FINAL REPORT

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Executive summary

The SHOWE-IT project is a collaborative project that aimed to reduce energy and water consumption in social housing, providing favourable conditions for all stakeholders. The goal was to attract interest in new Information and Communication Technologies (ICT) solutions and Human Machine Interfaces (HMI) to allow tenants to have a better understanding of their energy and water consumption and to allow them to develop new saving practices. To make the project financially viable, it was expected to reach savings of around 15-20% in energy and water consumption, based on the assumption that the technical solution would cost around 1000 € (marketable price estimated in 2011, at the beginning of the project).

The project completed most of its qualitative targets: it has allowed to gain extensive feedback from tenants on expectations, perceptions and new behaviour regarding energy and water consumption, as well as on communication between housing companies and their tenants. It has allowed housing companies to gain first-hand experience on field deployment of ICT solutions, and valuable lessons were learnt for the future, as detailed in this report.
However, all of the quantitative targets were not achieved. The project did not produce a low cost affordable ICT solution (final cost around 3.000 €), and several technical issues hindered the achievement of the savings expected. The target savings were achieved only in one out of three pilot sites, for heating and cold water consumption. It should be noted that:

- The fact that major technical issues were encountered during the project period was common to most other similar European projects carried out at the same time;
- Savings can, by definition, only be estimated. There is no way of actually knowing what the consumption would really be if there was no ICT system installed, this can only be calculated based on assumptions. Thus the figures provided are the result of calculations based on the actual consumption metered, and on a specific methodology to estimate the savings (Kriging) – for which advantages and limitations are explained in this document.

The project involved leading European companies from the social housing industry and from the supply side industry. Other actors in the value chain (including utility companies and Small and Medium Enterprises, **SME´s**) were also represented. Through the involvement of a Mirror Group of social housing companies (240.000 dwellings across Europe), SHOWE-IT created a strong and direct network that could interest large scale replication.

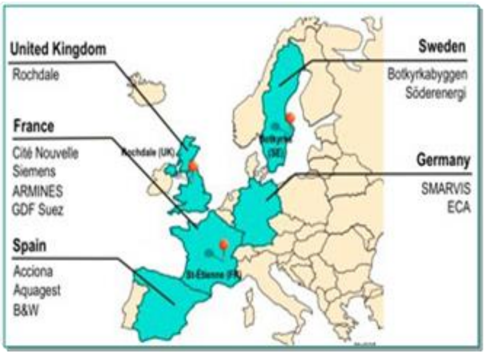
Housing companies	Cité Nouvelle	BOTKYRKABYGGEN	RBH
R&D and consultants	Bax & Willems Consulting Venturing	ARMINES	acciona
"Providers" (hardware, software)	SIEMENS	ECA	SMARVIS
Energy and water suppliers	SÖDERTÖRNS FJÄRRVÄRME	ENGIE (ex GDF SUEZ)	AQUALOGY

The partners involved in the SHOWE-IT project

Notes : The Spanish company Aquagest is to be understood the same as Aqualogy, which is another division of the same company. GDF SUEZ has become Engie since April 2015.

SHOWE-IT was comprised by three pilot sites in Rochdale (UK), Ecully (FR) and Tumba (SE), which were equipped with a multi-fluid (electricity, heating, hot and cold water) smart metering solution and a heating management solution.

A total of 118 households (plus 70 households in a control group) were provided with human-centred, Information and Communication Technology (ICT –enabled) services to save energy and water.



The Showe-IT pilot sites: (UK), Ecully (FR) and Tumba (SE)

Substantial effort was put in developing an ICT interface with a real "human-centred" approach, as well as to study the acceptability of the interface by tenants and their final users. There was also a strong emphasis on the interaction between housing providers and the households themselves, motivating them in energy and water saving behaviour.

Main activities

During the SHOWE-IT project, we were able to:

- Test a multi-fluid ICT architecture and a Smart ICT interface in real conditions. This project is among the few that propose an integrated architecture including electricity, heating, hot and cold water, which were metered and displayed in a dedicated domestic interface. The monitoring stage covered a full year, during which all pilot households (plus control group households) were monitored in near real time;
- Develop a complete integrated "Human centred" and "User centred" approach with a global socio-designed innovative method of development, combined with communication plans to interact with tenants. In-depth long term surveys, both qualitative and quantitative, allowed to assess the use of the new systems as well as the final (excellent) satisfaction level.
- Study extensively methodologies to calculate energy and water savings, and adopt a transparent and critical approach - presenting advantages and limitations of the one used (Kriging vs linear regression);
- Participate in an important number of scientific conferences and industrial congresses to present and compare the results with other stakeholders.

Main results

The smart interface developed was a success

- 76% of tenants who responded to the quantitative survey have interest in smart services proposed in the project for water and energy (... and 70% wanted to keep the SHOWE-IT tablet!)
- 84% of respondents assessed that the interface is easy to use: this is the result of the « user-centred design » approach.

- The tenants who declared to pay more attention to their consumption after the project than before have the characteristics of being frequent users of the interface.

	Water	Electricity	Heating
Level of attention	49% pay more attention after the project	Important control practices. More important for 46% after the project	Poor control practices
Specific profile?	Household without children	Frequent users	Frequent users
Perception of a decrease in the bills	23% yes (tested only in France)	30% yes 46% pay more attention	19% yes

Today the satisfaction level of tenants with the ICT devices and the collaborative process to develop it (co-design) allows us to expect the following elements to be particularly interesting and replicable for future ICT devices: graphics, functionalities and sociological analysis explaining the detailed expectations and the usability from a users' point of view.

Both energy and water savings were estimated in some of the pilot sites. However, overconsumption was also observed. The table below shows the final results of the project in terms of percentage of savings (positive green values) or overconsumption (negative red values). The values in brackets correspond to uncertain outcomes.

Parameter	France	Sweden	UK
Heat	0% (±6%)	+15% (±6%)	-14%
Electricity	-4% (±20%)	+8% (±14%)	+12%
Warm water	-13% (±7%)	+12% (±4%)	-
Cold water	-2% (±4%)	+15% (±4%)	+13%

These results are in line with the results obtained in other similar European projects[1].

For most sites and fluids, the initial objectives set in order to provide a cost-effective solution, i.e. 15-20% of energy and water savings, were not achieved. The quantitative analysis does not highlight specific variables that can explain these results. According to the results of sociological surveys, tenants can be persuaded to have interest in energy savings as long as the solutions offered actually work, are reliable and deliver the functionalities promised at the start of the project. This was mostly not the case in this project, due to technical issues detailed later in this report.

It can be concluded that savings are highly dependent on end-user engagement, therefore the effort to define the strategy and secure the execution of engagement should always have high priority, even during the monitoring period.

[1] cf. eeMeasure portal, with energy savings obtained in 14 projects

An extensive sociological and technical REX (Research and Experimentation) was acquired

The other main results consist of experience gained, especially by the Social Housing Companies, both in:

- Drafting and implementing communication plans with tenants – accompanied by a sociological expert team. Key elements allowing to understand tenants' expectations regarding smart energy and water services, as well as key levers for behavioural change were identified.
- Identifying technological bottlenecks for the implementation of a multi-fluid smart metering technological solution. The key lessons learned, and recommendations for replication, are detailed in this final report.

Main limitations

Technical solution

The project has not demonstrated a realistically replicable and cost-effective technological solution for social housing circumstances. One of the main problems was the fact that the solution was not actually "off-the-shelf" technology, contrary to what was initially expected. Additionally, the technical solution needed to be tailored to each of the three pilot sites in order to work properly, which increased costs (especially installation costs) and time consumption to make the solution work.

The main reason why the costs exceeded the original budget were due to the technical complexity to make the different technologies communicate (interoperability) and the fact that these new technologies are not fit top operate within the technical characteristics of the existing buildings (they are clearly developed for new buildings). We still consider the biggest challenge to design one solution that can be used in different situations and is therefore ready for large scale replication (one fits all). The solution should really be off-the-shelf, tested and easy to install and to operate.

Calculation of energy and water savings

It should be stressed that evaluating savings, by definition, means comparing what happened in the pilot project compared to what happened with a:

- Baseline situation, that is a situation which did not actually happen but is supposed to represent what would have happened if there were no smart services installed; or
- Control group that is a group of users similar to those in the pilot project where the smart services were installed, with similar characteristics and undergoing similar situations (climate, patterns of consumption, holidays, etc.).

Therefore, there is no way of knowing exactly what the "real" savings are.

In ICT PSP projects, different methods and strategies have been used to estimate energy and water savings. They all provide an estimation of consumption, a "reference", to calculate savings. The choice of the methodology can be based on different aspects. In the SHOWE-IT project, this decision has been based on uncertainty criteria, which means that the model with lower uncertainty (Kriging) was proposed as the most relevant to be used. However, even though the model was considered relevant, the results can differ from actual measurements of control groups.

Considering the values of savings obtained for heating energy consumption in Sweden, the feedback from the Social Housing Companies (SHC) showed that the value obtained should be lower than the savings that were determined by the project of 15%. The real data obtained from the energy provider showed lower savings. However, the data of the housing company represented the whole neighbourhood including much more dwellings than the SHOWE-IT project and thus it is hard to establish comparisons between these two groups of data. Before further replications of the SHOWE-IT technology, all data used to verify the results should be made comparable on order to be certain about the credibility of the results.

Structure of the final report

In order to make this final report an easy read we have decided to choose for the following structure:
1. The socio-technical results
2. The architecture of the ICT system
3. The calculated electricity, heat and water savings
4. The potential impact and replication strategies for the project
5. The communication performed throughout the SHOWE-IT Project

The above structure gives the different stakeholders a quick overview on the results of the project and can easily detect the elements of interest for the reader of this report.
Key lessons and recommendations for replication are provided at the end of each chapter.

It should be noted that during the SHOWE-IT project, the work carried out was structured around six Work Packages:
- WP 1 - Diagnosis, monitoring, and analysis of results
- WP 2 - Tenant involvement for energy and water saving
- WP 3 - Detailed design, integration and roll-out of the ICT system
- WP 4 - Socioeconomic viability and replication strategies
- WP 5 - Communication
- WP 6 - Project Management

Table of content

Table of figures

Table of tables

1 Interaction with tenants: expectations, perceptions, new behaviour with the user interface and communication plans

1.1 Socio-design approach to develop a human-centered interface

Since 2011, the Design Interface Team, coordinated by ENGIE and in collaboration with ECA, Armines, Bax & Willems, Aqualogy and Botkyrkabyggen, has supported the development and implementation of the SHOWE-IT interface. Especially, an innovative research approach to design and study the acceptability of the interface and the smart services associated was developed in the context of a PhD in Sociology of Innovation funded by ENGIE for the SHOWE-IT project.

One of the important lessons of the SHOWE-IT project was the knowledge gained about the *HOW*? How to develop an interface that will be appreciated by tenants and that will lead to a better understanding of their energy and water consumption as well as to new (saving) behaviour?

Below we present the key stages of the research and design process developed as part of the thesis for a PhD during the project. It should be noted that this process was implemented since 2011, at a time where such "user-centered" methodologies were not as popular and mainstream as they now start to be in energy ICT´s. The fact that this mixed sociological and UCD (user centered design) approach was applied in the project enabled a great acceptation of the resulting interface and this was in itself an important achievement. This on top of bringing useful information, for replication and for the development of other ICT energy services, to the market.
The key concept of our approach was inspired by the iterative design method: the development of a product with one or more design cycles and in addition a testing process with qualitative evaluations of the interfaces' usability.

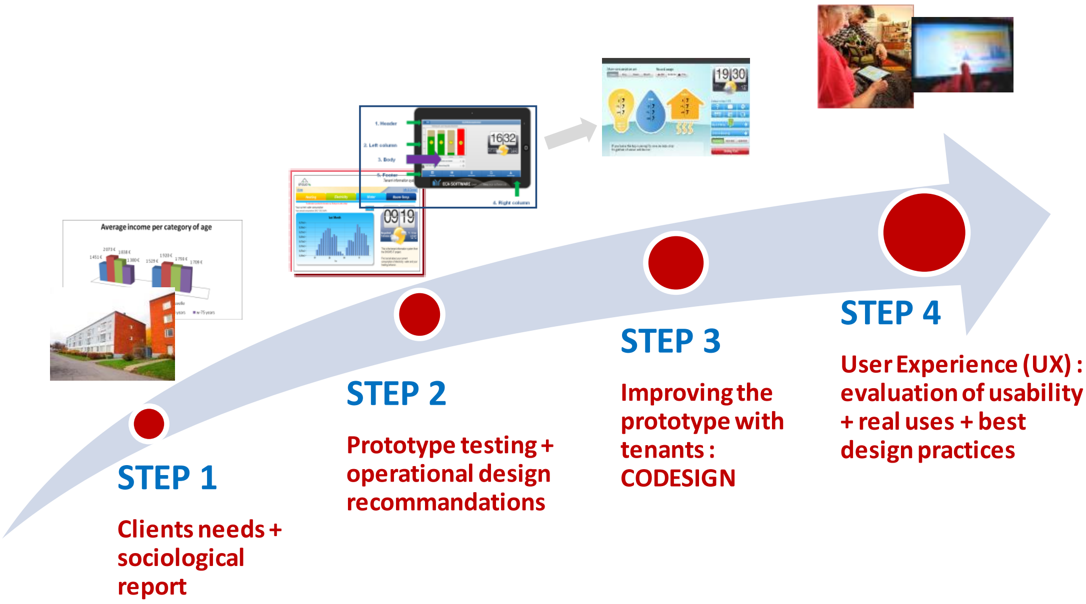


Figure 1. Our innovative socio-design approach to develop a human-centered interface

118 French, Swedish and English tenants have experienced in the years 2013 and 2014 the smart interface dedicated to their domestic consumption of water and energy.

Key lessons learned and recommendations for replication

Development of the interface

- A dedicated support – It should be noted that at the time when conceptual choices were made, neither tablets nor smartphones were so evolved and widespread as today, especially tablets;
- Access to content facilitated by integrating the user habits already acquired with other tactile interfaces on the market (learned skills) such as Apple and Samsung devices (iPhone and tablets);
- A relevant location of the interface: habits determine the location of the tablet in the domestic space. The interfaces are used in specific spaces inside the dwellings. The selection of the place where the interfaces are located is very important, as well as the height, orientation, brightness of the tablet (non-exhaustive list);
- A limitation of the intrusiveness of this new interactive support (standby, alarm, voice, brightness are elements to develop subtly in order to avoid the intrusiveness of the device in the private space).

Appropriation of "smart" interfaces by tenants

During the development process of the interface, we have established key elements facilitating the appropriation of "smart" interfaces. This has enhanced tenants to participate in choosing new consumption practices:

- *Before* the development process and the installation of the device, *the visit of energy auditors* (audit inside the household + personalized advises given to tenants on energy and water consumption) turned out to be highly appreciated by tenants and has led to very quick and direct change of some energy habits;
- *During the development* of the interface, tenants appreciated to be *interviewed by sociologists* and especially to do *product-tests* in order to improve the prototype until the final version. Tenants revealed to be excellent collaborators to improve the services and the usability of the interface during our co-design approach (collaborative approach where final users are directly participating in the design process);
- *Throughout the deployment,* some *people were identified as "peers of trust"* by tenants. Those persons were mainly found in the private circle, such as members of the family, neighbours but also professionals who were identified as "neutral", that is to say professionals who have nothing to gain from giving advice to tenants and to make them save energy.
- *Throughout* the entire project, several *collective meetings* were organized to inform tenants on the roll-out of the project and to give advice on how to use the tablets. Dedicated meetings were organized by the housing companies, as illustrated below in Sweden.

Figure 2. Collective meetings organized by the housing company to inform Swedish tenants

Tenants expectations for smart energy and water solutions and services in housing

- After the introduction of the project tenants expected smart solutions and services, but they also expected the solution to have quality standards at least equivalent to their smart phones or tablets in terms of interest /relevance of the services (utility), intuitiveness and easiness of use (usability);
- Decreasing the energy bill (which was the main informative tool on the interface between tenants, housing companies and suppliers) by lowering consumption of energy and water, was compulsory. The information should be made easier to understand (e.g. with visuals) and should provide additional information (e.g. break down by use, tips for savings);
- The same data should be displayed on both "smart" interfaces and energy bills: there should not be any discrepancy when an ICT solution is provided to support tenants in understanding their energy and water consumption behaviour (this may look obvious, but in practice this was not so easy, since bills were often based on previsions whereas ICT usually provided near "real-time" data);
- The level of information displayed should be adapted to the knowledge that tenants have about their habits. If they already know about their daily habits – as was the case with SHOWE-IT participants – then they expect more advanced options and services than only feedbacks:
  - Advanced graphics: time/historical comparisons with explanations related to equipment or practices (including graphics, curves and comments). The graphics must allow to create the link between consumption volume, paid costs and consumption habits;
  - Intelligent automatic optimizations of the heating in order to consume less without loss of comfort;
  - Easy budgeting service, with graphics showing the trends of consumption and the impact of behavioural changes;
  - Anticipation option: alerts with thresholds and estimations of current and future costs, especially in households experiencing fuel poverty.

In general, the bills and the final costs for heating and water should be calculated on the basis of real individual metering, and not anymore by collective metering as still is practice in some countries or neighbourhoods. Indeed many tenants interviewed explained that due to the collective metering they had no idea of their actual household consumption, neither about the structure of the final costs included in their rents.

Figure 3. A representative of the French housing company during a visit with tenants

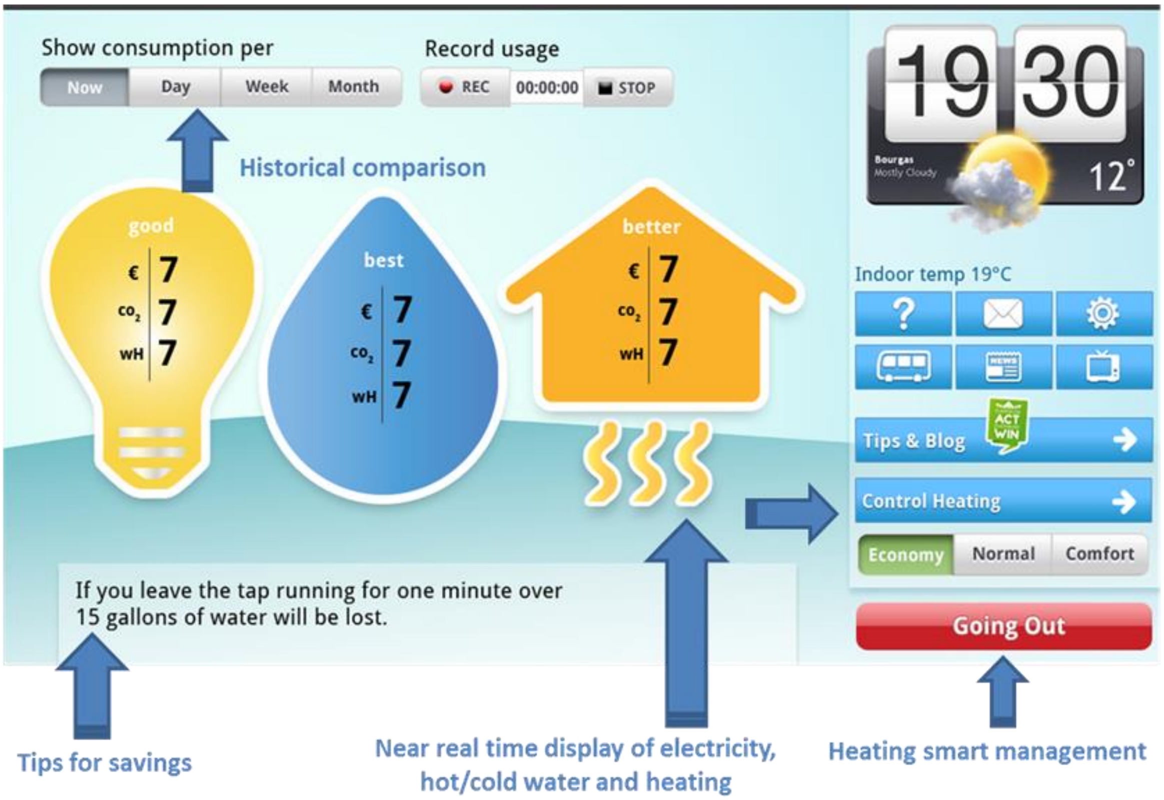


Figure 4. The final SHOWE-IT interface takes into account the information collected and analyzed during the interface-tests with tenants and the collaborative design process.

1.2 Interaction with tenants: communication plans

The focus on tenant involvement and engagement was mainly directed to:

- Gain tenants acceptance, support and enthusiasm for the project;
- Identify the drivers for tenants´ energy and water saving behaviour and their acceptance of change;
- Obtain the tenants perspective on their current living conditions and their behaviour towards energy and water consumption as input for the project design as covered in Work Package 1 (diagnosing, monitoring and analysis of result);
- Develop and evaluate a common methodology of tenant involvement that can be adapted for local conditions and serve as a basis for further ICT-based energy and water saving actions in Social Housing across Europe;
- Deliver relevant information to tenants and social housing staff to get the best results of the used applications and equipment;
- Investigate how occupants experience the installed ICT-based solutions and how they interact with them;
- Organise knowledge sharing actions between the different actors in the value chain (from end users to utilities or ICT providers) to ensure higher levels of interest and better use of the technology.

A major task of WP2 (tenant involvement in energy and water saving) was to establish a task force within each ICT pilot project & control group. The main work and documents produced here comprise:

- *Qualitative interviews* carried out by Engie sociologists, which provided information used to develop other areas of work alongside tenant profiling;
- The creation of a *tenant task force* and the organization of *local tenant meetings*;
- The development of *consultation with tenants*, and a detailed *communication plan*, with examples of documents to be used – all of which were translated into the local language and adapted to suit the needs of each housing association;
- A set of documents setting out *a programme of requirements, checklists, planning & dialogue strategy*, which each social housing company could use and adapt to their needs;
- An *Action Plan*, with associated planning & assigned responsibilities, to give structure to this element of the project. However due to technical delays, it was not always possible to stick to the planning set;
- A *Tenant Interaction Plan*, which provided *communication* material about the aims and objectives of the project. It also set out how each housing company could keep tenants informed, including explanations about tenant consultation & participation. Other information incorporated was what type of *training* could be expected by the tenants and who to *contact* for feedback;
- *Training material & guidelines* to help tenants save energy & water. The information included advisory booklets, information & suggestions of engagement, workshops, guided tours, energy saving tips for the user interface, Interactive Quiz & board game, and publications as well as promotional posters;
- Throughout the project, *meetings* were held with various groups of employees and tenants and a *manual on tenant meetings* was produced, to lay the foundation on how these meetings should be conducted. It highlighted the themes to address, alongside the aims & objectives of the meetings and also provided information on incentives for tenant participation.

Of course, it was important to evaluate the work that has been produced so that others can learn from our experiences which would assist potential replication strategies. In this perspective:

- The *evaluation* was broken down into *"Before", "During" and "After" the interaction programme*;
- We then looked at the *barriers* the project faced, broken down into *"Technical", "Behavioural" and "Regulatory"* barriers;
- This allowed us to look at *continuity plans* for longer term viability, including technical feasibility in a Social Housing setting.

What became clear was the importance of tenant involvement, and more specifically, their engagement and attitude towards ICT, their acceptance and their needs and expectations regarding digital inclusion.

Key lessons learned and recommendations for replication

We have learned during the project that installing In-House Displays (IHD) is considered a positive action by tenants but the interfaces themselves can't be installed without a proper communication plan from the housing companies in order to inform their tenants before and during the installation process. We can state today that the acceptability of new energy services and interfaces in collective buildings is also linked to the global information set that tenants receive from their housing company, as well as from energy suppliers:

- Elements of communication must be integrated in energy efficiency programs for tenants;
- Better feedback on energy consumption and clear communication are expected from housing companies and energy suppliers:

- The transparency of information has become a key factor for users to estimate the quality of the energy service: better information is needed, especially with regard to the fees paid and the contractual requirements (subscription price, price trends, contracts, billing method)
    - Institutional communication is also a central challenge. The main paradox for many users is the fact that the producer and/or distributor of energy and water also gives advice to make savings. This matter needs to be addressed by both energy suppliers and housing companies. They need to give clearer information about their energy efficiency objectives and their optional services offered to control energy consumption. The bills, and/or the energy costs integrated in the rent, must be better explained in the feedback received by tenants. The housing companies should improve the information provided to tenants. On the calculations, on the choice of the energy/water suppliers for collective consumption and to get easy access to more information on these topics.
- A fair distribution of the energy efficiency responsibility was expected, with the engagement of all: tenants, housing companies and suppliers. Tenants need to see that the companies from which actions are required also play their part (e.g. improvement works in common areas, etc.), if not "anti-reflexive" behaviour can appear.
- The so-called trend of "peer-pressure" and community building in energy management was a complex phenomenon observed throughout this project but instead of using it as a "tool" to "influence" tenants, we recommend to make tenants a direct part of the process to design local collective programs of awareness/actions, housing companies must be very transparent during each action set as well as in their communication plan.
- Additionally, it was apparent through the project that one size does not fit all. This appears to be true for both the technical installations as well as tenant engagement. What works well for one organisation/country may not work for another. The reasons behind this have been explored by the sociologist's contribution to the deliverables.

1.3 Real acceptance of user interfaces and new behaviour with ICT

The key sociological results of the quantitative and qualitative surveys performed from 2011 to 2014 show tenants who responded to the questionnaire as follows:

- a positive global assessment of the user interface but uncertainty about the perception of the non-responding tenants;
- 76% of tenants who responded to the quantitative survey had interest in smart services proposed in the project decreasing water and energy consumption and 70% wanted to keep the SHOWE-IT tablet;
- 84% of respondents assessed that the interface was easy to use, a result of the « user centered design » approach.

Especially concerning the usability the outcomes were:

- three out of four households who responded thought that the interface was intuitive;
- three out of four households who responded said that they received enough information on the operation of the tablet.

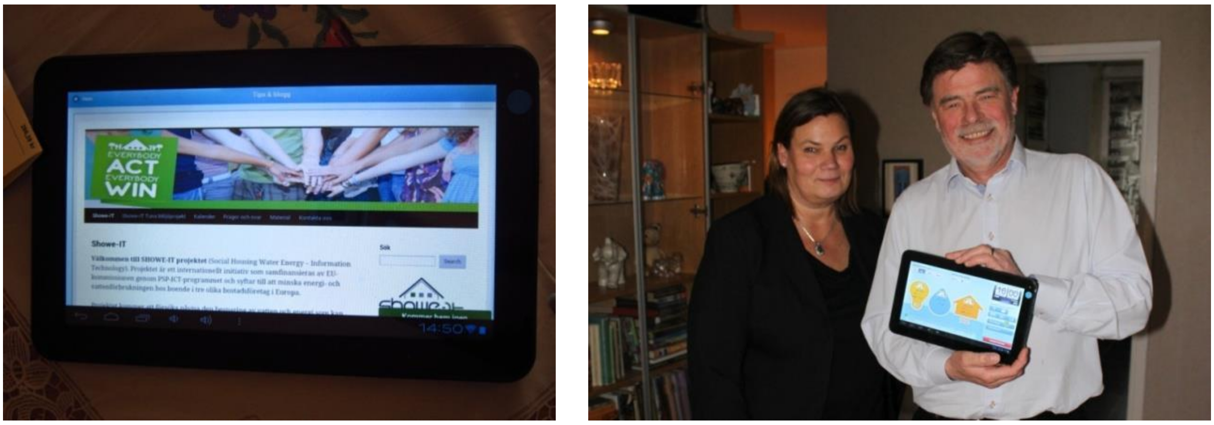


Figure 5. Swedish users with the SHOWE-IT tablet

Seven out of ten households who responded to the quantitative questionnaire were satisfied with the interface, but with significant differences across countries that can be explained mainly by the technical problems encountered by the French tenants[2].

The quantitative survey allowed us to understand that the number of technical issues with user interfaces (bugs, problems with display etc.) were proportionally linked to the level of dissatisfaction and disinterest in the tablet (especially in France where the tablets have had a lot of dysfunctions):
In a context where the tablet works almost perfectly, tenants express a very high level of satisfaction with the interface.

This result is key for future projects: it means that prior to assessing the acceptability of interfaces, a high level of functioning of the device is required. Indeed too often research projects make a direct link between the level of satisfaction of tenants with the tested devices and their global level of interest for ICT energy services. But to be frank, the level of properly functioning different elements of the tablets (options, navigability, buttons etc.) must be regarded as a key explicative factor when evaluating the final acceptance of those new devices for end users.

Impact of the tablet on tenants perception and behaviour towards energy and water savings

The tenants who declared to pay more attention to their consumption after the project than before have the characteristics of frequent users. We have also established a link between the pre-existing familiarity of tenants with ICT and their frequency of use of the SHOWE-IT interface.

We discovered that tenants with interest and skills in energy and environmental issues were also frequent users, whilst those who are not interested in those topics were infrequent users.

[2] Precisions about the quantitative survey 2014: Respondents of the survey: 42 out of the 103 tenants → 37 filled in the questionnaire entirely. Differences according to the country and the data collection: 28% of the Swedish pilot group, 35% of the French pilot group and 100% of the British tenants have answered

	Frequent users (at least 1 or 2 uses per week)	Infrequent users (less than 1 use per week)
Percentage (from this survey)	52%	48%
Familiarity with ICT	Yes	No
Energy/environment skill(s)	Yes	No
Interest in the device	From the beginning	Not really

Table 1. Users can clearly be divided into frequent and infrequent users

The perception of savings depended on the relevance of the information provided and on the frequency of use, as shown in the following table.

Who thinks consumption has fallen? → Frequent users

- Users who use the tablet regularly;
- Users that did not have technical problems during installation and with the user interface;
- Users between 40 and 59 year old;
- Users concerned about environmental issues.

Who thinks consumption hasn't fallen? → Infrequent users

- Profile is almost the opposite as for frequent users. Because people don't use the tablet, the project has little impact on their practices;

The tenants who responded to pay more attention to their consumption pattern after the project have the characteristics of frequent users.

	Water	Electricity	Heating
Level of attention	49% pay more attention after the project	Important control practices. More important for 46% after the project	Poor control practices
Specific profile?	Household without children	Frequent users	Frequent users
Perception of a decrease in the bills	23% yes (NB. Only tested in France)	30% yes 46% pay more attention	19% yes

Table 2. Impact of the interface on tenants perceptions, per profile

Why do tenants make energy savings?

Usually the topics of water, electricity or heating consumption are not central in the family life of tenants except for those who were already invested and active in savings. Though we observed that a

lot of tenants had already began to move towards more efficient practice during the project not all tenants initiated with the aim of "protecting the environment", nor with the aim to save money.
Several key factors explained according to tenants their (existing) saving behaviour that was revealed during the qualitative interviews at the beginning of the project and once the interface had been installed:

- **The country's culture** especially Sweden, with the attention it gives to avoid excessive consumption. In all 3 countries we observed habits learned during childhood as "not to waste" (especially the generation up to 50 years);
- **To educate children** and to show them "good behaviour" (especially for families with parents up to 40 years old)
- **To control the budget** especially for families and couples – issues around energy consumption create few domestic conflicts or discussions
- **Finally the protection of the environment** - especially for the generation under 40 years of age.

During the experiment, the habit of “non-wasting” has proven its importance for the generation of tenants up to 50 years, and environmental awareness played a key role for younger generations who are willing to pay more to choose for green suppliers of electricity (as noticed in Sweden with several tenants). We identified existing and new saving behaviour: purchase of energy efficient equipment, adapted usage with daily savings and changes in habits (in frequency, duration or intensity of use of energy and water) and in the rarest occasions improved maintenance of equipment.
Another factor that stimulated change during the project is the visit of the energy auditors because of the following motivation according to tenants:

- Detailed and personalized information given directly regarding the tenants´ particular situation, their equipment and the structure and layout of the dwelling (thermal and isolation characteristics);
- Information on a consumption level - to make comparisons and to situate the tenant in respect to average consumption or compared to more “extreme” levels of consumption;
- Delivering personalized advice to make savings that were simple and more important affordable or feasible in the short term.

Key lessons learned and recommendations for replication

The targets with the highest “success rate”, that is tenants who are the most willing to make energy savings with a new interface, were those for whom some leverage of actions exist and have been clearly identified. On the contrary users with low levels of consumption feel they have little leverage to make savings, for example elderly couples or singles with few equipment, low consumption and who already applied saving behaviour.

Consumers of high volumes of energy and water have a lot of options to lower their consumption (that is a family with multiple equipment used simultaneously, with the heating on all day long and with children). For those consumers, a range of new energy habits can be adopted. Examples are: minimizing the time spent under the shower and check directly on the interface the decrease of water consumption, use the “eco-button” for the heating, switch off the lights etc. For future projects we recommend to create household profiles for saving opportunities and specific targets with a proportionality rule where smaller consumers have a lower target of savings and bigger consumers higher objectives for savings.

2 Architecture of the ICT system

2.1 Technical multi-fluid ICT system installed in the 3 pilot sites

A complex, multi-fluid, multi-actor system

SHOWE-IT had the particularity to be a multi-energy experiment with a complete ICT architecture that allowed advanced energy metering at a household level for hot and cold water, electricity and heating consumption.

The system also displayed the energy data in a dedicated In-Home-Display (IHD).
The IHD was installed in 118 testing households living in affordable housing in 3 pilot sites managed by 3 different housing organisations situated in England (Rochdale Boroughwide Housing), in France (Cité Nouvelle) and in Sweden (Botkyrkabyggen).

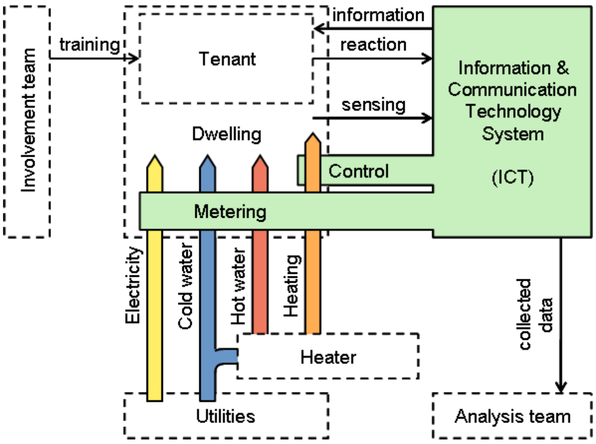


Figure 6. Schematic view of the SHOWE-IT ITC architecture

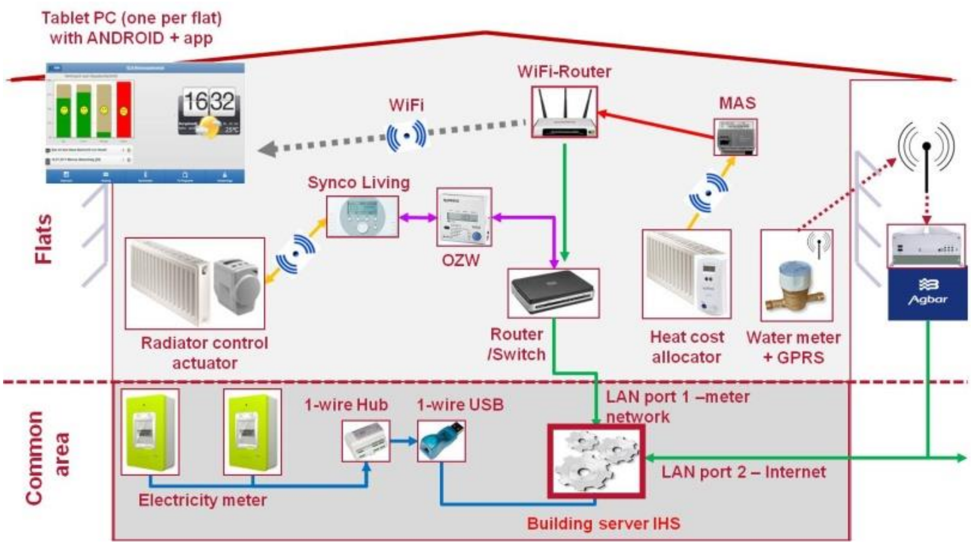


Figure 7. Final architecture installed

The following context diagram shows the relationships of the main components of the ICT system with external actors during normal operation. Actors may be human, other components of the ICT system, and third party systems. Each element was connecteed with an interface.

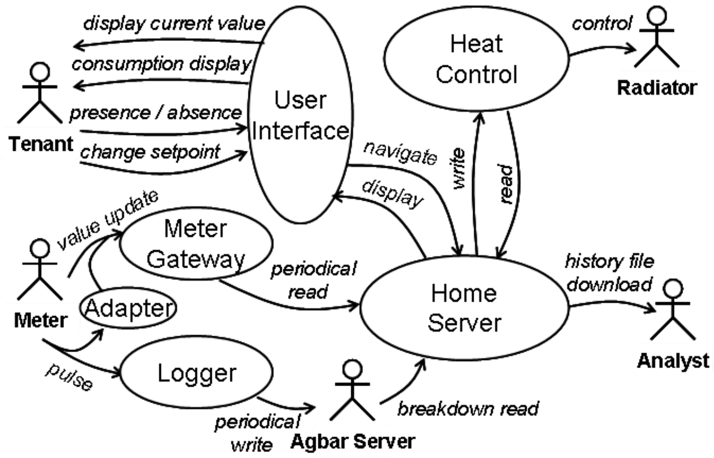


Figure 8. Context diagram - relationships between ICT components and external actors

Data collection, storage and processing

All the data to be analysed was stored on a global server that could be accessed from every computer connected to the internet. The access was easy and based on a username and password procedure. Information relating to data collection and data processing are detailed further in this document. Depending on the parameters considered, the acquisition period was between 15 min and 1 day.

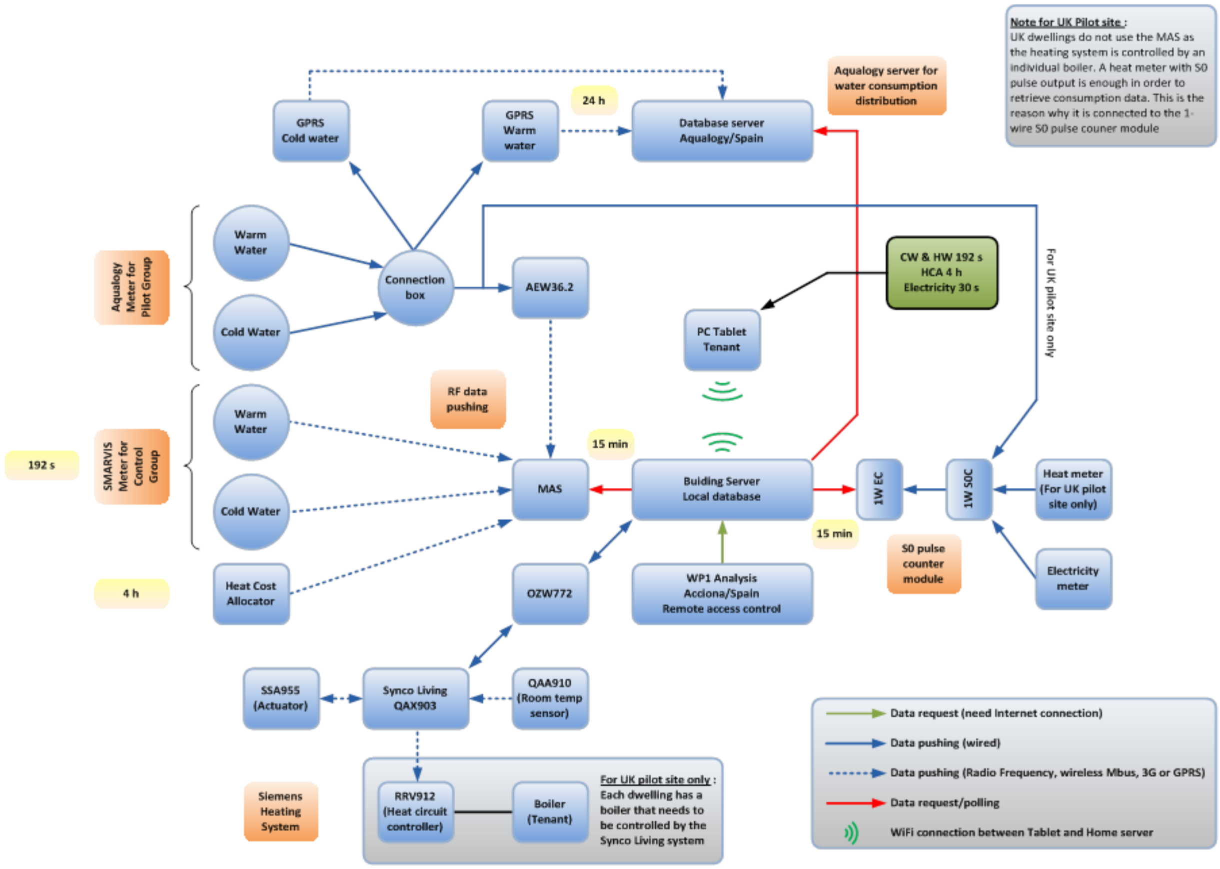


Figure 9. Data transmission and timeframe

Input towards standardization bodies

The SHOWE-IT project used system components whose functionalities were mainly defined by European standards. This allows the copying of such systems in applications of other European countries and projects without major adaptation work being necessary. The standard only left space for flexibility in the Local Metrological Network, which manufacturers have interpreted differently, leading to a lack of interoperability and a lack of manufacturer independence. Project partner SMARVIS has used its influence in the OMS (**O**pen **M**etering **S**ystem) Group, in which 10 European countries are currently represented, to limit this freedom in the standard to such an extent that the independent requirements for manufacturer and media are met and certification is possible. This OMS specification was also a component of the German protection profile for a smart metering system and has been submitted to the European standardization bodies. Parts of EN 13757 (**E**uropean **N**orm) have already been agreed or will be submitted for European voting shortly. This means that all the pre-conditions have been created to be able to use the systems and principles developed in the SHOWE-IT project in a wide range of applications in Europe without major adaptation work being necessary.

Recommendations for further standardization efforts:

To make energy saving solutions available for the mass market, the following commercial and industrial goals should be considered:

1. In regard to protocols and the related communication model such as the usage of wireless M-BUS (EN 13757), the SHOWE-IT approach can be widely applied and has been adapted for the OMS specifications. Several companies have registered their meters in the meantime to receive the related OMS-Compliance label to benefit from easy interworking. EN 13757 will be used by CEN (CEN is the European Committee for Standardization) TC294 for Mandate /M441 for communication between Non-electricity systems.
2. The communication system is compatible with:
    a. Specifications made in mandate M/441;
    b. The rules of the OMS Group;
    c. Data protection and privacy mandatory in Germany whenever the data usage is authorized and restricted to the indicated usage only.
3. The costs of the hardware and installation should be kept as low as possible to encourage mass implementation. More specifically, the hardware should be consolidated, avoiding the need for different electronic boxes for HVAC controllers and data gateways.
4. Similarly, the complexity should be reduced by minimizing the number of different communication channels and protocols.
5. And, whichever standards was chosen, it should preferably be based on standards that are in common use and open to multiple manufacturers in the future.

Compared with the goals stated above, the SHOWE-IT solution could be improved by consolidating the HVAC controller (Synco living QAX9) and the meter data gateway (the MAS) in one device.
To make this practically achievable, we recommend making KNX (wired and RF **R**adio **F**requency) the standard protocol for HVAC control in the apartment.
This would be a good solution, since KNX uses the same physical layers as already established by the Mbus/OMS standard meter data interfaces. Additionally all meters, including electricity meters, should communicate using Mbus/OMS, as this is already an established standard in the market thus avoiding the S0 communication (S0 is a communication converter). Furthermore Ethernet would be a good standard for the backbone communication in the building.

Some developments in the communication world speak about the "Internet of Things" (IOT). We expect that IOT will be a reality in the future and form a bridge between different communication systems. It was expected that new applications will reduce the costs of devices and systems and further push the development of new businesses.

Technical problems

During the installation of the SHOWE-IT methodology we found problems that were mainly caused by the fact that the systems that were used weren´t ¨of the shelf¨ solutions as was assumed before starting the project. In fact some elements had become obsolete and were hard to acquire and get delivered. Furthermore the correct interoperability of the technique caused a lot of issues and was solved on the spot by tailor made solutions. This was not what we had hoped for since we were looking to find a ¨one fits all¨ solution. Accordingly costs rose and frustration grew. We collected the data of all problems that were encountered during installation and kept a logbook on how we solved the issues. Per pilot site there were different problems with different solutions or similar problems with different solutions. In our logbook we recorded a total of 97 different issues and we now give a summary of what they were related to:

Error logbook SHOWE-IT

Rochdale installation	12
Boby installation	10
Cité Nouvelle installation	15
User Interface	53
Database	7

We had expected most errors to occur with the User Interface since we developed that part of the technology ourselves. We had not anticipated so many problems in the physical installation of the infrastructure. Moreover some of these errors were repeated and not solved at once. After appointing someone within the consortium to take the full technical responsibility things improved and we strongly recommend other consortia to give one partner the overall responsibility for the technical implementation.

2.2 Feedback on the technical solution

2.2.1 Social Housing Companies (SHC)

The overall project had a good concept, specifically being able to control the heating zones remotely (via the tablet) and also to be able to see the consumption data in real time. The reality was more complicated due to outdated technology, poor quality hardware and equipment that did not have a proven track record of working together harmoniously. An additional problem for social housing companies was the fact that they did not have the in-house skills to deal with such a complex system. Despite this situation, SHC´s have been able to educate themselves and managed to make the SHOWE-IT solution work with their internal technical experts or with subcontracted partners.

- The pilot site for Cité Nouvelle was not performed according planning. Installation was initially scheduled for the summer of 2012 but technical issues appeared at the same time. Due to lack of time, a first installation created an unbalanced heating system.
- The pilot site of RBH created other problems because each property had an individual, independent heating system rather than a communal setting. There was also an issue related to the transmission of data. Data was transmitted using a SIM card and a UMTS ‘stick’ which was inserted into a USB port in the PC. RBH used Vodafone as they seemed to have the strongest signal in that area but the system relied on a good 3G signal and this solution was very intermittent.

- At the pilot site from Boby there were problems with data collection and data collision. Also meters had to be reset physically by a member of staff. Moreover during the project it was found that heating valves did not work and thus managing the valves did not have any effect on consumption. Boby decided to replace all valves in order to be able to correctly finalize the SHOWE-IT project.

To improve the reliability of the system a selection would be needed of properties that match the type of equipment being installed. If social housing companies were ever to replicate this project or something similar they would ensure themselves that the technology was current and had a proven record. Housing companies would also ensure that all the equipment and hardware was of good quality and simple use. The ideal scenario would be a 'plug & play' product that requires a straight forward installation and operation.

2.2.2 Local SME

A local SME or contractor must be involved from the start of a project. This involvement would enable the different technical solutions to be validated before installing them on site. Even if you had a validation of each system by the different suppliers, the integration must take into consideration the specific features of a building. The overall job to make systems perform has caused disturbances for tenants. It should have been better to limit this installation time in order to avoid misunderstandings and problems with tenants. In order to avoid bad data transmission or collision, it should have been easier to harmonize the communication standard. The SHOWE-IT project had to gather too many different standards and that has caused complications during the integration (installation of gateways).

Key lessons learned and recommendations for replication

Organisation

1. The performance of a proper laboratory pilot solution should have had priority over the overall Project time schedule. No laboratory pilot solution was produced in the SHOWE-IT project as there was no building available at the scheduled time. The lack of a laboratory setting not only delayed the project planning and overall costs of the project team members, it also increased the risk of failing to achieve the project objectives.
2. There should be a clearly delegated project manager for the implementation on each site who is properly trained in all aspects of the solution and who has the authority to sub-contract suppliers. This project manager could be employed or subcontracted by the relevant housing company. In the SHOWE-IT project this approach has been adopted. This intention was good and gave better results however the technical experts in the team also made them responsible for some technical issues and a good advice for the future would be to make the organisations with the technical expertise fully responsible for the installation of the concept.
3. The selected installer/integrator for each location should also be properly trained and have the necessary technical expertise in HVAC (**H**eating, **V**entilation and **A**ir **C**onditioning), metering and ICT. We do not recommend housing companies to acquire these skills internally unless a housing company has enough scale to self-employ such type of staff.
4. There should be only one supplier for the whole solution (with a long term reliable track record). For the hardware infrastructure, for the HVAC controls, meters and IT equipment. Having multiple suppliers' resulted in unclear responsibilities in the event of any difficulties.
5. The content of the Work Packages in the Description of Work of European projects should be clarified in much more detail at the start, especially in terms of responsibilities and the delegation of jobs and tasks.

Installation sites

1. Before commissioning the HVAC controls there should be a properly functioning hydraulic system in place. This means a system that is (a) hydraulically balanced; (b) vented, to remove airlocks; and (c) has a primary plant that is properly integrated with the room controls.
2. Furthermore all older mechanical radiator valves for the heating system (approximately > 3 years old) should be replaced in any case to avoid problems with valves that are stuck (open or closed) or that have threads that are not compatible with the valve actuator.
3. The building operator should have a clear plan for controlling heating. The heating should not be left running 24/7 (this may sound obvious, turned out not to be so obvious in practice).

Technical options

1. Future installations should be simpler. For example without real-time meter data for presentations, which in any case bring little value but for monitoring and without comfort modes) with just a simple "in/out" control. In particular real time monitoring required a technical complexity that did not relate to the extra created value or enhanced performance.

2. Wireless, Short Range Radio Frequency (868MHz) devices must not be installed in metal cabinets (Faraday Cages) as this inevitably leads to RF **R**adio **F**requency communication problems. Extended testing in this case has proven that the chosen metal boxes in Boby staircases had no negative impact on any signalling. But of course, other types of material can be chosen.

3. Short Range Radio Frequency technologies (868MHz) were not optimal for this scale (beyond dwelling scale) since they required the Housing Companies and Facility Managers to develop asset management skills to deal with a complex implementation and maintenance system. Long Range Radio Frequency solutions available in the market would have avoided a number of incidents. For example, Boby experimented with a different receiving unit for 868 MHz that gave them reception for metering units not only in the same staircase, but the entire block of buildings and some buildings belonging to the next block! It is clearly a matter of the correct choice of equipment! The antennas in the MAS and the receivers were not as good as could be expected.

4. A suitable solution must prove to support a clear business case. The SHOWE-IT experience clearly showed that the technical approach and the technology mix did not meet the expectations.

5. The In-home display (tablet) did not create real value and therefore was not in alignment with project goals. Together with the associated (high) costs, there were other factors to be considered: battery charging required almost daily attention, life cycle is much shorter than other hardware systems (2 years instead of 15 years) and internet connection was required (why should you use a local server and the short range radio frequency technology?)

Characteristics of the data and adaptation to the needs for analysis

The objective of a monitoring and data acquisition system was to store values of key parameters that were going to be analysed in order to produce the outcomes of the project (in format).

Every analysis introduced an uncertainty in the results. The amount of data used to perform the analysis were very relevant to reduce the incertitude as much as possible (more data is less uncertainty). Reliable input data were important to come to meaningful output. To determine a set of input that could be used in the calculation tools we first had to define the characteristics of the data. The main and most common characteristics that define energy and water consumption must be defined prior to designing the data acquisition system. The characteristics in SHOWE-IT were defined as follows:

- Acquisition period;
- Units;
- Location of meter devices;
- Procedure or typology of metering;
- Uncertainty introduced by the meters and other devices of the system;
- Other issues considering the parameters monitored.

Our recommendation would be to take all the above characteristics into consideration before deciding on the design of the data acquisition system. Within SHOWE-IT we made the mistake to not have a full definition before starting the installation of our solution.

3 Electricity, heating and water savings

The quantification of success of the SHOWE-IT concept and pilot projects, was based on energy and water saving values. To obtain these values was the main objective of the data analysis.

3.1 Data available and harmonization process

As has been explained in previous sections of this document, the SHOWE-IT data analysis has been based on the acquisition of consumption data for heating, electricity, hot water and cold water from three pilot sites located in three different countries with the general characteristics as shown in the table below:

Parameter	Technology	Unit	Frequency
Heating	Meters in radiators	kWh	1 day
Electricity	Electric meter	kWh	15 min
Hot Water	Volumetric meter	L	15 min
Cold Water	Volumetric meter	L	15 min

Table 3. General data characteristics

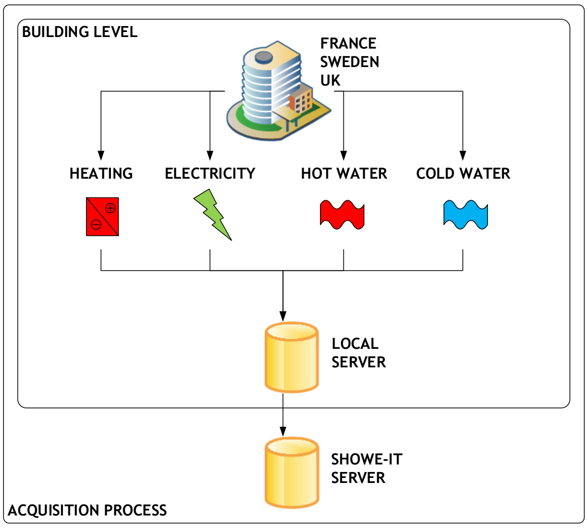


Figure 10. Acquisition process

Raw data stored on the global server were distributed into three folders (one for each pilot site). Each folder presented a different structure, depending on the characteristics of the physical system of data acquisition of each site. The common characteristics of all files stored on the global server were; the base time period of data generation and the separation of values for each parameter monitored. Every week a new file (*.csv) was generated containing the last data acquired during this period.

The data acquired was structured in two groups of dwellings (Pilot group dwellings which included the full ICT system and Control group which included a partial solution of the ICT system), with similar characteristics, to be compared at the end of the monitoring period, determining the result in terms of savings.

A harmonisation of data process was needed in order to produce useful data for the analysis planned. First of all, a complete check was necessary, correcting or deleting anomalous values. The following steps consisted the application of various Matlab (**mat**rix-**lab**oratory a multi-paradigm numerical computing environment and fourth-generation programming language) based routines to organize and transform the data in different time bases in order to produce the input for the different calculation methods and techniques that were selected. Finally, the data available for the analysis were presented according to the following time units: *Hourly; Daily; Weekly; Monthly; Seasonal; Annual.*
All these data were related to a corresponding dwelling which were also related to the corresponding technical/structural and sociological characteristics of the dwellings and its inhabitants.
As described in previous sections of the document, a detailed monitoring system was designed, adapted and installed in each pilot site to obtain, at least, one full year of data for analysis. We have been very careful in using the data and made sure that privacy of the tenants was guaranteed. We practically established this security by codifying the individual results per dwelling. The codified data were used as input for our calculation models.

3.2 Consumption characterization and data analysis process

3.2.1 General process

The indicators that have been produced and used in the analysis are the following:

- General characterization of consumption:
  - Average consumption (kWh and L).
  - Average specific consumption (kWh/m² and L/m²).
  - Percentage of dwellings which present higher than average consumption.
  - Monthly distribution of average consumption.
  - Percentage distribution per range of consumption.
- Consumption analysis based on seasonal behaviour.
- Contribution to consumption analysis.
- Global consumption comparison between pilot group and control group.
- Comparison of consumption per categories.
- Analysis of consumption patterns.
- Savings calculation.
- Behaviour of savings in monthly and weekly bases.

The final objective was characterising consumption and impact of the ICT solution using structural and sociological parameters that characterised dwellings and tenants in order to establish the relation between these variables and consumption. Saving calculations just showed the difference in percentages between consumption of different groups but the explanation of these results was executed using a complementary analysis based on the previous indicators.

The general procedure followed was as described below:

1. *Detailed classification of pilot sites.*
2. *Classification of users´ typology.*
3. *Energy audit intervention.*
4. *Establish a Pilot Group-Control Group approach as general procedure.*
5. *Definition of groups.*
6. *Definition of the monitoring program.*
7. *Selection of methodologies for consumption estimation.*
8. *Definition of complementary analysis.*
9. *Acquisition and harmonization of raw data coming from the data server.*
10. *Calculation of savings and generation of complementary figures.*

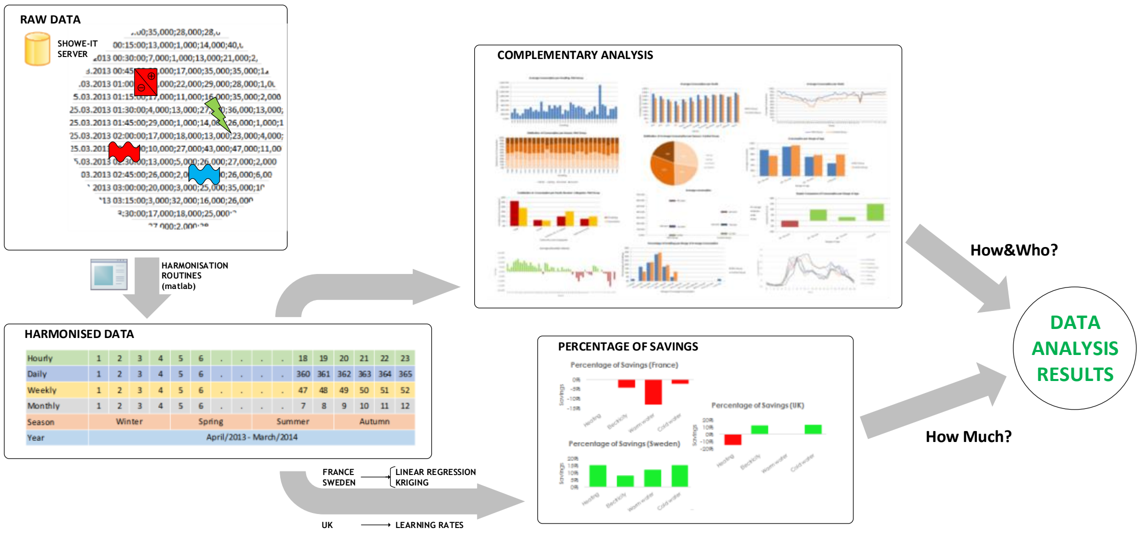


Figure 11. General scheme of data analysis procedure

The mentioned structural and sociological parameters were the following:

- *Surface.*
- *Floor.*
- *Orientation.*
- *Type of dwelling.*
- *Range of age.*
- *Range of income.*
- *Family structure.*
- *Number of tenants.*
- *Number of rooms.*

The analysis, based on the Pilot group – Control group (PG-CG) approach, compared the data acquired between both groups, by simple comparison, to obtain the percentage of savings. The main assumption of this approach was that tenants of the Pilot group were influenced by the SHOWE-IT project whilst tenants of the Control group just provided data as usual, representing the reference to establish the comparison.

To avoid the high incertitude introduced by the direct comparison of data acquired, consumption values of the Control group have been estimated establishing the assumption of a Control group with the complete ICT solution. In this situation, the simple comparison between consumption (real and estimated) determined the amount of savings achieved.

Of course, the estimation of consumption was based on real data obtained from the Pilot group and the structural and sociological characteristics of dwellings and tenants, as has been described in previous paragraphs of this document.

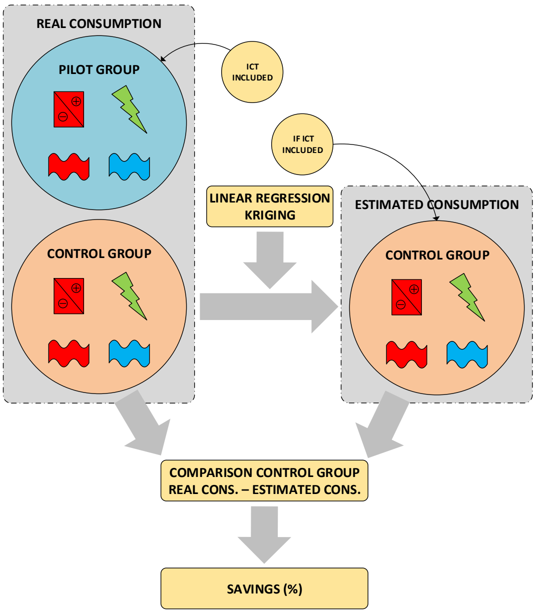


Figure 12. Integration of consumption estimation methods in the savings calculation process

To estimate consumption, two methods have been used in order to compare the results. The methods selected were linear regression and Kriging.

- **Linear regression** is a method that consists in finding the best p + 1 coefficient: β0, β1 … βp so that the consumption can be predicted at each date j by a linear combination of the p explicative parameters: $\hat{Y}_j = \beta_0 + \beta_1 X_{1,j} + \beta_2 X_{2,j} + \dots + \beta_p X_{p,j}$
- On the other hand, **Kriging** is a geo-statistical method that infers the value of a random field at an unobserved location. It is based on the idea that the value at an unknown point should be the average of the known values of its neighbours; weighted by the neighbours' distance to the unknown point.

The statistical analysis was performed with free statistical software: R. (R. is a free software environment for statistical computing and graphics). It was endowed with the Dice Kriging package [Roustant, 2012] developed at the Ecole des Mines de Saint-Etienne. This package allowed fitting different Kriging models. Another useful tool was the Bootstrap package developed by Rob Tibshirani and Kjetil Halvorsen. It enabled us to perform the 'leave one out cross validation'. Nevertheless, some key phases that needed an accurate arbitration such as the selection of variables and the choice of the best calculation model (between Kriging and Linear Regression) were not fully automated.
The detailed results are now shown (positive values = savings / negative values = overconsumption):

Parameter	Linear regression		Kriging	
	Result	Uncertainty	Result	Uncertainty
Heating	-2%	±17%	0%	±6%
Electricity	-7%	±26%	-4%	±20%
Hot Water	-17%	±43%	-13%	±7%
Cold water	-7%	±35%	-2%	±4%

Table 4. Detailed results for the French pilot site

Parameter	Linear regression		Kriging	
	Result	Uncertainty	Result	Uncertainty
Heating	+13%	±16%	+15%	±6%
Electricity	+10%	±15%	+8%	±14%
Hot Water	+9%	±20%	+12%	±4%
Cold Water	+12%	±20%	+15%	±4%

Table 5. Detailed results for the Swedish pilot site

The comparison of results showed a clear reduction in the incertitude of estimations offered by the Kriging model, providing more accurate results with an absolute difference between 1% and 36%.

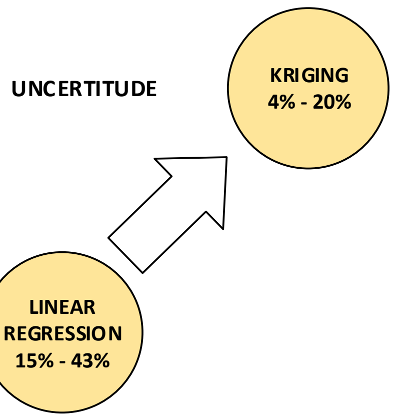


Figure 13. Improvement of uncertainty level, thanks to the Kriging method

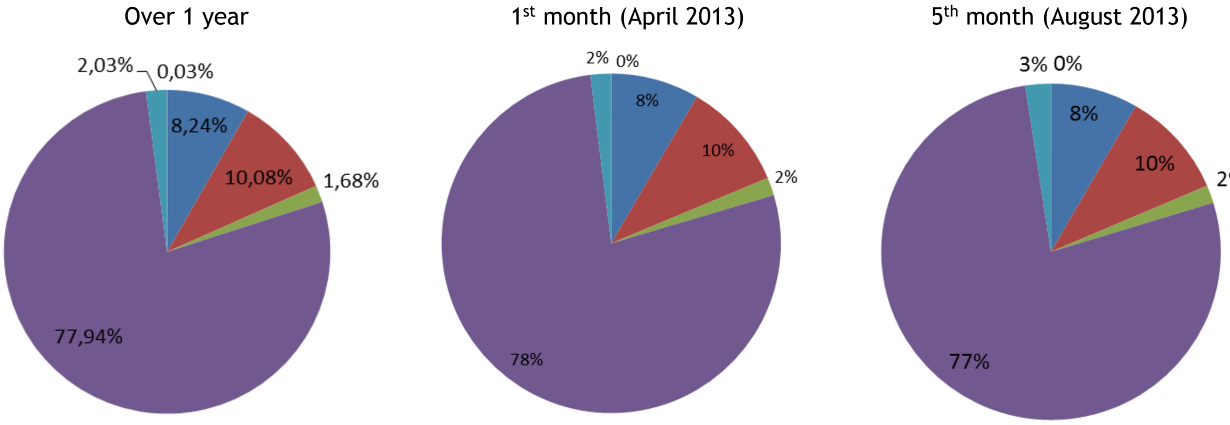
The utilization and comparison of these two methodologies were an added value of the project.

3.2.2 Refined water use data analysis

A complementary analysis of water consumption has been done based on the refined water consumption metering.

The diagrams show the usage distribution identified by the SHOWE-IT prototype that was implemented by Aqualogy. The system was based on the high speed logging system provided with the iMeter. The methodology that was prototyped had been previously tested in a monitored environment with an accuracy of 80% for use identification. The system deployed within the framework of the SHOWE-IT project was adapted to the requirements found during the project and the significant local particularities detected, including the plumbing layout, diversity of usage patterns, etc. The fine-tuning of the system was limited to the pilot group in Sweden.

Figure 14. Assessed distribution by use of water consumption, Swedish pilot site



Sweden

The results obtained in Sweden showed the huge impact that shower usage had on consumption.

The reader may have to take into account that communal laundry services were available to the tenants in Sweden, which would explain the low proportion of water used for laundry machines. Additionally, some water saving mechanisms, such as a dual cistern discharges were already in place.

Legend

- Kitchen faucet
- Cistern
- Toilet faucet
- Shower
- Laundry Machine

A comparison of the monthly aggregated figures showed similar results throughout the year. Actually, the first and last month of the project showed identical usage distribution (April 2013 compared to March 2014). This may lead to the conclusion that the training strategy benefits were met at the beginning of the project and were maintained over time, or that savings were homogenously distributed. However, it may also be due to the potential missed identification of usage over the time period, that is to say, changing habits might be identified by a system that has been trained for specific conditions? Users must carefully draw their own conclusions.

The fact that the first and last month showed identical statistics may also be the result of a similar period of observation, meaning, similar conditions may lead to similar behaviour. To assess whether the season may have any impact on the results, similar figures were extracted for August, the fifth month of the observation period. In that case, some minor differences were observed but still the same overall usage distribution was found, which meant that the results should be considered from a prudential distance.

The results obtained in Rochdale, England were clearly challengeable due to the inconsistent trial conditions.

United Kingdom

Figures identified in Rochdale, UK, were negatively affected by the lack of an on-site fine-tuning process. The diagram on the right is clearly challengeable due to a disproportionate use of the cistern. These mismatches were found in a situation where a timed button push shower system was available.

An additional source of uncertainty in this pilot´s results was the fact that measuring conditions were different from those in the other pilots. The Rochdale plumbing layout required single meter measuring, therefore no hot/cold water segregation was available as input to the algorithm.

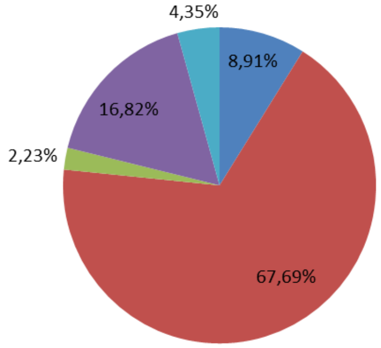


Figure 15. Assessed distribution by use of water consumption, United Kingdom pilot site over 1 year

Cité Nouvelle

The figures that corresponded to Cité Nouvelle pilot site were not available since the water use monitoring algorithm could not be configured in time due to the lack of data regarding the pilot conditions. Technical difficulties made it impossible to define the parametric variables.

3.3 Heat, electricity and water savings obtained

The table below shows the final results of the SHOWE-IT project. Percentages of savings (positive green values) on energy and water consumption or overconsumption (negative red values):

Parameter	France	Sweden	UK
Heat	0% (±6%)	+15% (±6%)	-14%
Electricity	-4% (±20%)	+8% (±14%)	+12%
Warm water	-13% (±7%)	+12% (±4%)	-
Cold water	-2% (±4%)	+15% (±4%)	+13%

Table 6. Final results of the project, in terms of energy and water savings

As becomes clear, different outcomes have been monitored. According to the results of the sociological survey, it can be concluded that savings were highly dependent on end-user engagement. Hence the importance to define and manage a clear tenant engagement strategy should be stressed, even during the monitoring period.

The results shown in the table above were in line with the results obtained in similar projects.

The main outcomes of WP1 (diagnosis, monitoring, and analysis of results) were the following:

- Positive verification of the possibilities of successful replication of the SHOWE-IT project concept considering that it was possible to achieve savings with this solution.
- Identification of risks. There were identified possibilities of overconsumption and/or bad usage of the system.
- There were indications that proofed the benefit of a methodology as used in the SHOWE-IT project where testing and validating consumption estimations were used in a Pilot Group-Control Group approach.
- Consumption characterization using structural and sociological parameters seemed to be valuable. Some clear patterns were detected but complementary analysis should be executed to explain where savings (or overconsumption) were produced.
- A clear standard definition of monitoring systems and standards could strongly improve the results of the work that is being done in different smart metering projects. A proposal for a global methodology for further analysis is strongly recommended.

Key lessons learned and recommendations for replication

First recommendation is a proposal for an improved global methodology concept based on the necessary interactions definition. That methodology should include a coordinated and optimized data collection framework to support the set objectives and to be able to constantly involve tenants in the short, medium and long term.

A global combined strategy has to be defined from the beginning of a project, based on the main objectives and outcomes identified. Taking into account that consumption and potential savings depend mainly on human behaviour, experts on this behaviour should be responsible for the coordination and definition of the mentioned strategy. Sociological experts are the most adequate specialists for this task, supported by experts on data analysis and ICT systems which would base their work on the specifications made by sociologists.

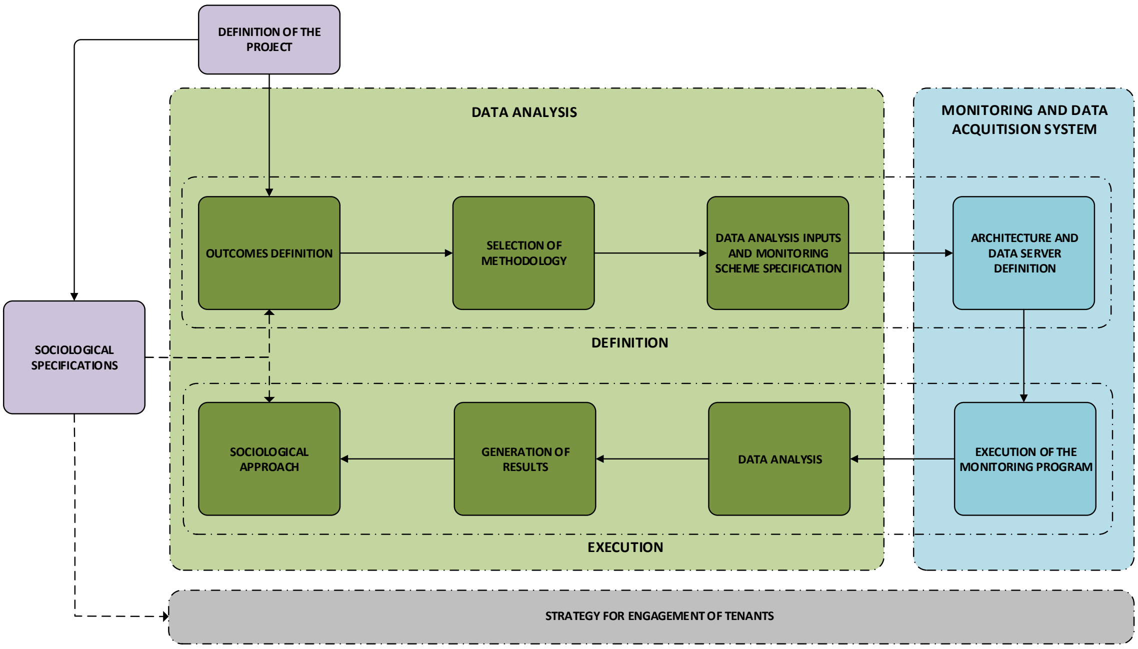


Figure 16. Global coordinated methodology actuation scheme

As can be seen in figure 16, in the design of the SHOWE-IT monitoring methodology two main elements are identified (Data analysis and Monitoring and Data acquisition system) In addition the design also used two different periods (Outcomes definition period and Execution of the monitoring program period). Sociological specifications should be present in all relevant steps of the process, in order to assure the integration of crucial requirements.

First of all, data analysis requirements based on the expected outcomes should be defined. The selection of the appropriate methodology is important in order to assure these outcomes and define the specifications of outputs coming from the monitoring/data acquisition system. At the same time the selection of computational tools for data analysis affect the effort needed to process the data. This task must be executed carefully.

Therefore, specifications of the ICT solution should be based on the requirements established by the data analysis procedure. The synchronization of both definitions (data analysis and ICT solution) is crucial. Characteristics of monitored parameters (frequency, magnitude, unit, etc.) as well as the structure of the data server should be defined considering the analysis in which is going to be used.

Once the tools for data analysis have been defined and the monitoring period has started, a continuous checking is important to evaluate the quality of the data. Periodic reports can provide responsible staff of other tasks the information necessary to detect failures. The content of these reports and the relevant parameters of control should be defined before the project starts and according to the further analysis and technical specifications of the ICT solution.

Finally, the complete analysis of data provided several types of results. On the one hand the percentages of savings pf the SHOWE-IT project were obtained. These were considered the main results coming from the data analysis. But on the other hand these values could be explained by a complementary analysis of consumption patterns. The sociological interpretation of these results can explain how and why end-users consume energy and water, giving possibilities to adjust the engagement strategy to continuously improve the results.

Furthermore, the application of a strongly recommended methodology which had been tested and submitted to public analysis was very important to provide more credibility to the calculations and results published. In this case, the publication of uncertainties and assumptions made during the analysis of data was very important and provided added value to the results and outcomes of the project.

Sociological specifications were very important because, as has been said before, engagement of tenants is crucial to the success of these kind of projects. In this situation, the combined project strategy should be centred on tenant’s experiences, maximizing the involvement and minimizing the intensity of these experiences at the same time. It is very important to note that involvement of tenants is a hard and riskful task because they can get easily stressed about the project, affecting the overall client relation (not only related to the project).

The balance between intensity of the tenant’s experience and revenues (for example in terms of economic savings or other savings identified as interesting for the partners) determine the success of the project.

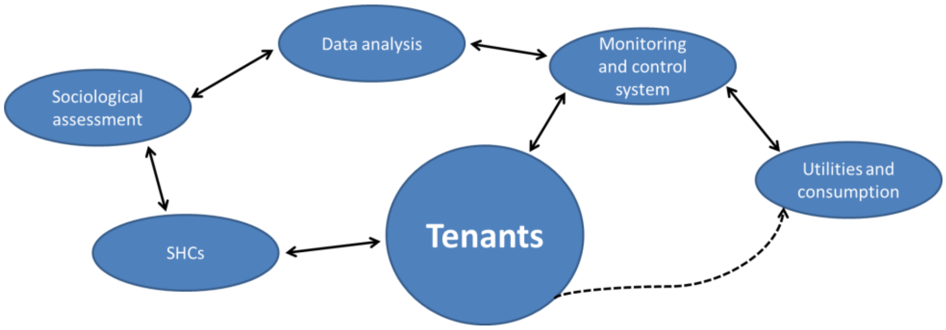


Figure 17. Global coordinated methodology of interaction recommended

Figure 17 represents the concept of a tenants centred interaction strategy.
Tenants would receive the following input:

- Real time consumption data from a monitoring and control system;
- Outcomes from short term data analysis of monitoring and control systems, that is:
  - Consumption compared to average values;
  - Personalized tips for consumption;
  - Environmental impact and potential consequences.
- Outcomes of long term data analysis of monitoring and control systems;
- Interaction with Housing Companies.

Both results of data analysis and Housing Companies´ interaction with tenants should be submitted to sociological assessment to make the proper adjustments according to the input received and in line with the project objectives, in order to optimize the interaction with tenants and consequently their behaviour, improving the results of the project.

4 Potential impact and replication

4.1 Socioeconomic viability and replication strategies

According to the European Commission (EC) houses and buildings are responsible for 40% of total EU energy consumption considering their whole life cycle. Buildings are also the largest source of greenhouse gas emissions, accounting for 36% of overall European CO_2 emission[3] and their total energy consumption has been rising since 1990. In order to cut CO_2 emissions and address the climate change the EC has set 2020 targets (20% energy demand reduction, 20% CO_2 reduction and 20% of energy from renewable sources). The EC objectives known as the 20/20 targets are to be achieved by 2020.[4]

Taking into account that 85% of the total energy consumption within the life cycle of a building is related to the operational phase[5], savings related to usage of buildings seem to have the highest potential impact for a consumption reduction. According to BPIE (**B**uilding **P**erformance **I**nstitute **E**urope) in 2009 European households were responsible for 68% of the total final energy used in buildings where as much as 70% of the energy is used for space heating. Considering global sustainability challenges, ICT enabler technologies are expected to become a key solution for the reduction of energy consumption in residential housing in the upcoming years.[6]

ICT based solutions developed and tested in the SHOWE-IT project provided the home automation and consumption monitoring equipment for the residential housing sector with the goal of achieving 15% - 20% reduction in gas and energy consumption.

The SHOWE-IT project provided an excellent opportunity to try in a real life environment a system, which was meant to become an optimal combination of technologies to address the energy reduction challenges in residential buildings.

Over the lifetime of the project it became clear that a combination of off-the-shelf technologies did not always perform as expected. The project resulted in many lessons learned, which can be considered in the future development and application of ICT based technologies for the residential housing sector.

4.2 Potential of the residential (social) housing sector

The residential sector is expected to have the highest replication potential for ICT solutions for energy efficiency due to a high number of residential buildings in the overall European housing stock (75% of all houses in Europe) as well as their relative poor energy performance. A big share of the whole European stock in Europe is older than 50 years with more than 40% of residential buildings constructed before 1960. The statistics provided by BPIE show that the highest energy saving potential is associated with the old building stock. Particularly buildings from the 1960´s where the insulation

[3] http://ec.europa.eu/research/industrial_technologies/eeb-challenges-ahead_en.html
[4] http://www.e2b-ei.eu/default.php
5 ICT for a low carbon economy. Smart Buildings. July 2009. European Commission, Directorate – General Information Society and Media.
6 ICT for a low carbon economy. Smart Buildings. July 2009. European Commission, Directorate – General Information Society and Media.

standards in construction have been very limited are assumed to have very high improvement potential. The average energy consumption of the residential sector is around 200 kWh/m^2.[7]

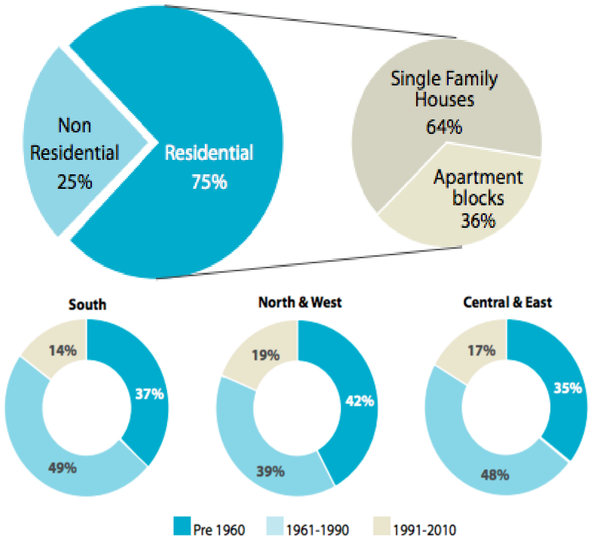


Figure 18. Residential building stock (m2) and age of housing stock in Europe (Source: BPIE)

The residential housing sector can be divided by tenants' rental structure. The majority of occupied European housing is privately owned. However, as much as 12% of all European housing stock is owned by Social Housing Companies. Furthermore, in some of the European countries social housing accounts for around 20% and more of the total country´s housing stock (in the Netherlands 32%, Austria 23%, Denmark 19%, UK 18%, Sweden 18% and France 17%). Considering the possibility for a large-scale rollout of ICT solutions for energy efficiency, social housing is the part of the residential sector with a high replication potential. The potential is not only related to the number of dwellings within the sector but also because of the organizational structure of Social Housing Companies. Furthermore social housing has very specific target groups with particular needs for home automation and monitoring systems, which have not been addressed yet by the solutions available on the market. Nowadays, social housing represents 35 million homes across Europe, housing 120 million people and accounting for some 18% of greenhouse gas emissions.[8]

Considering social housing as a target group for ICT solutions it is worth to take a look at the disposable income of households. Even though the social housing sector is characterized by affordability, due to the size of the market (around 20% of all housing stock in some of the EU countries) the social housing sector covers a variety of population with different levels of disposable income. The compilation of data from CECODHAS (European Federation of Housing Companies) below shows that on average tenants living in social housing have a reasonable part of their disposable income available after paying the rent. Furthermore, housing cost overburden rates show that in most of the cases significantly less than one quarter of the population living in social housing spend more than 40% of their disposable income on rent.

[7] BPIE European´s buildings under the microscope. 2011
[8] Showe-IT Deliverable 1.2.1

	Housing cost overburden rate[9] (as % of population)	Share of social housing in disposable income (%)	Total housing cost in Purchasing Power Standard[10]	Disposable Income in Purchasing Power Standard
Netherlands	13.2%	28.1%	805.30	2,865.84
Austria	5.1%	22.4%	452.20	2,018.75
Denmark	24.4%	33.8%	812.50	2,403.85
UK	16.7%	28.8%	694.40	2,411.11
Sweden	10.2%	24.1%	540.00	2,240.66
France	3.4%	17.1%	416.50	2,435.67
EU average	12.2%	22.9%	477.50	2,085.15

Table 7. Social housing costs, incomes and cost overburden rates (Source: CECODHAS)

Social housing as a targeted market sector includes a big variety of people in terms of their age, income and needs. Considering overall distribution of household types across Europe we can distinguish two main categories of single adults or couples without children representing around 55% of all households. Those two categories are expected to include a great share of young people and elderly people. The provided statistics are also representative for the social housing sector especially taking into account its affordability. According to statistics of Eurostat those two categories grew also faster than others during last years.

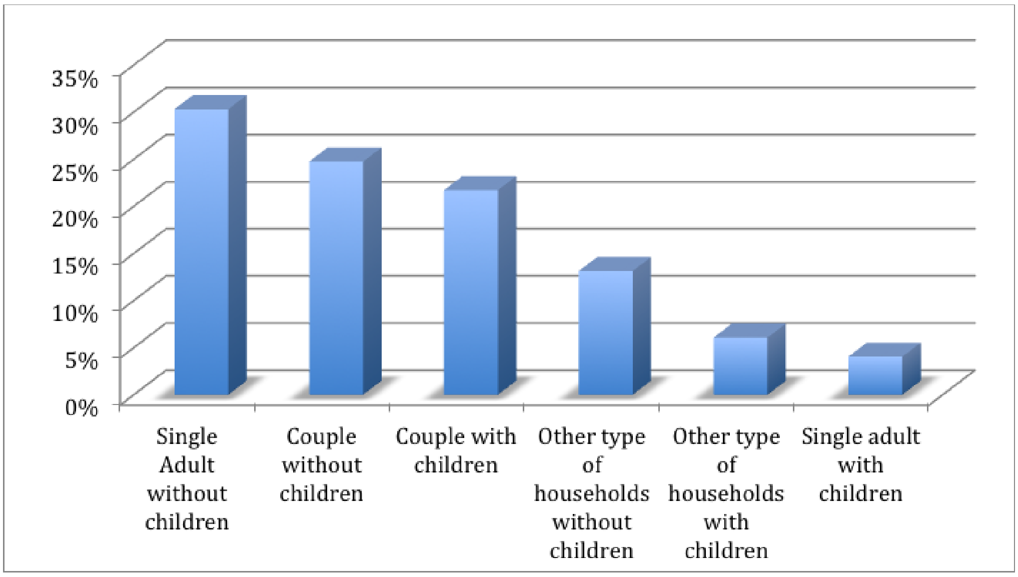


Figure 19. Private households by household composition in 2009 (Based on source: CECODHAS)

[9] The housing cost overburden rate is the percentage of the population living in households where the total housing costs ('net' of housing allowances) represent more than 40 % of disposable income ('net' of housing allowances).
[10] The purchasing power standard is an artificial currency unit. Theoretically, one PPS can buy the same amount of goods and services in each country. However, price differences across borders mean that different amounts of national currency units are needed for the same goods and services depending on the country. PPS are derived by dividing any economic aggregate of a country in national currency by its respective purchasing power parities.

Social Housing Companies can be an ideal starting point to roll out the ICT solutions at a large scale, since they have strong incentives to invest in energy efficiency measures. In particular housing owners are interested in:

- Increasing living quality standards of tenants;
- Lowering consumption costs of tenants (tenants have more disposable income to pay rent);
- Reducing energy consumption. Thus, decreasing CO2 emission;
- Communicate a message of Corporate Social Responsibility.

4.3 Possible business models for ICT based services in residential housing

While considering large-scale applications of ICT based services, business models play a crucial role. However, it is important to emphasise that the industry did not establish standards in this area and companies, both industrial and SME´s look for suitable business models, which would match their service offerings and ensure a sustainable growth. At the moment companies are experimenting mainly with 3 models. The first model focuses on the hardware sales, the second one is a subscription model and the third is a combination of those two.

Hardware sales

This model is based on the sales of the technologies as a package. The focus is mainly put on high volume and standardisation of the technology. Examples: OWL, Nest, TED - The Energy Detective. Main advantage: no need to maintain involvement with the clients, the product is hardware (possibly with basic software). Main disadvantage: no long-term recurring income from individual customers.

Subscription model

The model foresees subscription payments for the services offered and no initial (or limited) hardware costs. This is a similar approach of mobile phone providers, who charge a monthly bill for their services (calls, messages and internet). Example: Vivint. Main advantage: monthly cash flow, securing the sustainability of the company´s operations. Main disadvantage: no initial revenue from the hardware sales, need to provide services fully operational.

Combined model

The combined model consists of initial hardware purchase and subscription payments for additional services. By charging a low initial price for the hardware technologies companies are able to attract a major part of customers who cannot finance a complex ICT system at once. Such customers purchase additional services for which they are charged monthly. This allows the ICT vendors to satisfy customer needs while maintaining a sustainable revenue stream.

Most of the vendor solutions on the market today come in a subscription form or are in the process of adding subscription services if from hardware companies. Depending on the business model, the fees are covered either by the end customer or the utility. In both cases, subscriptions are common and effective pricing tools.

4.4 Cost benefit analysis

It is reasonable to assume that European households spend €100 per month on energy, which makes €1,200 a year. National statistics from the UK show £ 110 of energy spending per household. We assume that an average EU household´s energy consumption would be slightly lower.

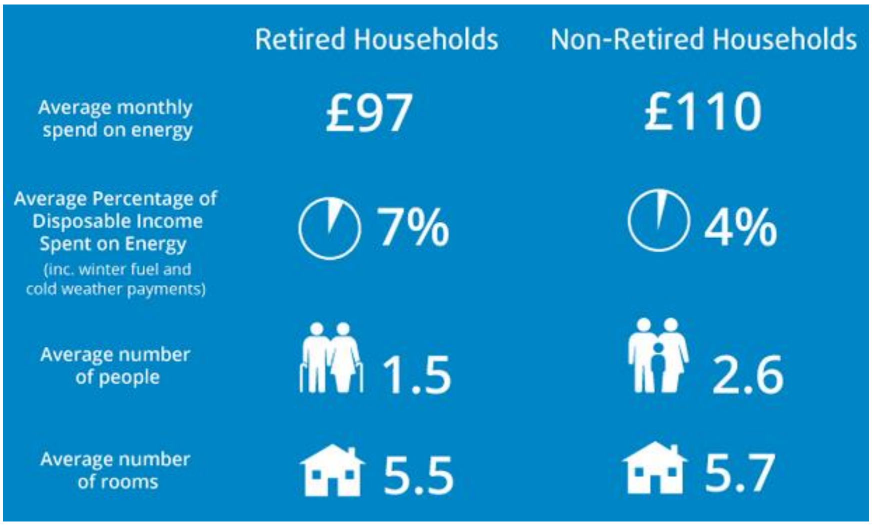


Figure 20. Energy spending by a household in the UK (Source: Office for National Statistics UK) [11]

Different sources[12] and results from multiple projects[13] indicate that the usage of ICT based services can bring energy consumption savings within a range of 5% - 20%. Considering a household energy consumption of €1,200 annually and estimated savings of between 5% - 20%, result in monetary gains within a range of €60 - €240 annually. Additionally, we should keep in mind that 20% of savings is a very optimistic scenario.

Estimated annual monetary savings with 10% energy demand reduction

€1,200 x 10% = €120

Having an estimation of possible savings within a range of €60 - €240 annually per household, we can calculate a reasonable cost of the ICT solutions. Based on the interviews with building owners it is reasonable to assume that the payback period of an investment in ICT systems would need to be lower than 5 years (considering relatively new technologies and uncertainty about its lifetime and the battery lifetime. This means that the acceptable cost of the technology should be lower than €300 (€60x5) in the pessimistic scenario; and lower than €1.200 (€240x5) in the optimistic scenario. Considering that the ICT solutions have not been tested at the market on a large scale, building owners will seek rather for a 3 year payback period.

[11] http://www.ons.gov.uk/ons/rel/household-income/expenditure-on-household-fuels/2002---2012/full-report--household-energy-spending-in-the-uk--2002--2012.html
[12] https://www.ewgeco.com/blog/decc-consultation-encourages-energy-demand-reduction/
[13] http://eemeasure.smartspaces.eu/eemeasure/generalUser/

Estimated costs of ICT based solution with 10% energy demand savings potential and 3 years payback period

€120 x 3 = €360

This does not include the maintenance costs (which differs across technologies) and does not consider the problem of split incentives. With split incentives is meant that one stakeholder (normally the landlord) invests in Energy Efficiency but another stakeholder (normally the tenant) benefits from lower consumption costs because of this investment. In such a scenario the investor is unable to earn back his investments.

The SHOWE-IT project used a combination of off-the-shelf technologies, which turned out to be difficult to integrate, thus the costs of the technologies per dwelling were around €3,800. This means that this particular set of technologies is not replicable from a financial point of view.

Considering different elements which influence the possibility of large scale rollout of ICT based solutions, there are key messages to be emphasised:

- Sustainability is increasingly becoming part of our every-day life. The current level of natural resource consumption is destructive for the environment. Buildings account for 40% of the European energy consumption and one third of the GHG (greenhouse gasses) emissions[14]. It makes buildings one of the most important targets for the energy consumption reduction.
- Prices of energy are rising (although they have dropped dramatically in 2015) and are expected to rise even further. An average bill for gas and electricity in UK grew almost 62% within the period 2010-2014, reaching a total of £1,352 per household[15]. Consumption savings will not only contribute to the overall sustainability but also help to keep costs stable in relation to the dispensable income of tenants.
- Social Housing in Europe accounts for 12%[16] of total housing stock, with some Western countries over 20% (e.g. Netherlands 32%, Austria 23%)[17]. Considering a scope of the sector, any consumption reduction in social housing will have significant impact on overall European consumption performance. Furthermore, suitable solutions for social housing can be promptly leveraged on a large scale due to the organizational structure of social housing companies (investment decisions taken on a large scale).
- Consumption monitoring and home automation. Research in the area of ICT systems in residential housing shows evidence that smart metering and home automation can reduce electricity and gas consumption up to 20% of the overall consumption. However, in the SHOWE-IT project this target was not reached in all pilot sites (cf. main results).
- Data should probably be stored and accessed in a cloud environment, now that technical opportunities have improved and costs have been reduced. This was not the case at the time of the project.
- Investments in ICT based solutions in the social housing sector should not be higher than €360 per dwelling in a realistic scenario. Even at this level more confidence is needed that such an investment would indeed yield monetary savings for the tenant.

[14] http://www.sciencedirect.com/science/article/pii/S0360132305004671

[15] http://www.thisismoney.co.uk/money/bills/article-1607475/Cheapest-energy-tariffs-We-reveal-todays-cheapest-energy-gas-prices-including-fixed-deals.html

[16] ICT for a low carbon economy. Smart Buildings. July 2009. European Commission, Directorate – General Information Society and Media.

[17] CECODHAS Housing Europe. Housing Europe Review 2012

- It is difficult to compare measured savings with utility bills. The billing process is different across Europe, from pre-paid bills, to collective bills, to individual bills. Utility companies are not very collaborative and transparent in sharing and explaining historical consumption data. In our project we have not been able to make a reliable comparison based on the utility bills.

As said before the final costs of the SHOWE-IT solution were far too high to make a feasible model for replication. We now give you the final costs for the respective pilot sites per dwelling:

Cost details Rochdale (UK)

	Total cost	Pilot group	Control group
Tablet PC + communication	14.140,00	14.140,00	0,00
Electricity meters	760,00	760,00	0,00
Heat meters	4.108,65	4.108,65	0,00
Synco Living system	13.012,00	13.012,00	0,00
Water meter	5.105,00	5.105,00	0,00
Programmable timeswitch + TRV + heating auto-bypass	3.067,50	3.067,50	0,00
Installation, commissioning and technical support	24.911,50	24.911,50	0,00
Audit energy	2.070,00	2.070,00	0,00
Total (without delivery charges)	**67.174,65**	**67.174,65**	**0,00**

Number of dwelings in different groups	**9**	**9**	**0**
Total cost per dweling (per group)		**7.463,85 €**	**- €**

Cost details Boby (SE)

	Total cost	Pilot group	Control group
Tablet PC + communication accessories	12.414,00	12.414,00	0,00
Heating meter (heating boiler)	28.136,00	16.822,00	11.463,00
Water meter + communication	38.642,00	22.899,00	15.743,00
Synco Living system	69.766,00	69.766,00	0,00
Electricity meter	5.756,00	3.411,00	2.345,00
Internet connection + monthly fees	29.842,00	18.948,00	10.894,00
Installation, commissioning and technical support	148.711,00	88.125,00	60.586,00
Audit energy	14.956,00	8.863,00	6.093,00
Total (without delivery charges)	**348.223,00**	**241.248,00**	**107.124,00**

Number of dwelings in different groups	**108**	**64**	**44**
Total cost per dweling (per group)		**3.769,50 €**	**2.434,64 €**

Cost details Cité Nouvelle (FR)

	Total cost	Pilot group	Control group
Tablet PC + communication accessories	17.930,00	14.209,00	3.721,00
Heating meter (heating boiler)	4.341,20	2.604,72	1.736,48
Water meter + communication	27.073,00	22.938,00	4.135,00
Synco Living system	35.003,00	35.003,00	0,00
Electricity meter	7.885,71	4.779,22	3.106,49
Internet connection + monthly fees	2.084,00	1.250,00	834,00
Installation, commissioning and technical support	87.340,00	61.240,00	26.100,00
Audit energy	20.773,00	12.464,00	8.309,00
Total (without delivery charges)	**202.429,91**	**154.487,94**	**47.941,97**

Number of dwelings in different groups	**66**	**40**	**26**
Total cost per dweling (per group)		**3.862,20 €**	**1.843,92 €**

5 Social Housing Companies´ Pilot Reports

The project composed three pilot project sites where metering was installed together with equipment to obtain the data of all energy and water consumption in the chosen dwellings and to report that consumption back to the tenants. This information should raise the awareness of tenants and with the help of professionals result in a lower consumption of energy and water. The general idea was to have one pilot group with full access to information of all consumed water (hot and cold), electricity and heating. The read-outs of this group were to be compared to a similar arranged group named the control group, but no consumed energy was reported back to that group, by this having the group blinded to their consumptions.

The three Social Housing Companies in Sweden (Botkyrkabyggen), the United Kingdom (Rochdale Boroughwide Housing) and France (Cité Nouvelle) were responsible for appointing subcontractors to perform all necessary installations. All equipment had to be supplied by other partners in the project, to be state of the art and ready-to-be-installed, giving no additional technicalities to worry about.

The total number of dwellings participating in the 3 pilot sites were:

	Pilot Group	Control Group
Sweden	64	44
England	14	
France	40	26

Table 8. Number of participating dwellings in the 3 pilot sites

The efforts were initially focused at all 97 dwellings in the English programme, where the legal position of tenants determined that participation should be 100% voluntary, having as a result a lot less participating tenants. More details on this in the UK section.

5.1 Tumba, the Pilot Site in Sweden

The work to be performed was: fibre optic cable installations, perforation of concrete walls and ceilings, electrical installations, wire based communication (KNX, 1-wire and S0 systems), HVAC with extensive plumbing, control and regulation programming and finally installation of wireless RF systems like wM-BUS and wKNX.

Figure 21. Visit at the Swedish pilot site

No subcontractor could be found having all the mentioned items in their overall service and product offer. Actually, it was quite a challenge to find any subcontractors willing to accept the assignment of some of the items at all. The SHC's had to accept additional work and costs in order to execute an extensive procurement process for several subcontractors, arranging a workflow of all installations. Moreover the tenants had to accept a change to the original agreement of having one or maybe two visits by subcontractors in their dwellings, now having to accept multiple visits over a longer period of time.

It was also decided to have an initial (laboratory) pilot installation (not to be confused by the pilot site concept) where one staircase of dwellings in France was to be used to verify all the installation procedures, the equipment to be installed, as well as the outcome of data in good orderly fashion. It was unfortunately decided to omit this pre pilot installation due to primarily time pressure, but also due to the lack of availability of some key components.

The meters were available yet the entire ICT system was not. The PC Tablets and the underlying system presenting consumption data to the tenants were not adapted to the configuration that was requested and would not be for months. Not only had the mix of several data systems to cooperate together in a fashion never tested before, the actual meters themselves were also re-configured, giving entirely new challenges to handle. All water meters, originally set for transmitting read-outs every 4 hours, were now set to transmit any consumption at every 192 seconds, giving RF congestions where also the HCA units (Heat Cost Allocators, energy meters mounted on all radiators) had to share exactly the same radio space as the water meters. Thick concrete walls in the Swedish housing situation also prevented the radio signals to reach their destinations; radio repeaters were installed to solve this issue, only to give additional radio congestion.

Even if the omitted pilot installations were understood to be a necessity, a decision was still taken to start all installations at the 3 pilot sites where missing components and subsystems should be added as time went by. In retrospect this decision is deemed to be the main mistake made by the project. Numerous technical issues occurred that needed to be solved on site in the actual pilot site dwellings. With as a result multiple visits to the dwellings, all against increased costs and tenant´s dissatisfaction.

The lesson to have a complete laboratory pilot test setup installation previous to any main installations is key to success for any future project of the same kind. The SHC's have been heavily loaded by technical issues during the project where the support from either local subcontractors as well as technical partners of the project where not at the standard that was expected. All three SHC's had to engage local technical expertise to have the installations working. Support was given by the project partners, although not as much as needed. It is important to understand that SHC´s do not have in-house technical expertise to sort out any issues regarding technical metering systems. Any system of some higher level of sophistication will lead to items to be solved before any of these systems can be installed. The technical partners of this project have all wrongly anticipated that local support by subcontractors or in-house at the SHC's were in place. They could not have been more wrongly.

The outcome of this project has though been of importance to all SHC's, where the know-how and outcome have highly gained the SHC´s understanding of what does work and what does not, as well as how to organise similar activities in the future. In some parts this new knowledge is invaluable.

For the Swedish market Botkyrkabyggen has been contributing to the Government directives regarding individual energy metering and billing. Unavailable knowledge present at no other company in Sweden, has strongly contributed to help some other 400 SHC's in gaining knowledge to future installations and technologies in this area. Work has been done in order to set common standards about rules and techniques we know that work well. This is now widely spread knowledge amongst the SHC's and the Federation of these organisations SABO. Actually Botkyrkabyggen has been requested to inform the Government partners in order to have them understand the possibilities and difficulties regarding individual metering. In this way dissemination is guaranteed and the information provides benefits to all stakeholders.

Key lessons learned and recommendations

- After this project we know that SHC´s should not be considered to be PC suppliers. The households already have a high number of personal computers, where adding another one offers no real contribution to the solution. The solution should instead be using common accessible websites where the consumption of energy is presented. Considering this we will not have SHC's operating as PC suppliers with all the support and technology needed.
- Real time read-outs of energy consumption posed big technical challenges as well as increased the costs. The question has been raised if real time read-outs have any positive impact on the consumption, or if the more common solution with monthly presentations of consumption will be just as good. The SHC's believe the latter solution the better.
- Heat metering of any dwelling that was constructed for having one common source of energy provision resulted in very difficult challenges in order to obtain a solution where debiting is accurate. With vertical piping to radiators and a building construction where the primary shell is in the outer building walls solutions are awkward. Algorithms can be obtained to find fair billing systems to any dwelling within a larger building. To have these algorithms work in a 100% fair billing solution will not be easily achieved. On top of this the technical solutions available today have all serious drawbacks where none give a 100% acceptable and fair solution.

- To provide the tenants with technical solutions where the energy consumption can also easily be increased. Better heating tends to result in tenants to accept the higher costs in return for higher comfort (so called rebound effect). The system providing information on the extra monetary costs for increased comfort make that decision easier. This behaviour has been seen constantly during the project test period.
- Tenants tend to have some interest in manipulating the metering system, primarily heat, in order to cheat the consumption of energy and gaining comfort. This erratic behaviour has been addressed as not acceptable by the SHC's at several tenant meetings, even with a fine declared of €300 Euro each instance where any tampering with any installed equipment is discovered. Dismounting heat actuators on radiators has been seen in a surprising number of instances, where even more surprisingly elderly persons seem to be keener to execute these unhelpful actions. Removing batteries in the actuators is also a popular tampering action, when the actuator is left in an open position, by this providing full heat flow regardless of indoor temperature in any dwelling.
- The French solution regarding electricity metering with so called "smart meters" has been providing extra technical challenges on several levels. The technical S0 pulse needed for any metering was not available. These smart meters are also available in a number of configurations and constructions where no one is the same as any other. The solutions have all been designed to install an additional standard (not "smart") electricity meter in series with the existing "smart" ones.
- All equipment to be installed **MUST** be obtainable locally with any local service provider taking full responsibility of the installed solution. There is no acceptance from any SHC to be the party carrying all the risks. The less obtainable the solution, equipment, service providers and installer are, the less likely it is to be able to address the local market with any solution, regardless of sophistication and quality.
- Any technical solution needs to follow open standards, allowing interchangeability to other vendor products. Open Metering Solutions are preferred at all times, giving the SHC's full freedom of choosing any solution in any combination, at any time. All proprietary components and solutions are to be avoided at all times. Interchangeability is the key to success. The key word to mention here is solutions. Market actors with components to any energy metering installations will have no success at all, unless any local provider/installer/service centre will act as an integrator with total responsibility for the entire solution. This item alone might be the top outcome from this project to any SHC interested in any energy metering installation.
- The installation was initially budgeted at €3.000 Euro per dwelling, where the outcome was a lot more expensive in all countries due to necessary re-installations, change of equipment and additional subsystems necessary on top of all the issues to be solved.
- The key elements of the interaction plan with tenants were determined during the project: follow-up information, transparency and comprehensive understanding of the problems encountered by tenants, improvement of the information elements (especially the bills). The management of expectations of tenants about new energy services, as well as the key elements to provide in an interface displaying domestic energy consumptions are better understood now.

5.2 Rochdale, the Pilot Site in the United Kingdom

The UK based Housing Association (RBH) experienced difficulties in identifying a suitable pilot site after the original site was deemed unsuitable due to the nature of the buildings pipe configuration and the demographic of the tenants that would not have provided the project with good results.

Figure 22. The United Kingdom site

Further options were explored, finally having to settle with a neighbourhood with individual properties rather than a block of flats with a communal element.

The first problem RBH encountered was in regard of tenant participation. With a total of 96 properties in the neighbourhood that could potentially have participated only 16 tenants showed an initial interest in participating, despite the best efforts of RBH. This number then gradually decreased to 7 properties in full participation and 2 properties where monitoring only took place.

The reasons for this decline have been heavily documented within the deliverables of the project but are listed below for the purpose of this report:

- Lack of trust in the Social Housing Company and the energy suppliers;
- Suspicion around metering (big brother effect);
- Lack of interest & motivation.

Despite the low numbers of participants the project continued with a limited number of tenants involved; this was the correct decision as this was a pilot project and it is good practice for all successes and failures to be recorded in order to improve future projects.

Further problems occurred with finding a technical solution that was within the budget and that met the requirements of the project and the end users.

As the UK pilot site had separate properties with individual heating systems the technical solution presented challenges different to the Swedish & French pilot sites.

Outline of Technical Solution

The heart of the system is an industrial specification PC programmed to gather and store information received from pulse counters, temperature control systems and a user interface.

In order to record energy consumption it was necessary to receive pulses from meters which should have a relatively straightforward exercise but it was discovered that on the pilot site there were 4 variations of electricity meters, 8 variations of gas meters and no water meters at all. None of the existing meters were capable of producing pulses without expensive alterations. The solution was to fit additional electricity meters along with the existing meters, provide new water meters and install new heat meters on the boiler circuits.

To enable close control of room temperatures, each radiator was converted to automatic operation using radio-frequency controlled actuating valves (Synco Living); these valves needed to be carefully calibrated to ensure correct operation.

At the other end of the control sequence was a user interface in the form of a tablet PC with colour display, wirelessly connected to a signal router. The function of the tablet was to adjust room temperatures, access information relating to the project and to see current and historic energy use.

Key lessons learned and recommendations

Throughout the technical solutions design and implementation many problems occurred, most of which were resolved. However this resolution came at a price with the final solution costing over €7.000 Euro per dwelling.

A great deal of knowledge was gained throughout the duration of this project and a lot of lessons learnt an overview of which is listed below:

- Gain your audiences trust;
- Good technical skills / a contractor with a proven track record;
- Good quality equipment (hardware & software);
- Use of technology with a proven track record;
- Communication – what do tenants need to know and how to manage their expectations for energy tips /savings/services

In terms of replication, RBH did feel that elements of this project do have a place in a social housing setting but the solution would need to be simple, cost effective and need a minimal amount of maintenance. Our participating tenants did give positive feedback about some elements of the project, specifically the user interface (tablet) and they liked the fact that they could see their energy use. Some expressed that they would like to see this technology further developed so that the functionality of the tablet could offer the tenants more such as contact with their housing officer or being able to pay their rent via the tablet.

The future for this technology at RBH is limited, primarily due to costs; however RBH plans to incorporate elements of the project (Synco Living) into another project starting in spring 2015. On this project at a Sheltered Accommodation site a major refurbishment is planned and as part of this a central heating upgrade will be installed where RBH planned to use the Synco Living technology to control the heating in the communal areas of the building.

5.3 Ecully, the Pilot Site in France

In France, the pilot site was managed by Cité Nouvelle. Ecully is a quiet neighbourhood just outside of Lyon. The pilot project was executed in a block of flats that had recently been renovated and thus at first the tenants were not very keen on other works in their dwellings. During the project the tenants started to become interested and in general they were participative. In the business plans of Cité Nouvelle there are high ambitions towards sustainability and therefore at the start of this projects there was a lot of enthusiasm for the project. Once the project had started the organisation went through an organisational restructuration what did complicate things for the staff that was involved in the project. Because of the issues with the SHOWE-IT solution that we have described in detail in this report the limited staff resources combined with the challenging issues put a heavy strain on the organisation. The main issues on the French pilot site were to begin with the electrical meters that were in place. These meters do not send out pulses as was required for our solutions and we had to find a way around this issue. Another big problem was that the space where the water meters had to be installed were too small and hence we had to find a creative solution to manage that problem. Apart from these issues there was a lot of annoyance when the needed hardware could not be delivered in time. In general the technical solution was not of the shelf and was not plug and play. All the above resulted in a delayed planning and finally in this project the monitoring of water consumption could not be realized in time.

Figure 23. The French pilot site

Key lessons learned and recommendations

The lessons learned by the French Housing Company:

- The experience of technical problems encountered during the SHOWE-IT project is an interesting learning element for the organization;
- The REX (research and experimentation) on equipment, interoperability of devices and the management of teams will help Cité Nouvelle to better anticipate those problems in future projects;
- The way to improve communication with tenants in energy programs.

In France, the housing company has discovered the real expectation of their tenants for energy savings is that they are curious and eager to engage themselves in these kind of projects. With the SHOWE-IT project Cité Nouvelle learned that they should have more people like sociologists or partners working on site to inform people, as it revealed to be received positively. What the SHC learned to understand within this project is that influencing human behaviour is the key to success, something that technicians or building managers often forget. For the future interest was expressed on hiring someone to manage specifically the communication with tenants in this type of projects.

During the whole project, Cité Nouvelle has made a lot of information available to tenants. All stakeholders involved like the concierge, Armines, technical partners from Aquagest and the sociologists created an excellent interaction with tenants during the installation process. The energy auditors made great work to inform tenants on their levers for energy savings.

For future projects, the French housing company recommended to be careful and to anticipate important budgets both for communication and management of all the technical problems. Their other conclusion was that tenants were waiting for a tablet displaying energy consumption. The problems in the SHOWE-IT project were mainly technical problems, but the interest of tenants was and remained very strong for services reducing energy and water consumption.

6 Communication

From the start of the SHOWE-IT project it was accepted that there should be a strong emphasis on communication. Actually communication of the findings of the projects could be one of the main objectives in itself. The communication and documentation should help others to improve results in the future.

Because the project was executed with existing technical solutions that were combined and established in different geographical locations the results were not always equal in the different settings. In our communication we tried to pick up on the trends that were recognized but we also communicated the local differences. The SHOWE-IT project did not only have technical elements but also a strong sociological element. Again we stress that we tried to find sociological trends but observed also strong local differences.

To execute the communication task at a high level we did research on how communication works and what would help us to get the message across. The SHOWE-IT consortium studied best practice and came to a plan that was set as a guideline for all our communication.

6.1 The way to communicate

The first purpose of scientific popularization is not to teach, but to provide information to the public in such a way as to create a desire to learn. To do this we had to be able to tell a story and share our adventure. Why were we interested in this field of research? Which questions remain unanswered? What is at stake? What obstacles did we encounter? Did we find the results surprising? What are the benefits, the repercussions? Will the results influence people's lives and how?

6.1.1 Caring about different attention groups

In the field of popularization, the public's attention and interest are never a given fact. Contrary to situations involving peers, scientists and suppliers the general public was under no obligation to read our writings or even listen to us. It was up to us to motivate them to do so! This is why we directly divided our audience into different groups that were interested in different elements of the project:

- Communication with tenants: internal audience with especially the tenants and staff;
- External communication: external audience with stakeholders, media, universities, scholars, energy efficiency experts, companies etc.

Communication with tenants

Tenants were personally invited to participate. There were telephone calls, there was door knocking and information events all focused on gaining support for the SHOWE-IT project.
We understood that the most common rule stated that the more complicated our message was, the richer our channel should be, so when presenting the project for the first time to potential participating tenants we made sure that we put the greatest effort in presenting ourselves and our project personally. On the other side, when the message was more informative or routine and easy to understand, an indirect channel was used as being more appropriate because it was assessed as more efficient.
So we used a wealth of channels in this project from the most personal way to involve the local tenants to the less personal way of sending out a press statement. We now sum up all channels we used in our project:

- **Participants meetings;** there were meetings with the participants in the projects (tenants) and it was attempted to make the project as attractive as possible to people. In theory the concept of holding regular meetings with participants involved in the project seemed a simple and useful process but sadly the reality of this was not as successful as first thought. This was true in all three countries, however Sweden & France did have more success than the UK Pilot site. Reports from Sweden & France were that participants used the meetings as a social gathering or as an opportunity to complain about other housing issues. It was also recorded that it were the same participants that repeatedly attended the meetings with little interest from others. The meetings were primarily to explain the concept of the project and for the participants to gain an understanding of some of the technology (specifically the user interface). Overall the participants understood the concept of the project but unfortunately the technical issues with the user interface monopolised the meetings;
- **Door knocking;** where we did not manage to get in contact with tenants over the phone or by e-mail contact we tried traditional door knocking. By using this channel we managed to reach people that are rather remote from modern communication channels;
- **Notice boards;** were used on the locations of our projects in Sweden, France and the UK to inform tenants on progress;
- **Interviews;** were both held orally as in writing. Especially for the sociological research in depth interviews were executed to get the most detailed view of individual motivation.

Since 2011, we have gained an important knowledge about how to communicate internally with tenants in such ICT Energy Efficiency programs. Indeed good work has been done by the partners during the project especially the Housing Companies, accompanied by the sociological team of Engie, and in collaboration with Armines, to inform their tenants, to guide them at the beginning of the testing period with the interfaces, and to help them when technical problems occurred, or simply by showing them how to use those new devices.
The communication plan as was set in 2012 has been achieved by Housing Companies beyond expectations and this has led to an excellent satisfaction of the Swedish and English tenants for the information they have received during the project, as the quantitative survey confirmed in 2014.
Some improvements could nevertheless be made regarding the type of information tools used and their contents (accuracy, enough detailed and attractive information), the frequency (more follow-up information).

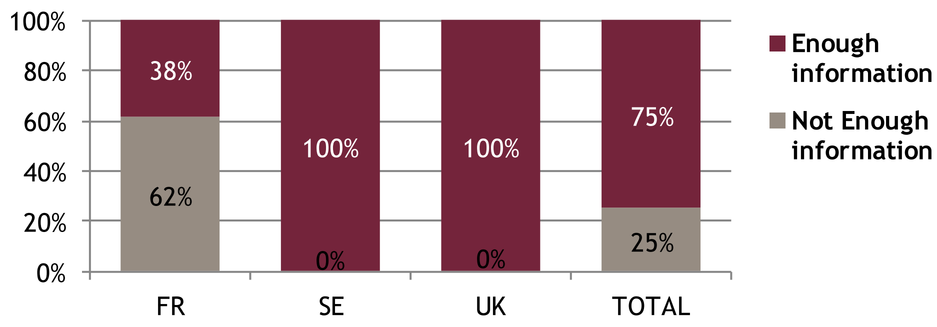


Figure 24. Households' opinion on information received on the functioning of the tablet upstream and during the installation (unit: number of households - source: ENGIE)

The vast majority of tenants composing the sample of the survey thought they had received enough information about the project progress and sufficient information on the tablet at the time of installation. Tenants answered the same questions twice ("before" and "during" the project).

Internationally we saw cultural differences determining the success of different ways of engaging tenants in the SHOWE-IT project. Where we saw that in Sweden and France there was interest in group meetings the English tenants preferred an individual approach. The people in England seemed sceptic towards changes where the perception in Sweden was mainly positive. This was also perceived in the participation grade. There are however also clear differences in the national housing systems that may have caused these differences. In Sweden there is no such thing as social housing. Houses are priced according to the market and people are supported on the basis of their income rather than on the dwelling they inhabit (in Sweden the system is subject based rather than object based as in England and France). Another big difference was the acceptation of incentives. In England even with incentives like free cinema tickets it was difficult to engage people, in Sweden some sandwiches were enough to satisfy the attention of people.
Often expectations had to be managed. People thought that the tablet they were provided with could also be used for other applications and other purposes. We also found that the savings were not always banked as a monetary gain but as a tool to raise the comfort level (or temperature). In general tenants preferred as few as possible visits from installers on the other hand people did not seemed bothered by interviews and enquiries. Furthermore we experienced that verbal communication is highly appreciated compared to paperwork that is often not read or too difficult to understand for the attention group.

External communication

- **Mirror group meetings;** we met regularly with the mirror group. The mirror group was a group of housing associations that closely followed the SHOWE-IT project. The mirror group was formed by the members of the so called REX Group. REX stands for **Re**search and **Ex**change. This group of housing associations is formed of peers from different European countries (Sweden, the Netherlands, UK and Germany) and these housing associations managed all together some 260.000 dwellings;
- **E-mail;** we used e-mail as a source for direct mailing. Our newsletters were sent over e-mail and we invited people for our conferences by e-mail;
- **Video;** we produced a video explaining the SHOWE-IT project. The video was loaded on YouTube and on the SHOWE-IT website;
- **Conferences and events:** The articles and abstracts produced by SHOWE-IT partners have been accepted in several international scientific conferences and key industrial congresses. We also organized our own workshop and conference (list provided in this document);

- **Newsletters;** as already said the newsletter was distributed per e-mail but when necessary there were also pdf versions of the newsletter available as handouts;
- **Information sticks;** during conferences we handed out memory sticks with information and presentations about the SHOWE-IT project;
- **The SHOWE-IT website;** the website was used as an interactive tool to reach a broad audience. The website was linked to the corporate websites of the participating organisations and was made attractive by a number of elements like games, tips and tricks etc.
- **Press conferences;** we held press conferences to give a general presentation on the project and to answer any potential questions;
- **Press statements;** because we were aware that press conferences might not be picked up by all magazines and newspapers we also distributed two press statements;
- **Posters and leaflets;** mainly within the participating organizations awareness of the project was raised by putting posters on the walls and by distributing leaflets.

Key lessons learned and recommendations

We have reached the communication objectives that were set before the project. As recommended we kept track of all the communication activities and number of people and type of stakeholders we reached. This is what is called the communication output. Before the project we set the objectives in quantitative terms. We can confirm that within the housing associations that have executed pilot projects all tenants have been informed about the project. The mirror group has contributed all through the project and has given the SHOWE-IT team useful feedback.

Other direct contacts like local governments, industry, the sustainability sector, local newspapers, etc. were informed. More information about the project is also available on the website of CECODHAS or the European Commission. We worked with an international peer group of housing associations and we must confirm somewhere in this report that this worked extremely well. This was because of high commitment towards the project but also because this long standing international peer to peer network was used for international cooperation and understood the dynamics of different challenges in different countries.

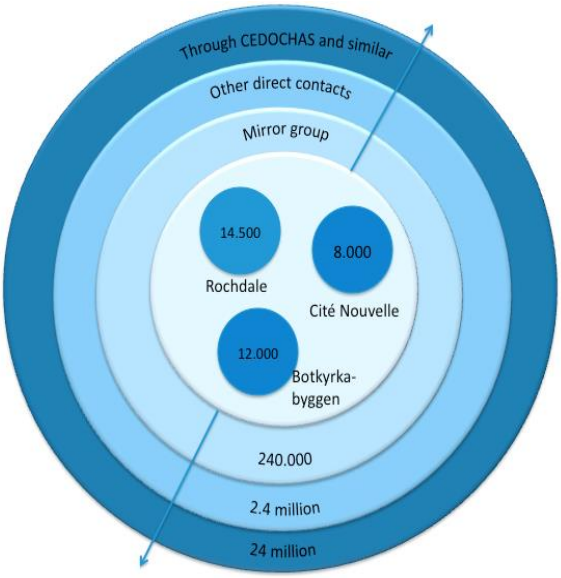


Figure 25. Our different target audiences

We found that everybody understood that our project had one main objective: to save energy and water. It was harder to explain more detailed elements of the project to non-specialists. Sociological, technical and smart elements all have their jargon and peculiarities. For professional, industrial and scientific audience the contrary was true: the design aspects, the technical architecture, the sociological results, the methodology to estimate savings and the final uses were particularly interesting and a lot of stakeholders have continuously expressed their interest in the SHOWE-IT results (especially R&D centres, Universities, equipment companies, designers, sociologists, energy efficiency experts).

To conclude, we identified the ways of communication in our dissemination plan and divided between internal communication with tenants and external communication with experts, scholars and stakeholders in energy efficiency for collective building. We experienced some help of the EC regarding communication around our project. On the official website of the EC you could find information on our project and the conference we organized was also mentioned on the EC website. Moreover the EC officer visited the conference to see what was being communicated. Apart from appreciation by the consortium this seemed to be highly appreciated by external visitors to the conference.

Finally we come to some recommendations that could be useful for communication in other projects:

- Manage expectations; set clear objectives but be open and clear to participants of the project (in this case tenants). Tell them that objectives are no guaranteed and that there is a possibility that they will not be reached;
- Regarding the planning of communication and dissemination we believe that there is space for some improvement. The structure of projects supported by the European Commission gives clear moments in the planning where the officers will be informed about progress of the project;
- As a team we experienced support of the EC but there were a few things that we thought could be improved. For example we failed to find a central place of the different ICT PSP projects on the EC website. We believe it would be good to create an information area for all the ICT PSP projects. We did communicate with the other ICT PSP projects but maybe an ICT PSP website would be more efficient (especially for users of the information) rather than visiting all the individual websites;
- We concluded that some ways of communication were not as effective as others and that it was important only to communicate when we had something important to tell. Especially the workshop at the end of the project where we invited professionals to be informed about the results of the project was not well attended. To justify an international journey to attend a workshop seems not to be accepted in Europe although we believe that by offering free entrance a free lunch and a goodies bag we did all we could to incentivize participation;
- We also suggest doing a joint presentation of ICT PSP projects at the end of all the projects. The EC will be able to organize and to incentivize an event that attracts hundreds of interested stakeholders. Such an event could be organized in 2015 to conclude the former series of ICT PSP projects co-funded by the EC for the period 2011 /2014.

List of published articles

Name publication	Where	Target group	Year
SHOWE-IT consortium: reduce residential energy and water consumption in Social Housing	Newsflash CECODHAS September 2011	Housing associations and national housing federations	2011
Newsletter I SHOWE-IT	Full mailing list	The wider public and professional world	2012
Newsletter II SHOWE-IT	Full mailing list	The wider public and professional world	2013
Newsletter III SHOWE-IT	Full mailing list	The wider public and professional world	2014
Press Statement I	Newspapers and magazines	The wider public and professional world	2012
Press Statement II	Newspapers and magazines	The wider public and professional world	2013
Rochdale online	Online newspaper	Local general audience	2011
Website smartgrids CRE	Website	National professional audience	2012
eeMeasure Smartspaces	Website	International professional audience	2013
Website ALE-Lyon	Website	Regional general audience	2013
Journalisted	Website	National general audience	2013
Energi & Miljö	Website and magazine	National professional audience	2013
YouTube	Streaming video/presentation	The wider public and professional world	2012
Power House Europe	Website	International professional audience	2013
Encerticus	Website	International professional audience	2013
Ecole des Mines	Website	Scientific world	2013
Université Pierre Monnet	Website	Scientific world	2013
Smartspaces	Website	International professional audience	2013
Product Design & Development	Website	International professional audience	2013
Hopwood Electrical Services	Website	SME professionals	2013
Workshop TIC logement social	Online presentation	Housing professionals	2013
Acciona-infrastructure	Website	Industrial professionals	2014
Centre de Sociologie de l´innovation	Website	Scientific World	2013
Global Habitat	Website	Housing professionals	2013
SGParis 2014	Website	Housing professionals	2014
ICT Sustainable Homes	Website	International professional audience	2014
Edea Renov	Website	Industrial professionals	2014
Reducing Domestic Energy Consumptions Thanks to ICT and Smart Technologies: Key Factors of Social Acceptance from the European Project SHOWE-IT (IEPEC)	Paper and website	Scientific world	2013
Hal Archives Ouvertes	Paper and website	Scientific world	2014
Terra Tec	Presentation	Scientific world	2013
Energy cities	Website	Professional audience	2013

List of events/conferences

What	Where	When
General explanation of SHOWE-IT to the Mirror Group	Barcelona, Spain	13th April 2011
Workshop Pilot Site Sweden	Stockholm, Sweden	March 2012
Workshop Pilot Site France	Lyon, France	June 2012
Workshop Pilot Site England	Rochdale, England	April 2012
Workshop "Energy efficiency ICT: towards smart social housing?" – Angers Nadjma Ahamada (ENGIE), Rosa Sitja (B & W)		Angers – France - 2 and 3 February 2012
International Conference "Energy and Society" Maud Minoustchin and Kathleen Zoonnekindt (ENGIE)	Lisbon, Portugal	March 22 to 24 - 2012
1st International Colloquium on the Sociology of Energy – France Kathleen Zoonnekindt (ENGIE)	Toulouse, France	October 25–26 - 2012
Energy Congress S2E2 Jonathan Villot (Armines) and Kathleen Zoonnekindt (ENGIE)	Orleans, France	20 and 21 November 2012
Congress Smart Grid Paris 2013 Kathleen Zoonnekindt (ENGIE)	La Defense, Paris, France	2013
Conférence Ecobat – Session Transition énergétique Kathleen Zoonnekindt (ENGIE) and SIEMENS	Paris, France	March 2014
Conférence E3D- Waste, water and sustainable development Jonathan Villot (Armines) and Kathleen Zoonnekindt (ENGIE)	Ales, France	June 2014
Innovative City Léa Thonat (ENGIE)	Nice, France	25 June 2014
Worldwide Convergences Forum Kathleen Zoonnekindt (ENGIE)	Paris, France	10 September 2014
Conférence IEPEC – International Energy Program Evaluation Conference Kathleen Zoonnekindt (ENGIE)	Berlin, Germany	11 September 2014
Smart Energy day Memo Hussein (BoBy) and Etienne Drouet (ENGIE)	Paris, France	March 2014
E-world Energy&Water	Barcelona, Spain	12 March 2014
Showe-IT Conference SHOWE-IT team	Brussels, Belgium	June 2014

7 List of Beneficiaries

AB Botkyrkabyggen, Sweden *AB Botkyrkabyggen* *Tumba Torg 101* *147 21 Tumba* *Tel: 08-530 693 00* *Fax: 08-530 600 12* *www.botkyrkabyggen.se* …………………………………………………... *Botkyrkabyggen - En bra start i Stockholm* *Vi äger, bygger, hyr ut och utvecklar bostäder och bostadsområden i Botkyrka kommun.* BOTKYRKABYGGEN	BOTKYRKABYGGEN
Rochdale Boroughwide Housing, England RBH ALL TOGETHER BETTER LIVING Visit us at **rbh.org.uk** or talk to us on **0800 027 7769** or **(01706) 274100** **Sandbrook House | Sandbrook Way | Rochdale | OL11 1RY** Rochdale Boroughwide Housing Limited is a charitable community benefit society. FCA register number 31452 R. Registered Office: Sandbrook House, Sandbrook Way, Rochdale OL11 1RY. Registered as a provider of social housing. HCA register number: 4607	RBH ALL TOGETHER BETTER LIVING
Cité Nouvelle, France Siège 13, place Jean Jaurès 42029 Saint Etienne cedex 1 Tél : 04 77 42 37 80 Fax : 04 77 42 37 81 citenouvelle@citenouvelle.fr	Cité Nouvelle GROUPE ENTREPRISES-HABITAT Action Logement

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Aqualogy, Spain Aqualogy Solutions S.A. TORRE AGBAR Av. Diagonal, 211 08018 Barcelona +34933422116 Aqualogy.net	

8 The Showe-IT team from 2011 to 2014

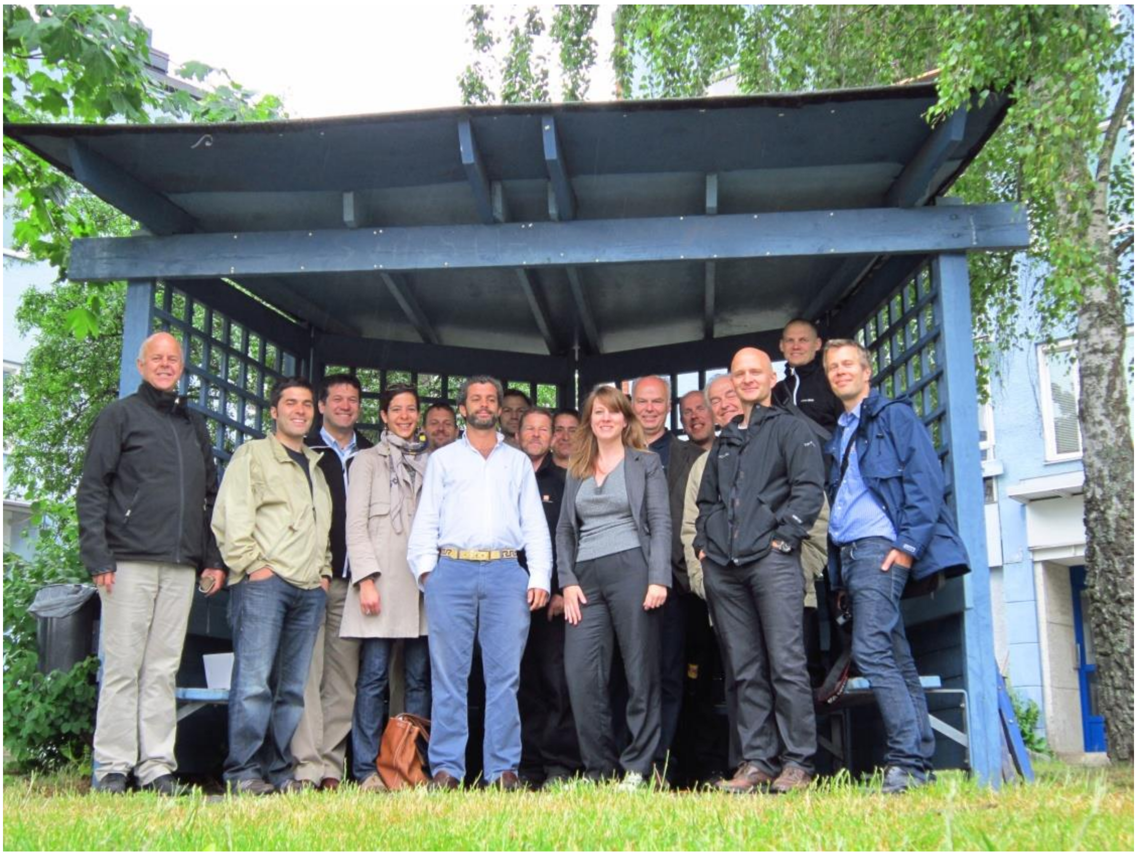

Figure 26. The team early 2011 in Tumba, Sweden

Figure 27. (Most of) The team late 2014, this time in London during the final General Assembly

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Luis de Juan
Juan Ramon Cuevas
Leonardo Subias

Aqualogy
Francesc Cabrespina
Cristina Vila d'Abadal

Armines
Natacha Gondran
Jonathan Villot
Florence Thepenier

Bax & Willems
Laszlo Bax
Piotr Zietara
Pau Llado
Brian Vinans
Rosa Sitja

Botkyrkabyggen
Christian Hollmann
Memo Hussein
Kasper Nilsson
Martin Svensson

Cité Nouvelle
Robert Kéchéchian
Christophe Planet
Henri Hayet

ECA
Uwe Domschke
Marcus Jungk

ENGIE
Nadjma Ahamada
Ivan Bel
Etienne Drouet
Julie Koskas
Elsa Lagier
Léa Thonat
Kathleen Zoonnekindt

Mirror Group
Corné Koppelaar

RBH
Ros Martin
Wendy Stewart
Peter Williams

Smarvis
Werner Domschke
Stefan Hammermüller

Siemens
Mouthou Soudarissanane
Jörg Hammer
Jonathan Copley
Arnaud Monnet

Södertörns Fjärrvärme
Hans Andersson
Cecila Nordin

Thank you all!