of some appliances are key. From the third point of view, which is represented by 'the market' in Figure 31, the main interests are towards reducing fraud and unpaid invoices as well as eventually using load profiles to propose new tariff schemes.

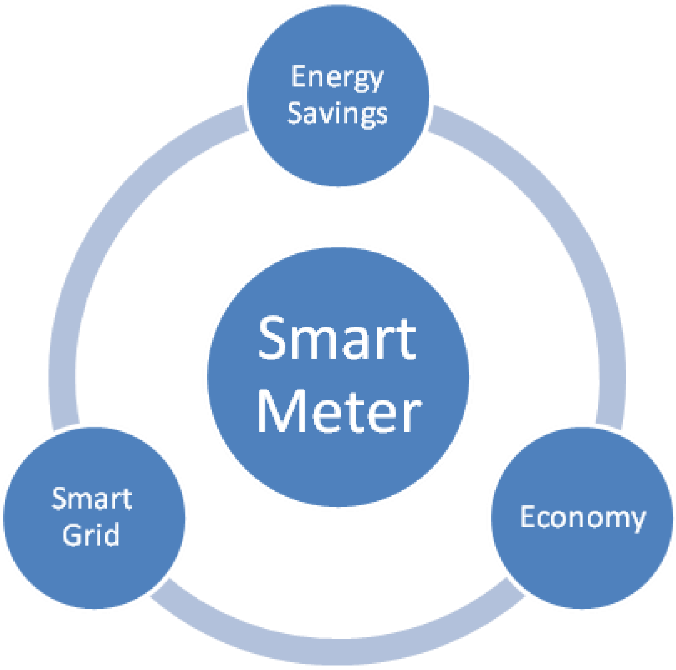

Figure 31: Three different view of a smart meter

How those interests can converge is a complex issue, but as the authors argue, this issue is currently mostly left "in the hands of the techno-economical actors, with an underrepresentation of consumers and of "energy savings" as a main objective" (Klopfert and Wallenborn, 2011, p. 12).

Energy saving potential of smart meters

Studies have aimed at defining the energy saving potential of smart meter technology for households. A first prerequisite is to draw a clear line between the effects for households of just replacing an old analogic meter by a smart meter which enables more regular billing on the basis of actual consumption, and the effects of adding devices and services to smart meters, such as in house displays for feed-back or tips for lowering energy consumption. This difference is reflected in studies under the form of indirect and direct feed-back. Figures between 0-10% were usually given for indirect feedback and 5-15% for direct feed-back (see, for instance, Darby, 2006).

However in recent studies the potential is more limited and seems to reach a ceiling of 4%, even when accurate billing plus in house display plus energy efficiency advices are used (see EDRP, 2011 for instance in Klopfert and Wallenborn, 2011). In the study carried out for Brussels Environment by PWC (2012), figures around 1.5% energy savings for households are considered. Klopfert and Wallenborn (2011) set forth several reasons to explain why results may vary regarding the energy saving potential of smart meters. Those include the important role of motivation (selection of samples, Hawthorne effect, etc.). Most interestingly, in the only study where households were not informed about the experiment going on, the replacement of the old meter by a smart meter did not impact their consumption (EDRP, 2011). Motivation, as well as capability seems thus to play a key role in empowering households to make energy savings

Adding non-financial incentives (complementary currencies) to smart meters

To increase household motivation, innovative policy instruments are designed in the INESPO project by adding non-financial incentives (complementary currencies) to smart meters. This is building on the emerging trend to use complementary currencies as policy instruments for sustainability (see, for instance projects such as E-portemonnee, Torekes or the former NU-Spaarpas project). Considering the fact that those projects have not been designed for research (for instance, there is no zero time evaluation, neither control groups) it is difficult to draw scientific evidence on their impact on behaviours at this point. If one turns to research on commercial loyalty schemes, which have some common features with the considered CC schemes regarding the system used, there are mixed reports in the literature regarding their effectiveness on consumer loyalty (see, for instance, Reinartz and Kumar, 2002; Noordhoff et al., 2004; Demoulin and Zidda, 2008; Smith and Sparks, 2009). Further researches are thus necessary to address this question. However, thousands of companies around the world are carrying on with loyalty schemes that reward millions of customers. It can thus be argued that there are at least some success indicators for this kind of systems.

Although there is still room for research regarding the impact of complementary currencies on behaviours, the nature of those instruments provide indications on the added-value they can bring.

Indeed, if designed properly, complementary currencies should have the potential to:

- Sustain behavioural change over time thanks to the potential of complementary currencies systems to repetitively remind and motivate participants over time
- Reduce the rebound effect by choosing adequately the using of the complementary currencies obtained
- Be cost-effective compared to direct subsidies for instance due to the fact that each Euro invested in the scheme can serve to promote at least two sustainable behaviours (obtaining and using). Besides, a leakage effect (i.e. participants not using some CC units they have earned) is commonly observed in complementary currency schemes.

More specifically regarding the coupling of complementary currencies and smart meters

- The systems integrating complementary currencies and smart meters that are designed in the INESPO project are adapted to different roll-out schemes (for instance, systems based on rewarding could be more interesting if a niche of households with about average consumption is targeted).
- The systems designed in the INESPO project are (apart from the one with a marked-based system of white certificates) isolated from the financial systems.
- The taxonomy developed in the INESPO project shows that there are many parameters on which public authorities can play so that the resulting instruments reflect their choices in terms of energy policy for the household sector.

Technical requirements

Systems including feedback and incentives such as the ones developed in the INESPO research project involve some technical requirements. Indeed, high quality measurements are necessary for such system to deliver reliable information to the households. Various and evolving feedback devices should be foreseen in order to take advantage of the future development in this domain. Besides, potentially high data rates are necessary.

Since the future is unknown (including its technological and behavioural dimensions), it is necessary to avoid situation of potential lock-in by caring for the access to data of consumers. Modularity as well as open standards should be preferred, in order for the future developments to be integrated. Besides, as emerging energy services provide added-value to households, their development should be eased by technological choices made for the smart meter infrastructure.

2.6.4. Recommendations

Smart Meter roll-out should include:

- Free accessible communication port for in-house use
- Consumption data that can be managed by the consumer independently of the SM-DSO connection
- Optional feed-back systems (displays, websites, etc.)
- Optional transfer of data to chosen third-party (ESCos, energy services such as the ones that could be built around the INESPO concept, etc.)

Minimum requirements for in-house connectivity should be defined prior to the roll-out

This includes the question of who can define connectivity standards

At least the following elements have to be taken into consideration:

- Stakeholders
- Legal constraints
- Owner of the connection
- Selection of standards
- Physical aspects (cable, connector, protocol, etc.)

Trials should be performed to validate the new CC-SM instrument

CC architecture should be defined according to the selected deployment scheme

This includes the question of the governance of a CC architecture

At least the following elements have to be taken into consideration

- Developing of an appropriate scheme
- Interest of stakeholders
- Privacy / Legal
- Rewarding vs. Regulatory

2.7. Further policy recommendations and conclusions

The INESPO project is pioneering the innovative idea of using the smart meter infrastructure to motivate households for energy savings through the adding of an incentive scheme. This incentive scheme is based on complementary currencies, with a variant of "white certificates for households. In this early stage of research the INESPO project is exploring possible system designs for the coupling of complementary currencies and smart meters.

Considering the exploratory nature of the research carried out in the INESPO project, further research are absolutely necessary before policy instruments can be built from the designs developed in the project. Amongst others, the legal and privacy aspects should be investigated, which have not been covered in the INESPO project:

Besides, further studies on the aspects linked to stakeholders, governance and social acceptability are equally necessary.

Bearing those limitations in mind, the INESPO project has nevertheless contributed to filling a gap in the researches carried out on smart meters regarding the issue of motivating households for energy savings. Indeed, at the core of the INESPO project is the design (including the technical aspects) of system architectures that integrate complementary currencies or "white certificates for households" and smart meters. The research carried out in the project results in two system designs that lay the foundation for using complementary currencies as a non-financial incentive for energy savings in the household sector (with a marked-based variant). Those systems are intended to be used and financed by public authorities.

2.7.1. System designs

A major step stone in the design of the systems is the taxonomy of constitutive parameters which is developed in the project. This taxonomy allows reducing the complexity of the systems and is the key element on which the systems are designed and later evaluated.

The work carried out in the taxonomy sheds light on the importance of the choice of the model in the design phase. Indeed, the research on the possible rationale for the models shows a polarity between a rewarding and a regulatory architecture. This polarity is used as a fundamental distinction between the two systems designed in the INESPO project.

System design 1 (S1) based on a rewarding architecture

In S1, households participate to the system on a voluntary basis and are "rewarded" by public authorities for their energy savings. This occurs in two major ways:

- Households can obtain CC units through their ***relative consumption reduction*** over a given period of time (Δ in consumption)
- Households can obtain CC units for some specific actions related to increasing a dwellings' energy performance, buying basic energy efficient appliances / products, energy audit, maintenance, as well as energy education.

How households can be using their CC units is a key parameter to bring participants on board in a rewarding system. Therefore, on top of using their CC units for further investments in all the actions that allows them to obtain CC units, extra possibilities have been foreseen to make the system more attractive. Those possibilities to be explored comprise paying green electricity bills or converting into CC units from other existing systems that have compatible objectives (provided agreements are concluded with suppliers / governance of other CC systems).

System design 2 (S2) based on a regulatory architecture

Using a ***regulatory*** model is an option which has not been implemented yet but has been proposed for other CC systems. This type of model is radically different as it based on mandatory participation and the willingness to comply with regulations put in place by public authorities. Such a ***regulatory*** system allows working on the ***total energy consumption*** and setting ***targets*** for household energy consumption.

In the architecture of S2, the system is based on a model with mandatory participation of every household. S2 is based on energy targets which are calculated for households taking some elements of their profile into account. Each household obtains a number of CC units that corresponds to its energy targets.

As a household consumes energy, it also uses CC units accordingly. At the end of the period for which the target was set, a given household energy consumption can

- meet their energy target: all CC units have been used
- be more than their energy target: they are is a shortage of CC units
- be less than their energy target: they have remaining CC units

The price paid for energy itself remains unaffected in the INESPO S2 system and since the target is given in CC units, it does not physically limit the energy consumption as a quota would do. However, the fact that households earn or pay some extra Euros for CC units according to their consumption has a global effect on their budget for energy consumption.

Technical aspects

Regarding technical options for the smart meters, two options were considered:

- a base scenario where neither the metering infrastructure nor the meter itself can be accessed directly by the INESPO system. It provides remote reading of the measurement indexes without any further processing.
- an advanced scenario where smart meters can be extended to incorporate INESPO specific functions. It foresees in-home displays, recharging/redeeming at home, driven by an extendable smart meter platform.

The research carried out on the use cases mainly comprises consumer as well as back-office use cases. First insights for the underlying database are derived from those use-cases. Besides, architecture outlines are also developed for the base and the advanced scenarios.

Possible bottlenecks

If a central back-office is used in the INESPO system, the following bottlenecks would require special attention:

- Computation of CCs
- User statistics
- Transaction management (buying/selling)

The front-end can play a major role in the offloading of the back-office because it is in an ideal position to act as both a caching and load-balancing system. More on this subject is found in the next section on scalability considerations.

Scalability considerations

Because the INESPO architecture potentially has to serve millions of users, scalability is a major concern. But just as in any other high availability business application, two methods can be used to increase the service capacity: scaling up (adding more resources to a system, such as more memory, disks or CPUs) and scaling out (adding more computer systems).

Furthermore, several general design considerations can be taken into account when a more concrete implementation is built, such as splitting, service-oriented architecture or functional partitioning, or asynchronous handling of requests).

Social acceptability

The focus groups provide insights on the social acceptability of the designed systems (S1 and S2). As could be expected, the rewarding system (S1) is preferred to the regulatory system (S2). Besides, participants in general are very favourable to the idea of using complementary currencies as non-financial incentives. The concern about the system being unfair to the households which have made the most effort to reduce their energy consumption which is inherent to the S1 system is spotted by the participants, as well as the owner / renter issue.

Regarding the system design S2, as could be expected, it is only favoured by a minority of participants. However, it is generally conceived as a potentially very effective system to reduce households' energy consumption. In fact, when asked about the readiness of people to adopt this kind of systems, concerns raise especially for the short and the medium term. It is considered that, if announced in time and backed by sufficient transitional measures, the core of the system is generally valuable in the long run. Complementary concerns rejoin those described in the system designed, such as complexity or fairness of this system, and the possibility to escape the system by switching to other type of energy sources (wood pellets, coal, etc.).

2.7.2. Further policy recommendations

The research carried out regarding the technical aspects and the social acceptability of the designed systems (S1 and S2) does not seem to raise any insurmountable issue. Those systems seem thus to be workable. However, it is important to understand the strengths and weaknesses of those systems which are inherent to their design.

Strengths - weaknesses and recommendations– S1

Strengths:

- S1 has the potential to promote energy savings among those who are consuming the most, and have made little to no effort yet to reduce their consumption. Indeed, it will be easiest for them to make the necessary investments and be rewarded by the system.
- S1 is more attractive (rewarding) and socially acceptable (voluntary participation).
- In its mechanism, S1 is close to a subsidy, although in CC.
- Through the obtaining-earning and using lists, S1 allows for public authorities to focus on specific aspects of their energy saving policies.

Weaknesses:

- This system over-rewards households which are consuming the most and have made no efforts yet to reduce their consumption. On the contrary, households which have already made all necessary investments and efforts to change their behaviours are penalised. Indeed, it is more difficult for those who have already made the necessary investments to continue reducing their energy consumption. In this sense, this system can be seen as over-rewarding those who have made the least efforts yet and penalising those who have made the most efforts towards reducing their energy consumption.
- Because S1 is based on a voluntary participation, its impact is reduced in comparison to a regulatory system.

- This system needs public subsidies to function. It is not self-sustaining, and is costly to public authorities
- This system has a tendency to “kill itself over time”. Indeed, as households perform the actions that the system promotes, they have less and less opportunity to earn CC units over time.

Recommendations S1

The attractivity of the using list is the key mechanism to bring households on board the S1 system. It is thus recommended to enlarge the using list compared to the obtaining-earning list by including some extra items. However, special attention must be given to the consistency of the system which should be kept in line with its energy saving objectives. It is thus necessary to make a sort of trade-off between attractivity and consistency. The proposed ideas to be explored for enlarging the using list of S1 are the following: paying green electricity bills or converting into CC units from other existing systems with compatible objectives (provided proper agreements and infrastructure are put in place).

Regarding the “over-rewarding” of households which have made the least efforts yet, it was purposely decided to use the polarity rewarding – regulatory to design the systems. This implies that the logic of S1 was pushed to its extreme without trying to fix its weaknesses, as was also done for S2. However, if a policy instrument inspired by S1 was to be developed, two options seem possible:

- Selecting as the target of the system the households with high energy consumption which have done the least efforts yet. This could be based on the rationale of using such a (costly) rewarding system to promote energy savings in the segment of households with the most energy saving potential.
- Introducing some mechanisms of profile computation and capping for the initial energy consumption on which the Δ in consumption is calculated.

Strengths, weaknesses and recommendations - S2

Strengths

- Every household has to participate to the system
- Targets can be set for energy consumption (energy policy)
- Financial sustainability of the system (once installed) if targets are properly set
- Depending on the choices made for the parameters of the calculation of energy targets, the rationale of the system can be relatively easy to understand (“everyone gets an energy target”)

Weaknesses

- Households that are high above the energy targets when the system is put in place will have major problems to comply
- The S2 architecture is vulnerable to an excess of CC units (too much CC units allotted = energy targets set too generously). Special attention should be given to establishing the energy targets in this respect.
- S2 is close to a tax system/ progressive tariff for those exceeding their energy targets, and is most likely to be perceived in a negative way.
- A key parameters for social acceptability is the way the energy targets are calculated and the perceived fairness of the system. The penalty applied is also important.

- Households might need an adaptation period in order to understand the functioning of the system (how to buy/exchange CC units, etc.)

Recommendations S2

A central issue in the S2 system is its social acceptability and fairness. Setting the targets properly is key in this respect. Targets which are too difficult to reach are, of course, not acceptable. But the system is also very vulnerable to an excess of CC units (too much CC units allotted = energy targets too easy to reach). Besides, from the households point of view, the parameters taken into account to calculate their target and allotted number of CC units is key for their perception of the fairness of the system and, in turn, its social acceptability. At this stage of research, it is not yet possible to give more precise recommendations specially bearing in mind the fact that those decisions are inevitably involving multiple stakeholders and governance structure.

Regarding the complexity of the system, it does not seem to be an insurmountable obstacle, as was stated in the focus groups, provided proper communication and support is provided. Comparisons with other options to reach the same energy savings objectives should be done to recommend, or not, the development of a policy instrument inspired by S2.

The issue of households that are high above energy targets is inherent to the system design of S2 and, as for S1; it was decided to bring the system to its limit by not trying to fix it. However, a variant of S2 is built with market-based "white certificates for households". In this variant, on top of the rationale for obtaining and using CC units that operate in S2, households have the possibility to trade their CC units in an eBay-like virtual market. According to mainstream economic theories, this could be an efficient way of reaching energy saving targets. It might be less expensive for households which are high above targets and could also motivate some households to outperform their targets in order to benefit from the (limited) stream of revenue obtained by selling the extra CC units when consuming less than the target. However, this leads to a lower autonomy of the S2 system as it becomes coupled to a market in euro subjected to fluctuations. Public authorities also lose control to some extent on the target / penalty equilibrium of the system. If the prices on the market are lower than the penalty, this could weaken the motivation of households that are high above target to take the appropriate measures for energy savings. Besides, this could make the system less sustainable on a financial basis for public authorities, and especially vulnerable to an excess of CC units (too much CC units allotted = energy targets too easy to reach).

General recommendation

The tenant / owner issue is relevant for both S1 and S2. At this stage of the research, it is recommended to use the EPB certificate as a corrective factor. However, further research is needed concerning mechanisms to promote investments of owners in rented housing.

It can also be argued that S1 could be used for free-riding by households which planned to do the investments anyway. This could be tempered with the using list of S1, if the CC units obtained by participating households can only be used for further investments in energy efficiency. However, as explained previously, the system has to be attractive enough for households to get on board. Special attention should however be given to the using list in order to limit free-riding.

Regarding S2, it can be argued that targets set for households could lead to a risk of energy consumption shifts to other sectors (e.g. systematically showering at the sports club, etc.). Further research would have to investigate, however, to which extent such a consumption shift is conceivable and practicable for households, which proportion would be ready to change their practices accordingly and which influence it would have on consumption. Another potential risk of S2 is that households switch to other types of energy sources than electricity and gas to escape the system (e.g. wood pellets, coal, etc.). The only way to limit those shifts is to develop mechanisms to monitor those energy sources as well.

Modelling S1 and S2

A model is built for S1 and S2 with the aim of providing first qualitative insights regarding the potential energy and CO2 savings of the systems, as well as their economic evaluation.

Figure 32 shows how the total energy savings and costs of S1 and S2 evolve in function of the rewarding rate (for S1) and the penalty rate (for S2). The modeling of S1 and S2 tends to show that S2 is a much more efficient system both regarding energy / CO2 savings and economic aspects. This is mostly to be explained by the much higher participation rate that is expected in S2 compared to S1. Besides, S2 seems to be promoting behavioural changes more which lead to lower costs for households to achieve energy savings. Finally, the penalty applied in S2 brings the system to an economic equilibrium.

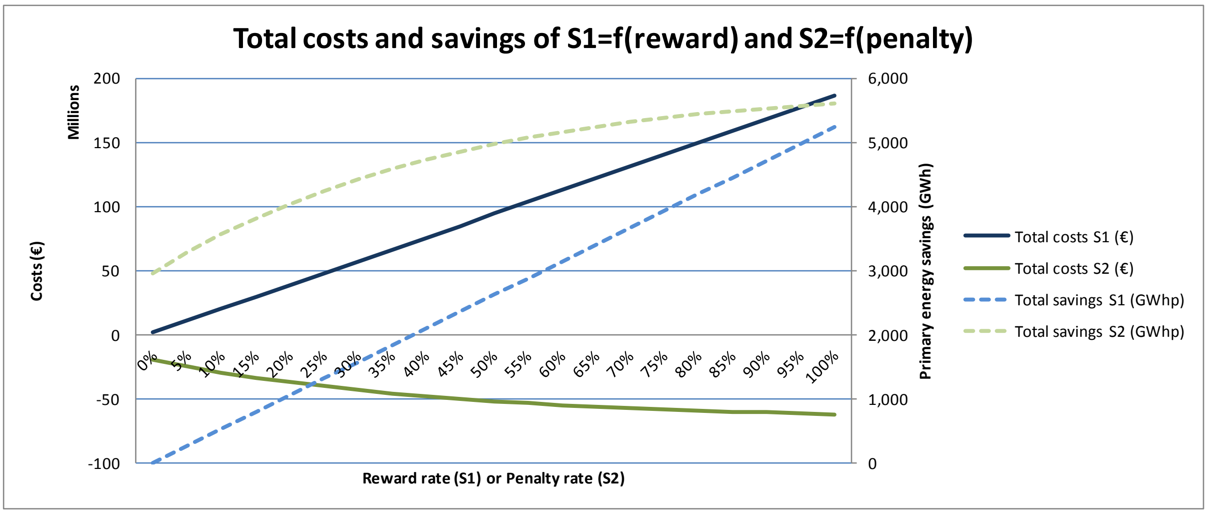

Figure 32: Costs and savings of S1 and S2 models

However those modeling are based on the hypothesis of 80% smart meter deployment. Although for S1, this hypothesis is not critical, S2 cannot be implemented otherwise. Figure 33 shows the total costs of S1 and S2 when the extra costs of installing more than 20% smart meters are taken into account. For S2, a theoretical rate of 100% of installed smart meter is considered, and the costs for installing the missing smart meters for electricity and gas have been calculated accordingly. For S1, only the costs of the extra percentage of smart meter installed have been taken into account. As can be seen, an installation rate of around 50% marks the limit where S2 becomes more interesting on the basis of the total costs of the systems.

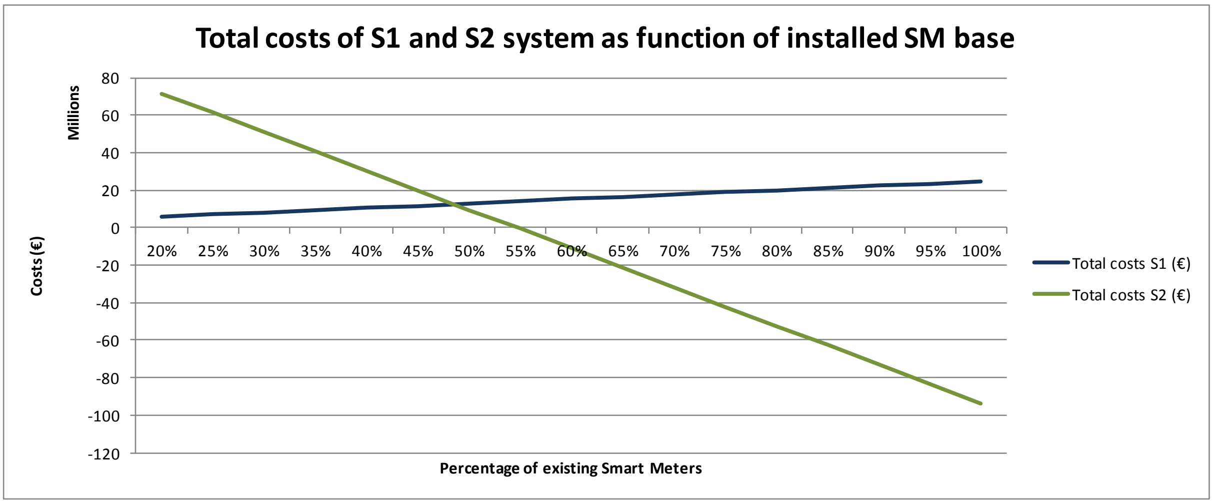

Figure 33: Costs of S1 and S2 taking into account a partial deployment of Smart Meters

The hybrid solution

Bearing the strengths and weaknesses of S1 and S2, a third system design (S3) is proposed, based on a hybrid architecture. In this S3 system, some features of the rewarding model are integrated into the regulatory model. Targets are still set for households which receive a number of CC units accordingly, such as in S2. However, the households that are high above target have the possibility to obtain extra CC units by being rewarded for some specific actions (such as in the obtaining-earning list in S1). The same rationale is applied to how the CC units can be used. Indeed, the households with a consumption lower than their target have more ways to use their remaining CC units (cf. the using list in S1).

In this hybrid system S3, every household still has to participate, but the integration of some features of S1 allows extra flexibility to the system.

However, further research is necessary to understand the impact this would have on the energy and CO2 savings, as well as the economic aspects of such a hybrid system

2.7.3. Conclusions

The INESPO project has pioneered the way for using complementary currencies (with a market-based variant for « white certificates for households) as an incentive scheme coupled to the smart meter infrastructure. The designed instruments resemble existing ones. Indeed, S1 is close in essence to a subsidy and S2 to a progressive tariff. However, the specificities of using complementary currencies make them different in many respects such as the rebound effect, the social network aspect or de-coupling.

Many aspects of the designed instruments deserve further research, and trials should be made in households to investigate their impact on behaviours.

However, as exposed in the Position Paper, the possibility to effectively develop those instruments leads to practical recommendations regarding the roll-out of smart meters. Although there is no clear vision yet on if, how and when the roll-out takes place, the implementation of such instruments require:

- invoicing quality measurements
- various and evolving feedback devices and services
- potentially high data rates

This can be achieved via an access to MDM system, but preferably via a direct connection to the smart meter. Besides, in order to avoid DSO lock-ins, special attention should be given to consumer's access to data.

Most importantly, it implies defining prior to deploying smart meters the necessary standards and requirements for

- free accessible communication port for in-house use
- consumption data manageable by consumer independently of the SM-DSO connection
- optional feed-back systems (displays, websites, etc.)
- optional transfer of data to chosen third-party (ESCos, energy services such as INESPO, etc.)

Indeed, if those choices are not made prior to the deployment of smart meters, it could hamper for decades the possibility of using the smart meter infrastructure to develop instruments designed to motivate households for energy savings.

3. DISSEMINATION AND VALORISATION

3.1. Presentation of Research Papers

International workshops and conferences

H. Joachain, (presentation) "Innovating Complementary Currencies International Workshop", organised by the University of East Anglia (CSERGE), London, UK, 20 September 2010.

G. Deconinck, H. Joachain, F. Klopfert, L. Holzemer, Z. Qui, K. De Craemer, K. Bachus, M. Hudon, "An approach towards socially acceptable energy saving policies via monetary instruments on the smart meter infrastructure," Proc. NGInfra 3rd Int. Conf. on Infrastructure Systems & Services - theme Next Generation Infrastructure System for Eco Cities, Shenzhen, P.R.China, 10-12 Nov. 2010, 7 pages.

H. Joachain, (presentation) Learning workshop "Microfinance and Environment: Informal and Formal Financing of Ecosystem Services for Poverty Alleviation", organized jointly by the University of Oxford (Wolfson College and SIAS), ULB (CERMi) and Paris I-Sorbonne (IRD), Oxford, UK, 9 and 10 December 2010.

H. Joachain and F. Klopfert, « Emerging trend of complementary currencies systems as policy instrument for environmental purposes: changes ahead? » First International Conference on Community and Complementary Currencies, University of Lyon, France, February 2011.

H. Joachain, (presentation), Working workshop organised by the University of East Anglia (CSERGE), London, UK, March 2011.

Z. Qiu, G. Deconinck, "Smart Meter's Feedback and the Potential for Energy Savings in Household Sector: A Survey", IEEE Int. Conf. on Networking, Sensing, and Control (ICNSC-2011), 10-12 Apr. 2011, Delft, The Netherlands.

H. Joachain, F. Klopfert and K. Maréchal, "Energy saving policies for the household sector: can 'smart money' make a difference?" 2nd International Conference on Sustainability Transitions, University of Lund, Sweden, June 2011.

G. Deconinck, B. Delvaux, K. De Craemer, Z. Qiu, R. Belmans, "Smart meters from the angles of consumer protection and public service obligations," Proc. 16th Int. Conf. on Intelligent System Applications to Power Systems (ISAP-2011), Hersonissos (Crete), Greece, 25-28 Sep. 2011, 6 pages.

H. Joachain, F. Klopfert and and L. De Smet, "Rewarding or regulatory policies for energy savings? The difference between perceived and modelled efficiency in the case of an innovative instrument for the household sector". Paper presented and accepted (poster) for Eceee Summer School on Energy Efficiency, [forthcoming, 2013].

Workshops and conferences in Belgium

K. De Craemer, G. Deconinck, "Analysis of state-of-the-art smart metering communication standards," Proc. 5th Joint IEEE IAS, PELS & PES Benelux Chapter Young Researchers Symp. in Electrical Power Engineering (YRS-2010), Leuven, Belgium, 29-30 Mar. 2010, 6 pages.

Bachus K., Instrumenten voor klimaatbeleid: een multilevelperspectief. Paper gepresenteerd op het Vlaams Wetenschappelijk Economisch Congres, 19 November 2010, Gent, België.

De Smet L., Social acceptability of innovative instruments for energy saving. ISDO (Intern K.U.Leuven Seminarie Duurzame Ontwikkeling), 13 September 2011, Leuven, België.

Bachus K., Subsidies en duurzame ontwikkeling. Studiedag 'Duurzame ontwikkeling: een beleid in transitie', 19 December 2011, Brussel, België.

3.2. Follow-up committees

The organisation of follow-up committees allowed sharing insights, obtaining feed-back and disseminating results of the INESPO project to members from:

- Public authorities (regulators, federal public services, institute for environment, Regional Energy Agency)
- Energy-related actors (Producers-Suppliers, technical actors, commercial actors)
- Civil society (Consumer's organisation, environmental non-profit organisation)
- Complementary currencies specialists
- Scientific experts

Besides, important stakeholders in the roll-out of smart meters in Belgium were invited to an extended follow-up committee where the Position Paper was presented

3.3. Final workshop and website

The Final workshop was organised as an event of the EU Sustainable Energy Week (organised by the EU Commission). This allowed disseminating the results to a larger public, as well as gaining visibility as an event of this major event for sustainable energy in Europe. More information on the project is also available on the website www.inespo.be

4. PUBLICATIONS

4.1. Proceedings form International Conferences

G. Deconinck, H. Joachain, F. Klopfert, L. Holzemer, Z. Qui, K. De Craemer, K. Bachus, M. Hudon, "An approach towards socially acceptable energy saving policies via monetary instruments on the smart meter infrastructure," Proc. NGInfra 3rd Int. Conf. on Infrastructure Systems & Services - theme Next Generation Infrastructure System for Eco Cities, Shenzhen, P.R.China, 10-12 Nov. 2010, 7 pages.

Z. Qiu, G. Deconinck, "Smart Meter's Feedback and the Potential for Energy Savings in Household Sector: A Survey", Proc. 2011 IEEE Int. Conf. on Networking, Sensing, and Control (ICNSC-2011), 10-12 Apr. 2011, Delft, The Netherlands, pp. 281-286.

G. Deconinck, B. Delvaux, K. De Craemer, Z. Qiu, R. Belmans, "Smart meters from the angles of consumer protection and public service obligations," Proc. 16th Int. Conf. on Intelligent System Applications to Power Systems (ISAP-2011), Hersonissos (Crete), Greece, 25-28 Sep. 2011, 6 pages.

4.2. International Journals (Peer-reviewed)

Joachain, H. and Klopfert, F. (2012) 'Emerging trend of complementary currencies systems as policy instruments for environmental purposes: changes ahead?' International Journal of Community Currency Research 16 (D) 156-168 www.ijccr.net

4.3. Further prospects

H. Joachain and F. Klopfert, "Smart meters as an opportunity to motivate households for energy savings? Designing innovative policy instruments based on the coupling of smart meters and non-financial incentives". Submitted to the European Society for Ecological Economics (ESEE) 2013 Conference, June, Lille.

H. Joachain, F. Klopfert and L. De Smet, "Rewarding or regulatory policies for energy savings? The difference between perceived and modelled efficiency in the case of an innovative instrument for the household sector". Paper presented and accepted (poster) for Eceee Summer School on Energy Efficiency, 2013.

H. Joachain, F. Klopfert and K. Maréchal, "Energy saving policies for the household sector: can 'smart money' make a difference?" this paper presented at the 2nd International Conference on Sustainability Transitions, University of Lund, Sweden, June 2011 is being finalized for submission to Energy Policy (International Journal with peer-review).

H. Joachain and F. Klopfert. "Compteurs intelligents et monnaies complémentaires. INESPO, un outil innovant pour réduire la consommation énergétique des ménages". This note for the Veblen Institute for Economic Reform is currently being finalised for publication.

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ANNEX 1: COPY OF THE PUBLICATIONS

Will be available on the website of the project www.inespo.be

ANNEX 2: MINUTES OF THE FOLLOW-UP COMMITTEE MEETINGS

Will be available on the website of the project www.inespo.be