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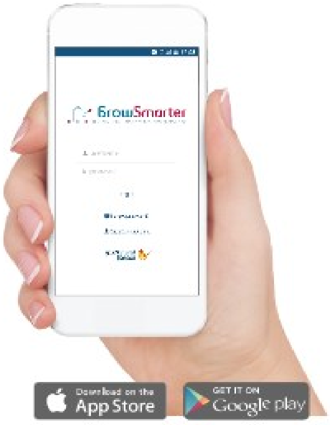
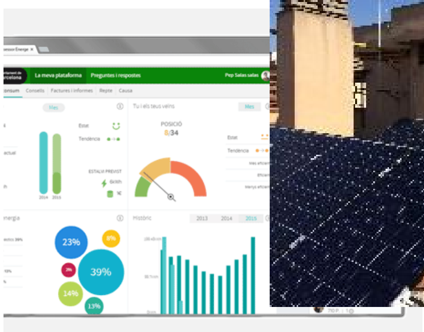
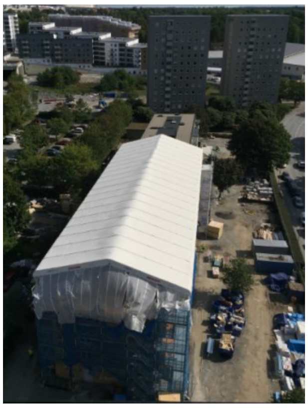
Transforming cities for a smart, sustainable Europe

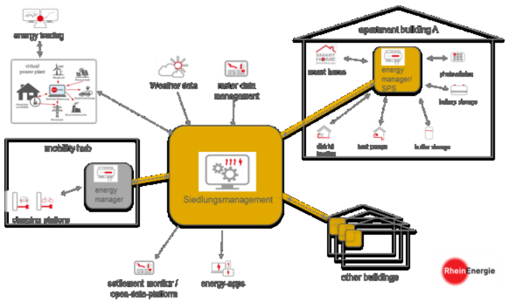
IMPLEMENTING SOLUTIONS FOR LOW ENERGY DISTRICTS IN EUROPEAN CITIES – EXPERIENCES FROM GROWSMARTER

D2.3. IMPLEMENTATION REPORT WP2









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EXECUTIVE SUMMARY

This report describes the implementation of 23 measures of the Growsmarter smart solutions on Low Energy Districts at the three “Lighthouse Cities” of Barcelona, Cologne and Stockholm.

The report begins with a general introduction and overview of the measures, before proceeding with short case studies in Chapter 2 describing the implementation of each measure; its main stakeholders and business model; key activities, achievements and challenges; and lessons learned.

In Chapter 3, the lessons learned per measure are described and discussed with reference to each Smart Solution and several thematic challenges are identified. These findings inform the general conclusions of this report, which include the identification of challenges and opportunities related to:

- Stages of technology development;
- Business models and issues related to gathering, use and ownership of data;
- Administrative processes, laws and regulations (within countries, and in terms of variation between countries).

Key conclusions include the need to achieve user acceptance and a well-defined business model by type of building for the implementation of energy efficient retrofitting, the importance of addressing data privacy issues at the project definition phase for the deployment of Home Energy Management Systems, and the critical role of the current National regulation to foster the installation of on-site electricity generation with solar power and smart electricity management systems.

The report thus provides readers with information on lessons learned per measure, per Smart Solution and per Lighthouse city, along with thematic and general conclusions emerging from the implementation phase of GrowSmarter. In doing so, the report provides key insights into the practical steps taken to implement low energy districts measures and replicate good examples from GrowSmarter lighthouse cities in other cities and contexts.

1 INTRODUCTION

Across Europe, cities are embracing the pursuit of smart and sustainable development. Transformative action is required to, for example, reshape processes and practices influencing the design, construction and end-use of urban infrastructure.

In this context, the cities of Barcelona, Cologne and Stockholm, together with a diverse group of public and private sector partners, formed the GrowSmarter project. GrowSmarter seeks to integrate, demonstrate and stimulate the uptake of '12 smart city solutions' in energy, infrastructure and transport, to provide other European cities with insights and create a ready market to support the transition to a smart, sustainable Europe.

This report presents experiences from the implementation of smart city solutions addressing Low Energy Districts in GrowSmarter. The report is based on analysis of interviews with measure leaders and other project participants, along with project reports and other relevant source material. In total, experiences from 23 measures are described to inform key conclusions and recommendations to policy-makers.

2 LOW ENERGY DISTRICTS IN GROWSMARTER

The deployment of energy efficient measures in order to lower the environmental impact of the existing building stock of districts is the main objective of GrowSmarter Work Package 2 (WP2). In total, 123 000m2 are refurbished in the three lighthouse cities (including private and public buildings, tertiary and residential buildings), and local energy generation is promoted by using District Heating and Cooling networks, on-site renewable electricity production and advanced smart energy management of the local energy generation. Finally, the project promotes the deployment of Home Energy Management Systems to raise awareness on energy efficiency and energy savings among the citizens.

This report presents the experiences of participating actors in the implementation phase for the deployment of these measures and offers conclusions and recommendations to cities aiming to replicate measures.

Table 1: Overview of the Smart Solutions, measures, cities and partners involved in WP2, along with the page number on which each measure is presented in this report

Solution	Measure	City	Partner(s)	Contact person
SS1. Efficient and smart climate shell refurbishment	1.1 Energy efficient refurbishment of the building – Passeig Santa Coloma	Barcelona	Barcelona Municipality, IREC	Manel Sanmartí (msanmarti@irec.cat)
	1.1 Energy efficient refurbishment of the building – Ca l'Alier	Barcelona	Barcelona Municipality, IREC	Manel Sanmartí (msanmarti@irec.cat)
	1.1 Energy efficient refurbishment of the building – Library Les Corts	Barcelona	Barcelona Municipality, IREC	Manel Sanmartí (msanmarti@irec.cat)
	1.1 Energy efficient refurbishment of the building - Residential buildings by GNF	Barcelona	Gas Natural Fenosa	Milagros Rey (mreyp@gasnaturalfenosa.com)
	1.1 Energy efficient refurbishment of the building – Sports centre CEM Claror Cartagena	Barcelona	Gas Natural Fenosa	Milagros Rey (mreyp@gasnaturalfenosa.com)
	1.1 Energy efficient refurbishment of the building – Hotel H10 Catedral	Barcelona	Gas Natural Fenosa	Milagros Rey (mreyp@gasnaturalfenosa.com)
	1.1 Energy efficient refurbishment of the building – Educative centre Escola Sert	Barcelona	Gas Natural Fenosa	Milagros Rey (mreyp@gasnaturalfenosa.com)

Solution	Measure	City	Partner(s)	Contact person
SS1. Efficient and smart climate shell refurbishment	1.1 Energy efficient refurbishment of the building - Brf Årstakrönet	Stockholm	L&T	Peter Andersson (peter.andersson@l-t.se)
	1.1 Energy efficient refurbishment of the building – Valla Torg	Stockholm	Skanska, Stockholmshem	Harry Matero (harry.matero@skanska.se)
	1.1 Energy efficient refurbishment of the building – Slakthusarea	Stockholm	City of Stockholm	Mika Hakosalo (mika.hakosalo@stockholm.se)
	1.1 Energy efficient refurbishment of the building – Stegerwaldsiedlung	Cologne	Dewog	André Esser (a.esser@dewog.de)
SS3. Smart, energy saving tenants	3.1 Virtual energy advisor	Barcelona	Barcelona Municipality, IREC	Manel Sanmartí (msanmarti@irec.cat)
	3.1 Home energy management system (HEMS)	Barcelona	Gas Natural Fenosa	Milagros Rey (mreyp@gasnaturalfenosa.com)
	3.1 Energy Saving Centre	Stockholm	L&T	Peter Andersson (peter.andersson@l-t.se)
	3.1 Active House	Stockholm	Fortum	Johan Ander (Johan.Ander@fortum.com)
	3.1 SmartHome	Cologne	RheinEnergie	Christian Remacly (c.remacly@rheinenergie.com)
SS4. Local Renewable energy production and integration with buildings and grid	4.1 Energy HUB	Stockholm	L&T	Peter Andersson (peter.andersson@l-t.se)
	4.1 Siedlungsmanagement	Cologne	RheinEnergie	Christian Remacly (c.remacly@rheinenergie.com)
	4.2 Smart energy and self-sufficient block	Barcelona	Gas Natural Fenosa, IREC	Milagros Rey (mreyp@gasnaturalfenosa.com)
	4.2 Resource Advisor	Barcelona	Schneider Electric	Adrià Casas (adria.casas@schneider-electric.com)
SS6. New business models for district heating and cooling	6.1 Open district heating with feed in of waste heat	Stockholm	Fortum	Martin Brolin (martin.brolin@fortum.com)
	6.2 District heating rings	Barcelona	Gas Natural Fenosa	Milagros Rey (mreyp@gasnaturalfenosa.com)
	6.3 Smart local thermal districts	Barcelona	Barcelona Municipality, IREC	Manel Sanmartí (msanmarti@irec.cat)

2.1 Smart Solution 1: Efficient and smart climate shell refurbishment

Smart Solution 1 demonstrates the impact of the combination of shell thermal envelope refurbishment (such as wall/floor, attics and roofs thermal insulation) and other energy efficient measures (such as windows with low U-values, heat recuperation from ventilation and sewage, air tightness and Heating, Ventilating and Air Conditioning (HVAC) equipment replacement) on the energy consumption of buildings. The combination of these measures is expected to drastically reduce the net energy demand for all buildings. GrowSmarter aims as acting as a showcase for the replication of technical and practical innovations that save energy and improve living conditions for the tenants or users of existing buildings.

Measure 1.1 Energy efficient refurbishment of the building – Passeig Santa Coloma, Barcelona

Implementation and Activities

Barcelona Municipality has promoted the energy refurbishment of the residential building in Passeig Santa Coloma 55-71 with 207 dwellings and over 14,000 m2, a building owned by the Municipal Institute of Housing and Renovation of Barcelona (IMHAB), previously called PMHB. The building facade (17-years old thermal clay facade) was significantly deteriorated thus needed a renovation, and the Municipality decided to invest on better thermal insulation.

The aim of this measure is to improve the envelope thermal insulation of the existing building in order to increase the indoor comfort of the residents. The scope of this measure has been: facade retrofitting blinds replacement for the entire building and energy consumption monitoring in some dwellings. One of the key aspects in this type of retrofitting works is the tenants' involvement in the project, in order to guarantee a majoritarian acceptancy. Accordingly, IMHAB created at the beginning a project board including representatives from both the Urban planning Department of the Municipality and the neighbours' commission of the building (that had been created for this purpose). In this way, tenants were also part of the project design prior to the bidding process.

For more information see the factsheet named "Smart shell and equipment refurbishment – 200 unit apartment building" on the link given on the Sources/References section.

Stakeholders & Business Model

The building owner is the Municipal Institute of Housing and Renovation of Barcelona and the residents of the building are tenants. The third stakeholder is the contractor that was awarded by the public tendering process.

The trend of investing on better thermal insulation in buildings with deteriorated facade is being followed by the Municipal Social Housing Institute of Barcelona with buildings with similar characteristics.

The measure is not intended to be self-financing, as the building owner fully pays for the refurbishment but does not receive direct benefits from the investment (the energy bills are paid by the tenants before and after the refurbishment, and rents are not increased either).

With this solution, the Municipality (owner) invests in the building in order to achieve a higher standard building, and the tenants benefit from this with lower energy invoices and better indoor comfort after the refurbishment.

Achievements

In general, this kind of projects may suffer from long and complex public tendering. More specifically, in this case there have been delays on the implementation of this measure because the first contractor awarded by the public bidding process resigned and left the project at the beginning of the building works. This presented a challenge as IMHAB had to start a new bidding process awarding a new contractor. Notwithstanding, the new contractor performed the building works under a high pace that partly compensated the delays, and even added some new features that were included in the contract. Apart from this, once the second contractor started the works, only a small delay occurred due to some cracks found on the wall of one of the facades, but this was not a significant delay considering the dimensions of the building.

Lessons Learned

- The involvement of the tenants in the project design through the created board has shown to be beneficial for the energy retrofitting, as it creates both acceptance and energy efficiency awareness among the users of the energy-retrofitted building.

Recommendations

- Very tight budgets on the public bidding process may lead to non-feasible contractual conditions (as it happened in this implementation). This in turn could lead to significant delays because of re-tendering processes and the costs increase. Therefore, the public bidding process should consider this before awarding a contractor.
- Involve the tenants from the very beginning of the project to avoid misgivings and increase their energy consumption awareness.

North facade before and during refurbishment

Measure 1.1 Energy efficient refurbishment of the building – Ca l'Alier, Barcelona

Implementation and Activities

Barcelona Municipality has implemented integral retrofitting actions on 2 tertiarty buildings (6,500 m2 in total), putting a focus on low-energy and nZEB buildings. One of the 2 tertiary buildings integrally refurbished is Ca l'Alier.

The aim of the measure is to transform an abandoned textile factory acquired by the Municipality to an R&D centre for Smart Cities and the Internet of Things. This has been done by doing an integral refurbishment of the existing building with the goal of demonstrating the feasibility of a Zero Net Site Energy Use through the installation of photovoltaics (85 kWp), connection to district heating and cooling (DHC) network, the installation of an energy management system, and the use of open communication protocols with HVAC equipment.

For more information see the factsheets named "Re-build of an industrial site" and "Smart local thermal districts" on the link given on the Sources/References section.

Stakeholders & Business Model

Ca l'Alier building is an example of the public-private partnership (PPP) that Barcelona Municipality promotes in building refurbishment. This integral renovation is part of a wider renovation plan by the Municipality to re-use industrial buildings in the 22@ district of Barcelona. The renovation investment is therefore proposed as a public-private partnsership signed between the Municipality and private companies, giving them the temporary use of a large part of the building.

In Ca l'Alier, the PPP has been signed between Barcelona Municipality and Cisco. The Institute for Municipal Infrastructures of Barcelona (owned by the Municipality) has played a key role on leading and managing the construction works. The last stakeholder is the contractor that was awarded by the public tendering process for the building refurbishment.

Achievements

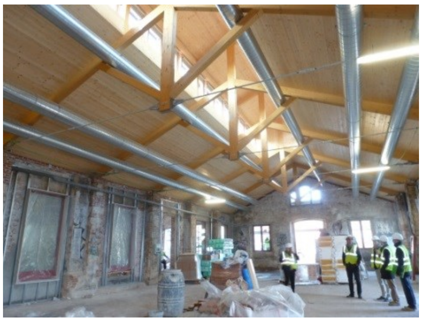
The start of implementation was significantly delayed for this building due to the paralysation of the original plans by the change of Government in the city before the building works started, and due to one (out of the 2) private partner leaving the project. After a long negotiation period and re-adjustments of the investment to be done, the Municipality was able to continue with the project. It must also be considered that this building is classified as an historic building, thus the definition of the final technical solution for the retrofitting of the building structure and facade was restricted (e.g. impossibility for external facade insulation). Accordingly, the original structure and remaining walls of the old factory had to be preserved, and the ground foundation works prior to the actual refurbishment were more complicated precisely to be able to conserve these walls, despite it would have been less complex to re-build some of them due to their bad conditions.

Lessons learned

- Projects promoted by the public administration sometimes depend on the current Government of the city, thus ambitious renovation plans for building retrofitting fostered by one Government may not be approved by the following one. The will to implement this kind of ambitious integral refurbishment strongly depends on the political will and well defined and approved action plans
- When retrofitting historic buildings, the technical solutions for energy-efficient refurbishment must be adapted to the technical specifications of such buildings balancing historical interest with energy efficiency interests.
- Calculation of energy performance baseline is not trivial when the building completely changes of use and has even been abandoned for a long period of time. In order to justify the energy savings, the baseline definition will need to be addressed by specialists.

Recommendations

- If the building is intended to be nZEB, it is advisable that the awarded bidder must fulfil specific conditions included in the technical specification, such as develop an energy management plan to optimize consumption and achieve the "net zero energy balance", as well as achieve a building energy performance certificate, such as BREEAM or LEED.
- Consider technical obstacles that may appear when retrofitting a historic building (e.g. ground foundation works more complicated, higher costs) by performing risk analysis and adding a contingency plan.




Refurbishment works in progress in Ca l'Alier

Measure 1.1 Energy efficient refurbishment of the building – Library Les Corts, Barcelona

Implementation and Activities

The refurbishment of Library Les Corts is another example of an integral refurbishment of a municipality-owned industrial building in Barcelona. In this case, 3 adjacent buildings are retrofitted (a former industrial building lately used as a warehouse and 2 offices buildings), so they altogether will become a new public library. The aim of the measure is to transform an old building into a public library with low energy consumption and on-site electricity generation. The scope of the works includes improvement of facade, roof & ground floor insulation and glazing, efficient radiant floor system for heating and cooling, Building Energy Management System (BEMS), and PV installation.

Stakeholders & Business Model

The Municipality fully finances the investment, while the final owner of the building is the District Les Corts (sub-organization within the Municipality), and the only user of the building is "Biblioteques de Barcelona" (the public library network in the city). In this case, the Municipality (owner) invests in the building in order to achieve a higher standard building and new public facilities. The energy retrofitting will lead to lower energy invoices for the Administration.

Achievements

The public administration included in the bidding process a requirement for obtaining the BREEAM certificate with a "Very good" score for the renovated building. The contractor was awarded according to this, which guarantees that the building is renovated according to high energy standards.

The implementation of the integral refurbishment of the library went as planned, starting in February 2015 and ending in September 2017.

Lessons learned

- Budget needs to be allocated for the training of public staff in using advanced energy management systems.

Recommendations

- If the building is intended to be a low-energy building, it is advisable that the awarded bidder is obligated in the project specifications to achieve a building energy performance certificate such as BREEAM or LEED.
- Calculation of energy performance baseline is not trivial when the building completely changes of use. For instance, in this case the building energy consumption is higher after the retrofitting works compared to before. In order to justify the energy savings, the baseline definition will need to be addressed by specialists. In this case, baseline was calculated by computer simulation, by modelling the energy usage of a building with the same shape, dimensions, indoor zoning, type of use and external obstacles, and with performance levels according to National regulation (constructive quality of enclosures and shadow elements, lighting level, thermal installations, and minimum solar energy contribution).

Refurbishment works: primary phase (left) and last phase (right) of Library Les Corts

Measure 1.1 Energy efficient refurbishment of the building – Residential buildings by GNF, Barcelona

Gas Natural Fenosa (GNF) has implemented retrofitting actions with the aim of lowering the energy consumption of buildings in nearly 20,000 m2 of residential floor in Barcelona, that is, 4 residential buildings named Canyelles, Ter, Lope de Vega and Melon District.

Implementation and Activities

The common measures implemented in Canyelles, Ter and Lope de Vega buildings are: improvement of facade and roof insulation, replacement of old windows by new ones with low-U values (e.g. the U-value of the new windows in Lope de Vega is 1.1 W/m2 k), and installation of efficient water taps. In Canyelles, the retrofitting approach was wider as 32% of dwellings participated in the substitution of old boilers for new ones, and shading elements like blinds were installed. In Melon District, the measure implemented connects the residential building to the local DH (District Heating) network in Barcelona, where this technology is not widely spread.

For more information see the factsheet named “Efficient and smart climate shell and equipment refurbishment of residential buildings” on the link given on the Sources/References section.

Stakeholders & Business Model

Through the implementation of this measure GNF was able to test a new business model acting as an energy services company (ESCo) in the refurbishment of residential buildings.

Public-private partnership:

GNF reached public-private agreements for retrofitting Canyelles, Ter, and Lope de Vega buildings. In the 3 buildings, the public administration has the role of proposing ways to help in the amortization of building refurbishment (through subsidies), and the private enterprise solves the problem of high investments for individual owners, acting as an ESCo. Therefore, the implementation of these measures was financed by public subsidies and partly by fees that owners pay during a period established by the ESCo. The period established for the residential buildings is 5 years in which the tenants pay almost the 30% of the initial investment. In the case of Lope de Vega, another private company also participated on the financing of the retrofitting works.

Private residential partnership:

GNF demonstrated the possibility of carrying out an ESCo model with a private residential partnership based on the connection of such building (Melon District) to the nearest DHC network.

Achievements

In order to select the buildings, an agreement was signed among GNF, AHC (Agencia de l’Habitatge de Catalunya) and the housing consortium of Barcelona, which gave the possibility of developing a communication channel to engage residential building owners. A specific Task Force was created to improve the engagement process (involving experts in refurbishment and user engagement). This made the projects of public-private partnership more attractive for the residential owners.

In order to cope with the doubts that rose from both owners and tenants of the selected buildings to collaborate in the retrofitting action, information campaigns were done and, in some cases, GNF subcontracted a company to perform the campaign.

Some obstacles were encountered on the installation of low U-value windows' frame because it is not very common practice in a city with a mild climate such as the one in Barcelona, and the installer was not used to the high standards requested. However, this only involved small delays.

The main achievement during implementation was related to the successful coordination with all neighbours regarding the required entrance in their houses for the realization of the different works (assembly of boilers, rehabilitation of facades, etc.).

The main obstacle to implement the measure of Melon District was the selection process of the building, since the areas where a building can be connected to a DHC network in Barcelona are limited. Moreover, when asking potential residential building owners to participate in this measure, it was found out that many have doubts to connect their households to an unknown technology such as DHC. This issue did not arise for Melon District as this building was already connected for the cooling and domestic hot water supply to the existing DHC network, besides there was already a refurbishment project of the rooms in the building going on, which helped in reaching an agreement.

Lessons learned

- In buildings where most of the dwellings are owned by a unique owner (e.g. Ter building has aunique owner to 80%, and Melon District has a unique owner), the communication between the ESCo and the tenants is easier and facilitates the start of implementation (the signature of the majority of owners in the building is required). The creation of a Task force may simplify the achievement of the agreement.
- The heating demand in the Mediterranean climate is very low and therefore the energy savings from energy retrofitting are not that significant compared to other climates. In this case, the combination of private investment by the ESCo and public funding from the Municipality has been the solution.
- One main challenge found once implementation started is the need for execution of the works in full coordination with the tenants, considering there is no evacuation of them. Therefore, good communication was critical to succeed in the implementation.
- Due to implementing energy retrofitting works in existing old buildings, structural problems like some found in Ter building (i.e. unknown structural problems in the balconies) may appear, which lead to delays on the energy retrofitting works (as they must be solved beforehand).

Recommendations

- It is advisable to find Public-Private collaboration, especially in countries were the heating demand is low, in order to lower the cost for the residents. The reason is that a low heating demand is a crucial variable that affects the economic viability of the energy refurbishment. Even if energy prices will increase in the following years, the help of the administration to support the initial tenants/owners' investment will still be needed.

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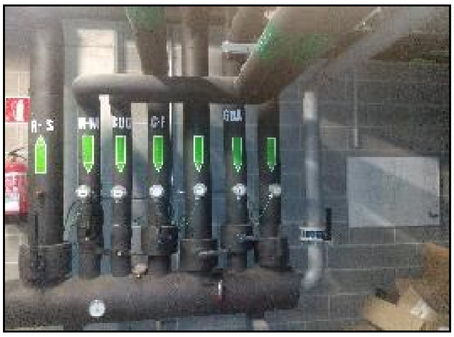
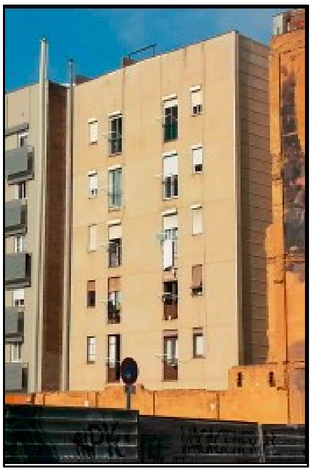
- Installers and all the personnel that will participate on the refurbishment tasks should be properly trained and qualified to achieve the requested high standards on insulation and infiltration in order to guarantee the expected energy savings.
- It is important to be sure that all the tenants have an active attitude - and not only the property - in refurbishment projects in buildings that include rented flats. Communication and user engagement campaigns lead by professionals are highly recommended.
- It is advisable to select buildings with high energy density that can justify the works needed to implement energy efficiency measures.
- In countries like the Mediterranean ones, where DHC is not frequently used, it is important to explain to the potential users the advantages of a district thermal network. The potential customers should understand the economic benefits but also the technical and maintenance benefits that DHC would provide to concerning their installations and consumption.

Canyelles building while and after the refurbishment



Manifold of DH connection in Melon District

Refurbishment works in Ter building



Lope de Vega facade to be refurbished

Measure 1.1 Energy efficient refurbishment of the building – Sports centre CEM Claror Cartagena, Barcelona

General information on refurbishment of tertiary buildings in Barcelona by GNF

GNF has implemented retrofitting actions by acting as an ESCo to lower the energy consumption of buildings in over 10,500 m2 of tertiary floor in Barcelona. Three buildings with very different uses are retrofitted: the sports centre CEM Claror Cartagena, the hotel H10 Catedral, and the educative centre Escola Sert. The energy efficiency measures implemented in each building differ significantly, but a common measure is the installation of BEMS to evaluate how energy management tools can help the building operators in implementing better practices and inform the users/customers of the building about the energy savings obtained thanks to the project.

For more information see the factsheet named "Efficient and smart climate shell and equipment refurbishment of tertiary buildings" on the link given on the Sources/References section.

Sports centre CEM Claror Cartagena

Implementation and Activities

The aim of the measure is to improve the energy efficiency and decrease the energy invoice of the sports centre. Natural gas consumption will be significantly decreased due to the usage of heat recovered from a heat pump and the installation of high efficient condensing boilers. Savings in the electricity invoice are achieved thanks to the installation of a new dehumidifier and LED lighting, although they are not so significant because a new consumption is introduced with the installation of the heat pump.

The measures implemented in the sports centre are: roof insulation, new dehumidifier, substitution of chiller by electrical heat pump, new boilers, sectorization between High and Low Temperature of the distribution collectors, swimming pool isolation and efficient lighting.

For more information see the factsheet named "Energy-efficient swimming pools" on the link given on the Sources/References section.

Stakeholders & Business Model

For tertiary buildings, the refurbishment contract offered by GNF through the ESCo model is a Business-to-Business (B2B) contract. The ESCo invests in the assets needed for the refurbishment and owns the assets during the duration of the contract. In the specific case of the sports centre, the offer and contract negotiation had also to be discussed with the Municipal Sports Institute, as this is a public-owned building managed by a private foundation.

An Energy Performance Contract (EPC) with guaranteed energy savings was signed with the foundation that manages the sports centre, after a detailed energy audit. An important barrier to consider is that the customer that has to sign the contract with the ESCo may not necessarily be the owner of the building but the building operator through a public award in a procurement process. If the ESCo contract is longer than the operation period awarded, this can be an important barrier to launch ESCo services in this sector as the economical savings normally arise at the end of the ESCo project.

Achievements

The main challenge of this implementation has been the need for performing a deep refurbishment without interruptions in the normal usage of the building. In order to overcome this challenge, a very accurate planning of the works together with the customer has been necessary as well as moving the most critical tasks to non-working hours or holiday periods (multiple stops and working hour flexibility need to be considered as they normally cause an extra cost on the budget).

Additionally, the space for equipment/installations is very limited in this kind of buildings, which demands a very accurate design.

Lessons learned

- Most of the heating demands in sports centres are low temperature heating demands, but old installations normally have a single primary circuit at high temperature. The separation of this collector in two different collectors, one for low and the other for high temperature heating demands, allows extracting the potential of high efficient technologies.
- In Mediterranean climates, cooling needs are high in sports centres. This promotes installing heat pumps with heat recovery to simultaneously satisfy cooling needs and low temperature heating needs.

Recommendations

- It is very important to implement measures that decrease the energy demand of pools, since this is the most important consumer in sports centres.
- Passive measures, e.g. roof insulation, are critical to achieve important energy consumption reductions although not always considered.
- Implication of the Public Administration is critical in ESCo projects for public buildings, since the benefits are not only for the building operator, but also for the building owner.
- When retrofitting public buildings with a private operator, the concession contract length is a critical factor in order to apply an ESCo model.
- Consider all the safety and health aspects during the audit phase. Since the works will run in parallel with the regular operation of the building, additional measures are normally required and this has a significant impact in the budget.
- Normally sport centre operators manage several buildings and are used to do refurbishments, thus it is critical to introduce their regular engineering partners since the beginning of the project. The customer wants to ensure that the aspects related to the particularities of sports centres are considered in the ESCo project, since its common partner is normally expert in this area.

New LED floodlights in the sports centre

New heat pump in the sports centre

Measure 1.1 Energy efficient refurbishment of the building – Hotel H10 Catedral, Barcelona

Implementation and Activities

The implementation for the hotel differs from the sports centre. The aim of the measure is to validate the technical and economic feasibility of executing an energetic refurbishment by the ESCo *as part of* an integral building refurbishment (promoted by the customer).

In the case of the hotel, the refurbishment works involved a change in the use of the building (from residential to tertiary). This is a common case for the hotel sector in city downtowns, where the available area to construct new buildings is very limited. The measures implemented in the hotel are: HVAC system, lighting, high-efficiency windows, and rooftop insulation.

Stakeholders & Business Model

The relationship between the ESCo and the hotel owner brings the opportunity of having an energy expert in charge of adapting the project to consider energy aspects in the refurbishment while the building owner/operator focuses on its expertise area (e.g. for the hotel, adapt the building to offer better services to its guests). Moreover, from the economical point of view, it is an advantage that part of the investment is financed by an ESCo in exchange of an annual fee, since it fosters the consideration of a broader scope for the refurbishment.

Achievements

GNF acts as a co-promoter (the energy retrofitting works are executed simultaneously with the other refurbishment works managed by the building owner). This involved an additional effort from GNF side for coordination besides imposing the direct assignment of the energy efficiency works to the same contractor(s) that the building owner had selected through the bidding process for the structural refurbishment.

It must be considered that this building is classified as a historic building, and this involves aesthetical restrictions for building facade refurbishment. Also, in European city centres, it is not so uncommon that archaeological findings or any other external contingency from the surroundings may appear (as it happened with the hotel). This normally has an impact on the project scope and planning. In these cases, the promoter and project management team need to be highly qualified to rapidly perform a contingency plan and significantly adapt the technical solution.

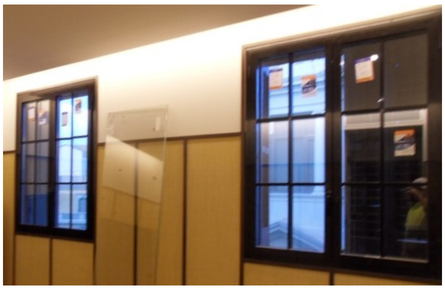
Lessons learned

- The importance of considering energy efficiency aspects together with an integral building refurbishment (and not separately) is highlighted. The sizing of equipment is significantly affected by the passive measures to be implemented, and the simultaneity allows defining the most convenient solution for both, active and passive measures.
- The installation of BEMS may help the hotel operator to optimize the energy consumption, but also make awareness of the hotel energy policies to the guests.
- It is not so easy to adapt an historic old building to the new regulation requirements and technologies that guarantee high energy efficiency standards and, therefore, the relation between the hotel and the ESCo allows having an accurate design of the most convenient solution.

Recommendations

- It is essential to be in contact with the urban landscape municipality department since the very beginning of the project, with the aim of jointly determining the most appropriate technical solution.
- For historic buildings located in the city centre, the promoter and project management team need to be qualified to perform contingency plans and adapt technical solutions if necessary.

Roof insulation in the hotel



New windows in the hotel

Measure 1.1 Energy efficient refurbishment of the building – Educative centre Escola Sert, Barcelona

Implementation and Activities

The aim of the measure is to validate the technical and economic feasibility of adding renewable energy generation to a tertiary building in the form of building integrated photovoltaics (BIPVs) for self-consumption. This was done on top of the integral refurbishment of the facade of the building.

GNF is responsible for the PV glass and the PV panels supply. The efficiency of the PV panels combined with the PV glass is approximately 11% and once the refurbishment of the building finishes, it will be easy to evaluate how much energy consumption the PV panels are able to supply since an energy monitoring system is introduced as well.

Stakeholders & Business Model

The implementation for the educative centre demonstrates the technical and economic feasibility of executing energetic refurbishment by the ESCo as part of an integral building refurbishment promoted by the customer (the owner of the educative centre).

The business model offered by GNF is an ESCo model. The ESCo invests in the assets needed for the refurbishment and owns the assets during the duration of the contract. The energy savings associated to the local electricity production are a benefit for the owner.

The retrofitted building offers professional training services for architects and, therefore, the building can be used as a showcase for direct knowledge transfer to the market.

Achievements

On the one hand, the project has been delayed due to the difficulty of finding PV glasses that accomplish the technical requirements and the technical barriers found during the refurbishment works on the building structure, which have implied modifications in the project and works to be done. In addition, the aesthetical aspects for BIPV were a critical factor for the customer and therefore involved an accurate design from GNF’s side.

Lessons learned

- The collaboration of an ESCo in such a project is an opportunity to consider energy refurbishment in integral building refurbishments. This relationship gives the energy expert, an ESCo, the possibility to adapt the project including energy aspects in the refurbishment. In this case, the results of the collaboration with an educative centre managed by architects was an optimal design of a PV installation integrated in a building facade, minimizing the visual impact, and, an adequate location in the facade and connection to the building to maximize the self-consumption.

- It is very important to install BEMS to make awareness of the benefits of PV installations for self-consumption. Moreover, in this case the system has another functionality which is to support training strategies. Thanks to the BEMS, the students will be able to understand the implications of installing PV generation on the façade and, also, to analyse the differences between the real values for on-site energy generation and the theoretical ones.

Recommendations

- Consider BIPVs is a relatively new technology of photovoltaics, so there is limited number of suppliers. The delivery period and the investments required are also related to the aesthetic restrictions that the customer may impose for its facade.
- Study the National regulation regarding on-site solar generation as it is a critical factor for the cost-effectiveness of this measure. The Spanish government has a strict rule about the electrical self-consumption which is not favourable, and this implied an increase in effort for the management team. A regulation evolution is required in Spain to foster PV installations. The current regulation obliges a building with more than 10 kW of PV installed to pay some taxes for each kW produced. Therefore, the framework in Spain does not foster the economic viability and replicability of that measure.

PVs to be integrated on the educative centre facade

Electrical installation on the inner part of the PV facade

Measure 1.1 Energy efficient refurbishment of the building - Brf Årstakrönet, Stockholm

Implementation and Activities

L&T has installed different technologies and tools for smart energy management in the private condominium Brf Årstakrönet with 56 dwellings.

This measure includes an adaptive control system for heating, indoor temperature meters in all apartments, smart ventilation control of the garage, water saving equipment, installation of electricity meters, District Heating meter and water measurement equipment. With the installation of these technologies and tools, the aim of this measure is to control and secure energy savings from different energy consuming facilities in the building. The entire installation is supervised through L&T's Energy Saving Centre. For more information see the factsheet named “Energy quality assurance” on the link given on the Sources/References section.

Stakeholders & Business Model

The installation of these smart technologies is intended to be self-financed through the energy savings generated for the tenants, as it is not a significantly expensive measure compared to other energy refurbishment measures, and the customers benefit from a heating and electricity costs reduction.

Achievements

During implementation, all the installation works were supervised by L&T as a single stakeholder and the common subcontractors were selected. This has proven to be positive for L&T regarding project timings (easy communication, fast decision making and very few meetings).

Lessons learned

- Finally, the single installation of the smart technology equipment is not enough to guarantee the energy savings, but an on-going work involving people living in the building is required, together with the right maintenance.
- In the case of Brf Årstakrönet by L&T, it has been proven to be advantageous that the industrial partner in charge of installing the equipment is the same one as the technical facility manager of the building after the installation works.

Recommendations

- Have a realistic baseline for the energy consumption of the building and a realistic Energy Saving Target, since the items/techniques are installed with promised savings that have to be proven.
- It is also advisable to have good planning in order to install all the energy saving equipment as quick and effective as possible to lower costs.

Smart control of ventilation in garage

Adaptive control for heating

Measure 1.1 Energy efficient refurbishment of residential buildings – Valla Torg, Stockholm

Implementation and Activities

Stockholmshem owns the 6 buildings being retrofitted in Valla Torg by the project management of Skanska.

The scope of the refurbishment works in Valla Torg is very wide, as this is a full renovation of the dwellings and tenants are evacuated during the works. Overall, the aim of this measure is lowering the total energy consumption of the 6 buildings by 60%, thus obtaining lower energy costs, more consistent indoor climate and better living comfort. This will be pursued by the following energy efficient retrofitting measures: insulation of ground, facade and roof, exhaust air heat pumps, new heating system (all buildings have District heating except one which has geothermal energy), new substations per each building (better pipes insulation), new windows with low U-value, installation of LED bulbs in common areas, water saving fixtures in all apartments, installation of PV, wastewater heat exchange recovery system from drain water to pre-heat DHW, new energy-efficient fridges, new energy-efficient elevators in 4 buildings, and energy-efficient washing machines and dryers in common laundry rooms.

For more information see the factsheet named "Smart, efficient climate shell refurbishment in Valla Torg" on the link given on the Sources/References section.

Stakeholders & Business Model

Skanska's business model is to lower the real estate cost of the building, i.e. lower management and maintenance costs. Skanska invests in a green business model in the sense of deploying measures in line with the future market for low-energy retrofitting and low carbon footprint.

Skanska designs and coordinates that all installed and mounted components work optimally together, and Stockholmshem pursues a good relationship with the tenants, providing higher standard and better comfort.

In order to implement this measure, Skanska's subcontractors were procured in competition. L&T and Fortum were also involved in the project as GrowSmarter partners and provide smart energy management systems and the replacement of DH pipes in the ground for a better thermal insulation, respectively.

Thanks to this implementation, the building owner achieves higher standard apartments while the tenants benefit from lower energy costs and better indoor comfort after refurbishment.

Achievements

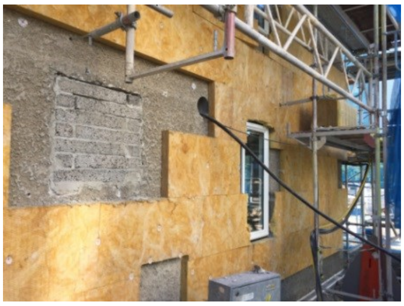
The main obstacle up to now has been the tight timetable defined for the project by both the building owner and the project manager considering that unforeseen obstacles always occur in large retrofitting projects. In this case, moisture and mould in apartments were found and, in order to keep the schedule, more staff than planned was added. In addition, the refurbishment of the 6 buildings (around 300 apartments) including the process of evacuating the tenants was planned to take 3 years. However, the evacuation process with the tenants took longer than expected but their comfort was guaranteed.

Lessons learned

- The engagement of all the stakeholders has been critical to be able to overcome the main obstacle of the measure, i.e. accomplishing a large retrofitting project in a very tight time schedule. The coordination of the moving out and in of tenants with the refurbishment works has been critical.
- In order to keep the schedule, unforeseen obstacles may demand more staff than planned, which means a higher cost for the project over all.
- In order to follow up the energy savings, a baseline is required. The baseline measurement campaign is very time intensive, so this must be considered.

Recommendations

- Look for engaged industrial partners.
- Have the right resources for this kind of project (many stakeholders to be included in the planning).
- In the design stage, follow standard procedures and study the house behaviour before deciding which measures to implement.
- Pay attention to the border lines between subcontractors to not to duplicate tasks.
- Do many inspections/investigations of the status of the building to prevent unforeseen events such as moisture and mould.
- Plan in advance the evacuation process with the tenants in order to reach the best coordination possible for their comfort and follow up of timings.



Facade insulation in Valla Torg

PV cells on the rooftop in Valla Torg

Measure 1.1 Energy efficient refurbishment of the building – Slakthus 8, Stockholm

General information on refurbishment of tertiary buildings by the City of Stockholm

The City of Stockholm has in the framework of the project implemented energy efficient retrofitting actions on 2 public-owned tertiary buildings, namely Slakthus 8 (Tarmrenseriet) and Kylhuset with the aim of lowering their energy consumption.

Slakthus 8

Implementation and Activities

The measures implemented are: adaptive control system for heating & ventilation, heat recovery in the ventilation system, excess heat from the kitchen to heat hot water, integrated PV in the glass of the skylight with battery storage, and LED lighting. A pre-study was made to use waste-heat from the nearby Sportsarena and it showed that it would be possible, but the board of the Real Estate Administration decided that they could not operate a waste-heat pipeline, which was required. Finally, this building will use waste heat from a nearby datacentre (like in Kylhuset).

Stakeholders & Business Model

The City of Stockholm owns this building and is responsible for its refurbishment. The refurbishment measures in this tertiary building have reasonable pay-back times (less than 10 years), so it could also have been fully self-financed. Another stakeholder is the procured company for the retrofitting works, and the building users.

Achievements

The main challenge with the implementation of this building is that it is listed as culturally and historically valuable. Consequently, very thorough studies were required to define how the energy targets could be reached with the prelisted energy efficiency measures. Also, the aesthetical values were important to follow, and every single measure had to be carefully evaluated and agreed upon. The challenges in the implementation for Tarmrenseriet have mostly occurred in the preparatory, planning and procurement phases, whereas the actual implementation has advanced without any bigger obstacles by using open bid processes for subcontracting.

Lessons learned

- When refurbishing historical-classified older buildings, it is important to have much time for planning and procurement phases.

Recommendations

- Make thorough pre-studies.

- Work patiently with building permits and be convincing in reasoning why new innovative technology should be installed in an old classified building, and how it can be done in a sensitive way.
- Make sure your budget is not cut when you start the implementation.

The finalised interior of the building with integrated solar panels on the outer glass roof, an insulating inner glass roof and LED lights

The external window is original and the inner window with an u-value of 0,6 was installed

The original structure of the building was brought forward in the demolition phase

Measure 1.1 Energy efficient refurbishment of the building – Kylhuset, Stockholm

Implementation and Activities

Originally, two buildings from the 1910s were going to be refurbished. However, due to severe cuts on the Real Estate administration's budget, the City Management Board decided they could only continue with the refurbishment of Slakthus 8. Following this decision, the City of Stockholm evaluated two alternative buildings in order to find a suitable replacement for the 2nd building. Finally, Kylhuset, a commercial office building built in 1965, was selected.

The aim of the measure is to lower the energy consumption of the tertiary building via both passive and active measures. The proposed measures for this building include the use of waste heat from a nearby data centre by a heat pump, new highly efficient air handling unit, improved thermal insulation of the roof, and solar panels connected to a battery storage (which in turn is connected to charging points for electric vehicles using a smart integrated control system).

Stakeholders & Business Model

The City of Stockholm owns this building and is responsible for its refurbishment. The refurbishment measures in this tertiary building have reasonable pay-back times (less than 10 years), so it could also have been fully self-financed. Another stakeholder is the procured company for the retrofitting works, and the building users.

Achievements

The timings for the building works could not be fulfilled because the implementation of the waste heat solution must be done outside the heating season, and it will be done in summer 2018. Except for that, the retrofitting works advanced in a high pace and with no obstacles.

Lessons learned

- The quick selection of this building as a replacement of the building from 1910s proposed at the beginning of the project has proven that there are public-owned buildings around where energy saving retrofitting can be applied and with good pay-back times.
- As the implementation in this building started late in the project, the limited time schedule set boundaries to what type of buildings could be chosen as well as what type of measures could be implemented. There were for instance no possibilities to improve the climate shell of the building, more than putting extra insulation on the roof. So the success factor was to define such measures which would have a good energy saving potential, a good pay-back time and the possibility to fully implement these during 6-8 months.

Recommendations

- It is important to analyse each building as part of its surroundings. In this case, it turned out that there was a large waste heat source in a nearby data centre which, after closer analysis and pre-study, could be recovered.

Measure 1.1 Energy efficient refurbishment of residential buildings – Stegerwaldsiedlung, Cologne

Implementation and Activities

Dewog is implementing energy retrofitting works in 16 residential buildings in order to lower their energy consumption.

The activities done during implementation are: insulation of buildings front, basement ceiling and roof; installation of triple glazed windows in some buildings; installation of efficient lighting in the staircase; and new heating systems.

Stakeholders & Business Model

The initial investment done by Dewog is expected to be financed in the future by the payments done by the tenants via future rent increase. Once the rent is increased, it will not be reduced after the measure is paid off. So, there will not be a specific period of time for the increase. Retrofitting measures that involved a high investment and therefore would cause a high rent increase were changed in order to decrease the investment amount, as there is a maximum on rent increase of 9.97 €/ m²/ month (= net rent).

During the implementation phase, the following stakeholders were involved: Architekturbüro Nattmann, technical department of AACHENER Siedlungs- und Wohnungsgesellschaft mbH (parent company of DEWOG) and commissioned craft companies

Achievements

At the beginning of the implementation of this measure, there were temporary problems with the preparation and granting of construction permits and it has been found difficult to find companies or engineers for commissioning. A low interest phase in the sector has led to a retrofitting boom in the region, with the consequent high utilization of construction companies and an increase of prices in the retrofitting sector. Additionally, some contractual issues were found along the implementation, since Dewog was not allowed to buy the air/heat pumps (in cooperation with RheinEnergie), but had to buy the air/heat pumps via the utility RheinEnergie. These obstacles led to some delays during the implementation phase but were overcome.

Due to the delays, a contingency plan had to be implemented by installing three heating stations (two rented and one mobile RheinEnergie heating station) because the heat pumps were not in commission and the district heating was not connected on time.

Lessons learned

- The good communication between Dewog/RheinEnergie and the tenants has shown to be critical for the success of the retrofitting project, as a good communication provides the possibility of cocreation with the tenants.

Recommendations

- Be prepared to react to unexpected obstacles such as the lack of labour force in case a tight time schedule has been set to the implementation works.
- A very good coordination between contractors is required due to large retrofitting project.


Facade retrofitting during (left) and after implementation (right)

2.1 Smart Solution 2: Smart building logistics and alternative fuelled vehicles

Smart Solution 2 is handed by WP4 Sustainable Urban Mobility. See more information on the D4.3 Implementation report WP4 "Implementing Sustainable Urban Mobility in European cities – experiences from GrowSmarter".

2.2 Smart Solution 3: Smart, energy saving tenants

Smart Solution 3 demonstrates several ways to inform tenants on how to optimize their behaviour to achieve maximum energy efficiency and reduce their energy bill and consumption. The basis for this smart solution is the collection of individual consumers‘ energy data and the corresponding analysis to conclude with different advices to give to the tenants.

Measure 3.1 Virtual energy advisor, Barcelona

Implementation and Activities

Barcelona Municipality launched an on-line platform with the aim of decreasing the electricity consumption in the residential sector of the city. It was an innovative measure within the Municipality, as it was the first time that energy policies were focused on citizen actions. With this tool, the Municipality is also able to gather information on the electricity consumption profiles depending on the city district and other variables, which may help in fostering suitable energy policies for the city.

The tool provides information on dwelling electricity consumption, while it also gives tips and advices on how to reduce the consumption, among other features. In order to acquire the electricity consumption data to be displayed on the platform, there are 2 options: Basic level, where the user allows the Municipality to directly request monthly or bimonthly invoice consumption data from the Distribution System Operator (DSO) of the grid, or Advanced level, where the user agrees on the installation of a smart sub-meter to read electricity consumption on real time.

During the campaign (throughout 2015-2016), around 400 users received a free smart sub-meter installed at their home by the Municipality, and over 400 users signed up for the platform.

For more information see the factsheet named “Virtual Energy Advisor” on the link given on the Sources/References section.

Stakeholders & Business Model

This measure is not intended to be self-financing, as the aim of the Municipality is to both focus energy policies on citizen awareness and collect electricity consumption profiles to foster suitable energy policies for the city.

Achievements

The operation phase of the smart sub-meters has been challenging, as the devices of the awarded manufacturer presented connectivity issues. This has led to additional costs, as every sub-meter device that loses connectivity has to be checked by a technician. More budget was allocated in order to cope with this unforeseen obstacle.

Lessons learned

- The main barrier encountered during implementation of this measure is the data confidentiality constraints to evaluate the individual dwellings electricity consumption data. Barcelona Municipality signed an agreement with the users but this agreement does not allow doing a massive data treatment by third-parties due to the data confidentiality protection.
- The Municipality did not foresee the issue with the connectivity of the smart sub-meters and did not include this service on the agreement with the subcontractor for the meters installation, thus the process to send the technicians to each dwelling was not considered on the agreed budget.

Recommendations

- In order to avoid extra costs due to both smart sub-meter purchase and connectivity issues, a proposal presented by the Municipality for future implementations is to obtain the consumption data directly from the digital smart meters operated by the DSO.
- In order to avoid data privacy issues: include this discussion from the very beginning of the project.

Visualization of energy consumption in Web platform (left); Sub-metering installed (right)

Measure 3.1 Home energy management system (HEMS), Barcelona

Implementation and Activities

GNF has designed and developed a Home Energy Management System (HEMS) for its customers, and installed over 100 prototypes in dwellings in Barcelona. The aim of this implementation is to provide detailed information on electricity consumption and therefore create awareness on energy efficiency in the residential sector. Furthermore, HEMS are seen as a good opportunity for utilities to analyse the consumer's habits in energy consumption, which in turn allows offering personal services to the customers.

During the implementation phase of this measure, the activities carried out have been: market research to define the HEMS functionalities based on customers' demands, conceptual design of HEMS solution (internally and with external consultants), subcontracting the supplier for the meters and visualization platform (single supplier), installation of prototypes, development of a mobile App for customers' interaction, and development of a platform to receive and analyse the monitored data from all the dwellings.

For more information see the factsheet named "Home Energy Management System" on the link given on the Sources/References section.

Stakeholders & Business Model

In case of a successful pilot phase, it is expected that HEMS will be self-financing due to the fees that customers will pay to GNF for the new services supplied.

Achievements

One of the main barriers encountered during implementation has been the data communication between the subcontractor's hardware and GNF platform, which was solved by subcontracting an external consultant to perform the data integration (leading to non-expected additional costs).

The App was designed as intuitive and with a simple hardware in order to achieve a larger number of users, since the more active customers are, the more information on energy behaviour the utility may extract and analyse (and less probabilities that the customer will cancel the service).

Lessons learned

- Generally, it has been observed that the target customers group for this measure is limited, as it requires tenants with a minimum knowledge in technologies (smartphones, how to use an App, etc.). In this case, it has been observed that young people are the best target.
- It is possible that tenants have doubts to participate because they do not see the advantages of HEMS. In this case, information campaigns about the advantages of HEMS were done to motivate people.

Recommendations

- It is important to design a simple hardware and intuitive APP. If the hardware requires a lot of attention and the APP is not intuitive and simple to use, consumers will not see the advantages of using or even installing HEMS at home and a lot of data will be lost.
- The target for HEMS is young people or people with technologic knowledge. HEMS require a minimum technological knowledge to manage the hardware and APPs because HEMs are based on new technologies.
- Customers should be active clients with HEMS. This is important for the utilities: the more active the client is, the more information the utility can extract and analyse.

- The platform to analyse the data should be clear and simple, and able to extract energetic behaviour patterns useful for the utility.
- It is advisable to define all the details on data integration prior to implementation, so the communication between the subcontractor's hardware and the platform is guaranteed.

Mobile App development for HEMS (left); thermostats for HEMS (right)

Measure 3.1 Energy Saving Center, Stockholm

Implementation and Activities

The Energy Saving Center developed by L&T is an IoT platform that collects all the data on energy consumption monitored in a building with the aim of helping the decision-making process in order to apply energy efficient measures. This tool offers a proactive surveillance of their customers' installations with a very up-to-date energy surveillance collecting and analysing data regularly. The implementation of this platform has been completed in Brf Årstakrönet residential building, with activities such as the installation of TV screens in the Energy Saving Center facilities, automatic data collection, and education of personnel working with the platform (for the decision-making according to the collected data).

For more information see the factsheet named "Hubgrade – Energy Saving Centre" on the link given on the Sources/References section.

Stakeholders & Business Model

L&T owns the solution and is responsible for the maintenance of the facilities in the building where the solution is implemented. The idea is to develop the business model from B2C (Business-to-Consumer) to B2B (Business-to-Business).

Achievements

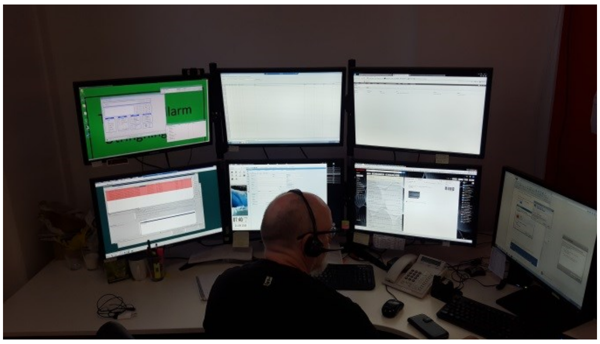
The market for automatic data collection is quite fragmented, with many companies selling mainly smart meters and trying to lock up the IoT platform to their specific products. In the same way, the "format" for connection (Mbus, LoRa, Bluetoth, RFID, BACnet, etc.) is quite fragmented and under fast development, making it necessary to have an open IoT platform that can receive different kinds of signals. By implementing the Energy Saving Center, L&T provides an independent IoT platform, not connected to a specific brand of sensors or control system that is able to overcome these barriers.

Lessons learned

- An important factor to be considered for this implementation is getting the right personnel sufficiently qualified to both develop the platform for the integration with metering equipment from different brands, and be capable of analysing the collected data and make decisions on the actions required for each building.
- It must be considered that collecting measurement data from third-party's buildings may present some technical issues regarding the correct operation of the communication chain through different nets (firewalls). However, no data confidentiality issues have been found in this implementation.

Recommendations

- Have your own independent IoT platform, not connected to a specific brand of sensors or control system.
- Get the right staff with the right competence.
- Always see energy savings/surveillance as an on-going process.



Energy Saving Centre in operation

Measure 3.1 Active House, Stockholm

Implementation and Activities

Fortum installs the Active House solution (a Smart Home solution) in 54 apartments in the retrofitted residential area Valla Torg, Stockholm. The aim of the measure is to increase tenants' awareness on their energy consumption, besides enabling tenants to control radiators and lighting in an easier way (which aims at lowering their energy consumption).

This is done by installing monitoring equipment and a tablet that shows how much electricity the tenants are using, how much it costs and how much carbon dioxide the usage is generating – right now or on a yearly basis.

The implementation of this measure involved several activities: integration of the sensors and dimmers to the cabinets, preparation of the cabinets to be installed in each apartment, installation and adjustments of the tablets in the apartments, get consent by tenants, and teaching the tenants to use Active House.

For more information see the factsheet named "The Active House" on the link given on the Sources/References section.

Stakeholders & Business Model

During implementation, all the installation works were supervised by Fortum as a single stakeholder and Fortum's common subcontractors were selected (equipment providers, platform developers, and installers).

Overall, this measure is a new business area for Fortum and these first implementations are an opportunity to start developing the market for this solution in the future. Fortum is now ready to start a commercial project in Stockholm and has customers from large building operator companies. The solution is further developed with new features such as burglar alarm, motion alarm and flooding alarm.

Achievements

In this case, the installation of equipment for the Active House solution was done in parallel to the retrofitting works in the building, thus it must be considered that an extra effort for coordination with the construction team was required and delays and re-planning of external resources caused extra costs. Notwithstanding, Fortum succeeded to deliver the solution to the tenants before they moved into the apartments, so tenants can monitor and visualize their energy consumption from the first day.

Lessons learned

- A key factor to succeed on the implementation of this measure is to create the solution with an advanced development team, as the development of a Smart Home solution takes time and energy.
- Flexibility on works schedule is required in case the installation of equipment for this solution is done in parallel to retrofitting works in the building.
- Participation of tenants is critical to make the solution work. It is important for people to understand the concept of 'energy savings' (care about the environment).
- The cost for the batteries for the sensors has presented a technical challenge as 15 of them were required per apartment. This may be optimised for future implementations.

Recommendations

- Identify your market niche, what your customer segment is.

- Put a lot of effort on engagement/motivation of users: explain the impact on both money and energy savings.
- Create trust by delivering quality work.

The Active House solution

Measure 3.1 SmartHome, Cologne

Implementation and Activities

In the first instance, the RheinEnergie had planned to design and develop an own Smart Home Solution for its customers and install 50 prototypes in Stegerwaldsiedlung neighbourhood. The aim of this implementation is to provide detailed information on electricity consumption, lead to an increase of quality of life and security of supply for the tenants, and lead to up to 20% of energy savings in the dwellings, depending on how the tenant uses the system.

For the implementation of this measure, the activities required are: analysis of the environment and the needs of the tenants in order to choose the suitable components, screening of the market for suitable providers of smart home systems, testing the chosen system in order to learn about the system and be able to instruct the technicians and the users, inform the tenants so they can apply for getting a prototype installed at home, and finally install the system.

At this stage, RheinEnergie has already chosen a smart home system from the market to to install 50 prototypes, and the order is currently in process. For more information see the factsheet named “Home Energy Management” on the link given on the Sources/References section.

Stakeholders & Business Model

In case of a successful pilot phase, it is expected that the SmartHome solution will be self-financing due to the fees that customers will pay to RheinEnergie for the new services supplied. In the GrowSmarter project, the SmartHome system will be for free for the tenants.

Achievements

Due to problems with the software provider for RheinEnergie's own Smart Home Solution, an external provider of the complete system had to be sought. During the screening of the market to find suitable providers of smart home systems, it was found that there was not a wide variety of existing smart home systems with the desired characteristics (looking at both the software and the hardware of the systems). The main achievement for this measure has been to apply a contingency plan in order to overcome the unforeseen challenge that came up with the cancelation of the first proposed software provider. RheinEnergie has now a new Hard- and Software provider for the smart home system.

Lessons learned

- Finding a good smart home system is not so easy. Many products are not well designed as they either have limitations within the software, the hardware or both.
- According to German legislation, it is not possible to install uncertified Smart meters, and tenant consent is required to install sub-metering.
- This measure is closely linked to measure 5.3 in Work Package 3, as smart meters were supposed to be linked to the smart home system. Since smart meters are not yet certified in Germany, the tenants did not give consent to install uncertified smart meters. This is the reason why AGT is now intending to install smart plugs, which measure individual appliances instead of the entire apartment's consumption. Again, this is possible only once the tenants' consent is given.

Recommendations

- Plan the communication campaign with the tenants well on time to inform about the advantages of this solution and overcome their doubts to share their energy consumption data (tenant consent is required to deploy this measure).

2.3 Smart Solution 4: Local Renewable energy production and integration with buildings and grid

Smart Solution 4 demonstrates the smart management of local renewable energy production together with local demands, integrating producers and consumers and combines the on-site electricity generation with heating/cooling and storage capacity for surplus production.

Measure 4.1 EnergyHub, Stockholm

Implementation and Activities

L&T is in charge of installing the EnergyHub system to maximize the investment in solar power in different buildings in Stockholm. Using advanced algorithms, EnergyHub gathers relevant information and optimizes the energy flow between solar panels, energy storage and the grid. Therefore, the aim of the measure is to add a battery to the solar generation system to allow the storage of electricity from the PV and the optimization of energy use (including peak shaving strategies). The target users of this technology are both residential and tertiary buildings.

The implementation of this measure has been done in Brf Årstakrönet residential building with EnergyHub at this moment, and within the GrowSmarter project it will also be installed in Stalkthus 8 and Kylhuset as well. In order to promote this measure, L&T will use the results of these first installations to extrapolate them to similar buildings and quantify the possible available power that could be sold/used otherwise by using the EnergyHub. The installation of the management system in different types of buildings will allow observing how the electrical power is used over time and find differences and possibilities in power equalization between different types of buildings.

Stakeholders & Business Model

The main stakeholder in this measure is the start-up company FerroAmp, which is the developer of the EnergyHub. No procurement process was done for the energy management system (it was done only for the PV cells), as there are not so many different products with these features in the market, so the goal of this measure was defined to prove the EnergyHub technology.

For L&T this is a new business area yet to explore, but the measure is intended to be self-financing thanks to the energy and power savings for the building users.

Achievements

The first installation in Brf Årstakrönet was completed without any problem.

Presently, L&T is working on the development of the visualization tool for the building users, as the measure includes work on user awareness in terms of solar power use.

Lessons learned

- Peak shaving is one of the main goals for the energy optimization in this measure, as it is considered that this is going to be a major topic in the near future due to the development of the electrical grids in cities.

Recommendations

- Start with measuring the electricity used (both energy and power) in order to size and study the technical and economic feasibility of such a system.

EnergyHub inverters (left), PV cells (centre), and control system (right)

Measure 4.1 Siedlungsmanagement, Cologne

Implementation and Activities

The Siedlungsmanagement is an intelligent energy management system that has been installed by RheinEnergie in Stegerwaldsiedlung neighbourhood.

The aim of this measure is to optimise the electricity consumption of the heat pumps and the heat production and generation of the residential neighbourhood, and therefore maximize the self-sufficiency of the settlement. The management system controls both internal (PV, air/water heat pumps, battery storage) and external (district heating) energy producers. The target groups are e.g. housing agencies, other energy providers, etc.

In general terms, for the implementation of this measure, the activities required are: collection and evaluation of all the requirements and functionalities the software should have, screening of the market for possible suppliers of such software with the needed know-how in this field, refinement of the specification sheet, tendering process, selection of supplier and set up the contractual conditions (how the requirements will be met), and set up regular meeting with the supplier to ensure the implementation goes smoothly and to solve all the little problems that occur during the implementation in time.

For more information see the factsheet named "Residential Estate Management" on the link given on the Sources/References section.

Stakeholders & Business Model

RheinEnergie sub-contracted a software supplier to develop the energy management system.

Achievements

The most significant challenge found during the implementation of this measure is a technical challenge, i.e. to control the devices as planned on the energy management system definition. Most of the manufacturers did not expect their devices to be part of such a complex energy management system. Intense discussions with the manufacturers on how their devices can be externally controlled in a new way were needed to adjust the devices according to RheinEnergie's vision of a new integrated energy management.

Lessons learned

- It is crucial not to underestimate the time required to collect all the requirements for the software and the controllable equipment.
- In case this measure is performed together with retrofitting works, delays on equipment and software installation may be expected as delays during construction works may be frequent. This must be considered in the planning.

Recommendations

- Good communication between the different departments and companies that provide software and hardware is essential for good progress.
- Be flexible during the implementation as this is a new technology.
- Pay close attention to the required standards for communication.

Measure 4.2 Smart energy and self-sufficient block, Barcelona

Implementation and Activities

With this measure, GNF aims to test the viability of a business model for the deployment of self-consumption installations including photovoltaic generation and electrical storage both in residential and tertiary buildings. The installations are smartly controlled by an energy management system (EMS) developed by IREC, which minimizes energy costs of the electricity bill via the operation of the battery under different strategies (i.e. maximizing self-consumption, peak shaving or energy arbitrage) using weather and demand forecasts.

Self-consumption installation with the EMS integrated is commissioned in one residential building and three additional contracts (with 1 residential and 2 tertiary buildings) have been signed for the self-consumption installation.

The implementation procedure starts with the procurement process and the elaboration of the detailed project design. Once the detailed design is completed, the application process for work licenses and network access starts. When work licenses are obtained and the health and safety supervisor has supervised the site, the work starts with the installation of PV modules, battery and inverter system, generation metering and establishing communication. Once the equipment is installed, the EMS is integrated in the installed inverter, in this case done by IREC.

For more information see the factsheet named “Smart energy and self-sufficient block” on the link given on the Sources/References section.

Stakeholders & Business Model

The installation projects require a signature between GNF acting as a promoter and the building owner acting as the installation owner (although GNF is the owner of the installation while the contract is in force). IREC acts as the software provider for the Energy Management System.

Achievements

Considering the existing regulation in Spain at the time of implementation, a generation installation can only feed one consumer. Hence, in order to implement the measure in residential buildings GNF installed it at the common rooftop of residential blocks, involving that the satisfied end-uses are only the common end-uses (i.e. elevators and lighting). This presents a challenge, as power peaks of elevators are significant and might cause relevant impacts on battery degradation. This challenge is overcome by installing a smart energy management system that aims at lowering the battery degradation, among others.

Lessons learned

- The mentioned requirement on the current self-consumption regulation could potentially be changed in the future, enabling one generation installation to feed more than one consumer. In this case, the deployment of the measure in the residential sector would have a higher potential.

- Municipal regulations by the urban landscape department of the city may affect the installation of PV on building rooftops (e.g. photovoltaic pergolas have to be approved by a Commission for each individual case). This must be considered in the planning.

Recommendations

- In case the self-consumption installation is done at a neighbourhood community level: involve individual dwellings from the very beginning and explain the project in neighbourhoods meetings.

- Send contractors to carry out a detailed visit before the economic and technical offer elaboration, so locations of the equipment (e.g. battery and inverter) are well ensured and the required cabling is considered.

First self-consumption installation in Barcelona by GNF

Measure 4.2 Resource Advisor, Barcelona

Implementation and Activities

The aim of the measure is to make use of a tool (the Software Platform called „Resource Advisor“) developed by Schneider Electric. This tool enables to follow up the Key Performance Indicators (KPIs) for the evaluation of the impact of energy retrofitting works in a building. In addition, it detects deviations on the expected values and makes sure that the savings are achieved over time.

In order to implement such a platform, the first activity performed was the data extraction from the original building databases and, secondly, the setup of all the new databases and other tasks needed to display the data in the platform. In this case, the technical experts from Schneider performed the data extraction and no subcontracting was required. Once all the data monitored in the buildings is available, the setup of the KPIs and dashboards of the visualization tool is discussed with the stakeholders interested in using the platform for retrofitted building KPI follow-up.

For more information see the factsheet named "Building Energy Management System: Resource Advisor" on the link given on the Sources/References section.

Stakeholders & Business Model

With this measure, usually the customer owns the data, while the software developer (Schneider Electric) owns the solution and makes the data available to the customer.

The setup, use and maintenance of this kind of software are usually subject to a contractual agreement between both parties, which in this case is covered with the Grant Agreement of the project. The platform is usually financed within a recurring services contract. As it is difficult to attribute savings to a monitoring platform, the measure is not intended to be self-financed as a standalone, though it is usually a necessary part of self-financed solutions of active energy efficiency measures, such as Energy Performance Contracts.

Achievements

Data protection has arisen as the key challenge of this measure, due to the concern of the stakeholders when it comes to sharing their building monitored data with a private visualization platform such as Schneider's. In order to overcome this challenge, specific Non-Disclosure Agreements have been prepared.

Lessons learned

- Automatic data gathering should start well before implementation to ease the creation and follow-up of the baseline, and also not bind the implementation of the monitoring to the rest of the measure's implementation.

Recommendations

- Data privacy as well as any IT security concerns should be tackled at the beginning of the project.

Data visualization tool by Schneider Electric

2.4 Smart Solution 6: New business models for district heating and cooling

Smart Solution 6 demonstrates the impact of the District Heating and Cooling technologies regarding the contribution to lowering the environmental impact of the existing building stock, compared to the use of individual and conventional heating and cooling energy sources. Also, in the city of Stockholm, a new business model with plug and play heat pumps and contracts where the district heating provider buys waste heat from local energy sources (such as data centres and supermarkets) is demonstrated, which brings new opportunities for the further deployment of this technology in countries where it is already a quite consolidated technology.

Measure 6.1 Open district heating with feed in of waste heat, Stockholm

Implementation and Activities

With Open District Heating, Fortum Värme aims to recover waste heat into existing DH networks in Stockholm to meet local energy demands. This is done by developing an innovative business model for a yet unexplored potential as an integrated energy solution. This new business model involves plug and play heat pumps and contracts where the district heating provider buys waste heat from local energy sources such as data centers and supermarkets.

More in detail, in this measure the heat is recovered from a data centre and a supermarket into the nearby DH networks. Data centres and shopping malls with many freezers and coolers generate lots of excess heat which is often costly to get rid of. The heat reuse of the data centre chosen for the GrowSmarter project is expected to increase gradually to a level of approximately 1MW, a heat recovery that is sufficient to heat more than 1,000 apartments while reducing annual CO2 emissions in Stockholm. From the technical perspective, the main innovative solution applied to the data centre is the heat pump model used, which is the first of its kind in Sweden. This is able to produce hot water at a temperature of 85˚C instead of around 68ºC. This is an advantage since a higher temperature is more convenient for the yearly total runtime with respect to the district heating network requirements to the DH customers. In addition, the supermarket connected to the DH network has the potential of recovering 0.5 TWh of heat annually and heat up around 40 modern apartments in Stockholm alone. The solution in this supermarket does not involve recovering for District Cooling.The implementation of this measure has involved the procurement of suppliers for pipes and heat pumps (trusted subcontractors of Fortum), the construction of pipes and heat pump installations and the optimization of heat pump parameters, and finally the start of heat delivery and invoicing (Fortum Värme pays for the heat to the data centre and supermarket).

For more information see the factsheet named “Open district heating using waste heat” on the link given on the Sources/References section.

Stakeholders & Business Model

Fortum Värme owns the heat recovery solution and equipment. With Open District Heating, it is possible to turn costs into revenues, as the heat suppliers gain an improved OPEX with an income for the excess heat. Therefore, the supermarket and data center in this case (the heat suppliers) are also stakeholders. As an additional benefit, the old cooling systems in the heat supplier facilities can become back-up systems reinforcing the cooling system.

Achievements

It must be considered that the stakeholders supplying the heat may have requirements on the continuous operation of their cooling systems during implementation phase, thus coordinated works were critical to avoid any stop on the existing operation and cooling of the data centre/supermarket.

In the supermarkets, fridges and freezers using CO_2 as cold media generate waste heat at 80ºC, which can be directly recovered into the district heating system. Waste heat at lower temperatures can be recovered in the district cooling return pipe in addition to the district heating network. By that, the very main portion of the total excess heat can be recovered and utilized.

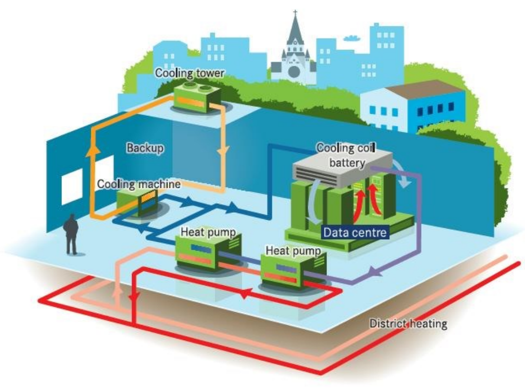
Lessons learned

- Large scale heat recovery as Open District Heating is based on the foundation of a vast infrastructure in the form of a district heating network (minor local heat recovery solutions can be done elsewhere).

Recommendations

- This measure is replicable in cities where the DH infrastructure is widely spread. If the foundation is in place and large scale heat recovery is possible, the main recommendations is to build a first case/pilot together with one or several customers (learning by doing), and focus on the data centre segment, a growing worldwide business where the cooling demand is the same throughout the year.

Heat pump installation in the data centre



Open District Heating concept (example for data centres)

Measure 6.2 District heating rings, Barcelona

Implementation and Activities

GNF will within this measure perform an analysis of the real potential for the application of distributed generation from renewable energy (PV+storage) and waste heat (DH with heat recovery) coupled with the real energy demand of a group of buildings in Barcelona with complementary consumption.

The implementation of this measure has changed considerably respect to its first proposal. At first, La Llacuna Block was analysed in detail, in order to create a DH mini-ring inside the block and connect a school and two residential buildings to the grid from the same substation. A detailed energy audit and technical study for DH connection was done and a technical offer was presented to the owner, but finally the project was stopped, due to the lack of public grant. After that, a new block was chosen with the objective of creating a thermal and electric high efficiency island. However, the will of the owners of Melon District island showed the impossibility to connect the island to DH and install PV with energy storage. After this negative feedback, the measure was adapted to an analysis with the aim of determining the real potential for the application of measures related to distributed generation from renewable energy sources and waste heat for a real group of buildings with complementary consumption.

Stakeholders & Business Model

The final measure consists of a static virtual analysis with the aim of evaluating the potential of the implementation of an energetic ring. In this analysis an energetic balance will be done among the buildings with distributed energy generation (renewable energy and waste heat) and the residential and tertiary buildings retrofitted within the project but with no distributed energy generation. The buildings that participate in the measure are: Melon District, Canyelles, H10 Hotel and all the buildings of the Measure 4.2 Smart energy and self-sufficient block.

There is no business model behind this measure due to the fact that only a virtual analysis is carried out.

Achievements

The real energy consumption profiles that will be used for this analysis are: Melon District (including real profile of DH use with a real substation connected to the DH network), Canyelles, hotel H10 and all the buildings of Measure 4.2 by GNF (including real profiles of PV generation and different storage's uses). These buildings are not in the same island, thus the analysis is carried out virtually and starts with the beginning of the evaluation phase of all the participant buildings.

Lessons learned

- This measure has been changed because of the non-favourable Spanish legislation regarding on-site electricity generation, the low participation of the building owners and the impossibility to find an island where connecting buildings to DH was economically viable.

Recommendations

- Implementation has not started yet, so recommendations cannot be given. The implementation of this measure will start when all the measures on the participant buildings are completely finished and monitored data are collected.

Measure 6.3 Smart local thermal districts, Barcelona

Implementation and Activities

The aim of this measure is to validate the impact on the building energy demand of the result from combining local electricity production with the connection to an existing DHC network together with smart energy management.

Within the project, this solution is implemented by connecting the building Ca l'Alier (a future innovation hub built from the refurbishment of an old factory, see Measure 1.1) to the local DHC network and by installing a large Photovoltaic installation on its rooftop to produce electricity for the building. These energy generation technologies will be coupled to an energy management system capable of optimising the energy consumption, attempting to reach a nearly-zero energy status (considering local heat and cooling from DHC network and the on-site electricity generation). The network uses waste energy sources (municipal solid waste or alternatives) coupled with energy-efficient equipment to reduce the consumption of fossil primary energy for heating and cooling production.

This implementation was dependent on the the work permits in order to lengthen the existing DHC network to the present building's street (as the network didn't spread through the nearby streets), and the underground network had to be built and extended to the building. The final connection to the network will be done in 2018.

Stakeholders & Business Model

In general, potential stakeholders for this type of measure go from tech companies and public administrations to citizens and neighbourhood associations committed to district regeneration and to reaching high shares of local energy production to cover most of the thermal and electrical needs of the buildings (with DHC and PV technologies, respectively).

In this specific case, the solution is implemented through a public-private partnership for the integral refurbishment of Ca l'Alier, which includes the installation of PV and the connection to DHC. The stakeholders in the PPP are Barcelona Municipality and Cisco. Another key stakeholder is the DHC network owner, i.e. Districlima S.A. (an ENGIE Group subsidiary company), which provides urban heating and cooling distribution in some districts in Barcelona since 2004. The network uses waste energy sources (municipal solid waste or alternatives) coupled with energy-efficient equipment to reduce the consumption of fossil primary energy for heating and cooling production.

Achievements

The aim of Barcelona Municipality is to show that the combination of technologies such as solar Photovoltaic energy and the connection to energy-efficient DHC networks can contribute to reach a nearly zero energy site, and demonstrate the technical, socio and economic viability of this type of solutions at a higher scale. Barcelona Municipality aims at fostering the replicability of this solution in the city, by targeting offices, residential and social spaces that need to be refurbished or converted into useful spaces for citizens.

Lessons learned

- The connection to the DHC network will be possible depending on the proximity of the building to the existing network, the energy needs and the planned expansion plans of the DHC company.

Recommendations

- A feasibility study must be performed prior to deciding whether to connect to a district network or use other individual systems. Both technical and economical features must be considered. In Mediterranean climates like in Barcelona, DHC technology is not widely spread, thus it presents in many cases a costly option in front of other heating and cooling systems. A thorough economical pre-study should be done to justify the required investment for this solution.


DHC substation under construction (left); Pipe installation process (right)

3 LESSONS FROM IMPLEMENTATION

More than 100 000 m2 of residential floor and 20 000 m2 of tertiary floor have been retrofitted, Home Energy Management Systems have been deployed, connection of buildings to district thermal energy networks has been done, as well as the implementation of building on-site energy production with smart energy management systems in the 3 cities. After 3 years of implementation, many lessons have been learned from the challenges that each kind of measure and each city has overcome. This section presents the main lessons learned from the Smart solutions' implementation.

3.1 Lessons per Smart Solution

This section gives an overview of the lessons learned during the project implementation for their consideration in the replicability of the GrowSmarter measures. A summary of the challenges encountered by all partners involved in WP2 measures is also given on the Tables 2-4.

Smart Solution 1. Efficient and smart climate shell refurbishment

Table 2: Overview of the challenges faced for the implementation of the Smart solutions on energy retrofitting of buildings

Technical challenges	Implementation challenges
- Setting up a clear baseline (if ESCo model, savings must be proven) - Aesthetic restrictions - Monitoring of savings	- Tight time Schedule - Decision-making and coordination of works in multi-owner residential buildings - Narrow border line between the different subcontractors - Unforeseen obstacles due to previous status of building (compared to new construction) - Coordination of energy efficiency works together with an integral building refurbishment
Regulatory challenges	**Business model challenges**
- Restrictions in the definition of the final technical solution for historic buildings - Tenants' right to appeal/acceptance - Long and sometimes complex process to obtain building permits	- Engagement of owners of residential buildings (if retrofitting is based on private ESCo model) - Commercial public-owned buildings with private operators - Differences among countries in energy savings model "who pays the energy bill (owners, tenants, operators…)?"

- ***Set up a clear baseline to justify energy and economical savings***

  In case of industrial partners promoting the energy retrofitting for particular owners, setting up a clear baseline is a key factor, as they are selling energy and money savings to the building owners, thus the measures performed and the promised savings have to be proven.

- ***Perform pre-studies and energy audits to study the building behaviour prior to implementation***

  Energy audits during the design stage are critical in order to adjust the proposed energy-saving technical solutions for each specific building. It is advisable to evaluate the potential energy sources on the surrounding buildings/facilities as waste heat integration solutions can be found.

- ***Energy retrofitting of historically valuable buildings presents extra challenges***

  The case of retrofitting historic buildings may challenge the planning and the procurement phases, as the final technical solution needs to be agreed upon with the Public Administration. Additional effort is required to convince the Public Administration in reasoning why new innovative technologies should be installed in an old-classified building. Restrictions as for example the impossibility to add external facade insulation may arise.

- ***Stakeholders engagement is critical to accomplish the time schedule***

  In total, a large surface of residential and tertiary buildings has been refurbished in the three lighthouse cities within Smart Solution 1, involving in some cases large building retrofitting projects that had to be accomplished in a very tight timetable. This has been a common challenge for many of the implementations within this Smart solution, as common delays due to unforeseen obstacles occur in large retrofitting projects. Thanks to the engagement of the stakeholders, the project has been able to overcome this challenge.

- ***Multiple ownership in residential buildings may be a decision-making barrier***

  The energy retrofitting of the residential sector proves to be more feasible in buildings where most of the dwellings are owned by a unique owner. This facilitates the process of reaching an agreement to start the implementation and the consequent communications with the residents once the implementation starts. In contrast, an additional effort for coordination with all neighbours is required if there are many owners in the same building. Information campaigns may be very useful to motivate the neighbours to be participatory.

- ***Look over the border line between the different subcontractors***

  In retrofitting projects involving several energy-saving measures, it is critical to look over the border line between the different subcontractors in order to guarantee there is no duplication of the contracting of one same activity. Collaborating with building construction companies may help to optimize resources and interfaces in this sense.

- ***Energy retrofitting works can complement larger retrofitting projects such as structural refurbishment or building adaptation***

  The importance of considering energy efficiency aspects together with an integral building refurbishment (and not separately) is highlighted. The sizing of equipment is significantly affected by the passive measures to be implemented and the simultaneity allows defining the most convenient solution for both, active and passive measures. The combination of structural renovation and energy retrofitting can overcome the low energy savings (for heating) in Mediterranean climates.

- ***Training for local architects and installers would be favourable***

  There is a need for quality assurance of the work performed by local architects, engineers and installers. Possibility to promote training courses by the Municipality to guarantee this.

- ***Differences in national regulation restrict the replication of measures***

  Each country has different economic issues concerning energy contracting that make business models different, e.g. on-site renewable energy generation or energy invoicing. In energy retrofitting of buildings, the business model will differ if the heat/electricity is included in the rent or not (who gets the economical savings?).

- ***Carbon footprint reduction may be the objective instead of economic savings in public investments***

  It must be considered that sometimes even though some measures do not make sense economically, they do have a positive impact on their carbon footprint. An alignment between public policies and urban planning is required.

- ***Replication of energy efficiency measures in building retrofitting is climate-dependent***

  The specific energy-efficient measures implemented in each building will mainly be replicable in cities with a similar climate.

- ***To scale up energy retrofitting in the residential sector, public-private partnerships are good options to explore***

  Although energy prices will increase in the future and, consequently, energy savings will increase too, some measures will still not be self-financing. Combining municipal grants for building retrofitting with ESCo services for the building energy retrofitting has shown to help in reaching a more economically-feasible and scalable solution.

Smart Solution 2. Smart building logistics and alternative fuelled vehicles

Smart Solution 2 is handed by WP4 Sustainable Urban Mobility. See more information on the D4.3 Implementation report WP4 “Implementing Sustainable Urban Mobility in European cities – experiences from GrowSmarter”.

Smart Solution 3. Smart, energy saving tenants

Table 3: Overview of the challenges faced for the implementation of the Smart solutions on energy consumption visualization platforms

Technical challenges	Implementation challenges
- Required time for own platform development - Technology robustness and simplicity: available software/hardware providers - Communication of large amounts of data. Fragmented automatic data collection market - User friendly design - High data analytics requirements - High number of data sources and interfaces. Large variety of communication protocols	- Limited target customers group for Home Solutions (due to the use of advanced technologies) - User acceptance/engagement - Data quality, availability and reliability - Personnel's professional qualification
Regulatory challenges	**Business model challenges**
- Data privacy issues and IT security concerns	- Client segmentation - Value proposition - Self-financing solution? (who pays/gets revenues?) - Technology obsolescence

- ***Development of a platform involves long development periods***

  The implementation of energy consumption visualization platforms has proven that the development of a Smart Home solution takes time and energy, thus it must be considered that a long development phase is required before the product can be installed and in operation.

- ***Data communication presents some challenges***

  The communication of large amounts of data is a key technical challenge for the implementation of these systems. It is advisable to define all the details on data integration prior to implementation in order to avoid non-expected additional costs. Hardware is already in the market, but it must be considered that the market for automatic data collection is quite fragmented, with many companies trying to lock up the IoT platform to their specific products. In the same way, the "format" for connection is quite fragmented and under fast development, so an open IoT platform that can receive different kinds of signals is required.

- ***Deployment may depend on potential users' skills and interests***

  The target customers group for the Home Solutions may be limited, as it requires tenants with a minimum knowledge in technologies (smartphones, how to use an App, etc.). At the same time, it is possible that tenants have misgivings to participate because they do not see the advantages of HEMS. In this case, information campaigns to inform about both energy and money savings thanks to such a system are recommended. Gamification tools are very useful to make these measures succeed.

- ***Treatment and analysis of data should be defined from the beginning of the project***

  It is critical to define from the very beginning the data treatment process that will be required to analyse the collected data, in order to avoid data confidentiality issues. Confidentiality laws may prevent the deployment of this measure due to impossibility of transferring the data analysis task from one company to another, etc.

- ***Diversification of data platforms by the public sector has been observed***

  Development of data platforms by public authorities could be more coordinated to avoid non-necessary costs (use a single platform for all the collected data). Standards and open protocols may help to integrate different platforms.

Smart Solution 4. Local Renewable energy production and integration with buildings and grid *and* Smart solution 6. New business models for district heating and cooling

Table 4: Overview of the challenges faced for the implementation of the Smart solutions on local energy production and smart energy management systems

Technical challenges	Implementation challenges
- Equipment available on the market is not developed enough for an advanced control (development work together with manufacturers is required) - Standards to be followed	- Adaptation: find providers of Advanced Management systems for PV+storage systems - Upfront investment
Regulatory challenges	**Business model challenges**
- National regulation regarding electricity self-consumption - Work permits	- High costs of storage systems - Electrical market conditions - Business model vs. climate/region - Business model vs. ownership - DHC in Mediterranean climates in front of other heating&cooling technologies

- ***Peak shaving to be considered in smart electricity management systems***

  Smart Solution 4 demonstrates the smart management of local renewable energy generation by photovoltaic installations with electrical storage. Peak shaving is one of the main goals for the energy optimization in this measure, as it is considered that this is going to be a major topic in the near future due to the development of electrical grids.

- ***Implementation of local renewable electricity generation is directly dependent on national regulation***

  The deployment of this measure is directly dependent on the national regulation regarding electricity self-consumption and electricity markets in general. In order for this measure to be self-financing, the energy and power savings obtained from the building users may not be sufficient, thus the possibility of selling the excess power generated by the private installation to the grid may be needed.

- ***Deployment of DHC is climate-dependent***

  In Mediterranean climates like in Barcelona, DHC technology is not widely spread, thus it presents in many cases a costly option in front of other heating and cooling systems. A thorough economical pre-study should be done to justify the required investment for this solution.

- ***Replicability of advanced DHC solutions is dependent on the city's existing infrastructure***

  Stockholm presents a very different context for this measure, as the technology is consolidated in colder countries. In this case, a new business model is presented in order to keep promoting the use of district thermal networks and foster the recovery of local waste heat. However, this measure is replicable in cities where the infrastructure for DHC technology is widely spread.

3.2 Lessons per Lighthouse city

Stockholm

In general terms, the partners responsible for the implementation of Low energy districts measures in **Stockholm** have highlighted the importance of the following topics to be considered in replication:

- ***Regulation in building retrofitting: tenants' acceptance, building permits, etc.***

  Stockholmshem owns the 300 apartments being retrofitted in Valla Torg by the project management of Skanska. In such a large project with so many tenants, a very accurate plannification was required to achieve all tenants' acceptance and comfort during the retrofitting works, considering evacuation of the tenants is included in this implementation.

- ***Business model definition for building retrofitting: who captures the economical savings?***

  Before any energy retrofitting project starts, it must be well defined who will capture the economical savings of such a project. In Stockholm, many residential buildings are owned by housing associations and tenants live there, thus it is critical to determine who funds the investment and who will economically benefit from the retrofitting works. In the case of the energy retrofitting works in the Stockholmshem's buildings, the association pursues a good relationship with the tenants. Thanks to this implementation, the building owner achieves higher standard apartments while the tenants benefit from lower energy costs and better indoor comfort after refurbishment.

- ***Energy consumption visualization platforms and smart energy management systems: dependent on electrical market conditions***

  In order to determine the margin of benefit thanks to the use of electricity visualization platforms and smart EMS, the conditions of the national electricity market play a key role. Users capture the economic benefit if they are able to choose specific electricity tariffs that allow optimizing the electricity consumption according to the price of selling electricity and the cost of purchasing it. In Stockholm, L&T puts an emphasis on the use of the Energy Management System for solar PV and storage able to perform Peak shaving strategies besides optimizing the energy bill by managing the purchase and sale of electricity accordinf to the market conditions.

- ***Technology development for energy consumption visualization platforms: robustness, user-friendly design of interfaces, etc.***

  In order to implement the Active House solution, Fortum Värme has succeeded thanks to the involvement of an advanced development team for its creation, as it was always kept in mind that the development of a Smart Home solution takes time and energy.

Barcelona

The partners responsible for the implementation of Low energy districts measures in **Barcelona** have highlighted the importance of the following topics:

- ***Business model definition for building retrofitting: need for Public-Private partnerships for building retrofitting, commercial building owner/operator agreements***

  GNF succeeded in implementing energy retrofitting actions acting as an ESCo in 3 residential buildings by achieving a Public-Private partnership that allowed a favourable funding for the building owners despite the relatively low heating energy demand.

- ***Business model definition for energy consumption visualization platforms: which is the value proposition?***

  The two energy consumption visualization platforms deployed in Barcelona have shown different value propositions: the Municipality deployed the free Virtual Energy Advisor, which aims at implementing a new energy policy focused on citizen action to decrease the electricity consumption in the residential sector; and the utility GNF deployed a commercial HEMS, which will create awareness on energy efficiency among tenants besides being presented as a good opportunity for the utility to analyse the consumers' habits in energy consumption that allows offering them personal services.

- ***National regulation for the implementation of smart energy management systems and self-consumption (PV+battery systems)***

Considering the existing regulation in Spain at the time of implementation, a generation installation can only feed one consumer. Hence, in order to implement the measure in residential buildings, the system had to be installed at the common rooftop of residential blocks, involving that the satisfied end-uses can only be the common end-uses in the residential block (i.e. elevators and lighting).

Cologne

The partners responsible for the implementation of Low energy districts measures in **Cologne** have highlighted the importance of the following topics:

- ***Technical and implementation challenges during building retrofitting: building permits, management of subcontractors, unexpected problems when retrofitting existing buildings***

  A low interest phase in the construction sector has led to a retrofitting boom in the region of Cologne, with the consequent high utilization of construction companies and an increase of prices in the retrofitting sector. Therefore, it must be considered that it can sometimes be harder than expected to hire all the subcontractors and have all the permits on time. Potential delays should be regarded when planning the implementation. In Cologne, Dewog achieved all the building permits although some delays occurred.

- ***Regulation on data privacy, IT security and user acceptance in the implementation of smart meters and energy consumption visualization platforms***

  According to German legislation, it is not possible to install uncertified Smart meters, and tenant consent is required to install sub-metering. Therefore, communication campaigns with the tenants were done by RheinEnergie to inform about the advantages of the energy consumption visualization platforms and overcome their doubts to share their energy consumption data.

- ***Technology development and national regulation for the implementation of smart energy management systems (standards, permits, etc.)***

  Many of the technology manufacturers do not expect their devices to be part of such a complex energy management system. Intense discussions with them on how their devices can be externally controlled in a new way were needed to adjust the devices according to RheinEnergie‘s vision, and standards and communication protocols are critical to develop the technology.

4 CONCLUSIONS AND NEXT STEPS

The deployment of a variety of energy efficient measures aiming at lowering the environmental impact of the existing building stock has been implemented in the three cities within GrowSmarter Low Energy Districts Work Package.

Building energy efficient retrofitting implies a strong user acceptance, a complex technical design and implementation phases with many industrial partners, and a well-defined business model by type of building. Multiple tenants and ownership in residential buildings may be a decision-making barrier thus information campaigns may be very useful to motivate the neighbours/owners to be participatory. Energy retrofitting works require coordination of large number of technical and administrative partners. Business models are highly dependent of the building use and ownership: in some cases, combining energy retrofitting with larger structural refurbishment or building adaptation may improve project feasibility. Public-private partnerships and/or strong collaboration between public-private sectors are key success factors to scale up energy retrofitting in the residential sector. Finally, the differences in national regulation restrict the replication of measures in other countries thus it is advisable to deeply explore the regulation before putting a focus on a specific measure.

The deployment of HEMS is mainly driven by technology development, data management and privacy, and user acceptance. It is highly recommended to address data privacy issues at the project definition phase, being open and interoperable IoT platforms a very good option. In addition, this type of solution is driven by technology development, thus requires user acceptance and qualified resources to deploy it.

In order to deploy on-site electricity generation with solar power and smart electricity management systems, national regulation is the main key barrier for the deployment and upscale of this measure, thus a favourable legislation is crucial to define a feasible business model.

Finally, the connection of buildings to district energy networks for heating and cooling is strongly dependent on the existing infrastructure of the city, which in turn may be coupled to the local climate. In cities where this technology is not widely spread, a thorough economical pre-study should be done to justify the required investment for this solution.

At this stage, the work continues within the GrowSmarter project with the technical and economical evaluation of all measures described in the previous chapters. The result of this evaluation phase will definitely provide more lessons learned from the project to complement the knowledge acquired up to now during the implementation phase of the Smart solutions.

5 SOURCES / REFERENCES

List of key GrowSmarter project documents		
Name of document	**Link**	**Finalised**
Fact sheets	http://www.grow-smarter.eu/solutions/	2016-2017
Technical and management reports, D1.3, D1.4, D1.5, D1.6	http://www.grow-smarter.eu/inform/reports/	Feb 2016, June 2017, Dec 2018, Dec 2019
Lighthouse cities market introduction, D6.2 Economic validation and assessments, D6.3 Smart city market introduction, D6.4	http://www.grow-smarter.eu/inform/reports/	Feb 2018 Jan 2019 Sep 2019
Reports on results of technical, economic and social validation, D5.3, D5.4	http://www.grow-smarter.eu/inform/reports/	Dec 2018 Aug 2019
Data management plan, D1.2	http://www.grow-smarter.eu/inform/reports/	First version 2015
Concluding reports, D2.4, D3.4, D4.4, D2.6, D3.6, D4.6	http://www.grow-smarter.eu/inform/reports/	Feb 2019 Oct 2019
Recommendations for policy makers and practitioners, D1.7	http://www.grow-smarter.eu/inform/reports/	Nov 2019
Project brochure, D8.3 Project result Brochure, D8.10	http://www.grow-smarter.eu/inform/press-corner/	Update 2017, Nov 2019

GrowSmarter
Transforming cities for a smart, sustainable Europe

About GrowSmarter

GrowSmarter (www.grow-smarter.eu) brings together cities and industry to integrate, demonstrate and stimulate the uptake of '12 smart city solutions' in energy, infrastructure and transport, to provide other European cities with insights and create a ready market to support the transition to a smart, sustainable Europe.

GrowSmarter project partners

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