GrowSmarter

Transforming cities for a smart, sustainable Europe

TECHNICAL FACTSHEETS

LOW ENERGY DISTRICTS

1. Smart building shell refurbishment
2. Smart building logistics
3. Smart energy-saving tenants
4. Smart local electricity management

• STOCKHOLM • COLOGNE • BARCELONA •

SMART SOLUTIONS 1: LOW ENERGY DISTRICTS

Developing low energy districts is the first of 3 action areas on which the GrowSmarter project has focused.

The main challenge in 'Sustainable Districts and Built Environment' is to reduce energy use, environmental impact and carbon footprint. Currently our existing building stock plays a major role in energy consumption (40% of EU final energy demand). This stresses the need for affordable and sustainable retrofit solutions at a large scale. The starting point of the actions is the building itself and the focus on cleverly combining and fine-tuning solutions on the market for existing as well as new buildings and districts.

1. Energy efficient refurbishment of residential buildings
2. Climate shell refurbishment
3. Energy quality assurance
4. Re-build an industrial site: Ca l'Alier
5. Efficient and smart climate shell and equipment refurbishment
6. Efficient and smart climate shell refurbishment of residential buildings
7. Efficient and smart climate shell and equipment refurbishment of tertiary buildings
8. Energy efficient swimming pools
9. Construction consolidation centre
10. Home Energy Management
11. The Active House
12. An Open Home Net
13. Energy Saving Centre
14. Home Energy Management System (HEMS)
15. Virtual Energy Advisor
16. Dynamic Pricing Models
17. Residential Estate Management
18. Smart Energy & Self-Sufficient Block
19. Building Energy Management System (BEMS) to minimise consumption of fossil fuels and electricity
20. Building Energy Management System (BEMS) - Resource Advisor

To find out more about the other solutions area please visit:
www.grow-smarter.eu/solutions

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FACTSHEET

Energy efficient refurbishment of residential building in Stockholm

PART OF SMART SOLUTION 1: EFFICIENT AND SMART CLIMATE SHELL REFURBISHMENT

Photo: Refurbishment, Valla Torg, Stockholm

LOW ENERGY DISTRICT

- Decreased energy consumption by 60%
- Lower energy costs and reduced CO_2 emissions
- New installations creating a more balanced extends the lifespan of the buildings.

Stockholm

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 646456. The sole responsibility for the content of this document lies with the author and in no way reflects the views of the European Union.

What is the solution?

This project concerns four fourteen-floor buildings and two four-floor buildings built in 1961. These buildings together host 324 apartments. Just like most old buildings there are problems with thermal bridges and the fact that the climate shell is not airtight. This in combination with today's standard of desirable indoor temperature leads to high energy consumption, since the warm air leaks out and cold air finds its way in. A lot of heat and energy is lost in the existing system of installations in our buildings, due to long distances of poorly insulated pipes for heating and water, as well as the absence of heat recovery.

Climate shell refurbishment of Valla Torg:

- Additional insulation by 80 mm to façade and 200 mm to basement walls.
- New type of construction for the roof with added insulation.
- New four glass windows with U-value 0,7 W/(m^{2}K).

New installations of Valla Torg:

- Separate heat exchanger in every building for district- /geothermal heating.
- Heat pumps recovering heat from the exhaust air and transmitting it to produce heat and hot water
- Wastewater heat exchange system to preheat fresh water.
- Installation of "pipe in pipe" system to reduce hot water circulation losses
- Water-saving tap water fixtures to reduce water consumption
- Electricity saving measures
  -Low energy lighting fixtures for common spaces
  -Modern and more effective elevators
- Renewable energy: PV cells to produce electricity

How does it work?

In this retrofitting, external insulation is added to the whole building envelope in an ambitious manner and new windows and balcony doors will be installed with the best possible U-values for the project. This way there is control over incoming air.
Once finished, the only air intake will be under the windows right behind the radiators to warm the air up before it continues into the apartment. The air exits by exhaust ventilation and the heat is recovered by a heat pump on the roof.

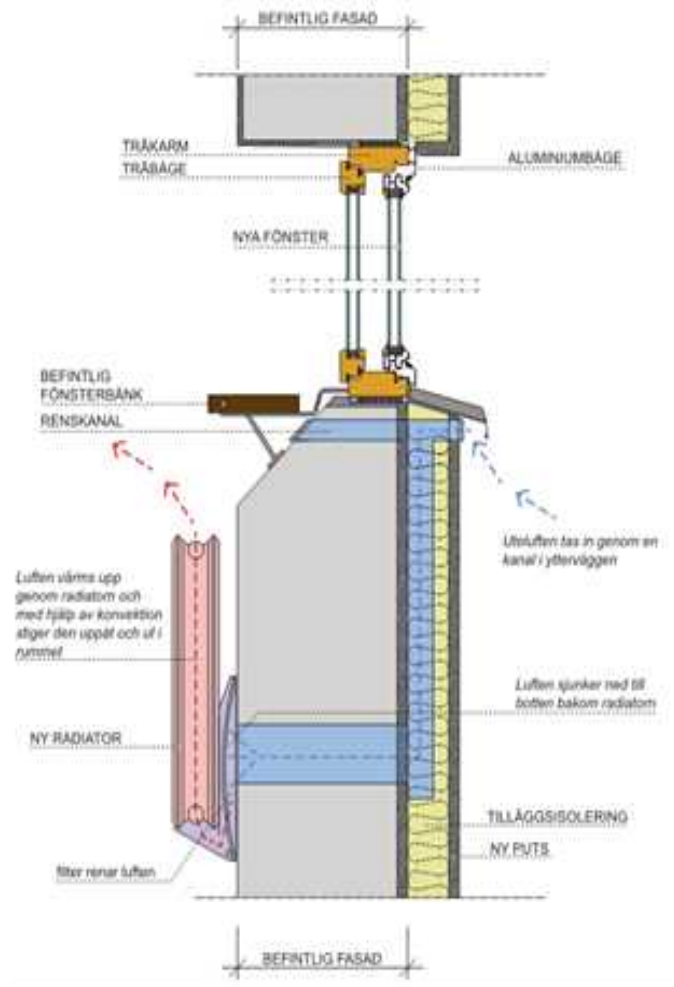

Fig 2: Ventilation diagram

The plumbing system will undergo significant improvement, and all new pipes are properly insulated and a system for wastewater heat exchange installed. Instead of installing a traditional system with a circulation pipe parallel to the water pipe, the project will use a solution where the two are installed one inside the other, to minimize the surface where heat may escape and keep the water temperature high.

Fig 3: "Pipe in pipe" system

New substations and heat exchangers for district-/geothermal heating will be installed in every building. This way decreasing prior culvert losses is possible and users will have enhanced control of heating, hot water and ventilation heat recovery in each building.

The new modern elevators are more effective and lighting fixtures in common spaces will be replaced with more efficient ones with motion control. In addition to this, PV-cells will be installed on the roof to provide renewable local energy for the building.
These smart installations combined will make the building require less energy and the consumed energy will be recovered in the best way possible.

Expected Impacts

- Providing a good example for energy renovation of apartment buildings
- Reducing environmental impact
- Promoting sustainable economic development

Replication potential

This model of energy renovation can be replicated as a total or by selected parts.

The project sets a good example for different locations since it includes systems for district heating for five of the buildings, but also a system for geothermal heating for one of them. These systems can also be used for cooling, so which one to use for a follower depends on what the preconditions are on their particular site.

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FACTSHEET

LOW ENERGY DISTRICT

Climate shell refurbishment

PART OF SMART SOLUTION 1: EFFICIENT AND SMART CLIMATE SHELL REFURBISHMENT

Example after refurbishing

- More efficient energy use thanks to networked devices and installations and the possibility to create automatic workflows
- Up to 60 % less greenhouse gas emissions and reduction in primary energy by up to 70%
- Reduction in costs for heating and warm water thanks to usage of photovoltaic electricity for the heat pumps

Cologne

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What is the solution?

DEWOG will insulate the building's facade, basement ceiling and roof as well as installing triple glazed windows in some buildings. In the third construction stage, new insulation technology will be trialled.

DEWOG will install modern heat-pumps in all buildings in combination with district heating delivered by RheinEnergie. High efficiency circulation pumps will be used for the heating system. Lifts with energy recovery will help create large savings through the use of new energy efficient technologies. The current staircase lighting will be replaced with LED lamps. All these measures combined will help to reduce energy usage and therefore save emissions.

In order to achieve the goal of an efficient and smart climate shell refurbishment, RheinEnergie will install a self-regulating decentralised energy management system for each building (PV, heat-pumps, district heating and storage).

How does it work?

The insulation allows the heat to stay in the apartments better. That means that tenants do not need to use so much heating. In addition, the efficient LED staircase lighting will reduce electricity consumption in communal spaces.

The decentralised management system (Siedlungsmanagement) is going to be placed in every building to monitor the electricity and heat production. It is connected with the "virtual power plant" from RheinEnergie on the automation level.


2: Example before refurbishment

The data for the management systems comes from the building devices (through the PLC, or programmable logic controller) which are connected.

The PLC collects a lot of data, for example the switching on/off of the heating pumps, the water pressure or the flow and return temperature. With the data the PLC can coordinate and execute complex processes. It acts as a basic control, which is subordinated to the Siedlungsmanagement software.

This system ensures that the plants (for example heat pumps) continue to work independently in the event of a communication breakdown with the virtual power plant.

Expected impact

Positive impacts of this solution include:

- Reduced green gas emission
- Reduced primary energy consumption
- Reduced heating costs
- Reduced public electricity consumption

Potential for replication

If efficient and smart climate shell refurbishment achieves its expected results, it has good replication potential. The refurbishment must anyway be done because of the climate objectives which must be fulfill until 2025.


1: Example during refurbishment

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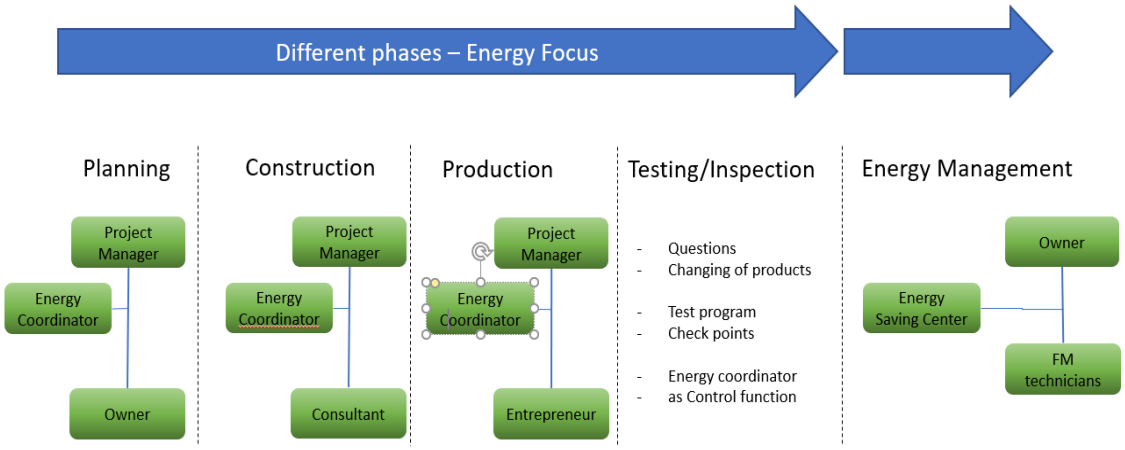
FACTSHEET

Energy Quality Assurance



PART OF SMART SOLUTION 1: EFFICIENT AND SMART CLIMATE SHELL REFURBISHMENT

LOW ENERGY DISTRICT

- Focus on energy savings throughout the building process
- Avoids delay in the building process by appointing an Energy Coordinator
- Avoids energy use increases due to staff changes within the project

Stockholm

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What is the solution?

By nominating an exclusive Energy Coordinator to follow the project in the construction/refurbishment phase, gaps related to staff transitions are avoided. Information is normaly not transferred between the phases. Based on earlier experiences, errors during planning and construction have been shown to lead to 10-20 % extra energy consumption.

How does it work?

The role serves as an advisory role to the Project Manager but is not responsible for decision making. The Energy Coordinator ensures that the right techniques are chosen and put forward in the projection phase. The Energy Coordinator also ensures that the techniques are used optimally once the building process is concluded.

Integration with other smart solutions

L&T is following the building process from the initial planning through the implementation phase, focusing on energy savings. The Energy Coordinator ensures that installed products are individually tested in order to ensure that they are operating efficiently.

By implementing this process alongside the Energy Saving Center, it is possible to ensure that the calculated energy use matches actual use both at the end of the project and during the coming years.

Expected impact

This solution has a positive impact to the city in terms of the key GrowSmarter objectives e.g.:

- No delay in the building process
- Avoids a projected 10-20 % energy consumption increase which would normally be expected due to errors during planning and construction
- Promotes sustainable economic development with less energy used

Potential for replication

Replication can be easily done by several operators and can be used in new production as well as in the refurbishment of all types of facilities.

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FACTSHEET

Re-build of an industrial site: Ca l'Alier

Part of smart solution 1: efficient and smart climate shell refurbishment

Fig. 1. Transformation of the industrial site into a centre of innovation and excellence on smart cities

LOW ENERGY DISTRICT

- Innovative public-private partnership to promote the concept of net zero energy buildings (NZEB) and serve as a reference for building refurbishment I industrial areas of the city.
- Development of the Nearly Net Zero Energy Building concept leads to 70% primary energy self-sufficiency.
- Natural lighting through heliostats and tubular skylights.

Barcelona

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What is the solution?

Ca l'Alier will demonstrate the feasibility of a Zero Net Site Energy Use through photovoltaics (85 kWp), connection to district heating and cooling network, and through the installation of an energy management system capable of optimising consumption and forecasting the future building energy consumption. It will also demonstrate the compatibility of open communication protocols with Heating, Ventilating and Air Conditioning (HVAC) equipment.

Ca l'Alier integrates the features of a low energy district (e.g. low energy demand in buildings and high energy self-sufficiency thanks to integration of renewable energy resources) with advanced infrastructures related to Information and Communication Technologies and advanced control of facilities. Information management will help saving energy and reducing carbon emissions by showcasing the development and replication of smart cities' solutions for low energy districts.

The active technologies implemented in Ca l'Alier are:

- Lighting: LEDs and occupancy sensors
- HVAC: variable speed fans, free-cooling
- On-site generation: photovoltaic panels
- Connection to local district heating and cooling (DHC) network
- Smart Energy Management System

Business Model Used

Barcelona is using a public-private partnership model with technological multinational companies in order to rejuvenate and area and demonstrate its potential as a research and development platform for new market opportunities in the domain of smart cities.

Integration with other smart solutions

This solution will be integrated with measure 6.3 "Smart local thermal districts" which will enable Ca l'Alier to connect to the District Heating and Cooling (DHC) network of "Districlima" utility.

The local utility Districlima has a DHC network in Barcelona with a total cooling capacity of 31 MW and heating capacity of 20 MW. The vast majority of heat and cold production is based on the use of the steam produced from the incineration of municipal solid waste (MSW) of the city in a nearby treatment plant.

Ca l'Alier will also be integrated with measure 4.2 "Resource Advisor", which will develope a platform to visualise the monitored energy data of some of the measures applied to buildings retrofitted in the scope of GrowSmarter.

The monitoring system of Ca l'Alier will communicate with Resource Advisor platform thus the energy performance of the retrofitted building will be easily

visualized. Additionally, Ca l'Alier will be integrated with measure 8.1 "Big consolidated open data platform" and measure 8.2 "Urban models", where an open data platform and a semantic urban model will be created, respectively.

Expected Impact

56% of annual savings on final energy are expected compared to a standard national reference building. The 22@ district will be regenerated into a knowledge and innovation area, creating a stimulating atmosphere for R&D units for high tech companies.

Potential for replication

This measure could be replicated in other abandoned urban industrial sites, which could be re-built or refurbished into useful spaces for citizens or devoted to R&D activities. Potential stakeholders involved go from tech companies and public administrations to citizens and neighbourhood associations committed to district regeneration. Whether or not a city chooses to participate in a public-private partnership depends on their approach to funding and finance.

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FACTSHEET

Efficient and Smart Climate Shell and Equipment Refurbishment

PART OF SMART SOLUTION 1: EFFICIENT AND SMART CLIMATE SHELL REFURBISHMENT

Fig. 1. Aerial view of the building with 207 dwellings. Source: PMHB

LOW ENERGY DISTRICT

- External insulation of the façade, substitution and upgrade of blinds, monitoring of heating, consumption and solar thermal energy generation
- Increased comfort, reduction in noise pollution and humidity
- Involvement of residents through a community wide association for the decision-making process before, during and after the works

Barcelona

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What is the solution?

Passive measures including external insulation in all façades and substitution and upgrade of blinds in all windows. Both wool and expanded polystyrene insulation will be employed, the former on ventilated façades and the latter on the rest of façades. Insulation design in each façade has been optimised in order to protect indoor spaces from weather conditions depending on the orientation and irradiation received.

Business Model Used

The Housing Agency of Barcelona (Patronat Municipal de l'Habitatge de Barcelona, PMHB) was set up back in 1927 to provide affordable housing for citizens with limited incomes. Its mission is to refurbish existing housing while fostering sustainable urban development. The residential building in Passeig Santa Coloma 55-57 is one of the buildings whose energy refurbishment is financially supported by the Agency. Monthly rental for the tenants will remain the same but the building's value will be significantly increased thanks to architectural renovation and energy refurbishment.

Integration with other smart solutions

The refurbishment of this building will be linked to measure 4.2, in which a platform to visualise the monitored energy data is being developed, and to measures 8.1 and 8.2, which cover the creation of an open data platform and semantic urban model.

Expected Impact

The refurbishment of the building in Passeig Santa Coloma will have a significant impact on the heating demand of dwellings. The insulation technique is expected to lead to a reduction of the final heating energy demand of the dwellings by approximately 43% on an annual basis due to the better air tightness.

The fuel for space heating in this residential building is natural gas, thus any reduction in space heating demand will directly lead to a reduction in greenhouse gas emissions. Calculations predict approximately 84.3 tonnes CO2 savings every year.

The intervention will improve the thermal comfort of end-users by repairing thermal bridges (i.e. areas of the building's façade which have a significantly higher heat transfer than the surrounding materials) with the exterior, which will result in an overall improvement in thermal insulation of the building.

These benefits will be assessed by means of thermal imaging before and after the refurbishment. Thermal imaging allows the evaluation of the current condition of existing building skins through infrared thermography, a technique that shows the changes in temperature of the different elements of the façade over a period of time, thus enabling sources of energy inefficiencies to be easily identified.

The Housing Agency of Barcelona has also implemented a monitoring system for the existing 13 Domestic Hot Water installations fed by a solar thermal system on the rooftop of the building. This measure lowers the consumption of natural gas for Domestic Hot Water heating in the building.

Finally, continuous communication with residents regarding the progress of the energy refurbishments will help increase their awareness of energy issues.

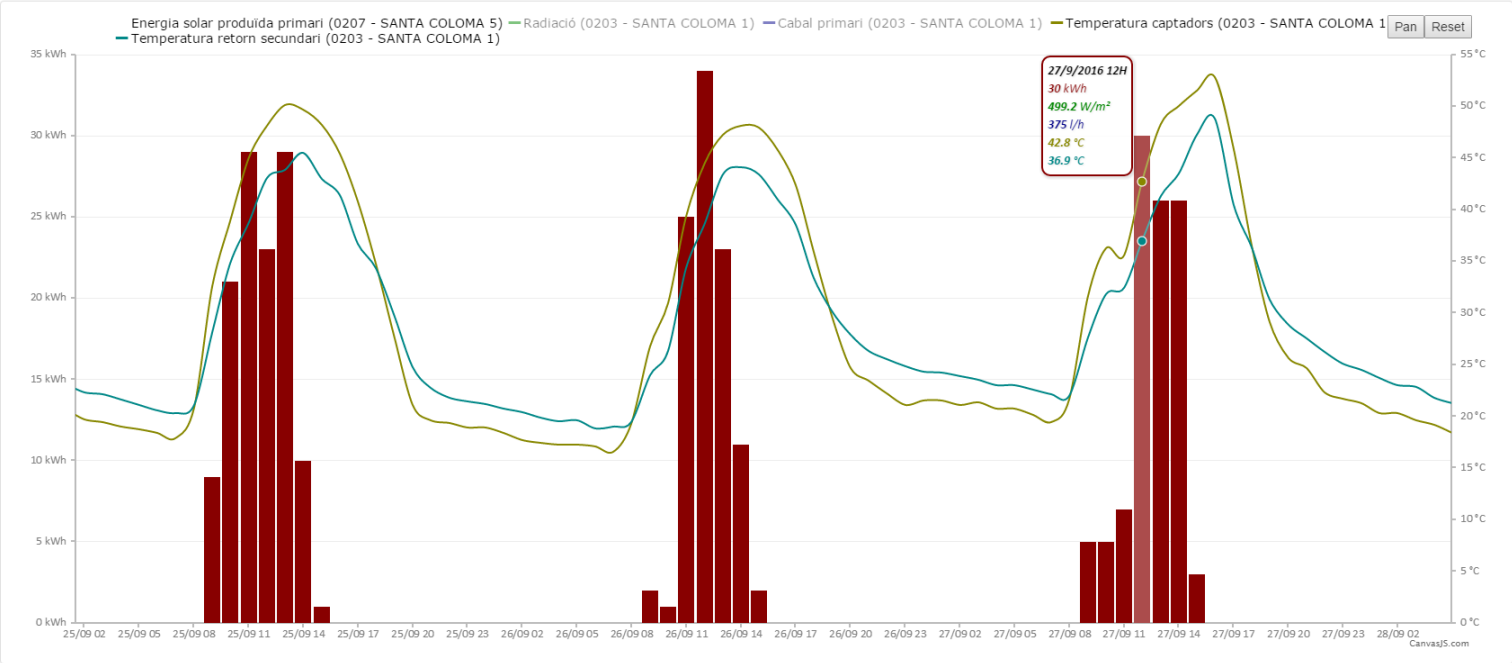

Figure 3: Data visualisation platform of the monitoring of solar thermal installations.

Potential for replication

Passive measures are strongly dependant on city climate and architectural aspects. The type of wall insulation technique is dependent on the prevailing climate in the city, thus this measure may be replicated in cities with similar climate. However, in general terms the Housing Agency's engagement with social housing tenants regarding energy aspects and refurbishment processes could easily be replicated elsewhere.

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FACTSHEET

LOW ENERGY DISTRICT

Efficient and smart climate shell refurbishment of residential buildings

PART OF SMART SOLUTION 1: EFFICIENT AND SMART CLIMATE SHELL REFURBISHMENT

Fig. 1: Image: www.idae.es

- Passive energy refurbishment is essential for improving comfort and reducing energy consumption in dwellings in the Mediterranean climate
- District heating can be applied to residential buildings to reduce gas consumption reduce greenhouse gas emissions, and improve air quality
- Efficient and smart climate shell and equipment refurbishment of residential buildings can reduce energy consumption up to 50%
- New business models of public-private partnership can incentivise energy refurbishment in the residential sector

Barcelona

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What is the solution?

This solution includes passive and active energy refurbishment of almost 10.500 m2 of residential buildings in Barcelona. The most representative constructive typologies of the city have been chosen, in order to promote replicability at scale.

Passive measures aim to solve typical problems of the Mediterranean climate such as thermal discomfort due to cold bridges and lack of insulation.

Active measures aim to reduce consumption and emissions, by using more efficient systems and/or renewable energy. It has been estimated that, thanks to this solution, energy consumption of the refurbished buildings will be reduced by almost 400 MWh/year.

Passive measures:

- Façade insulation, roof insulation
- Change of windows and removal of cold bridge between window and façade
- Blinds installation

Active measures:

- Change of boilers
- Connection to district heating
- Efficient water taps
- HEMS (Home Energy Management System) installation

How does it work?

Passive measures in residential buildings:

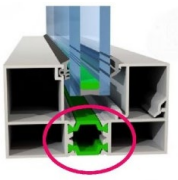
Façade insulation, roof insulation

External Thermal Insulation Composite Systems (ETICS) are incorporated into the façades, as part of the building's structural rehabilitation. For roof insulation, the use of external or internal solution depends on the construction solution chosen.

External thermal insulation helps reduce heating demand and to improve the internal comfort in winter. In summer, eternal insulation reduces heating of the façade caused by solar irradiation and prevents heat dispersion from inside to the exterior. In summer it is important to use natural ventilation and avoid direct sunlight, using solar protection systems. Furthermore, external insulation reduces cold bridges more easily than internal insulation.

Window replacement

(Image: Qualumsign)



In the buildings where windows have been replaced, the principal requirements were:

- Double glazing, transmittance U < 2W/m2K, solar factor g < 0,6, to improve thermal insulation and reduce solar transmission
- Thermal break, to solve the cold bridge
- Air permeability class 3 (UNE EN 12207), to reduce infiltration

Special requirements for wind resistance and water resistance have been included for windows in high buildings.

Cold bridge between window and façade

The cold bridge generated by the installation of the ETICS insulation system in the façade and the windows has been studied. The image on the right shows that it is possible to reduce thermal dispersions by insulating the window jamb, in comparison to the left figure, where there is no insulation.

Installation of blinds

Blinds have been installed to:

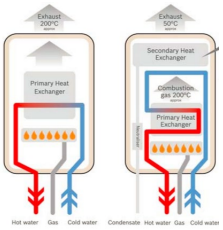
- Control direct solar transmission inside the dwelling, reducing cooling demand.

- Reduce thermal discomfort at night during the winter, providing additional protection to the window glass.

Adjustable roller blinds provide further benefits: changing the orientation of the slats can better control the transmitted solar radiation, ensuring that natural ventilation cools the dwelling effectively.

Active measures in residential buildings:

Change of boilers



(Image: Bosch): Conventional system (left) versus Condensing system (right)

Replacing existing boilers with condensing boilers reduces gas consumption and CO2 emissions due to the more efficient system. A condensing boiler achieves an average performance score of '1' (nominal performance 1.09) compared to an average 0.85 performance score for a conventional boiler.

Connection to district heating

Centralisation of the building's heating system combined with a connection to the district heating Districlima significantly reduces gas consumption by using (in this case) waste heat recovery from the incineration process.

This solution is one of the innovative concepts of smart cities of the future.

Efficient water taps

The use of shower flow regulators and aerators in bathroom and kitchen taps reduces gas consumption and energy emissions through reduced water consumption. It is estimated that this solution saves up to 50% of water compared to standard consumption.

HEMS (Home Energy Management System) installation

The installation of a HEMS helps to monitor and control energy (gas and electric) consumption. The possibility for each client to receive personalised advice and optimised services using monitors and mobile Apps helps to raise awareness about reducing consumption.

The components for gas and electric monitoring and control are:

- Smart home automation centre
- Smart thermostat
- Smart Plug (control of consumption and on/off).
- Energy monitor
- Sensors and actuators for monitoring gas consumption through low-range RF technologies.

The buildings chosen for this solution will be monitored before and after the refurbishment, until the end of the project.

The objective is to evaluate the energy savings caused by the refurbishment and to help the owners to know how their behaviour affects consumption.

Business Model Used

As there is low energy demand for heating and cooling in Barcelona's residential sector because of the local climate, energy refurbishment itself is not feasible. Furthermore, buildings often have no heating system, so that energy refurbishment can only be justified from the point of view of thermal comfort and not by energy savings.

The strategy to retrofit residential buildings that will undergo structural works aims to

reduce the investment cost of passive energy refurbishment, by sharing the expenses for the works that are required in both cases (for example the use of scaffolding). In Spain, the obligation to periodically submit buildings to preventive maintenance, after carrying out the Technical Inspection of Buildings (ITE), shows that existing buildings have a need for structural rehabilitation. In these cases there is the opportunity to combine them with energy actions.

The cost of energy refurbishment nonetheless remains high for the owners. The solutions carried out by Gas Natural in residential buildings is a business model of public-private collaboration, where the investment is paid part by grants from the council and European funds, and part by Gas Natural, acting as an energy services company (ESCO).

In the ESCO model the end customer will have a single interlocutor, which manages and coordinates all the agents needed to execute the energy rehabilitation. The ESCO guarantees the energy savings and assumes the maintenance costs and the owners of the building pay the investment in monthly instalments during the ESCO contract.

Expected Impact

Improving quality of life:

- Improved comfort of building typologies with a high level of occupancy: hotels, education and wellness centres.
- Better awareness and possibility by the tenants themselves to control consumptions

Reducing environmental impact

- Reduction of energy consumption by 30-70% depending on the building typology
- Reduction of CO2 emissions thanks to the reduction of consumptions and to the use of renewable energy and waste heat recovery
- Better quality of external air

Promoting sustainable economic development:

- Increase of the market value of buildings thus increased market visibility and customer attraction
- Creation of buildings controlling costs and emissions thanks to the energy management system.

Potential for replication

Pre-conditions for replication in other European cities:

- Existence of a building stock in need of refurbishment with high thermal and electric consumption.
- Existence of regulations requiring energy efficiency improvements in case of refurbishment.

Organisational resources and knowledge required within the public administration:

- Public administration should be aware of the high potential of consumption and emission reduction of these different solutions. Administrations should propose ways of promoting the amortization of rehabilitations through grants or tax incentives. In particular, it should update grants and incentives to the newest technologies and latest distribution processes and energy management.
- Public administration need to be aware of the conditions needed for a public-private collaboration within an ESCO business model

Stakeholders to involve:

- Owners and hotel industry brands, sports facilities, public and private educational sector
- ESCO companies
- Public administration
- Architects, Engineers
- Manufacturers and distributors of products for the generation, distribution, management and control of thermal and electric energy
- Tenants of the building

Potential barriers:

- Convincing owners to invest in actions with higher payback than the ones they use to accept for investing.
- Convincing owners of the importance of integral passive and active refurbishment

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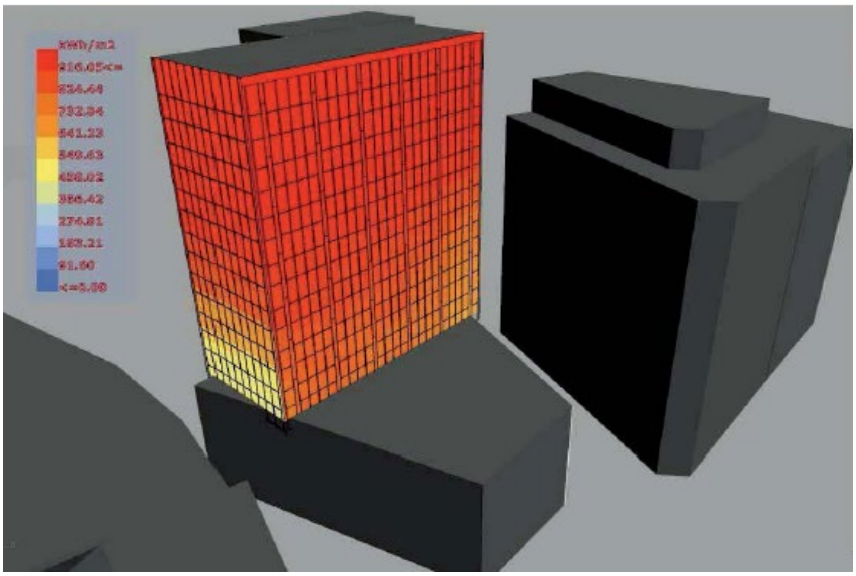
FACTSHEET

LOW ENERGY DISTRICT

Efficient and smart climate shell and equipment refurbishment of tertiary buildings

PART OF SMART SOLUTION 1: EFFICIENT AND SMART CLIMATE SHELL REFURBISHMENT



- Energy management systems can reduce the energy consumption of the buildings by around 10%
- Efficient and smart climate shell and equipment refurbishment of tertiary buildings can reduce energy consumption by 60%
- Efficient and smart climate shell and equipment refurbishment of tertiary buildings increase public awareness of energy saving actions. and verification of

Barcelona

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What is the solution?

This solution includes passive and active energy refurbishment of almost 12.500 m2 of tertiary building types including a hotel, a sports centre and an education centre. It is estimated that this solution will reduce combined energy consumption of the refurbished buildings by almost 2GWh/year.

Due to differences in the occupancy and use profiles between each building, each of these three typologies of building will need an individual solution for refurbishment. Although these measures have been proposed following specific energy audits, they have a high potentiality of replication in similar buildings needing refurbishment.

Hotel	Sport centre	Education centre
• Need for high standard of thermal comfort in the rooms (heating and cooling) • Requirement for individual temperature settings for each room. • Continuous consumption (lighting and air conditioning) for common areas	• Strict requirements for indoor air quality • strict requirements for quality and temperature of water in swimming pool • High internal gains due to occupancy • High consumption of water • High energy consumption for lighting	• Strict requirements for indoor air quality in classrooms • High internal gains in classrooms due to occupancy and computers • Need to quickly satisfy the heating/cooling demand during peaks of occupancy • High energy consumption for lighting • Different needs for each classroom depending on occupancy and exposure to external environment
Passive measures		
• Façade and roof insulation • Change of windows	In swimming pool area: • Pool insulation • Roof insulation • Insulation between dressing rooms and swimming pool (thermal zoning)	• Façade and roof insulation • Change of windows
Active measures		
• Replacement of existing boiler • Replacement of existing chiller high efficiency with heat recovery) and optimisation of chiller operation • Optimisation of water distribution loop usingtwo-way valves and frequency inverters) • BEMS (Building Energy Management System) installation (optimisation of the working calendar and improvement of the air-conditioning control system)	• New dehumidifier with heat recovery • Optimisation of the water distribution loop by applying two-way valves, frequency inverters and variable speed pumps) • Change of chiller, with a high efficient heat pump with heat recovery for heating and cooling. • Replacement of existing lighting with LEDs • Implementation of BEMS (Building Energy Management System)	• Installation of a high efficiency ventilation system, with heat recovery and free cooling • Installation of LED lighting in areas which do not yet have LEDs. • Building Energy Management System
Renewable energy contribution		
• Aerothermal heat pumps for the cooling process with performance higher than 2.5 (European Directive 2014/11/UE)	• Aerothermal heat pumps for the cooling process with performance higher than 2.5 (European Directive 2014/11/UE)	• Photovoltaic panels integrated into the façade

How does it work?

Implemented passive measures in tertiary buildings:

Façade insulation, roof insulation (Hotel, sports centre, education centre)

External Thermal Insulation Composite Systems (ETICS) reduce heating demand and improve internal comfort in winter.

In summer, external insulation reduces the heating of the façade due to solar irradiation while preventing heat dispersion from inside to the exterior. In summer it is important to use natural ventilation and to avoid direct sunlight using solar protection systems.

External insulation reduces cold bridges in comparison to internal insulation.

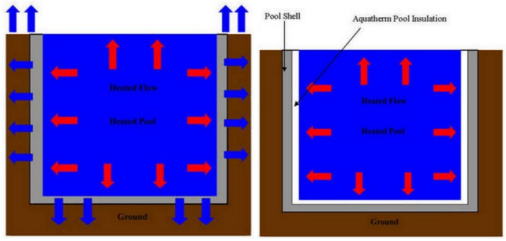
Change of windows (Hotel, education centre)

Changing the windows achieves multiple objectives:

- Improves thermal insulation (lower U than the existing windows) and reduces solar transmission to the inside, otherwise defined as the 'lower solar factor' – g, the percentage of heat that passes through the glass.
- Overcomes the cold bridge of the window itself by installing a window with a thermal break
- Reduces infiltration, thanks to a high quality installation and higher air permeability class (UNE EN 12207)
- Improves acoustic comfort

Insulation of pool (Sports centre)

The thermal insulation of the walls and ground surrounding the swimming pool helps to reduce the heating demand for the pool water because it reduces thermal losses through the structure.



Swimming pool with and without insulation

Thermal zoning between spaces with different design temperatures *(Sports centre)*

It is possible to further reduce energy consumption for heating and cooling by isolating the common walls between spaces with different design temperatures. In this way, each thermal zone will be managed individually and better control of consumption will be possible.

Implemented active measures in tertiary buildings:

Replacement of existing boiler *(Hotel)*

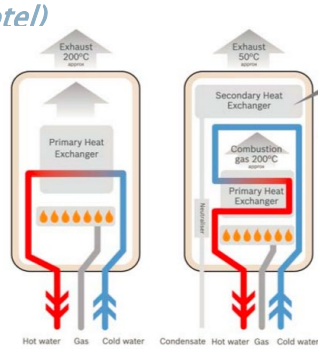


Image: Bosch – Conventional system (left) versus Condensing system (right)

The replacement of existing boilers with condensing boilers reduces gas consumption and CO2 emissions thanks to a more efficient system.

A medium performance of 1 is considered for the use of condensing boiler (nominal

performance 1.09), in comparison to a medium performance of 0.85 for the use of conventional boiler.

Replacement of existing chiller with high efficiency heating pump *(Hotel, sports centre)*

In the case of chillers with heat recovery, an evaluation of the recovered heat in comparison to the heating demand is required during months with simultaneous cooling and heating demand. This is important because heat recovery reduces the performance of cooling generation, and most of the recovered heat needs to be used to compensate for this loss.

It is also important to evaluate the performance of partial loads and to analyse the difference in performances when installing one or more chillers.

The chillers proposed within this solution have a seasonal energy efficiency ratio of 3.8-4.3.

Optimisation of the chiller operation by monitoring its performance allows further reduction of electricity consumption by improving the management of the on/off profile and adapting the load profile.

Optimisation of water distribution loop *(Sports centre)*

The installation of two way valves in a circuit with a lot of distribution points reduces energy losses caused by circulation of water in zones where there is no energy demand.

This leads to reduced electricity consumption by the pumps, helping to avoid thermal losses.The installation of frequency inverters will allow the group of pumps to work at variable flowrates.

Installation of dehumidifier with heat recovery in the swimming pool *(Sports centre)*

This solution allows the recovery of latent energy from the dehumidification process. It is a very efficient solution, because in a heated pool, water vapour is constantly created by the water evaporating into the air from the pool surface. The electricity consumption of this solution is optimised thanks to the use of variable speed fans to vary the recirculation airflow

Replacement of existing lighting with LEDs *(Sports centre, education centre)*

LED technology improves the efficiency of lighting systems as less power is required to meet the same lighting requirements compared to other existing technologies.

This solution is also an improvement in terms of its life cycle costs, as it has a longer life expectancy than other comparable technologies leading to lower maintenance costs. Replacements are rarer, leading to lower production-related energy consumption.

BEMS (Building Energy Management System) installation *(Sports centre, education centre, hotel)*

The Building Energy Management System (BEMS) is based on price and origin of the energy. It has been estimated that it reduces energy consumption by approximately 10%.

Functions:

- Monitoring of energy consumptions (electricity, gas, water..) and possibility to export monitoring reports to Excel
- Clear display of consumption for each system and zone
- Help controlling consumption and to take decisions for the optimisation of

the working calendar of different systems, in order to improve both the control system and thermal comfort.

Implemented renewable energy solutions:

Aerothermal heat pumps (cooling) *(Hotel, sports centre)*

This measure corresponds to the active measure "Replacement of existing chiller with heating pump of high efficiency with heat recovery".

European Directive 2014/11/UE certifies aerothermal energy from heat pumps as renewable energy if their performance is higher than 2.5.

Photovoltaics integrated into building façade *(Education centre)*

This solution has been proposed after analysing a building's orientation and shadows. It provides added value to the project as the roof of many buildings serves other purposes (HVAC equipment, services for building users, etc) and is therefore not able to host photovoltaic panels. This change will serve to test a new solution with higher replication potential.

Business Model Used

The business model used is an ESCO model, where Gas Natural Fenosa acts as an energy services company. In this model the end customer will have a single interlocutor, which manages and coordinates all the agents needed to execute the energy rehabilitation.

The savings guaranteed by the energy refurbishment will pay the investment of the energy services for the works during a contractual relationship accorded with the energy services company.

The ESCO guarantees the energy savings and assumes the operation and maintenance costs during the contractual period. At the end of the contract, the energy savings will be a direct benefit for the customer.

Integration with other smart solutions

In some cases, this solution is integrated with the smart solution "Smart Energy and Self-sufficient block", where the following services are offered to tertiary buildings and to residential blocks:

- Replacement of existing lighting with LED technology
- Installation of a photovoltaic system with energy storage
- Installation of Building Energy Management System

Expected Impact

A positive impact is expected in terms of the following key GrowSmarter objectives:

Improving quality of life:

- Improved comfort of building typologies with a high level of occupancy, for holidays (hotel), learning (education centre) and wellness (sporting centre).
- Better awareness and possibility by the tenants themselves to control consumptions

Reducing environmental impact

- Reduction of energy consumption by 30-70% depending on building typology
- Reduction of CO2 emissions thanks to the reduction of consumptions and to the use of renewable energy and waste heat recovery
- Better quality of external air

Promoting sustainable economic development:

- Increase in market value of buildings and consequently increased market visibility and customer attraction
- Creation of buildings controlling costs and emissions thanks to the energy management system..

Potential for replication

Pre-conditions for replication in other European cities:

- Existence of a building stock in need of refurbishment with high thermal and electric consumption.
- Existence of regulations requiring energy efficiency improvements in case of refurbishment.

Organisational resources and knowledge required within the public administration:

- Public administration should be aware of the high potential of consumption and emission reduction of these different solutions. Administrations should propose ways of promoting the amortization of rehabilitations through grants or tax incentives. In particular, it should update grants and incentives to the newest technologies and latest distribution processes and energy management.
- Public administration need to be aware of the conditions needed for a public-private collaboration within an ESCO business model

Stakeholders to be involved:

- Owners and hotel industry brands, sports facilities, public and private educational sector
- ESCO companies
- Public administration
- Architects, Engineers
- Manufacturers and distributors of products for the generation, distribution, management and control of thermal and electric energy
- Tenants of the building

Potential barriers:

- Convincing owners to invest in actions with higher payback than the ones they use to accept for investing.
- Convincing owners of the importance of integral passive and active refurbishment

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FACTSHEET

LOW ENERGY DISTRICT

Energy efficient swimming pools

PART OF SMART SOLUTION 1: EFFICIENT AND SMART CLIMATE SHELL REFURBISHMENT

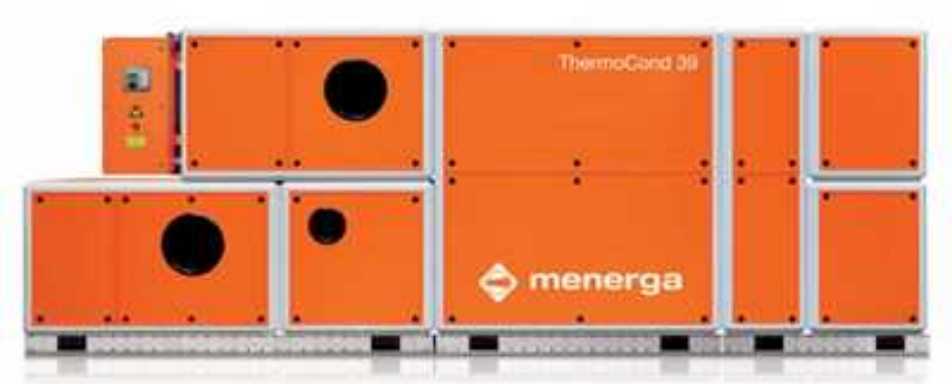

Fig 1: Menerga swimming pool dehumidifier (Source: Menerga)

- Indoor swimming pools are large energy consumers within sports centres. Air must be continuously treated to maintain low humidity and high temperature.
- A significant part of this energy is lost in the form of heat transfer through roof and walls. Reducing these losses has a strong impact in overall demand.
- Energy loss also stems from ventilation, which involves driving out hot air and replacing it with cold air which must be heated. Recovering part of this wasted heat reduces overall thermal demand.

Barcelona

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What is the solution?

This solution includes passive and active energy refurbishment of systems affecting pool space heating and electricity needs.

As a passive measure, insulating the pool roof (over 600 m² area) will lead to reduced heat transfer through the surface.

As an active measure, the current dehumidifier will be replaced with a new high-efficiency unit that allows recovering heat from exhaust air.

How does it work?

Pool roof insulation (passive measure)

Pool halls are kept at a warm temperature throughout the year, and therefore have a very large thermal demand. This solution consists of a layer of insulating material placed over the dropped roof of the swimming pool, reducing thermal losses through the roof. This significantly reduces thermal demand.

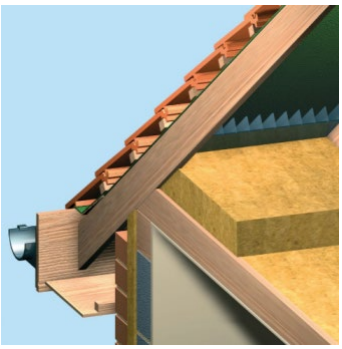

Fig 2: Pool roof insulation illustration (Source: Rockwool)

Installation of dehumidifier allowing heat recovery

In indoor heated pools, water is constantly evaporating into the air from the pool surface. To maintain user comfort and avoid unwanted condensation on surfaces, it is necessary to maintain humidity at a relatively low level. This is done through a thermodynamic cycle that consumes an significant amount of electricity. Electricity consumption for dehumidification can be reduced significantly by replacing existing equipment with a new high-efficiency unit. The electrical consumption for ventilation is also optimised due to the use of variable speed fans to adjust the recirculation airflow. The system automatically adjusts operation parameters (flow rates, air recirculation/mixture) depending on internal and external conditions to minimize energy consumption.

The new dehumidifier (Fig 1) will be equipped with a heat recovery module that pre-heats outside air entering the building using heat from inside air going out. This way, energy demand due to air renovation is minimized.

Fig 3: Ventilation process (Source: Northern Fans)

The system automatically adjusts operation parameters (flow rates, air recirculation/mixture) depending on inside and outside conditions to minimize energy consumption.

Business Model Used

The business model used is an ESCO model, where Gas Natural Fenosa acts as an energy services company. In this model the end customer will have a single interlocutor, which manages and coordinates all the agents needed to execute the refurbishment.

The savings guaranteed by the refurbishment will cover the investment of the energy services for the works during a contractual relationship agreed with the energy services company.

The ESCO guarantees the energy savings and assumes the operation and maintenance costs during the duration of the contract. At the end of the contract, the energy savings will be a direct benefit for the customer.

Integration with other smart solutions

This solution is integrated with the smart solution "Efficient and smart climate shell and equipment refurbishment of tertiary buildings", and will be implemented together with different active and passive measures.

- Replacement of thermal energy generation equipment (boilers, heat pump for heating and cooling)
- Installation of solar thermal system
- Installation of Building Energy Management System (BEMS)

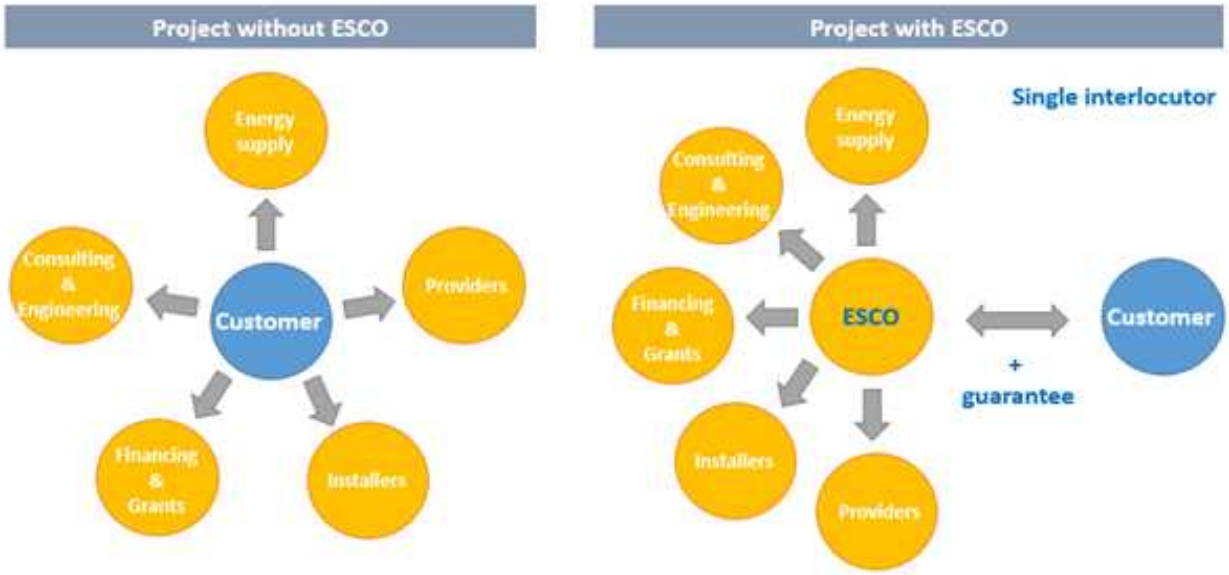

Fig 4: Business model used, with ESCO and without ESCO

Expected Impacts

Positive impacts expected to bring to the city in terms of the key GrowSmarter objectives:

Improving quality of life:

Precise and automated control of ambient conditions to ensure thermal comfort.

Reducing environmental impact:

- Reduction of pool space thermal demand of around 60% and dehumidifier consumption around 30%
- Reduction of CO2 emissions, owing to the reduction of consumptions and to waste heat recovery
- Better conditioning of external air

Promoting sustainable economic development:
Increase of market value of buildings and consequent increase of visibility in the market and customer attraction.

Potential for replication

The main precondition for replication of this measure is the existence of a stock of indoor swimming pools with relevant thermal and dehumidification needs that have not been recently refurbished.

Organizational resources and knowledge required:
Public administrations should be conscious of the high potential of consumption and emission reduction of different solution applied in passive and active energy refurbishment. They should propose ways of promoting amortization of rehabilitations, through grants or tax incentives; particularly, it should update grants and incentives to the newest technologies of generation, distribution and management of energy.

Public administrations need to know the conditions for a public-private collaboration within an ESCO business model and should take them into account when designing concession policies to foster investment in energy efficiency through Energy Services contracts.

Stakeholders to be involved:
- Sports centres/pool owners or managers
- Energy Services Companies (ESCos)
- Public Administration (if pool is publicly owned)
- Architects, Engineers
- Manufacturers and distributors of products for the generation, distribution, management and control of thermal and electric energy
- Final users of the building

Challenges to replication:
For pools owned by Public Administrations and operated by private companies through a concession scheme, it may be problematic to be able to provide net savings to the operator before their exploitation period is over (generally part/all of the economic savings for the duration of the Energy Services contract are transferred to the ESCo as compensation for its investment).

Convincing owners/managers to invest in actions with higher payback (passive measures) than the ones they use to accept for investing.

Convincing owners/managers of the importance of integrated passive and active refurbishment.

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FACTSHEET

Construction Consolidation Centre

SMART SOLUTION 2: SMART BUILDING LOGISTICS

LOW ENERGY DISTRICT

- Ensures greater economic and environmental efficiency during refurbishment.
- Coordinated deliveries reduce number of journeys to and from construction sites, lowering emissions and increasing air quality.
- More efficient building process leads to time savings, reduction in damaged or stolen material, and reduced transport time.

Stockholm

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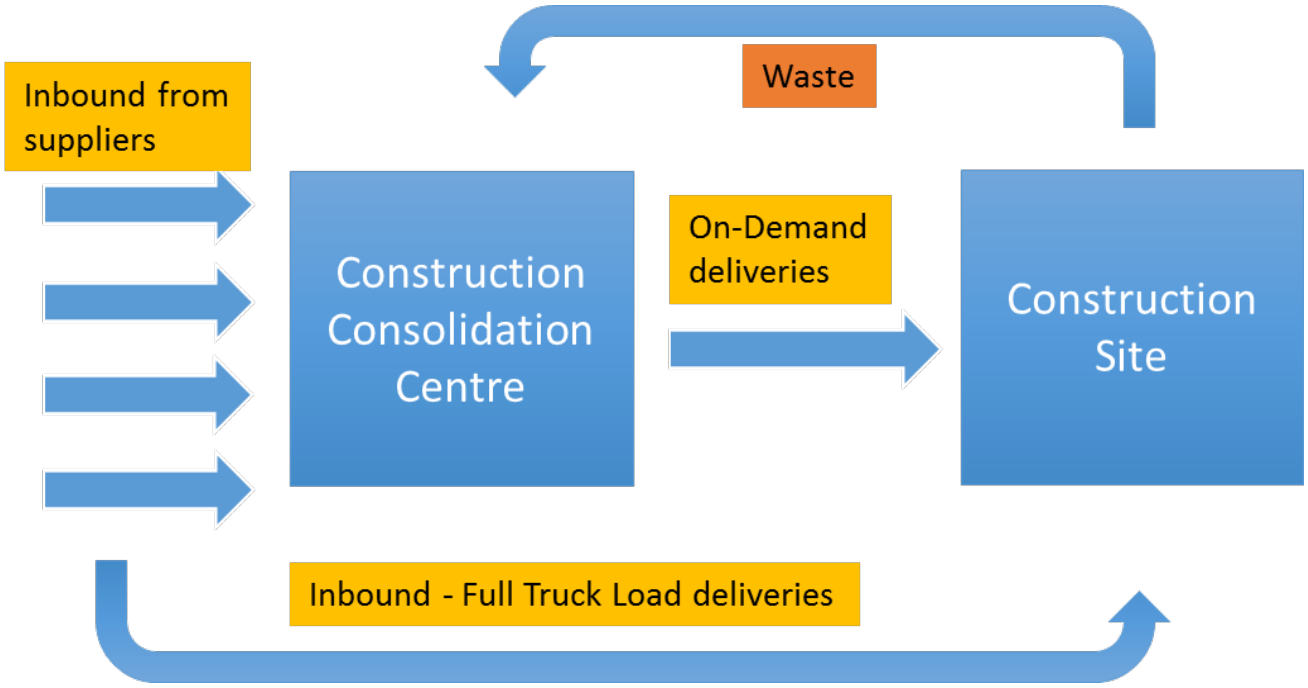

What is the solution?

The Construction Consolidation Centre is a logistical set-up to improve the conditions for construction projects such as new developments or refurbishments. By planning the material flow and steering inbound deliveries to the Consolidation Centre, it is possible to increase the efficiency of the building process. Possible savings are measured in reduced time, as well as damage to material during deliveries and handling, and waste. This can contribute to a major reduction in the environmental impact of a construction project.

The main benefit of the consolidation centre is an overall reduction in the number of deliveries to the construction site. This will lead to less damaged or stolen material, less time spent for workers waiting or searching for material, and a safer working environment on site. Deliveries between the Consolidation Centre and the two refurbishment sites in Valla Torg and Slakthusområdet in Stockholm will be made with alternative fuelled vehicles.

How does it work?

By planning the material flow to a construction site the efficiency in the flow of materials can be increased. Most of the inbound deliveries are directed to the Consolidation Centre instead of the Construction site allowing for better control of the inbound material. It will still be necessary, however, for some deliveries to go straight to the site. The Construction site will order material from the Consolidation Centre, when needed, at

a specific time and location at the site. This means that very little material will be stored on site. The number of deliveries to the site is reduced by 40-60%, since small direct deliveries are avoided and instead grouped as larger deliveries. The truck doing the delivery of building materials will bring waste from the refurbishment sites back to the Consolidation Centre. The same truck will be handling both new materials and waste, further reducing traffic to and from the site.

Expected impact

The Consolidation Centre is expected to provide the following positive impacts in terms of the key GrowSmarter objectives:

Reduced environmental impact

There will be less trucks delivering goods and collecting waste. The vehicles operating from the Consolidation Centre will use biofuels or an electric driveline. This will reduce both emissions and noise.

Improved conditions for more efficient building processes

Less time will be spent waiting for, searching for and picking up material to use for the building. Less risk of materials being stolen or destroyed by bad weather.

Promoting sustainable economic development

There will be a reduction in damage to materials and a reduction in time spent on activities other than building.

Potential for replication

Similar consolidations centres have been used in Stockholm with good results. This is the first time the solution has been applied to refurbishments and should hopefully inspire others to use consolidation centres in a similar way elsewhere.

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FACTSHEET

LOW ENERGY DISTRICT

Home Energy Management

SMART SOLUTION 3: SMART ENERGY-SAVING TENANTS

- Increases tenants' independence by giving them control over their energy mix and consumption in an easy way using the Smart Home application
- Provides clear data on energy consumption, allowing tenants to move towards lower energy consumption and increased renewable energy usage
- The dynamic "PV-Mieterstrom" pricing model allows citizens more control over their individual usage and expenditure, increasing their quality of life

Cologne

Technical partner: RheinEnergie & AGT International

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What is the solution?

Within the project, some apartments (50 to 100 from a total of 596) will receive SmartHome equipment which enables them to save electricity and warm water required by radiators.

RheinEnergie is working to create a dynamic price model by introducing PV-Mieterstrom. This is a tariff for the tenants of the settlement which allows them to use photovoltaic systems. This tariff combines solar electricity with our available electricity tariff FairRegio. Depending on the performance of the battery, which is still in the design stages, the balance of energy used for the current quarter will be between 30-50% from photovoltaic current with the remaining 50-70% coming from the public power grid.

In addition, the tenant should be able to receive information on their energy consumption for comparison and analytics. This will help tenants get a better feel for their energy use.

How does it work?

The SmartHome app allows tenants to turn off all electrical appliances and lights at any time and from anywhere. This can be done easily at home or on the move via smartphone, tablet or PC. In combination with smart plugs (SmartMeter), tenants can keep track of the current energy consumption of any connected devices. The application clearly documents consumption patterns of the devices for comparison and analytics.

Integration with other smart solutions

The information on energy consumption will be used by the Siedlungsmanagement software to improve forecasts for power and heat consumption. The data will be collected and prepared for the City of Cologne's Open Data-Platform and for the tenants themselves (SmartHome). The control of the Smart Home System will be integrated into the Siedlungsmanagement.

Expected impact

Positive impacts of this solution include:

- Reduced green gas emission
- Reduced heating costs
- Reduced public electricity consumption
- Improved quality of life

SmartHome enables individual devices to connect from anywhere via smartphone or tablet. Users can also create "scenarios" rules or schedules that are automatically switched. Tenants can therefore save energy without manually reconfiguring electrical appliances and heating.

Potential for replication

A system like SmartHome is easily replicable in other houses. There is no need to lay cables, so it can easily be installed in existing constructions. The only thing that is required is an internet connection with a router and a PC, tablet or smart phone.

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FACTSHEET

LOW ENERGY DISTRICT

The Active House

PART OF SMART SOLUTION 3: SMART ENERGY-SAVING TENANTS

Figure 1: the Active House system

- The state of the art graphical user interface provides real-time information on electricity, hot water, and apartment heating consumption patterns
- By using the combined price and environment function, tenants can choose to change energy consumption according to their environmental and financial needs
- This system aims to change tenant behaviour with regard to energy consumption

Stockholm

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What is the solution?

The Active House smart home solution is an intelligent system with a state of the art graphical user interface. This energy tool raises awareness among tenants on energy consumption from areas including electricity, hot water and apartment heating.

By using the combined price and environment function, the tenant can organise the household's energy consumption in an environmental and smart way.

This function is very useful when looking at the development of more locally produced renewable energy such as solar energy. This function will, in the long run, have an impact on how to use the hydro produced electricity in a more optimal way.

Other functionalities which the system offers include:

- 10.1 inch graphical tablet installed on the wall close to the kitchen
- Graphical state of the art interface
- Smart home gateway, a multifunctional communication gateway
- Remote Control of all lights in the apartment, room per room or individual lights
- Smart 230 V plugs used for switch off and on consumer products that consume energy in "standby"
- Remote control of radiator thermostats in every room
- Clear visualisation of apartment temperature

How does it work?

The picture on the first page (Figure 1) shows the Active House system overview screen. By touching the individual meters on the display, users can explore more of the system's functionality.

Behind the meters are histograms allowing users to follow consumption per day (24 hours), week, month and year. The meter overview provides current consumption patterns to the nearest second. If you touch the cube in the upper right corner you get to the smart parts of the UI.

Here you can use the routines, Home-Away-Eco Away and Night. You can also change your temperature or turn on or off your smart plugs. Here you also see the temperature in the apartment.

Expected Impact

The solution is expected to provide the following positive impacts:

- Gives tenants access to information about their own energy consumption
- Reduces environmental impact by changing energy consumption behaviour
- Promotes sustainable economic development
- Improves quality of life by empowering tenants to reduce costs and improve their environmental footprint.

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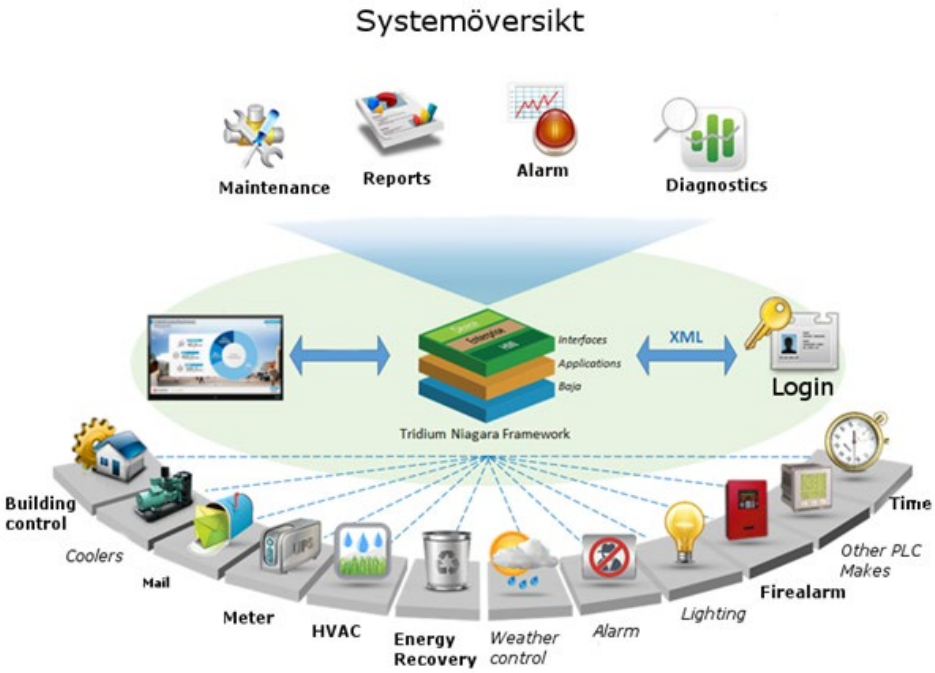
FACTSHEET

LOW ENERGY DISTRICT

Open home Net

PART OF SOLUTION 3: SMART, ENERGY-SAVING TENANTS



- A common platform for the property's technical system
- Decreased energy consumption by active property management
- Increased energy and environmental awareness of tenants and maintenance staff

Stockholm

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What is the solution?

Integration of a real estate server which is open and up-scalable for today's and future real estate related systems such as HVAC, meters, lighting, access control, CCTV, elevators etc.

The Open home Net system is an open system that is at the cutting edge of system integration and energy focused presentation. The solution's focus for Valla Torg is flexible and will be used primarily for energy monitoring and operational optimisation of the building's technical system but can also be used by others who use real estate-related systems.

How does it work?

The Open home Net system is adaptable and expandable to handle all systems in a property and integrate them to a common platform. It is a web-based tool for presentation which can be customized at a user level. For example, screens will be installed in the stairwells to give the tenants information about the building energy performance.

At the property owner level, the system will be used for energy and operational optimization as well as alarm management with the ability to connect to other technical systems in the property.

Expected Impacts

The solution is intended to give the following effects:

• Providing information about the property's energy performance and creating environmental awareness among tenants.

• The property owner has a single platform for all the property's technical systems and can easily customize the presentation individually to each user. It means that every individual gets the right information immediately and saves time.

Potential for replication

The Open home Net system solution is based on an open system, which means that the system is unlicensed and open to other integrators to perform work in the system. The system can communicate with the most common open protocols.

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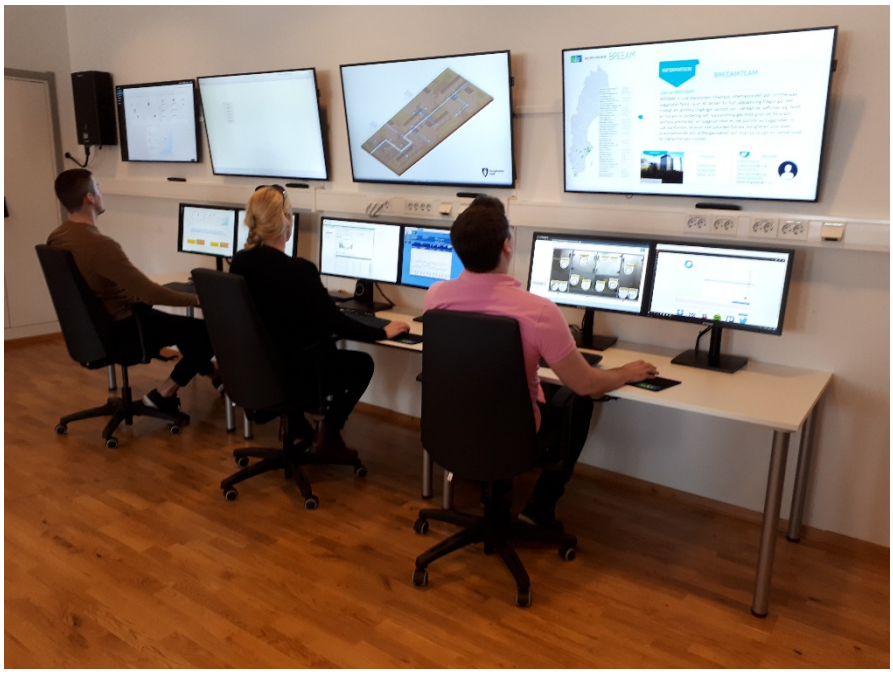
FACTSHEET

Energy Saving Center

PART OF SOLUTION 3: SMART, ENERGY-SAVING TENANTS



LOW ENERGY DISTRICT

- 24/7 remote control of buildings
- Provides continuous scrutiny of selected installation and/or energy saving activities
- Tracks trends in energy to allow users to proactively optimise energy consumption
- Provides alarms on sudden temperature fall or undesired increase in energy consumption

Stockholm

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What is the solution?

Energy Saving Center (ESC) combines a number of energy saving measures working in combination. These are described in this factsheet.

The ESC (Energy Saving Center) software complements the work started by the Energy Coordinator. It is available to all property owners and focuses on reducing the energy usage and energy costs. The combination of Technical Facility Management with Energy Management gives the property owner the possibility to secure the buildings energy performance.

We consider energy saving to be an ongoing process involving the right technique, the right maintenance but also the right behaviour.

How does it work?

The building's new or existing control systems are connected to the ESC. Also, other smart meters such as temperature-, CO2 sensors and moister meters, are connected in order to make a platform for a Smart Building. Data is collected from the District Heating Network, water sensors and electrical sensors through automatic meter readings, allowing users to read the "live" data and respond proactively.

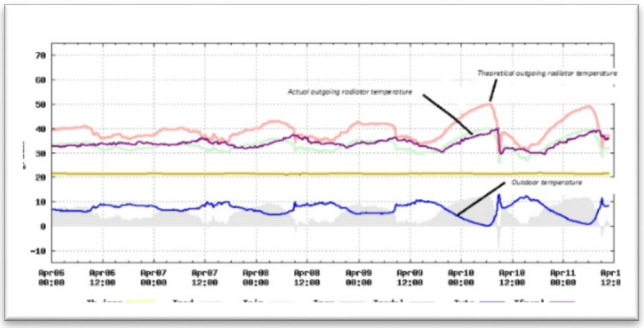
Analysis and comparison is also made to regulate consumption at the desired level. If necessary, the parameters should be able to adjust remotely from the Energy Saving Center.

In order to optimize the building's energy usage, several different solutions are being installed. These are described in the following pages.

1. Adaptive Temperature control system

An adaptive control system that influences but does not replace the existing controlling system.

A normal controlling system uses outdoor temperature to adjust the outgoing water temperature to the heating system. This system constantly monitors the indoor temperature to influence the existing controlling system for heating.



In this way the building's own "inertia" can be used by including solar radiation, various activities in the property etc. "Inertia" is in this case best described as using a buildings basic construction, possible insulation and activities inside, to keep indoor temperature at the desired level.

The system can thereby avoid unnecessary increases in water temperature due to sudden changes of outdoor temperatures. This often occurs during the autumn and spring, with warm days and cool nights.

How does it work?

The system is constantly measuring indoor temperature in selected apartments/rooms to get an exact reference temperature which can be used by the adaptive control system. Existing regulation systems are not replaced but rather influenced by the adaptive control system. The system

continuously provides the most efficient outgoing temperature to the heating system.

Expected impact

- Increases energy saving potential from 5 % to 15 %
- Reduces environmental impact
- Promotes sustainable economic development

Potential for replication

This system is installed on top of existing control systems using outdoor temperature as reference input. It's an easy roll out technique for a larger market. The system is managed and controlled through a cloud service making it easy to follow the energy saving results.

This solution has great potential for replication as it is easily installed in almost all types of buildings and can be used with almost every type of control system on the market.

2. Water saving Equipment

- Easy to install on standard taps
- Guaranteed flow regardless of building high or pressure in net
- Up to 60 % water savings on individual taps
- Target to save 20-30 % of overall water consumption

3. Adaptive Current Equalization

EnergyHub is an electrical Hub controlling electical use in a building. The EnergyHub consists of modular, distributed power electronics managing energy flow between PV production, energy storage and local consumption/grid export. It can also control charging staions for vehicles.

The smart meter and automatic energy analysis ensure optimal usage of the harvested PV energy with energy storage and self-learning algorithms. The hub is both modular and scalable, thanks to the DC nanogrid technology which allows for functionality and capacity to be increased over time with one single system control.

ACE

An important part of the EnergyHub system is the patented ACE (Adaptive Current Equalisation) function - which allows for a more efficient use of the three phase supply.

The EnergyHub transfers energy between the phase conductors when too many loads are connected to one phase conductor. This increases the headroom between the main fuse rating and the load, allowing for better dimensioning of cables and infrastructure and removing unwanted current in the neutral conductor.

The headroom can either be used to reduce the main fuse rating or allow for more efficient and faster eletric vehicle charging without costly upgrades to the electrical system.

How does it work?

The EnergyHub ACE function measures the electrical consumption of a building and transfers energy between phases as necessary in order to protect mains fuses and/or improve power quality.

The collected data is analysed by the EnergyHub cloud platform, which combines

the building's load profile with electricity prices and the weather forecast to create a basis for efficient system control. Automatic decisions are made to prepare energy storage for optimal use of electricity tariffs and solar production. As an example, batteries can be charged from the grid at night at lower cost if low PV production is expected in order to manage power capacity peaks.

This allows the EnergyHub system to be used for peak shifting/shaving and load control in order to reduce costly power capacity peaks. The EnergyHub system operates as a PV system during day time, storing excess PV in energy storage for use during the night and winter months.

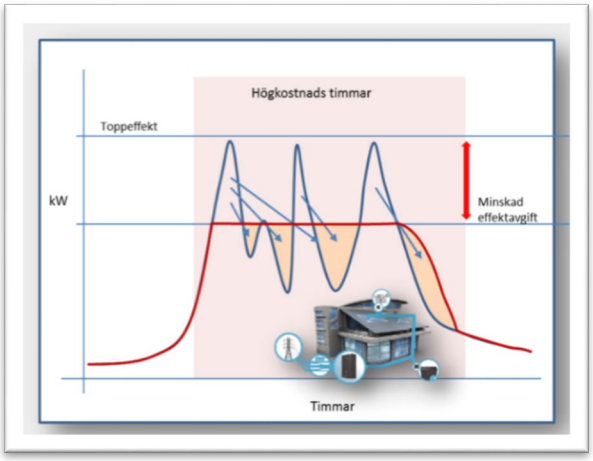
The EnergyHub can therefore be used 24 hours a day, 365 days a year for optimal usage of a building's solar energy supply.

Expected impact

- Energy saving potential is increased from 5% to 35%
- Enables better usage of PV solar investment
- Reduces stress on a building's electrical system with increased EV charging
- Reduces stress on electrical distribution systems through local production – storage – load control
- Prepared for new business models and smart grid support functionsReduces negative environmental impact

Potential for replication

This system has a high potential for roll-out in the broader market, as it can be installed on almost any three phase system and creates a more stable building and distribution grid, optimised energy use, sustainable energy integration and electrical system maintenance and control.



The control provided through ESC gives the opportunity to stabilise electricity usage in the long term.

Overall expected Impact of L&T Energy Saving Center

This solution has a positive impact to the city in terms of the key GrowSmarter objectives:

- Enables monitoring and verification of completed energy saving activities
- Improves quality of life
- Optimises energy used
- Reduces environmental impact
- Promotes sustainable economic development

Potential for replication

A lot of buildings can be affected positively by a 24/7 supervision, that allows for the monitoring and identification of unwanted rises in energy use or sudden temperature falls. With ESC the methods and processes are automated, and monitoring becomes easier.

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LOW ENERGY DISTRICT

Home Energy Management System

PART OF SMART SOLUTION 3: SMART ENERGY-SAVING TENANTS

- Helps to achieve the European union's aim of continuously improving energy management within the tertiary sector
- It is estimated that using an energy management system to monitor and control the consumption of a tertiary building can lead to an almost 10% reduction in the energy consumption of the building.
- Providing a graphic view of residents' own electric and fossil fuels consumption helps build awareness and empowers them to reduce their energy footprint

Barcelona

Technical partner: Gas Natural Fenosa

- Contact – barcelona@grow-smarter.eu

City partner

- Contact – rfuriod@bcn.cat

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What is the solution?

Home management energy systems will be installed in all the selected residential buildings to be refurbished within the GrowSmarter solution "Efficient and smart climate shell and equipment refurbishment of residential buildings".

The Home Energy Management System (HEMS) will also be offered in special conditions to residential buildings taking part in other GrowSmarter solutions such as theSmart Energy & Self-Sufficient Block.

This solution aims to help tenants optimise their behaviour to achieve maximum energy efficiency and reduce their energy bills. The collection and provision of individuals' energy data is fundamental to this solution.

For the refurbished buildings, the monitoring of the consumption will be carried out before and after the refurbishment for a period of two years starting from the end of the works.

Taking into account the limitations imposed by the Organic Law on Data Protection, information on aggregate consumption per building will be available on the platform of the City of Barcelona. Within GrowSmarter, dissemination of results will be done at the national and international level with the aim of achieving replicability in buildings with similar characteristics.

The final objective is to valuate the energy savings obtained through the efurbishment, to use the installed HEMS as a pilot to develop a more complete version of the software, and to help owners to know how their behavior affects consumption.

How does it work?

The functions offered by the Home Energy Management System to be installed are:

- Real time gas consumption calculation through monitoring of temperature
- Boiler control for energy efficiency improvements
- Real-time electricity consumption thanks to current clamp installation
- Gas and electricity consumption monitoring, energy efficiency indexes, advices and gamification
- Electricity hourly prices for invoice optimisation
- Smart plugs
- Boiler maintenance optimisation

The interacting hardware components for gas and electric monitoring and control are:

- **Gate:** smart home energy visualisation application, instant feedback on tablet or smartphone
- **Thermic:** Smart thermostat
- **Pod:** Smart Plug, which allows the user to control the electricity outlets remotely
- **Bat:** Energy monitor

Sensors and actuators for monitoring gas consumption through low-range RF technologies.

The technology applied for monitoring gas consumption has low energy consumption and high service life, allows long-distance

transmission, can serve multiple users and has a low implantation cost.

Business models used

As a collection of participants' energy behaviour data is needed within the GrowSmarter project, the HEMS is distributed to participants free of charge. We are also defining a business model for the commercial solution. We defined an initial price for the HW (including, transport and installation) and a monthly price for maintenance cost.

Integration with other smart solutions

This solution is integrated with the smart solution "Efficient and smart climate shell and equipment refurbishment of residential buildings", which includes passive and active energy refurbishment of almost 10.500 m2 of residential buildings in Barcelona.

Expected Impacts

The following positive impacts are expected in terms of the key GrowSmarter objectives:

Improving quality of life:

Remote control of the monitored systems of the dwelling will allow users to adapt conditions to their proper standard of comfort

Reducing environmental impact

The use of HEMS will allow the identification of problems in the monitored systems, giving the opportunity to stop unnecessary consumption

Promoting sustainable economic development

Raised awareness among owners of the different typology of consumption of their dwelling, and better knowledge of solutions and new technologies which can reduce consumption and costs.

Replication potential

Pre-conditions of replication in other European cities:

The low cost of installation of a HEMS system in a dwelling and of the service of visualisation and optimisation of consumptions offered by retailers such as Gas Natural Fenosa, do not require specific pre-conditions for replication. It is clear that this action must be accompanied by an awareness campaign for users in order to promote a diffusion on a grander scale.

Organisational resources and knowledge required within the public administration:

Awareness campaigns by public administration on the high potential for reduction of consumption and emissions thanks to the use of energy management systems.

Stakeholders to be involved:

- Owner communities
- Public administration
- Utilities
- Manufacturers and distributors of hardware and software for HEMS

Potential barriers:

Lack of awareness and/or mistrust of the importance of monitoring and management of consumption

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FACTSHEET

LOW ENERGY DISTRICT

Virtual Energy Advisor

PART OF SMART SOLUTION 3: SMART ENERGY-SAVINGS TENANTS

Figure 1: User Interface of Virtual Energy Advisor on the web or mobile app

- Enables tenants to become more efficient using their electricity consumption profile, behaviour and motivation.
- Aims to reduce electricity consumption within the residential sector by a minimum of 10%
- Aims to influence consumers' behaviour to help reduce energy consumption

Barcelona

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What is the solution?

The Virtual Energy Advisor combines a user friendly front-end which can be viewed from a number of devices (e.g. laptop, mobile app) and an intelligent back-end based on algorithms that use data from smart meters (i.e. meter used to determine overall dwelling consumption on an hourly basis) and other devices and sources.

This platform aims to reduce household electricity consumption by a minimum of 10% compared year on year by encouraging behavioural change amongst tenants. In case the smart meter is not installed at the dwelling, tenants may still use the tool with monthly data from their utility bills.

How does it work?

The Virtual Energy Advisor analyses electricity consumption and provides it to tenants in real time through a Wi-Fi connection. Tenants receive user-friendly, accessible and personalised information about their electricity usage and level of efficiency via the user interface, either on the web or via the mobile app which is available for download on smartphone devices, tablets or PCs.

The platform is also used by members of the community to exchange expertise, discuss energy-related topics and work towards achieving energy efficiency goals in order to become as energy-efficient as the other tenants with similar profile. The platform works with data provided by the smart meter and other sources, such as weather forecast.

Figure 2: Details of information displayed on user Interface of Virtual Energy Advisor

Emphasis is put on the direct interaction between the user and the platform in order to observe the level of efficiency over the course of the previous year and provide a point of comparison with other tenants with a similar profile.

This allows the appropriate advice to be provided in a personalized way, so the user can become more efficient and reduce his or her electricity bill by behavioral changes on an hourly basis.

Advice on support schemes for on-site Renewable Energy installation at home will also be provided.

Business Model Used

The Virtual Energy Advisor is being developed within the Barcelona Municipality project 'Take charge of your energy', which includes a Solar Potential Map using geographic information system (GIS) technologies. It is fully funded by the Barcelona Municipality.

Integration with other smart solutions

The Virtual Energy Advisor will be eventually installed in a number of residential dwellings included in Solution 1, 'Smart Climate Shell and Equipment Refurbishment'.

It will also be linked to measure 4.2, where the platform 'Resource Advisor' to visualize the energy data will be developed.

Finally, it will be linked to measures 8.1 and 8.2, where an open data platform and semantic urban model will be created.

Expected impact

The Virtual Energy Advisor is expected to reduce electricity consumption in the residential sector by a minimum of 10% compared to the previous year.

The development of Virtual Energy Advisor for Barcelona Municipality has been awarded to the company Enerbyte and the electricity analyser is currently being installed into alredy 300 dwellings. End-users can already check their real-time consumption, compare it with historical data, compare with other users and receive personalised advices on how to reduce their electricity bills.

The expected impact on user behaviour is mainly related to the following topics: active reduction of electricity consumption during the night, awareness of the possibility to change passive elements of the house (windows, wall insulation, etc.), purchase of devices with high energy efficiency label, use of LED light bulbs, among others.

Potential for replication

Replication in other European cities is dependent on electricity tariffs as well as on more general considerations such as electrical market regulations and data protection and privacy issues. Another aspect to be considered is the increased deployment of smart meters in Europe dwellings, which will ease the replication of this kind of solutions. Data collection is of significant relevance for future urban energy planning by municipalities.

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FACTSHEET

LOW ENERGY DISTRICT

Stochastic Model of Appliances Energy Consumption

PART OF SMART SOLUTION 3: SMART ENERGY-SAVINGS TENANTS

- Enables designers and engineers to accurately generate appliances' load profiles according to building type, number of occupants and stock of appliances.
- Aims at a better design of household installations, improving the estimation of energy savings.
- Provides tenants with detailed information about the appliances' consumption, comparing their energy consumption with high performance appliances.
- Aims to influence consumer decisions to improve the their appliances' energy labels.

Barcelona

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What is the solution?

The Stochastic Model of Appliances Energy Consumption is a tool that provides detailed load profiles for electric devices. This tool is able to generate the load profile of 15 different appliances, according to the characteristics of the household: the building type (single family house and multifamily house), the number of occupants (from 1 to 5 occupants) and the equipment stock (type and energy labelling).

The tool has two main applications, and consequently two different target groups:

Designers and engineers: Usually, energy consumption related to appliances is considered the same for all households. In that sense, the tool is able to estimate the energy consumption introducing the main characteristics of the households: type of building, number of occupants and stock of equipment. The results of the tool are the annual consumption and 3-min load profile.

End users, tenants: The energy labelling provides information about the energy consumption of the appliances. Comparing the energy labelling of different appliances it is possible to estimate the energy savings, based on normal use, more accurately than previous methods of estimation.

The tool has been designed to be integrated into common commercially-available energy building performance simulation tools.

How does it work?

The Appliances' Stochastic Model is a statistical model based on Time Use Data (TUD). The TUD is a European harmonized survey done in Spain by the Spanish Statistical Office (Instituto Nacional de Estadística, INE). TUD describes what the people are doing at every moment of the day, providing occupancy patterns and relating them to the use of the appliances (e.g. if the activity is "laundry", then the washing machine is matched to the activity). The structure of the Appliances' Stochastic Model is shown in Figure 1. To run the tool, the building type (single building or block of apartments), the number of occupants and the appliances' stock (type of appliances and energy labelling) must be selected.

As a result, the model will produce the following information:

a) detailed profiles of the appliances' consumption, with a resolution of 3-minutes (Figure 2);
b) a summary of the annual energy consumption of each appliance;
c) an energy comparison with more efficient appliances.

Figure 1: Stochastic Model structure for appliances

Integration with other smart solutions

This solution is included under Measure 3.1 Dynamic price models, as the stochastic models of electricity demand of appliances in households could be used to foresee tenant behavior and their interaction with the power grid. The model results will be compared with the monitored real consumption gathered in Measure 3.1 'Virtual Energy Advisor' in order to further validate the model in the Mediterranean climate context.

Expected Impacts

The Stochastic Model of Appliances' Energy Consumption is expected to be integrated in energy simulation tools and platforms to provide detailed information about the energy consumption of appliances in residential buildings.

From the point of view of the professional sector, this tool will generate detailed information related to electrical devices consumption. The aim is to design complete strategies to reduce and manage the energy consumption including all the energy uses of the residential sector, and not only thermal ones (heating, cooling and domestic hot water).

From the point of view of the end-user, the tenants will have on-hand accurate and personalised information related to their own consumption profile and will be able to improve energy performance of their homes.

The most important impact of the Appliances' Stochastic Model is to raise knowledge about appliances' consumption among citizens, in order to instigate appropriate strategies to improve energy efficiency in the residential sector and to contribute to consumer behaviour-change.

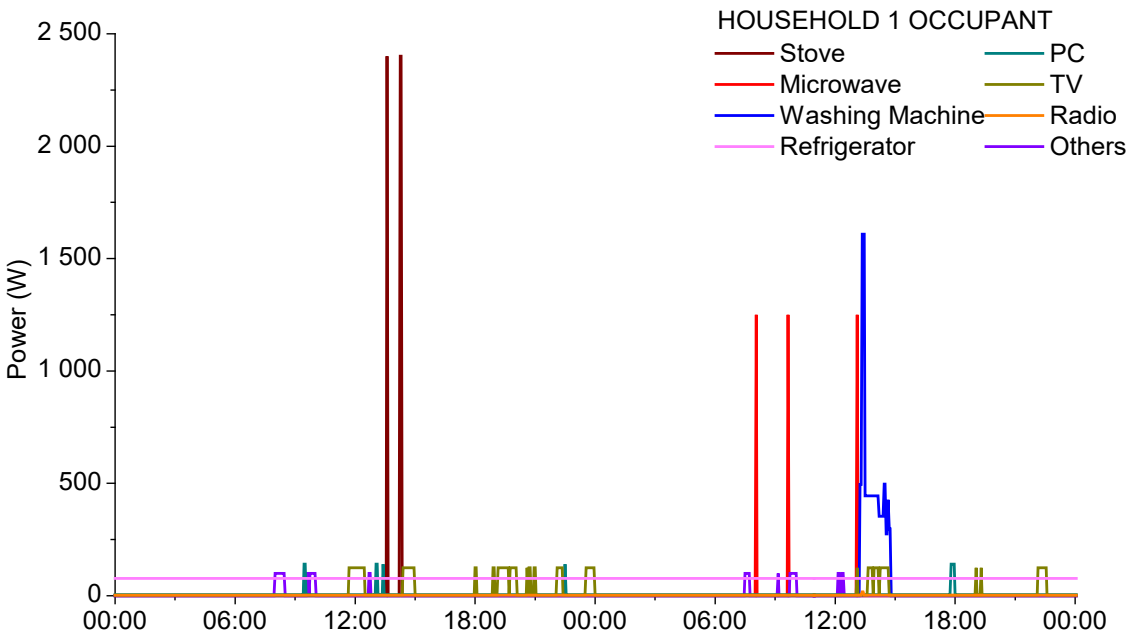

Figure 2 Appliances' load profile for a household with 1 occupant across two winter days

Potential for replication

The presented methodology for modelling the electricity consumption of appliances in the residential sector is applicable to residential uses in general, with a great impact especially on the trends of progressive electrification of households.

It must be considered that the appliances' use is highly dependent on social behaviour, which is different from one country to another. Since the model developed by IREC is currently based on Spanish data, the presented results are exclusively valid for Spanish households.

However, the tool is based on a harmonized European survey (Time Use Data) and it can be adapted to other countries using their Time Use Data and validating the results with their own monitored data.

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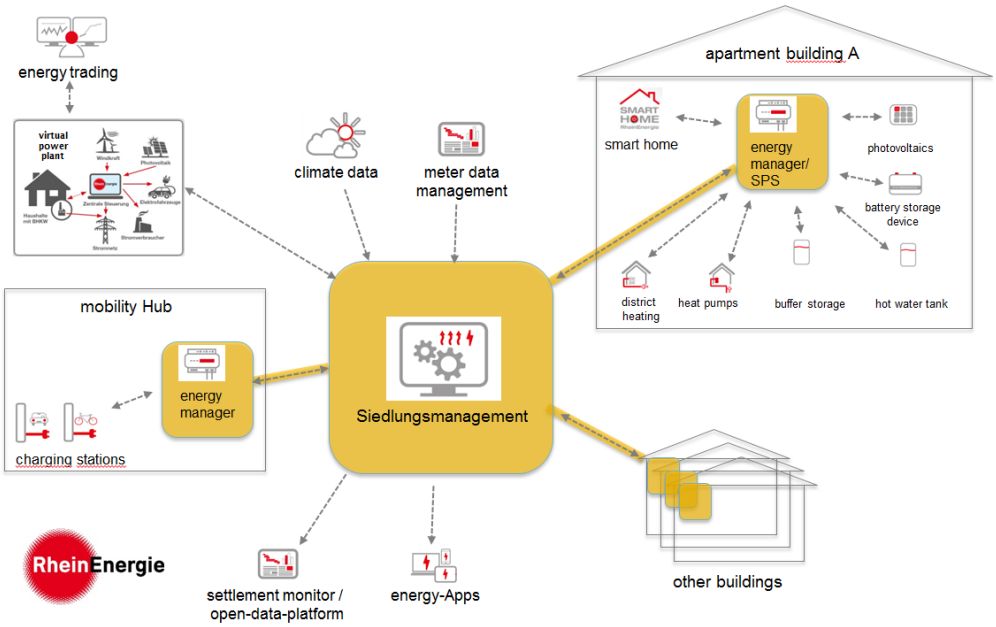
Residential Estate Management

PART OF SMART SOLUTION 4: SMART LOCAL ELECTRICITY MANAGEMENT



LOW ENERGY DISTRICT

- Leads to a partly self-sufficient energy supply
- Reduces carbon emissions and improves air quality
- As a result of this solution less external energy has to be supplied, relieving pressure on energy grids

Cologne

Technical partner:

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What is the solution?

The solution consists of a virtual power plant (Siedlungsmanagement) which connects local photovoltaic production, heat pumps and batteries. A charging station (solution 11) for electric vehicles (cars and pedelecs) will also be integrated into the settlement.

How does it work?

Siedlungsmanagement is an intelligent management system to optimise energy and heat consumption. It interconnects internal (photovoltaic, heat pumps, battery storage) and external (district heat) energy producers.

Based on information gathered from meters installed throughout the building, Siedlungsmanagement can measure what energy is currently being used within each apartment and can predict future energy consumption. It uses this information to optimise the energy production and consumption in order to reduce the need for external energy from the grid.

The Siedlungsmanagement software optimises the operation of the systems based on the load forecast which is calculated using consumption and production data. For example, if the heating pumps are mainly supplied by photovoltaic during the project, the charging stations should be supplied by photovoltaic too.

The excess current should be saved in storage or fed into the public grid.

To avoid fluctuations in the network, the electric circuit is controlled by the Siedlungsmanagement software.

The electricity from photovoltaic panels is used mainly to supply the heat pumps. Any excess electricity will feed into the tenants' own power supply (Mieterstrom).

Once local electricity demand has been satisfied, any residual current will be fed into the grid and remunerated through the German renewable energy act EEG.

Business Model Used

RheinEnergie is working on a business model to sell the Siedlungsmanagement system as a service. The software will only be available within Germany.

Integration with other smart solutions

Smart Home from Solution 3 will be integrated into the Siedlungsmanagement system. Load management will be calculated using the Siedlungsmanagement software. Based on the load forecast, the Siedlungsmanagement software is aiming to achieve high levels of self-sufficiency and minimise the external energy supply.

Expected Impact

The Siedlungsmanagement system meets the GrowSmarter aims in the following ways:

Reducing environmental impact:

The intelligent load management of the Siedlungsmanagement system increases the degree of self-sufficiency in buildings which use it. This results in a lower demand for external energy, helping to reduce the burden on energy grids.

Promoting sustainable economic development:

The ongoing energy revolution means that the electricity supply is going to be steadily decentralised. The virtual power plant supports this development, helping to replace coal and nuclear power plants with renewable energy systems and combined heat and power.

Potential for replication

Siedlungsmanagement is a cutting edge automation technology for settlements and could easily be used as a blueprint for other cities. Siedlungsmanagement by RheinEnergie is currently only available within Germany.

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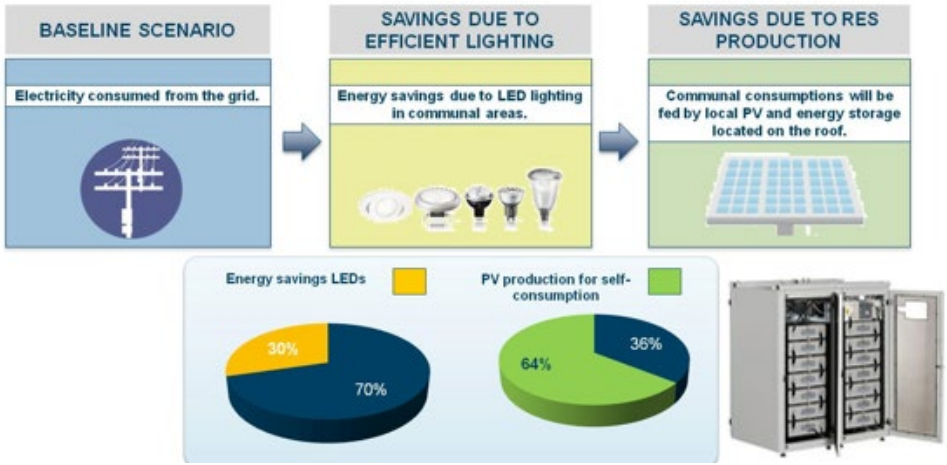
Smart energy and self-sufficient block

PART OF SMART SOLUTION 4: SMART LOCAL ELECTRICITY MANAGEMENT



LOW ENERGY DISTRICT

- Photovoltaic generation coupled with the use of storage batteries allows optimisation of the relationship between generation and consumption even in low solar production instances.

- Achieves sustainable economic development goals by promoting human interaction and small-scale collaboration. Achieves sustainable economic development goals by promoting human interaction and small-scale collaboration.

Barcelona

Technical partner: Gas Natural Fenosa
Contact: barcelona@grow-smarter.eu
Barcelona City Council
Contact: rfuriod@bcn.cat

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What is the solution?

The smart energy and self-sufficient block will be formed of buildings with residential and tertiary uses. For residential buildings, photovoltaic power plants with energy storage will be installed in order to supply community residential consumption.

The production and consumption of the systems installed in the buildings will be managed "virtually" in order to analyse possible scenarios for the electric grid at island level, particularly in cases of complementary consumption profiles.

The "smart" concept of this solution, particularly the management of photovoltaic generation and consumption, will be developed virtually, because according to the new law RD 900/2015 of 9 October 2015, present conditions of electricity self-consumption and feed into the grid which are not economically attractive.

For the implementation of this solution, a restricted zone within Barcelona has been chosen, which includes tertiary and residential blocks.

How does it work?

Services offered to residential blocks are:

- Electric renewable generation from photovoltaic power plants (1.5 – 6 kW photovoltaic power + Li-ion battery, depending on each community) to cover community consumption.
- Optimisation of community lighting consumption by installing LEDs

Information coming from the Building Energy Management System of refurbished tertiary buildings, thanks to the smart solution "Efficient and smart climate shell and equipment refurbishment", will be included in a virtual control software, integrating the block's energy demand, RES, and energy storage systems, that will balance production and storage capacity versus consumption needs.

Through the aggregator, these blocks provide virtual services to the grid, reducing the load during peak congestion and injecting power to the local grid.

The impact on the local grid will be analysed and the use of RES will be optimized. The variation of the energy price will be considered when combining Demand-Response with photovoltaic generation, which can change considerably according to the customer's demand during peak or off-peak times.
A platform will be developed to visualise energy data of residential and tertiary monitored buildings at island level.

Expected Impact

Improving quality of life:

The possibility of replication and improvement of this measure in multiple islands of the city will enhance the energy independence of small communities, promotingpositive and active interaction by the communities on energy efficiency.

Reducing environmental impact:

The use of the storage battery allows the use of all the renewable energy produced by the photovoltaic system even when there is no contemporaneity of generation and consumption. The use of HEMS with alerts will allow the identification of problems in the monitored systems, giving the opportunity to prevent un-necessary consumption.
Renewable energy generation and balancing generation and consumption in buildings with complementary consumption profile will reduce emissions for electric generation, leading to better air quality

Promoting sustainable economic development:

The measure allows cost reduction and optimised generation and consumption, promoting human responsibility, interaction and small-scale collaboration.

Potential for replication

Pre-conditions of replication in other European cities:

- Existence of blocks with minimal requirement for a photovoltaic installation such assurface, orientation, high electric consumption for common zones.
- Existence of island with blocks thathave complementary profiles ofconsumption (for the applicationof “smart-grid” and “demand-response” concepts)

Organisational resources and knowledge required within the public administration:

Public administration should promote the use of renewable energy for electricity self-generation and feed into the grid.

Stakeholders to be involved:

- Owners of communities and owners of tertiary buildings
- Administrators
- Public administration and promoters
- Utilities
- Facility Managers
- Manufacturers of RES (Renewable energy systems), HEMS (Home energy management systems), BEMS (Building energy management systems)

Potential barriers:

- Large number of stakeholders involved
- High payback
- Public administration. For example, in Spain the new law RD900/2015 of 9th October, presents conditions that are not economically attractive

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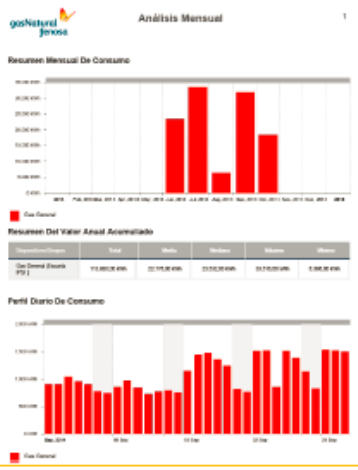
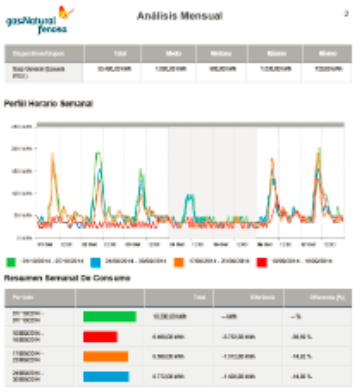
Building Energy Management system to minimise consumption of fossil fuels and electricity

PART OF SMART SOLUTION 4: SMART LOCAL ELECTRICITY MANAGEMENT





LOW ENERGY DISTRICT

- Helps to achieve the European union's aim of continuously improving energy management within the tertiary sector
- It is estimated that using an energy management system to monitor and control the consumption of a tertiary building can lead to an almost 10% reduction in the energy consumption of the building.
- Providing a graphic view of residents' own electric and fossil fuels consumption helps build awareness and empowers them to reduce their energy footprint

Barcelona

Technical partner: Gas Natural Fenosa
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What is the solution?

Building Energy Management Systems will be installed in all the tertiary buildings to be refurbished in order to monitor consumptions of fossil fuels and electricity. Monitoring of consumption will be carried out before and after the refurbishment for a period of two years starting from the end of the works. The main objective of the solution is to reduce consumptions by optimizing energy management and, at the same time, to evaluate the energy savings obtained thanks to these refurbishment actions.

How does it work?

The Building Energy Management System to be installed includes an acquisition and communication module which communicates with counters, sensors and an EMS (Energy Management System) platform through an internet connected server. The solution is oriented to the end-user and personalised services will be added depending on user needs.

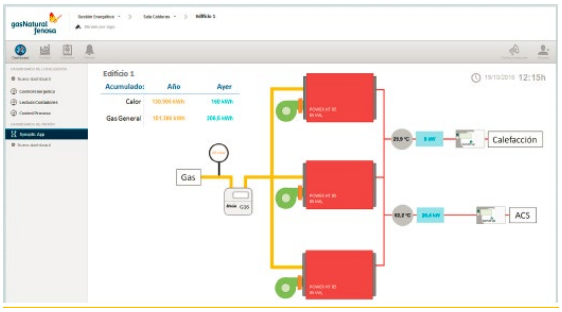
Functionalities:

Visualisation (15-20 minute time step)

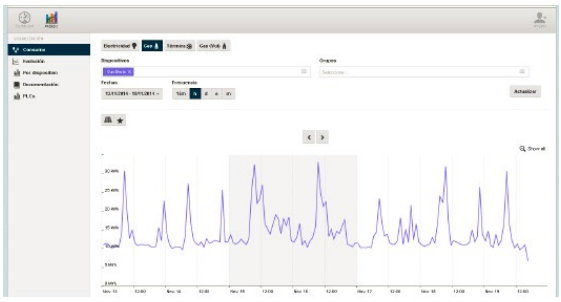
Customised report, depending on needs. Can include:

- Parameters of process(temperature, power, …)
- Meter reading (gas, electricity, …)
- Accumulated consumption data
- Location in map
- Monthly consumption
- Summaries and diagrams ofanalysed period
- Download in excel format
- Energy meter
- Level of service (temperatures,electric power, power factor…)
- Alarms

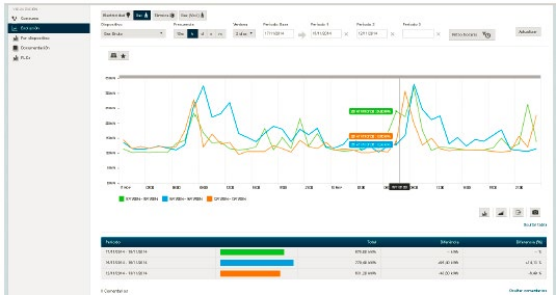
Synoptic App, for the visualisation of the scheme of the system



Profile of consumption, production, electric power, reactive consumption



Comparison to a base case (consumption, contracted power, …)



Business model used

The solution is offered as an added value to the refurbishment of the building and does not entail a specific business model. For this solution, the response of the client functions

as a test and will be essential to define the potential business model to apply.

Integration with other solutions

This solution is integrated with the solution "Smart Energy and Self Sufficient Block", which aims to reduce electric consumption in tertiary buildings through renewable energy, especially photovoltaic.

Expected Impact

The following positive impact are expected in terms of the key GrowSmarter objectives:

Improving quality of life:

Remote control of the monitored systems will allow ongoing adaptation of the conditions of different systems to the required comfort level of the users of the building.

Reducing environmental impact:

The use of BEMS will enable the identification of problems in the monitored systems, giving the opportunity to stop unnecessary consumption. Continuous improvements to the control system will help achieve reduction of consumption, emissions and costs.

Promoting sustainable economic development:

The use of the BEMS system is a sustainable solution for economic development in itself, because it helps to reduce costs by implementing an energy management policy.

Potential for replication

Although this solution does not require special pre-conditions for replication, it is important that the action is accompanied by an awareness raising campaign for users in order to promote diffusion on a grander scale.

Organisational resources and knowledge required within the public administration:

According to the Directive 2012/27/UE of European Parliament, public administration already includes the use of a BEMS system to realise energy audits in tertiary sector.

Stakeholders to be involved:

Owners and maintenance managers in tertiary sector

- Public administration
- Utilities
- Manufacturers and distributors ofhardware and software for BEMS

Potential barriers:

- Lack of involvement/commitment at decision-making level
- Lack of high-level training for the energy manager
- Lack of awareness on importance of energy management systems
- Lack of economic resources to implement the BEMS
- Lack of clear objectives after the implementation of the BEMS.
- Failure to achieve the organisational change required for the implementation of an energy management system (habits, recipes, attitudes, redefinitions of positions, to learn and unlearn, etc.)
- Communication problems between the energy manager and the decision-making level

GrowSmarter
Transforming cities for a smart, sustainable Europe

FACTSHEET

LOW ENERGY DISTRICT

Resource Advisor: a visualisation platform to assess the impact of energy retrofitting measures

PART OF SMART SOLUTION 4: SMART LOCAL ELECTRICITY MANAGEMENT

Figure 1 – Analysis Tools on Resource Advisor

- Tracking of energy consumption in buildings and calculation of carbon and energy savings compared to baseline
- Validation and verification of energy and carbon emission savings due to buildings' performance
- Clear communication and comparison of results across various Energy Efficiency Projects

Barcelona

Technical partner: Schneider Electric
Contact: adria.casas@schneider-electric.com
Resource Advisor homepage: www.resourceadvisor.com

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 646456. The sole responsibility for the content of this document lies with the author and in no way reflects the views of the European Union.

What is the solution?

Implementation of an Energy Management System (Resource Advisor) to allow tracking of energy conservation measurements. The system will allow the configuration of KPIs (Key Performance Indicators) and baselines, i.e. energy demand situation prior to retrofitting measures, enabling the user to calculate any energy demand savings achieved and the evolution of the variables that affect the consumption of buildings.

The Energy Management System will allow the creation of different user profiles with varied levels of access, making it accessible and secure.

How does it work ?

The Energy Management System will be cloud-based and based on HTML web-programming, making it accessible from any Internet connected device with a web browser . The Energy management System will be stored in a Tier III data centre, where the necessary data will be provided from an open data platform that collects energy-related variables of buildings retrofitted in Barcelona.

The Energy Management System will store and host historical information, while the data will be aggregated, hourly, daily or monthly, and displayed according to the users' needs through an intuitive user interface using dashboards and widgets on the internet. The data will also be available for download. Advanced users will be able to configure different KPIs and baselines in the platform, while general access users will only be able to view them.

Integration with other smart solutions

Connectors and APIs (Application Programming Interfaces) for the open data platform will be generated in order to feed the Energy Management System. Since the Resource Advisor allows for different metrics, data points and KPIS for other Smart Solutions could be tracked using the platform.

Expected Impact

The tool will allow users to track the evolution of the savings achieved by the Energy Conservation measures and ensure their continuity over time. The system will also provide clear data showing the impact of the various energy efficiency measures being implemented and how well they are meeting their targets. Therefore, the visualisation platform will also act as a validation tool.

The ability to provide different levels of user access allows for all stakeholders to have access to the data and achievements of the impact of the energy retrofitting measures of buildings in a transparent manner.

Potential for replication

Since the Energy Management System is cloud-based and allows for plain text data as well as customized metrics and KPIs, the solution is easily replicable if the appropriate systems are in place to collect data the goals are clearly defined.

MEET THE PROJECT TEAM:

GrowSmarter brings together cities, networks, academia and industry sharing a wealth of experience and technical know-how. To find out more, please visit **www.grow-smarter.eu/the-team**

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