An approach towards socially acceptable energy saving policies via monetary instruments on the smart meter infrastructure

Geert Deconinck, Hélène Joachain, Frederic Klopfert, Laurence Holzemer,
Klaas De Craemer, Zhifeng Qiu, Kris Bachus, Marek Hudon

***Abstract*—Energy savings are required, and behavioural change is a good guarantee for this. This paper presents an interdisciplinary four-step approach towards such energy savings. It is based on two types of monetary instruments (white certificates and complementary currencies), that make use of the smart meter infrastructure as a measurement platform for assessing the realised energy savings. A social component ensures that the system design will be accepted by the public at large.**

I. Introduction

The growing energy consumption raises many concerns: security of supply, environment, climate change, volatility of prices, energy poverty, etc.

Regarding energy production, directives have already been issued in Europe, among others to promote renewable energy (most recently, Directive 2009/28/CE on renewable energy [1]). But, although renewable energy production will 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 savings (ES) are therefore one of the most essential topics to address in the coming years. Unfortunately, energy savings can only be achieved in two ways:

- More efficient use of energy.
- Motivate energy consumers to change their behaviour.

So far, policies and measures have mainly been designed to tackle the former (Directive 2006/32/CE on energy end-use efficiency and energy services [2], Directive 2010/31/CE on energy performance of buildings [3],…) but despite energy efficiency gains, current trends show that consumption is still growing.

To cope with climate change and security of supply, public authorities urgently need to direct some policies and measures specifically at realising energy savings **by behavioural changes**. The household sector has been identified for its considerable ES potential through both efficiency gains and changes of behaviour.

This paper aims at presenting such an approach relying on two innovative instruments that can induce the required behavioural changes: White Certificates (WC) and Complementary Currencies (CC).

- White certificates are tradable documents certifying that a certain reduction of energy consumption has been attained and are generally combined with an obligation for some actors (generally energy suppliers or distributors) to achieve a certain target of energy savings. Some schemes foresee that the white certificates can be exchanged between specific actors (obliged actors and/or other eligible bodies).
- Complementary currencies represent some unit of value (for example CO_2 emission units or energy units) that can be exchanged in parallel with, and sometimes converted into national currencies. Recognised as a powerful motivation instrument, they are commonly used for inducing local behavioural changes to reach particular social goals. There are many ways to define and parameterise such currencies depending on their lifecycle characteristics (i.e. emission, management, duration and recycling in the economy).

Both instruments operate according to a similar rationale. Indeed, a white certificate can also be described as a means of exchange that is different from the official currency (i.e. EURO) and that is circulating in parallel with the official currency. In this sense, the use of white certificates can be considered as a complementary currency system. Besides white certificates, more elaborate complementary currency systems (designed, for instance, to allow the complementary currency to cycle in the system) will be investigated. It is thus of great interest to couple the study of both instruments, in order to enable comparative assessment and to benefit from the complementarities of the two system approaches. Besides both instruments. Besides, both instruments require an objective measurement system in order to be deployed successfully.

Both instruments will be considered in conjunction with smart meters. Indeed, they will take full advantage of the new smart metering infrastructure that must be deployed in all households in the coming years (Directive 2006/32/CE on energy end-use efficiency and energy services [2], Directive 2009/72/CE on the internal market in electricity [4]).

This paper presents an interdisciplinary four-step approach towards realising such energy savings. It is based on two

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G. Deconinck, Z. Qiu, K. De Craemer, are with K.U.Leuven, ESAT, Leuven, Belgium. (corresponding author: phone +3216321020; e-mail: geert.deconinck@esat.kuleuven.be).

K. Bachus is with K.U.Leuven, HIVA, Leuven, Belgium.

H. Joachain, L. Holzemer, F. Klopfert, M. Hudon are with ULB, CEESE, Brussels, Belgium.

types of monetary instruments (white certificates and complementary currencies), that make use of the smart meter infrastructure as a measurement platform for assessing the realised energy savings. A social component ensures that the system design will be accepted by the public at large.

II. Context

Up to now, policy-makers seem to have focused on increasing energy efficiency of domestic appliances (with, for instance, Directive 2005/32/CE on the eco-design of energy-using products [5]), and on improving the energy efficiency for housing (with, for instance, Directive 2010/31/CE on energy performance of buildings [3]).

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 behaviour that offsets the potential energy savings offered by those new technologies. Such behavioural responses like, for instance, increased use of an energy efficient appliance, may lead to a paradoxical increase in energy consumption [6]. This is confirmed, for example by the International Energy Agency indicators regarding final electricity consumption. Those indicators show an average annual growth rate of about 2% between 1990 and 2005 of the final electricity consumption in the household sector (for EU-27) and this despite effective gains in energy efficiency for household appliances over the same period of time.

Many studies have shown that behavioural factors play an important part in this trend. More specifically, the role of habits, and the lock-in of consumers in existing (carbon-based) socio-technical systems provide insightful explanatory factors for the current unsustainable trend of household energy consumption. In order to break those habits and lock-in, at least three major strategies can be used by policy-makers to trigger the necessary behavioural changes [7]:

- rewarding the desired behaviour;
- increasing feedback;
- contribute to a positive internal and external evaluation of the desired behaviour.

This paper presents an approach to design and evaluate two innovative instruments that have an important potential to induce the necessary behaviour changes:

- the first instrument integrates white certificates with smart metering systems
- the second instrument integrates complementary currency with smart metering systems

Those two instruments have indeed a great potential regarding the three major strategies to trigger behavioural changes mentioned above:

- desired behaviour is rewarded by earning white certificates / complementary currency units;
- feedback is increased through the smart-metering system;
- the set-up (and marketing) of white certificate-smart metering and complementary currency-smart metering systems can contribute to a positive evaluation of the desired behaviour.

The possibility of using white certificate schemes is foreseen in Directive 2006/32 on energy efficiency [2]. Some EU countries (Italy as from 2005, France as from 2006, and under another form the United Kingdom as from 2002) have already started using white certificate schemes as part of their national energy savings programme. By means of certification, such schemes aim to guarantee that, per white certificate emitted, a certain amount of energy savings has effectively been achieved. White certificate schemes in the EU have, up to now, been used in combination with mandatory energy saving targets usually for retail energy suppliers or distribution operators, implementing energy saving projects in the residential sector or other end-uses sectors. Tradability of the white certificate is often considered as a cost-effective way to reach the energy savings objectives, giving more flexibility to the actors to choose their strategy according to their resources.

Regarding complementary currencies, some European cities have already initiated pilot projects using such system in order to induce and facilitate more sustainable behaviour patterns. The NU-Spaarpas that was tested in Rotterdam from 2002 to 2004 offers a good example of such an experiment [8, 9]. Basically, the NU-Spaarpas works as an incentive system. Participants to the scheme can earn NU points (which act as the complementary currency) on their NU chip card by buying goods or services at participating shops. Sustainable products, which are defined as “environmental friendly and low on energy use, but also friendly towards humans and animals, and with regard to solidarity, social issues and quality of life” are given higher rewards. NU points can also be earned by performing other environmentally-friendly actions (a.o. waste separation). Once acquired, points can then be redeemed at the participating shops, but also e.g. for public transport use. During the testing period, its success was built on the image as a sustainable program, distinguishing it from other (commercial) loyalty projects, as well as on the public/private partnership, even if this brought some implementation problems [8]. The economic recession however decreased the interest of participating companies for further engagements.

Another good example of a pilot project (e-portemonnee) based on complementary currencies and aiming at fostering sustainable behaviour has been developed in Limburg, Belgium with the support of the Flemish authorities. The project called “Zet milieu op de kaart” (literally “put the environment on the chip card”) was designed to reward a series of green actions (like composting or switching to green energy, or refusing a paper edition of the yellow pages) [10]. The points earned could be exchanged for e.a. public transportation cards or energy saving lamps. It is coupled to the electronic ID-card and runs since 2005 successfully in the

6 contributing cities. During the testing phase 20% of the households took part in the pilot project; currently, the actual participating rate is around 15% in Overpelt, and 5 to 10% in the other participating towns that joined later in the scheme.

In the architecture of the designed systems, public authorities finance the project. It is important to note that the designed systems offer, besides their potential to trigger behavioural changes also an advantage regarding the impact of the funds invested by the public authorities. Indeed, as opposed to direct subsidies, complementary currencies have the potential to multiply the impact of the money spent by the public authorities (i.e. in the project in Limburg, for instance, sustainable behaviour will be encouraged both when earning points and when redeeming them). This leveraging capacity regarding the money invested by public authorities is enhanced when the complementary currency systems are designed in such a way that the complementary currency can cycle among the participating members before being reclaimed to the public authorities.

White certificate schemes as well as complementary currency systems have thus an important potential as cost-effective instruments to induce the required behavioural changes for energy savings in the household sector.

III. Approach

A. Step 1: Analysis and Benchmarking

In our approach, firstly an overview of selected white certificates and complementary currency experiences will be provided, the most relevant projects will be analysed and benchmarked in order to highlight their key success and risk factors [11]. Three main points have to be investigated:

- firstly, white certificate schemes have, to this point, been designed for retail energy suppliers or distributors. One needs to investigate how such schemes could be designed for the household / residential sector;
- secondly, to our best knowledge, complementary currency systems have not been specifically aimed at energy savings so far. A second innovative purpose of this project is thus to design such a set of innovative systems aiming at energy savings for the household sector;
- thirdly, both white certificate schemes and complementary currency systems seem only applicable if the energy savings performed in the households can be properly measured. A third innovative purpose of this research project is to develop such an energy savings measurement tool based on smart metering and to integrate it in the white certificate / complementary currency systems.

Existing solutions will be selected on a twofold basis: the relevance of the project vis-à-vis sustainable development objectives, and the relevance of the system itself (i.e. successful complementary currency systems that are not initially designed for sustainable objectives but could be adapted so that such objectives might be selected as well).

In the next step, the selected CC/WC projects will be analysed, in order to provide a profile for each system separately. The aim is to provide both a qualitative and quantitative assessment of the selected systems. The qualitative assessment will mostly be based on interview of selected experts and resource persons who play a key role in the design and implementation of each complementary currency system. The quantitative assessment will rely on data available for each system (statistics about the number of participants, the use of the complementary currency, etc.). A questionnaire will be used to systemise the gathering of information. The expected output at this stage will be a profile of each selected complementary currency system including a list of key features, success and risk factors.

Building up on this analysis of the complementary systems, a set of the criteria will be established. The following assessment areas and criterions might be considered: efficiency of the system (number of participants, effective cycling of the complementary currency in the system, etc.), environmental results, scale issues (national, regional, local, etc.), operational issues (relevance of the support used, for example a chip card, facility of use, etc.), economic issues (costs involved, etc.).

The last task of this first step will be to benchmark the selected CC/WC systems against the set of criteria in order to provide a comparative assessment of the different projects. If a particular project displays an outstanding score for a given criterion, it will be used as a benchmark for the second step (system design), and, when sufficient data is available, the reason for the superiority of this particular project on the other projects will be investigated (gap analysis).

Additionally, experiences with smart metering, and their potential for the support of such instruments will be analysed. An often-claimed advantage of smart metering is energy saving (and this is an important parameter in the business models deciding on the smart meter deployments), however very few research exists on the effect of smart meters on the energy consumption. It is believed that the more frequent billing of customers, based on monthly actual amount of energy that has been used, will provide incentives for less energy usage, or at least increase the consumer's awareness on his/her consumption. Some limited experiments have been reported in [12].

Since the first large European deployment of smart meters in Italy [13] in the beginning of this century, many EU-countries are in the process of defining, designing, experimenting or deploying a smart metering infrastructure: Netherlands [14], Denmark, Sweden, etc. [15-17]. Standardisation efforts are being grouped [18]. Some of these instantiations only cover the remote reading of measurement data (for billing purposes), while other allow for interactivity between the meter at the customer's premises and the energy supplier or distribution system operator (for changing suppliers, connecting/disconnecting customers).

Many other projects see the smart meter as an enabler for intelligent (smart) grid in which many parameters can be monitored and controlled. The objective of this step is surveying the different European approaches to advanced metering (from remote meter reading to really 'smart' controllable meter devices) and to analyse the features that allow for interaction with the user in order to improve energy efficiency or to change his/her behaviour concerning energy usage.

This latter is also the innovative aspect of the survey of the advanced metering infrastructure. This analysis will enable connections to complementary currency and white certificate approaches. Most European experiments deal with electricity metering only, but the scope of this project is to include other energy carriers as well (gas, heat, …), all in a context of residential customers.

B. Step 2: System Design

After this analysis of existing white certificates and complementary currency systems, the second part of the approach will be dedicated to the design of a set of new systems specifically targeting energy savings in the household sector.

Concerning the need for proper measurement tools for the energy savings performed, the project intends to take full advantage of the new Smart Metering infrastructure that must be deployed in every household, according to Directive 2006/32 and the recently approved European Third Energy Package [19] (Official Journal of the European Union *OJ* L 211, 14 August 2009). The smart metering infrastructure can monitor consumption in detail, transfer such information to other service providers and provide information back to the customer about momentary prices or peak consumption. Hence, we are investigating how smart meters could be used as a measurement tool for energy saving in the household sector (i.e. which interface with the user is necessary, etc…) and how smart meters can be integrated with white certificates / complementary currency systems.

Although the aim to obtain the maximum energy savings (and thus the maximum emissions savings) will be transversal to all the systems designed, other criteria will also be taken into account in this design phase, which will result in a set of different systems. The following criteria will be, among others, investigated:

- which system has the best potential to make the CC/WC cycle in the economy in order to enhance the multiplying effect (systems that allow multiple use of the CC/WC for energy saving actions before the CC/WC is redeemed,
- which support is optimal (i.e. systems using chip cards will be differentiated from systems using paper CC/WC),
- which system fits best for which project scale (national, regional, local),
- can the distributors, suppliers and operators be involved in the project (for instance "green shifts can be enhanced if suppliers agree to accept the complementary currency as payment for "green electricity").
- should the CC/WC scheme be set on a voluntary / mandatory basis for participation?

As far as the integration with smart metering is concerned, it is obvious that the complementary currency or white certificate systems will imply different requirements for the smart metering infrastructure. These technological requirements will be enumerated and elaborated. This will allow for different design options of the smart meter with its communication architecture that allow the functionality of complementary currency system to be executed at different performance levels.

Examples of such requirements for the smart meter include the information that needs to be monitored and stored, the available control knobs (e.g. the ability to selectively turn off less efficient devices for a specific time period), the communication interfaces that are available locally (in-home) and remotely (to central databases or to a service provider), the characterisation of the communication channel (bandwidth, response time, …), etc. All these parameters determine the possible and impossible features of the complementary currency system to be designed.

The final output of this second part will be a set of white certificates and complementary currency system designs that integrate smart metering and are specifically designed to promote energy savings in the household sector.

C. Step 3: Assessment for Social Acceptability

In a third step, the most promising white certificates-smart metering and complementary currency-smart metering systems designed during the second step will be assessed for social acceptability. It must be underlined that these two steps regarding system design and social acceptability will be performed in an integrated manner: as system design progresses, the outputs will be used for social acceptability assessments, and in a similar manner, the results obtained regarding social acceptability will feed the system design process.

A number of policy measures have been implemented to increase the energy efficiency of housing, heating and domestic appliances, both on the European and on national levels. However, energy savings, aimed at behavioural change, have been far less popular on all policy levels [9].

In this step, the general triggers of behavioural change towards energy savings will be reviewed based on the existing literature and international studies. The focus will be on the residential sector, including buildings, domestic equipment and energy behaviour of consumers.

The social impact of the two monetary instruments (CC/WC) and of smart metering is largely unknown. Some of the social aspects can be found in literature, but it has not been a real research issue thus far.

A number of social impacts will be explored, based on

literature and interviews:

- Distributional aspects: will the impact of the three instruments be positive or negative for poverty?
- Are certain social groups disadvantaged (tenants, low incomes, elderly, lone parents, low-skilled people,…)?
- Do these instruments change people's trust in government?
- Is there an impact on social cohesion ?

The project will study to which extent these innovative instruments are in line with the dominant values with citizens and other stakeholders.

A first step that will be taken is the identification of all the actors that are involved or impacted by them. The energy consumers are not necessarily aware of *white certificate* schemes as they exist today, since it is mainly imposed on the energy distribution companies or on the retail suppliers. However, as this research will also develop systems with WC aimed at the household level, these households obviously become a very important actor with regard to social acceptability.

Acceptability will be studied taking into account all the relevant stakeholders. Representatives from government, the sector of the distribution companies and the sector of retail suppliers will be interviewed.

Complementary currencies are a different kind of instruments. Indeed, in most cases they are grassroots initiatives by citizens or small companies. They are voluntary systems ; most people involved in them are people belonging to a (small) group of people who see sustainable development as their personal important project. Social acceptability research could be aimed at studying how people from other social groups feel about these systems. In other words, the research question could be 'to what extent are CC systems generalisable on a large scale?'. This question will be addressed by organising several focus groups in which these questions can be tested.

Smart metering systems are yet another different instrument. In this case, individual citizens are affected since they will have the meter in their houses. Some of the relevant issues with regard to acceptability are:

- How do citizens feel about having a smart meter in their house? Will they see it as an incursion of their privacy?
- Is acceptability related to the question who will bear the installation cost of the meter?
- Will citizens see it as an opportunity to get more control over their electricity consumption or not?

The outcome of this step will be a picture of which of the designed systems are socially acceptable by all the relevant actors, which success and risk factors can be identified, which to-be-reached energy savings are acceptable and which measures can be issued by government to make a non-acceptable system acceptable for households. User participation will be an important criterion for success.

D. Step 4: Architecture Analysis and Evaluation

The fourth step will be dedicated to an architecture analysis of the designed systems regarding the following aspects: energy savings, economic and CO_2 savings. Then, the results will be integrated using a multi-criteria analysis in order to provide policy-makers and other stakeholders with scientific advice on the potential and implications of integrating those instruments into climate change mitigation policy for the household sector, focussed on the Belgium case in a European context.

This step is building on the system design and social acceptability steps (step 2 and 3) and is aiming at providing a qualitative evaluation of the impacts of the implementation of the selected complementary currency-smart meters / white certificates-smart meters systems. This architecture evaluation concerns the following aspects: energy savings and green shifts, economic aspects and CO_2 savings.

Firstly, a qualitative evaluation is provided of the designed systems for the following aspects: energy savings and green shifts. Regarding energy savings, the systems are qualitatively evaluated against a set of criteria. The output is a multidimensional (number of axis equals number of criteria) graphical representation that allows a global positioning of each system. This multidimensional graphical representation also allows a comparative positioning of the systems vis-à-vis each criterion.

Green shifts like, for example, the switch to "green electricity" contracts or the switch to less CO_2 emitting energy sources (fuel to gas, diesel/gasoline car to electric / hybrid vehicle, ...) or the switch to appliances with a better eco-label are also investigated using a similar methodology.

Additionally, the designed systems are qualitatively evaluated for different cost components, among which:

- costs for complementary currency / white certificates systems (for instance, a comparative qualitative assessment of the costs of capital for complementary currency-smart metering systems using electronic chip card and complementary currency-smart metering systems using a paper support);
- costs due to the additional use of the smart metering infrastructure. This task will identify such costs, depending on the chosen design options of the instruments and the available (or not-yet-available) smart metering infrastructure. It is expected that specifically the amount of data to be transferred (bandwidth) and its time requirements (latency) will impact such costs, together with the communication media that is underlying to connection to the smart meter at the customer's premises.
- costs of operation (which costs have to be foreseen in order to make the system function? How do those costs qualitatively compare between different projects?)

The most appropriate methodology that enables the integration of the results obtained by the different partners and that allows for a comparative assessment of the several

systems consists in a *multi-criteria analysis*. Building on step 3 and on the economic evaluation, the final output will be a classification of the different designed systems on the various researched aspects (social acceptability, energy savings and green shifts, costs savings).

This provides an overview of the positive and negative aspects of each system, as well as a comparative assessment of the different systems. It can lead to set of recommendations for the design, set up and potential impacts of such systems in practice. It will provide policy-makers and other stakeholders with scientific advice on the potential and implications of integrating complementary currency-smart metering systems and white certificate-smart metering systems into climate mitigation policy for the household sector.

IV. Status

This interdisciplinary approach is currently being elaborated and the first step has been taken. An initial discussion with stakeholders in a Belgian context provides enthusiastic response, because it provides a strong approach towards realising the really required energy savings, riding on a smart meter infrastructure for measurement, and based on an integration with white certificates and complementary currencies. The parallel study of the social aspects shall make the designed systems acceptable for the general public.

It is however not possible to estimate the overall effect on the energy saving in advance.

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