GrowSmarter

Transforming cities for a smart, sustainable Europe

FACTSHEETS

LOW ENERGY DISTRICTS

1. Energy retrofitting of buildings
2. Smart building logistics
3. Smart, energy saving tenants
4. Local Renewable energy production

• STOCKHOLM • COLOGNE • BARCELONA •

GrowSmarter

Transforming cities for a smart, sustainable Europe

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About GrowSmarter:
In a rapidly urbanising world cities need to become smarter to respond to citizen needs and to reduce their environmental footprint. GrowSmarter brought together cities and industry to integrate and demonstrate '12 smart city solutions' in energy, infrastructure and transport, to provide other cities with valuable insights on how they work in practice and opportunities for replication. The idea was to create a ready market for these smart solutions to support growth and the transition to a smart, sustainable Europe.

About the publication: This booklet presents the solutions demonstrated in GrowSmarter under the action area Low Energy Districts.

More information: More information about the solutions described in these factsheets can be found in different reports on www.Grow-Smarter.eu/insights. Recommended readings include:

Concluding report Low Energy Districts

Report on technical and social validation

Report on Smart City market introduction

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SMART ACTION AREA 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.

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2. Energy efficient refurbishment of public tertiary buildings in Barcelona
3. Energy efficient refurbishment of private residential buildings
4. Energy efficient refurbishment of private tertiary buildings in Barcelona
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To find out more about the other solutions area please visit:
www.grow-smarter.eu/solutions

Energy efficient refurbishment of social housing

Smart solution 1
Energy retrofitting of buildings

Measured impacts

30%
gas energy savings for heating.

53%
of monitored dwellings increased thermal comfort in winter.

43%
reduction of dwellings dissatisfied due to temperature imbalance.

Barcelona

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What is it?

Energy efficient refurbishment upgrades existing properties in order to ensure a better quality of life for the residents, lower the environmental impact of the property and ensure a better safekeeping of the architectural heritage. This provides increased comfort and generates monetary savings for residents living in a social housing complex.

What did GrowSmarter do?

In Barcelona, different types of insulation were employed in the energy efficient refurbishment. Wool was used on ventilated facades while polystyrene was used on unventilated facades. This solution is designed to protect indoor spaces from outdoor weather conditions in hot and cold climates and help decrease energy leaks in the buildings that were retrofitted.

Within the scope of a broader city-wide action plan, Barcelona's Municipal

Housing and Renovation Institute included the passive energy refurbishment of a building of its property in Passeig Santa Coloma with a total of 207 dwellings and over 14,000 m2. External thermal insulation was added to the retrofitting of the deteriorated existing facade, and all blinds were replaced by more insulating blinds. The resulting impact is a proven increase of the indoor comfort of the tenants documented by survey campaigns before and after the intervention.

After the retrofitting, all baseline survey results were improved with fewer tenants being dissatisfied with indoor temperature during both hot and cold weather. The refurbishment also reduced gas energy consumption for space heating by 30%.

It is important to inform and educate tenants about the energy retrofitting value to increase social awareness and acceptance.

Lessons learnt

The Municipality gained new insights into user interaction aspects, such as the need for an early integration of neighbour-representatives into the project board in order to minimize social barriers and guarantee a majority's acceptance of the retrofitting action. Involvement of tenants also increased energy efficiency awareness among the users of the energy-retrofitted building.

Price-dumping in public tenders is a significant risk for this type of contracts. Guarantees and non-dumping strategies are recommended.

Upscaling & replication potential

It is recommended that relevant policies are adapted in advance to take advantage of the need for building structural refurbishment in the social housing sector and include energy efficiency criteria. This lowers the investment costs and fosters project replicability.

How did the measure work?

Technical feasibility ●●●

External Thermal Insulation Composite Systems is a proven technology to reduce building thermal load

Economic feasibility ●●○

Social housing owners generally cannot raise rents to balance their investments for energy savings. Reducing tenants' energy bills is a way to secure the solvability of the formers, thus limiting the amount of unpaid rents.

Replication potential ●●●

Social housing owners are key actors to be mobilized to reduce the energy consumption of the residential sector. The decision-making capacity and technical expertise in this sector is high, which facilitates reaching a very large number of dwellings with a single action.

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Energy efficient refurbishment of public tertiary buildings in Barcelona

Smart solution 1
Energy retrofitting of buildings

Measured impacts

48%
reduction in heating energy consumption (Library Les Corts)

12%
reduction in cooling electricity consumption (Library Les Corts)

84%
reduction of CO_2 emissions by the heating system (Ca l'Alier)

Barcelona

Technical partners

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What is it?

Retrofitting older and worn down industrial properties can be a unique chance to turn them into energy efficient and innovative public buildings. A wide variety of measures are used to achieve this, including on-site energy generation, connection to district heating and cooling networks, smart energy management and more. The retrofitting must be done in accordance with the municipal regulation for industrial heritage protection.

What did GrowSmarter do?

The Municipality of Barcelona has integrally retrofitted two abandoned textile factories to become new public buildings serving different purposes. One was transformed into the library Les Corts and the other into the urban innovation centre Ca l'Alier.

The retrofitting actions included both passive measures (natural ventilation, solar extractors, natural lighting, thermal insulation, etc) and active measures (radiant floor heating and cooling systems, LEDs with photosensors, variable speed fans, photovoltaics, district heating and cooling, etc.). Both buildings obtained very good scores in internationally recognized building energy performance certificates..

The renovation investment of the urban innovation centre Ca l'Alier was proposed as a public-private partnership signed between the municipality and private companies, giving these companies a temporary right to use a part of the building.

Public heritage buildings can be used as energy efficiency showcases. Adapting local building regulations can foster their energy retrofitting.

Lessons learnt

Energy-efficient renovation of heritage buildings provides a more attractive use and better occupation of these buildings while assuring a reduced energy bill. The integration of local energy generation respecting heritage preservation concerns has proven to be technically feasible. However, in order to ensure an optimal energy management of the building, it is crucial that staff receive training in the operations and maintenance of the innovative solutions in the building.

Working together with the urban planning department of the municipality already from the design phase of the project is strongly recommended in order to select the most appropriate innovative technologies that respect the historical value of buildings.

Upscaling & replication potential

Due to the high initial investment, all externalities must be taken into consideration when assessing the replicability of this type of action. Public-Private partnerships can be one path to locate the required initial funding. Studying the potential role of the building in a local energy community is recommended, since this kind of buildings can normally host large energy generation plants (photovoltaics) which may bring economic benefits from selling or exchanging the surplus electricity in the neighbourhood.

How did the measure work?

Technical feasibility ●●○

Passive energy efficiency measures must be adapted as heritage buildings limit any retrofit action involving modification of the external envelope. Integration of local energy generation respecting heritage preservation has proven feasible.

Economic feasibility ●●○

The economic driver is the creation of new public facilities while preserving the city identity through the revaluation of heritage. As such, the economic feasibility depends on a city's ability and desire to fund such projects.

Replication potential ●●○

Public heritage buildings can be used as showcases for social awareness on energy efficiency. Adapting local building regulations can foster the replication of heritage buildings energy retrofitting.

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Energy efficient refurbishment of private residential buildings

Smart solution 1
Energy retrofitting of buildings

Measured impacts

39% cooling energy savings at Canyelles building

22% heating energy savings at Ter building

38% cooling energy savings at Lope de Vega building

Barcelona

Technical partners

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What is it?

Energy retrofitting of private residential buildings with active and passive solutions. The buildings can be of different sizes, types and be located in different places in a city. The work can be done by a private Energy Services Company (ESCo) through both public-private and private-private agreements.

What did GrowSmarter do?

The Spanish energy company Naturgy retrofitted almost 20.000 m2 of residential property in Barcelona. The aim was to lower the energy consumption through different measures. In total 83 dwellings and 500 student rooms were retrofitted.

Four buildings were chosen for the retrofitting; Canyelles, Ter, Lope de Vega and Melon District. The three former all had passive solutions implemented and Canyelles also had active solutions implemented. Melon District was connected to the local district heating network.

Passive measures included façade insulation, roof insulation, new windows with less air leakage and blinds installation. The active measures included replacing old boilers, connecting to district heating and installing efficient water taps and a smart Home Energy Management System.

In some cases, Naturgy partnered with the public administration by participating in existing retrofitting programmes with the goal of reaching higher energy efficiency through a co-financing approach.

It is important to find low interest rate financing options to upscale the solution, as well as provide an insurance to the financing entity via for example the tax collection procedure.

Lessons learnt

Awareness campaigns with the tenants concerned before, during and after implementation, explaining the benefits of energy savings and higher comfort were found to be very important. These help reduce the so-called “rebound-effect”, where expected gains are not achieved due to a change in the behaviour of residents.

Low heating demand in mild climates such as the Mediterranean (compared to theoretical demand ratios) might lead to less significant energy savings compared to other climates. In this case, the combination of private investment by the ESCo and public funding from the Municipality has been the solution. There is a strong need for execution of the works in full coordination with the tenants, especially if they remain on-site during the refurbishment. When implementing energy retrofitting works in existing old buildings, structural problems may appear, which lead to delays on the energy retrofitting works.

Upscaling & replication potential

Subsidies from funds outside the municipal funding schemes are important to upscale this solution. In terms of replication, the approach of the private ESCo will be to partner with specific contractors in public energy retrofitting projects acting as the energy expert that controls and guarantees that the energy savings are achieved.

How did the measure work?

Technical feasibility ●●●

It is important to evaluate the impact with real energy consumption data (and use it as the base for subsidies), as it has been found that real demand is commonly lower than the theoretical ratios (existence of non-heated dwellings in mild climates).

Economic feasibility ●●○

The measure could increase its revenues by identifying everyone benefitting from the positive impacts. If residents change consumption habit (likely, as the cost of achieving better comfort levels is lower) and consume more energy, the energy savings (revenues) are lower than first calculated.

Replication potential ●●○

Economies of scale, i.e. the combination of structural and energy retrofitting works or large scale refurbishment (community scale) is seen as a very good option to explore for replicability. Shared costs reduce the investment costs and prepares tenants for the possible disturbances.

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Energy efficient refurbishment of private tertiary buildings in Barcelona

Smart solution 1
Energy retrofitting of buildings

Measured impacts

6%
of electricity covered by PV in educative centre

51%
heating energy savings in sports centre

58%
heating savings in the hotel

Barcelona

Technical partners

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What is it?

Energy retrofitting of tertiary buildings through a Business-to-Business (B2B) refurbishment contract offered by a private Energy Services Company (ESCo). The aim of the contract is to implement active and passive solutions to lower the energy demand of the buildings and guarantee that the targets are achieved through Measurement and Verification (M&V) plans.

What did GrowSmarter do?

The Spanish energy company Naturgy implemented retrofitting actions in order to lower the energy consumption of over 10,500 m2 of tertiary floor in Barcelona. Three buildings with very different uses were retrofitted: the hotel H10 Catedral, the educative centre Escola Sert and the sports centre CEM Claror Cartagena with a swimming pool included in its premises.

A wide range of measures were deployed including façade and roof insulation, replacement of windows, insulation of the pool and installation of dehumidifier in the sports centre, boiler replacement, new LED-lighting, a Smart Building Energy Management System, aerothermal heat pumps and adding photovoltaics into the building façades.

It is important to establish in the contract with the installers minimum quality levels

Lessons learnt

In order to guarantee potential energy savings of retrofitting projects, it is recommended that minimum quality levels and performance penalties are included within the ESCo contract.

The indicators to assess energy performance should be carefully reviewed by the ESCo and facility managers in order to understand all the variables behind the M&V plan. The monitoring equipment needed for the Measurement and Verification should be thoroughly designed in order not to add extra costs.

The installation of a Buildings Energy Management System can help the building operator to optimize the energy consumption and also make users (in this case students, hotel guests) aware of the positive approach they are taking towards consumption and production e.g. where photovoltaics were used.

Upscaling & replication potential

One aspect that impacts on tertiary refurbishment is the landlord-tenant split incentive issue (a circumstance in which the flow of investments and benefits are not properly rationed among the two parties). The company operating the facility may not invest on energy efficiency measures due to a too short concession period to recover the upfront costs. Possible solutions are public concessions that consider energy efficiency investments or green leases versus a regular lease by the Private sector.

How did the measure work?

Technical feasibility

The main technical obstacle is related to the definition of the baseline because of the lack of energy performance data.

Economic feasibility

Energy savings obtained by the implementation of active solutions has proven to have short payback periods attractive for private owners. Passive measures need longer paybacks, which can be shortened by combining the passive with active solutions

Replication potential

Private tertiary buildings are very good candidates for the replicability of energy retrofitting by an ESCo. For buildings with public concessions, the sometimes incompatible contract duration should be addressed by the public administration..

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Smart energy management in a private condominium

Smart solution 1
Energy retrofitting of buildings

Measured impacts

11% Savings on heating

19% Savings on electricity

14% Total energy savings

Stockholm

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What is it?

Implementing a series of energy-efficiency measures and a home energy management system to decrease the overall consumption levels of a private residential condominium. This makes the private apartments more environmentally sustainable.

What did GrowSmarter do?

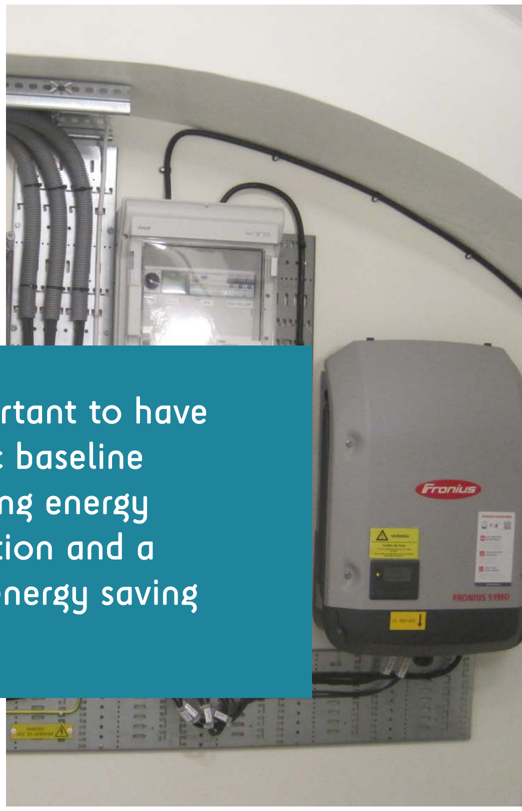
The service company L&T has installed different technologies and tools for smart energy management in the private condominium Årstakrönet with 56 dwellings.

These technologies include an adaptive control system for heating, indoor temperature meters in all apartments, smart ventilation control of the garage, water saving equipment, installation of electricity meters, district heating meter, water measurement equipment and photovoltaic installations and battery storage. An EnergyHUB was also installed to supervise the electrical usage *(See factsheet 16).*

All solutions implemented are monitored through L&T's Energy Saving Center *(See factsheet 14).*

Lessons learnt

A single installation of the smart technology equipment is not enough to guarantee the energy savings. In order to guarantee success, on-going work involving people living in the building is required, as well as proper maintenance and surveillance. It is advantageous in terms of lowering costs and benefitting from existing knowledge to make sure the industrial partner in charge of installing the equipment is the same as the technical facility manager of the building after the installation.



It is important to have a realistic baseline for building energy consumption and a realistic energy saving target.

When implementing energy efficiency actions in the private residential sector, it is recommended to have a really good communication with tenants' representatives (i.e. Board) and make them responsible for the contact with all the tenants/owners in the building. It is easier to reach a good communication/ acceptance with a group of representatives rather than all the tenants in the building.

Upscaling & replication potential

In order to succeed in replication, it is important to measure building energy performance prior to implementation. This will ensure a realistic baseline for the energy consumption of the building and a realistic energy savings target, since techniques are installed with promised savings that have to be proven. It is also important to coordinate the different solutions and techniques to avoid sub-optimisation.

When looking at achieved level of energy saving one have to take into consideration that this building is almost new where installed equipment is expected to have good function. Energy saving is in that way started from a higher level than from an older house.

How did the measure work?

Technical feasibility ●●●

Installation of the control and monitoring function is an established technology. It is an easy way to supervise installed solutions and ensure that theoretic values are achieved in actual savings.

Economic feasibility ●●○

The installation of these smart ad-on-technologies is self-financed with reduced heating and electricity costs.

Replication potential ●●●

Several different approaches to for optimize heating, electricity and indoor climate were tested at the same house. Each building has its own qualification making it important to select the right approach for each. it can all be supervised by Energy Saving Center.

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Energy efficient refurbishment of public housing area

Smart solution 1
Energy retrofitting of buildings

Measured impacts

76%
in total energy savings in buildings with geothermal heat pump

61%
in average total energy savings in buildings without geothermal heat pump

Up to 78%
in heating savings

Stockholm

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What is it?

Integration of energy retrofitting into a full-scale renovation of residential buildings owned by a public housing company. The scope of the energy retrofitting is very broad and is an outcome of the combination of passive and active technologies. The tenants gets apartments with higher standards and better indoor comfort after renovation, while the property owner benefits from lower energy and maintenance costs.

What did GrowSmarter do?

Skanska AB (project development and construction group) has implemented energy efficiency measures in six buildings with a total of 323 apartments in the area of Valla Torg in Stockholm. The buildings are owned by the public housing company Stockholmshem. Overall, the measure aimed at lowering the total energy consumption of the buildings being retrofitted by 60%.

The refurbishment involved the upgrade of thermal envelope and a combination of district heating, geothermal heat pumps, exhaust air heat pumps, photovoltaic cells and heat recovery from waste water. A new smart building management systems and indoor temperature sensors were installed. Tenants were also offered to have a home energy management system installed *(see factsheet 12: Active Home)*. Tenants had to be evacuated during the refurbishment.

The business model for the refurbishment is to lower the energy and maintenance cost of the building. Low-energy retrofitting like the one done at Valla Torg are expected be part of an attractive market in the future due to the low energy consumption and carbon footprint of the building.

It is important to use standardized solutions and to follow up on the building behavior in the evaluation phase.

Lessons learnt

In order to have the biggest impact of the energy renovation and to avoid barriers with tenants engagement and/or data privacy, energy measures at building level instead of the dwelling level are a good alternative. In this way, energy savings can be more easily quantified for the building owner. Information campaigns on being a climate-active-tenant by Stockholmshem also helped to get acceptance.

The main obstacle in this retrofitting was the tight schedule set for the project by both building owners and project managers. This is due to the fact that unforeseen obstacles often occur in large retrofitting projects. In this case, moisture and mould were found in apartments and more staff than planned were added to keep the schedule.

Upscaling & replication potential

In terms of replication, energy savings of 60% are a too ambitious target (the last 10-15% of energy savings are very costly). Interventions with the shortest possible evacuation of tenants should be pursued to enhance replication (very high cost and low acceptance).

How did the measure work?

Technical feasibility

The combination of active and passive technologies chosen for Valla Torg led to the ambitious goal of lowering the building energy demand by 60%.

Economic feasibility

The sum of all energy saving measures has a long payback time. However, some individual measures are very profitable. The value of the assets has increased after retrofitting, which significantly improves the financial analysis.

Replication potential

If the goal of a renovation is to reduce energy consumption and CO_2 emissions, Valla Torg is a good example. However, the last 10-15% of the energy saving measure can be a very high investment. Social approval has not been easy in this retrofitting project. In cases where the tenants must be evacuated, significant efforts are required for good communication between the housing company and the tenants.

Energy efficient refurbishment of public tertiary buildings in Stockholm

Smart solution 1
Energy retrofitting of buildings

Photo: Sven Lindwall

Measured impacts

28%
total energy savings in Kylhuset

57%
heating savings in Slakthus 8

47%
total energy savings in Slakthus 8

Stockholm

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What is it?

This type of energy refurbishment focuses on buildings that are listed as culturally and historically valuable. New energy efficiency criteria and local energy generation are introduced in an old industrial area of a city, now under transformation into a housing and commercial area with public services. It also introduces energy retrofitting of a publicly-owned commercial office building, mainly through active measures.

What did GrowSmarter do?

The City of Stockholm has implemented the integration of passive and active energy efficiency criteria in the full renovation of a heritage brick building (Slakthus 8) in the city’s old meat packing district. The building is now used as a cultural centre and is owned by the city.

Kylhuset, a publicly owned office building in the same area, had energy retrofitting interventions including the installation of a heat pump for waste heat recovery from a nearby data centre, delivered through the district heating network infrastructure, and photovoltaics.

Lessons learnt

Energy efficiency interventions in old heritage buildings are often justified by values other than mere energy savings, e.g. the will to protect the built industrial heritage and make it accessible for everybody or the use of the building as a kind of showroom for citizen education on energy-efficient practices.

The main challenge with the implementation was that the buildings are listed as culturally and historically valuable. Consequently, very thorough studies were required to define how the energy targets could be reached with the prelisted energy efficiency measures. It was important to carefully evaluate and agree on every single measure.

For the waste heat recovery action, the contractual condition that will determine the economic feasibility of the installation the price of the recovered heat sent to the district heating network, and the energy savings for the excess heat producer.

It is important to analyse each building as part of its surroundings to find possibilities for energy exchange.

Photo: Sven Lindwall

Upscaling & replication potential

Urbanization plans of the municipality affect the potential for replication, since the value of the building will increase when the area becomes more popular after the transformation process.

The intervention in Kylhuset has a high potential for replication as the applied active measures show a short payback time. The potential for upscaling the heat recovery from excess heat producers is directly dependent on the existing district heating network infrastructure and the number of stakeholders (the up-front investment for the heatpump is high).

How did the measure work?

Technical feasibility ●●○

The refurbishment and selection of energy saving techniques in buildings that are historically protected is challenging. The architectural demands can make installation cost higher.

Economic feasibility ●●○

Full renovation investments in old heritage buildings are often justified by other values than energy savings. The model used at Slakthuset could reach financial sustainability by marginally increasing rents

Replication potential ●●●

Due to the high initial investment, the replicability of energy retrofitting of publicly-owned heritage buildings is highly dependent on Municipality urban planning policies. The replication of heat recovery from nearby buildings depends on DH infrastructure.

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Energy efficient refurbishment of a residential settlement

Smart solution 1
Energy retrofitting of buildings

Preliminary impacts

Up to 59%
of heating savings depending on the building

Up to 61%
of total final energy savings depending on the building

687
dwellings refurbished with energy efficiency measures

Cologne

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What is it?

Integration of energy retrofitting into the renovation of residential buildings owned by a public housing company. The scope of the energy retrofitting is very broad and stems from the combination of passive and active technologies to reduce the net energy demand of the settlement.

What did GrowSmarter do?

In Cologne, the public housing company Dewog has implemented this large energy retrofitting project in 16 residential buildings with 687 rented dwellings in the Stegerwaldsiedlung neighbourhood. Initiatives taken include insulation of the buildings, triple glazed windows, efficient LED lighting in common areas, lifts with energy recovery and installation of photovoltaics.

Within the project, the energy company RheinEnergie was in charge of installing the photovoltaic panels, efficient heating pumps which are connected to the district heating network and monitoring equipment. Finally, all the buildings had a smart management system installed, which connects to RheinEnergie's Virtual Power Plant (see factsheet 17: Siedlungsmanagement).

In partnership with the City of Cologne, several events were held for the tenants with the aim of informing them about the impact of the energy retrofitting.

Lessons learnt

If rents are raised in order to finance the measure, good communication with the tenants is vital. Tenants may not appreciate the energy efficiency measures implemented in their homes until they experience a considerable reduction of their energy bills which is comparable to or more than the rental increase.

Intensive communication with the tenants is fundamental

In the implementation phase it is also necessary to be ready for unexpected obstacles, such as the lack of labour force, in case a tight time schedule has been set to for the retrofitting.

Upscaling & replication potential

The replication potential is high for this intervention since housing owners have the capacity to quickly reach a very large number of dwellings with a single action. The investment per dwelling can be lowered by contracting large projects.

In terms of construction works, the presence of scale benefits seems to be less significant, as current margins in the construction sector are already very tight. However, it is worth noting the existence of potential scale advantages at a building level through the single allocation of materials or the use of the scaffolding when having to work on certain elements of the facade.

How did the measure work?

Technical feasibility ●●○

Such large interventions require the nearly simultaneous recruitment of a wide number of contractors. A careful planning is crucial to guarantee minimal delays and ensure minimal impact on tenants' comfort.

Economic feasibility ●●●

Energy savings are enough to pay off the investment (high heating savings due to cold climate). However, the public housing company is not capturing the cost savings but dwellers do. Rents are raised due to the intervention according to legal limitations.

Replication potential ●●○

An ESCo (Energy Services Company) model could work to make the investment attractive for a private investor, as the tenants would be paying off the investment through a constant fee in their energy bills (the energy savings would be captured by the investor).

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Construction consolidation centre

Smart solution 2
Smart building logistics

Measured impacts

45%
reduction in CO_2 emissions

54%
less time spent by trucks in traffic

845
road minutes by trucks moved to nighttime

Stockholm

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What is it?

A centralised logistics depot for construction materials, where different product types are grouped into single deliveries for distribution to the construction site at the right moment. Waste can then be removed from the construction site using the same transport. With construction materials accounting for 30-40 % of goods moved around modern cities, this approach avoids multiple deliveries by various suppliers, and combined with using alternative fuel vehicles for distribution can help drastically cut emissions from freight transport.

What did GrowSmarter do?

The distribution company Carrier established a consolidation centre in Slakthusområdet, the GrowSmarter pilot area in Stockholm to supply an office-block construction site in Hammarbyhamnen with logistics for a refurbishment.

The original technical partner Skanska was unable to adapt the solution because it was introduced too late in the key planning process on the Skanska site. Instead a project by Arcona (a local Stockholm-based construction company), who was already preparing to handle logistics in a more advanced and digital way, at a challenging site in Hammarbyhamnen was chosen and the measure was moved to this construction site.

Lessons learnt

Carrier acquired experience in the operations of delivering consolidation services through the measure, enabling them to provide this service to other construction sites in the Stockholm area. Arcona, the local contract company, gained new insights into the organizational demands of logistics, such as the need for very early integration of consolidation into project planning and the need to adapt pre-existing supply agreements to enable consolidation to work more smoothly.

Municipalities could demand fossil-free transport at construction sites and regulate allowed transport volumes to promote consolidation centers.

Upscaling & replication potential

The scale of a construction project, along with its geographic location, influence the extent to which consolidation centres can deliver for less cost, less environmental impact and other benefits. Consolidation centres offer clear benefits when implemented at larger, complex sites (e.g. multiple construction projects, many actors operating and diverse deliveries' range).

The extent to which small-scale projects offer benefits varies depending on the local context and pre-conditions. To ensure maximum impact, regulatory authorities could introduce or extend zoning requirements to make consolidation of logistics services for construction and other traffic-intensive activities compulsory in the strategic context of reducing emission and traffic.

How did the measure work?

Technical feasibility ●●○

The measure is technically feasible.

Economic feasibility ●○○

The measure is not economically sustainable for a single agent or just one site. Including more actors or coupling the consolidation centre with major public infrastructure projects is needed.

Replication potential ●●○

Possible to replicate; important though to take into account what type of construction project it is (e.g. restoration/renovation or new construction) as the prerequisites can differ.

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Virtual Energy Advisor - open city home energy management system

Smart solution 3

Smart, energy saving tenants

Measured impacts

15%
electricity savings per household on average

>400
users signed up for the platform

300
dwellings with installed metering equipment

Barcelona

Technical partners

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What is it?

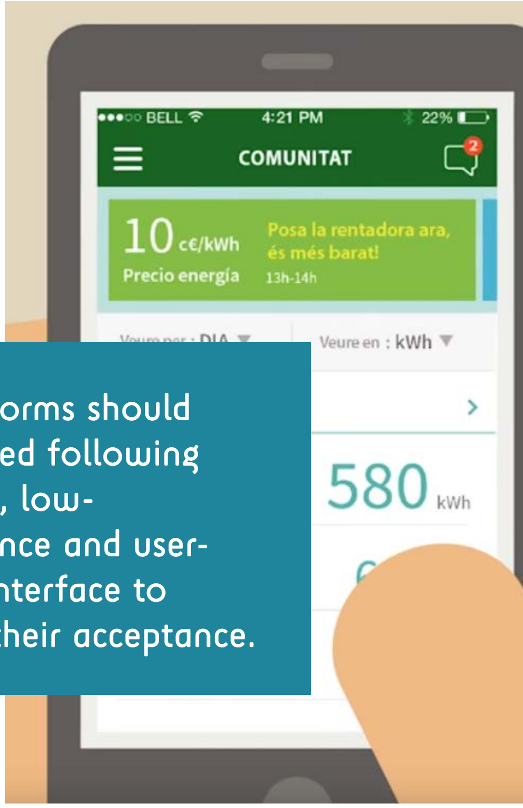
The Virtual Energy Advisor combines a user-friendly front-end visualisation with an intelligent back-end algorithm that uses data from electrical digital sub-metering equipment and other sources to share information about a household's electricity use. The front end can be viewed on multiple devices and it encourages behavioural change (and empowerment) among tenants.

What did GrowSmarter do?

Barcelona Municipality launched a campaign to encourage citizens to decrease their electricity consumption at home by providing the free electricity consumption visualization platform 'Virtual Energy Advisor'. The tool, provided to 450 citizens, is managed by a web platform and a mobile app.

The tool demonstrated several smart ways to inform and advice tenants on how to optimize their behaviour to achieve maximum energy efficiency and reduce their energy bill. On top of visualising the energy consumption, tips and advice on how to reduce electricity consumption, a virtual community to exchange experiences and comparison with earlier years, was all included in the app.

The measure was not intended to be self-financing as the aim of the municipality is to both focus energy policies on citizen awareness and collect electricity consumption profiles to foster suitable energy policies for the city as a whole. The Virtual Energy Advisor was developed within the municipality project 'Take charge of your energy' and was funded by Barcelona Municipality



City platforms should be designed following simplicity, low-maintenance and user-friendly interface to increase their acceptance.

Lessons learnt

The main barrier encountered during implementation of this measure was data confidentiality constraints related to evaluating the individual dwellings electricity consumption data. An agreement was signed with the users but massive data treatment by third-parties was still restricted. The discussion around data privacy should have been included in the process from the very beginning.

The impact of the platform on household electrical consumption has shown an average 15% reduction, which is 5 percentage points more than expected. However, it should be considered that the first campaign normally captures "early adopters" (citizens with an interest in energy efficiency), thus the impact of a massive upscaling could be lower.

Upscaling & replication potential

With this tool, the municipality is also able to gather detailed information on the residential electricity consumption profiles of the city based on district, building typology, etc. This feature can be the reason for Municipalities to upscale and replicate the measure, as they can use the information to foster suitable energy policies.

How did the measure work?

Technical feasibility ●○○

For its technical feasibility, it is important to clearly specify the operations and maintenance services required in the public tendering process and avoid connectivity issues to the maximum extent.

Economic feasibility ●●○

Based on a municipal policy, this measure has been completely financed with public funding, while the residents capture the economic benefits. The tool (targeting energy behavior) has proven as more beneficial in a Cost-Benefit Analysis compared to some passive retrofitting actions implemented by the Administration.

Replication potential ●●●

In order to avoid the costs of electricity sub-metering equipment, future implementations of this type could obtain the consumption data directly from the digital meters operated by the distribution system operator

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HEMS - private home energy management system in Barcelona

Smart solution 3
Smart, energy saving tenants

Measured impacts

18-27%
Electricity savings in combination with retrofitting

200
Installed prototypes

Barcelona

Technical partners

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What is it?

Deployment of a smart home solution to lower the energy demand in the residential sector through the visualization of customized individual energy data, real-time prices alerts of consumption, personalized recommendations on appliance level and control of specific appliances and indoor temperature. The solution includes a number of devices communicating to a central hub that sends data via WiFi to the corporate platform. The end user controls and sees those devices on an App. Devices include a thermostat, smart plugs and current clamps to disaggregate consumption.

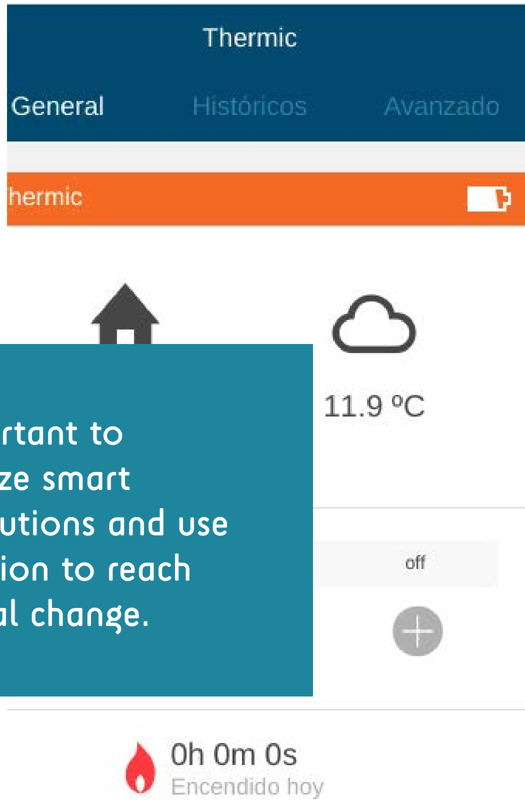
What did GrowSmarter do?

The energy company Naturgy developed a prototype a home energy management system (HEMS) for its customers in order to test the business model for allowing citizens to exploit smart services at home.

Naturgy has installed 200 prototypes in

different buildings around Barcelona that were already being retrofitted as part of GrowSmarter's efficient and smart climate shell refurbishment (see factsheet 3). The tool is managed by a tablet or smartphone, and also includes the visualization of electricity self-generation via photovoltaics.

Artificial intelligence algorithms are used to treat smart meter data in order to personalize energy advice and disaggregate end-uses of the household consumption.



It is important to personalize smart home solutions and use gamification to reach behavioral change.

Lessons learnt

It is essential for the correct technical operation of the measure, to work on reinforcing the communication chain to avoid connectivity issues. User engagement is crucial and HEMS must be accompanied by an awareness campaign for users in order to promote use on a larger scale. More active users will lead to better results.

Lack of awareness and/or mistrust of the importance of monitoring and management of energy consumption is the main barrier alongside end-user issues for tenants without basic technological knowledge. The app and hardware should be clear, intuitive and simple to use.

Upscaling & replication potential

The fact that the company providing the smart home system is an energy utility and retailer increases the potential for upscaling due to the existing easier access to consumer data (and right to use it). In order to scale up, an interesting option is to partner with construction companies to incorporate smart home equipment into new construction.

How did the measure work?

Technical feasibility ● ● ●

The battery duration based on communication protocols of devices should be optimized. The interoperability of final devices and gateways could be standardized.

Economic feasibility

The open home net is becoming a more common infrastructure in apartments, offering shared sensors and actuators. By sharing the sensors needed to provide different services in apartments, it is possible to add many services at a low cost and facilitate the upscaling of smart home systems.

Replication potential ● ● ●

The upscaling of smart home solutions is based on market demand of home monitoring and control services that will significantly increase on coming years. Demand-response and flexibility services will also have a direct impact.

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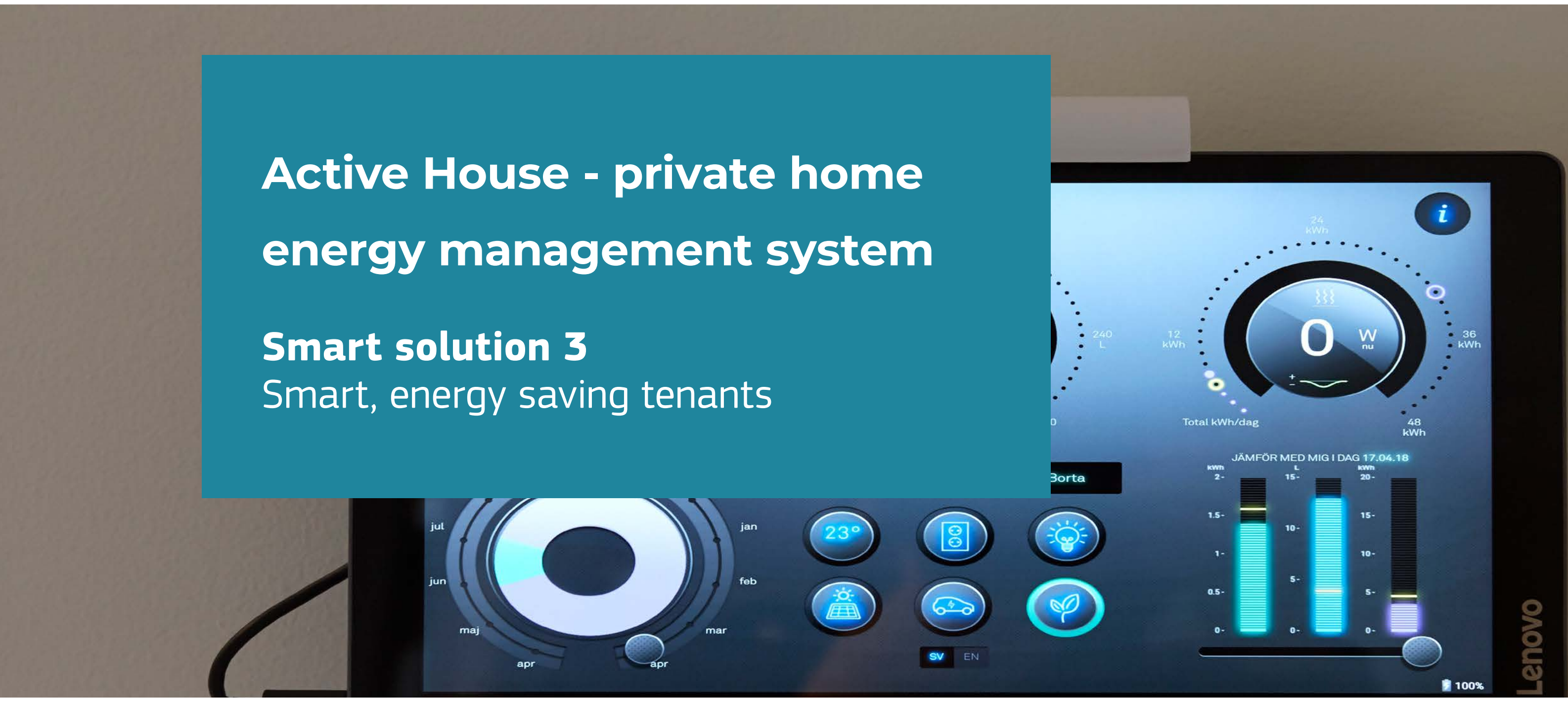

Active House - private home energy management system

Smart solution 3

Smart, energy saving tenants

Measured impacts

54
homes had the HEMS installed

RAISES
awareness of energy consumption

EMPOWERS
residents to discover and change consumption patterns

Stockholm

Technical partners

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What is it?

Deployment of a smart home energy visualization system to lower the environmental impact of the energy demand in the residential sector by influencing tenants' behaviour with individual energy data. The tool is linked to lights and thermostats that allow the user to control lighting and radiators remotely on top of monitoring consumption (electricity, hot water, space heating) in real-time. It is also possible to access a function that combines price data with environmental data, so the tenant can optimise the household's energy consumption accordingly.

What did GrowSmarter do?

A start-up within the Swedish utility company Fortum has developed the Active House application (a smart home solution) and installed it in 54 apartments in Valla Torg that have undergone energy efficient refurbishment as part of GrowSmarter (see factsheet 6). The tool is managed by a tablet and an app and presents customized individual energy data, temperature, etc.

The implementation of Active House requires several preliminary activities: get consent from tenants, installation of meters and dimmers and connect them to a smart hub for collecting the information data, installation and adjustments of the tablets in the apartments, and teaching the tenants to use the Active House tool.

Overall, this solution was a new business area for Fortum and these first implementations were an opportunity to start developing the market for this solution. The company is now planning to start a commercial project in Stockholm and has attracted customers from large building operator companies.

It is important to use the tool to tackle behaviour-awareness-change & teach tenants how to live eco-friendlier.

Lessons learnt

Teaching the tenants how to use the Active House solution is an essential activity in the deployment of this measure and the associated costs of these information campaigns are necessary. The basis for energy reduction is raising users' awareness and increase their willingness to become more environmentally friendly.

Upscaling & replication potential

The solution has already been further developed with new features such as burglar alarm, motion alarm and flooding alarm. Fortum intends to sell this solution by integrating it with other services for households in order to make the solution economically feasible.

How did the measure work?

Technical feasibility ●●○

In solutions that involve the use of so many sensors, improving battery life presents a challenge, as batteries normally need to be changed by the tenants or the building managers, thus the longer they last the more convenient for its technical feasibility.

Economic feasibility ●○○

If the implementation is done only to save energy, it is not economically feasible. If a bigger picture is taken with the future lack of power in urban grids, the potential economic benefits of this kind of tool are broadened.

Replication potential ●●○

The more people who uses this solution, the easier it is to scale up (more potential clients). Using the tool for demand-response at the overall building level (and not at the apartment level) is seen as a promising service that this solution can provide which would increase its replication potential.

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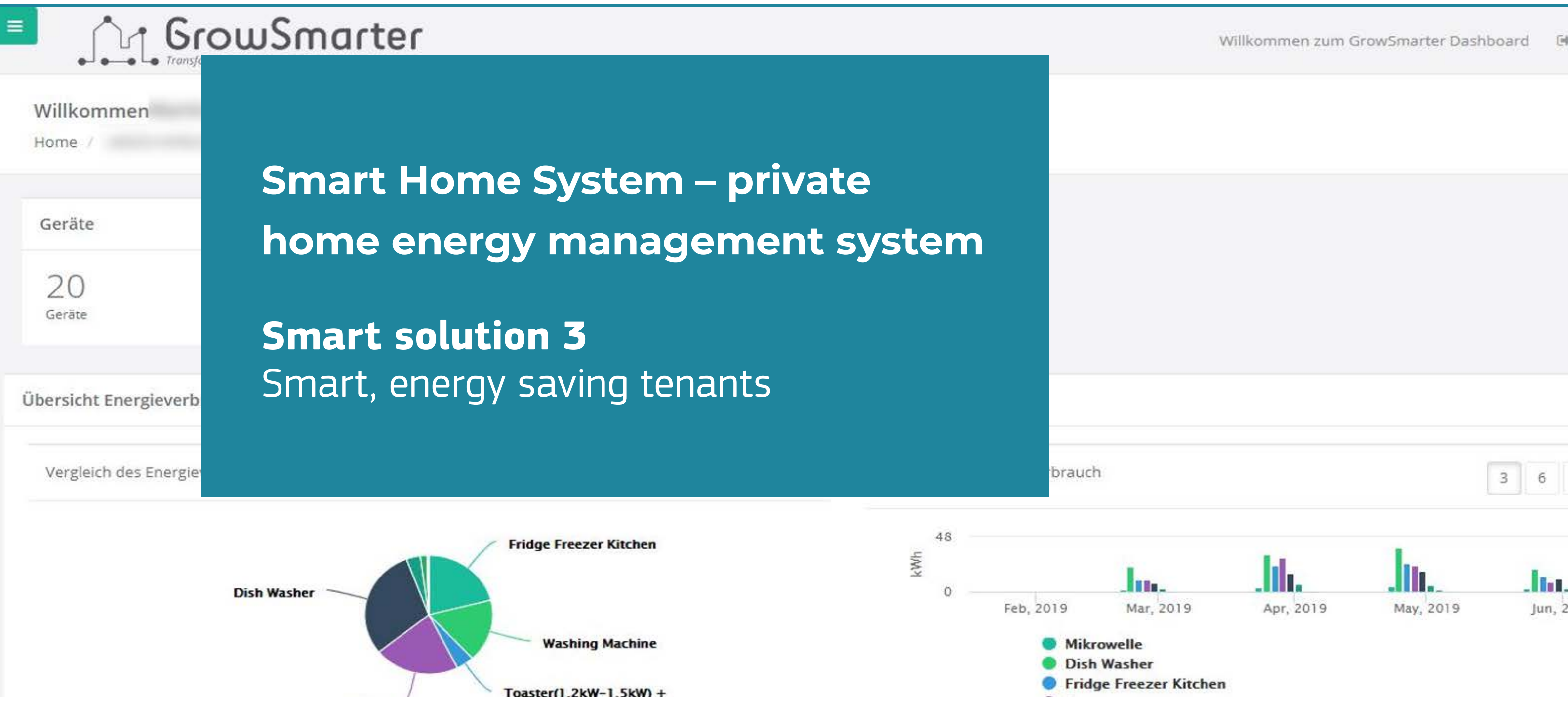

Smart Home System – private home energy management system

Smart solution 3

Smart, energy saving tenants

Estimated impacts

95 KG/A
reduction in CO_2 emissions

8%
energy savings

24H
automatic and optimized heating control

Cologne

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What is it?

Deployment of a smart home system focused on automation or better control of domestic appliances. The system includes heating thermostats, sensors for the state of windows (open/closed), smart plugs, indoor temperature and humidity sensors, and it offers the possibility of programming on/off status of devices from the app. The ultimate goal is to improve tenants' quality of life, as the decrease in energy consumption is not the main target.

What did GrowSmarter do?

The German utility RheinEnergie has developed a prototype of the Smart Home System for its residential clients. An evaluation process lead to the Smart Home System which supports multiple radio protocols and open API to integrate the data into AGT's system (See factsheet 23: 'Smart meter info'). The technology was offered to all households in the Stegerwaldsiedlung settlement and it has been installed in five dwellings.

The feedback from those five dwellings was generally very positive, and all responders in a qualitative survey reported having an easier time heating their home and better ability to estimate their power consumption.

Lessons learnt

The qualitative follow-up (via surveys) of the new technology performance is a good tool to evaluate how the Smart Home system improve the quality of life. Good communication with potential clients is essential. In terms of data collection, a contract must be drawn up which gives the participant a clear and comprehensible understanding of what data is being collected and for what purposes.

Early and extensive communication is beneficial

The communication campaign with the tenants should be planned well in time to inform about the advantages of this solution and overcome their doubts to share their energy consumption data.

Upscaling & replication potential

Expanding the functionalities of the Smart Home system by including information on disaggregated and real-time energy consumption data will raise the potential for scalability of the platform.

Considering the experience in GrowSmarter, an intensive market study to investigate the interests of residents in the target group is crucial. Citizens are in general not familiar with the technology. Information and engagement campaigns to raise awareness about the benefits of Smart Home systems would contribute to the upscaling of the solution.

How did the measure work?

Technical feasibility ●●●

Promoting dynamic energy visualization tools in the German residential sector is still very challenging, since tenants are reticent to trust uncertified individual meters and they prefer to wait for the certified ones (not deployed in the country).

Economic feasibility ●○○

The economic feasibility is very sensitive on data collection possibility. With the current functionalities, the monetization of the increase of comfort could justify the investment, although it is uncertain if clients are prepared to pay for this service.

Replication potential ●●●

Considering the experience in GrowSmarter, an intensive market study to investigate the interests of target residents is crucial. This should be accompanied by information and engagement campaigns in order to replicate or scale up Smart Home systems

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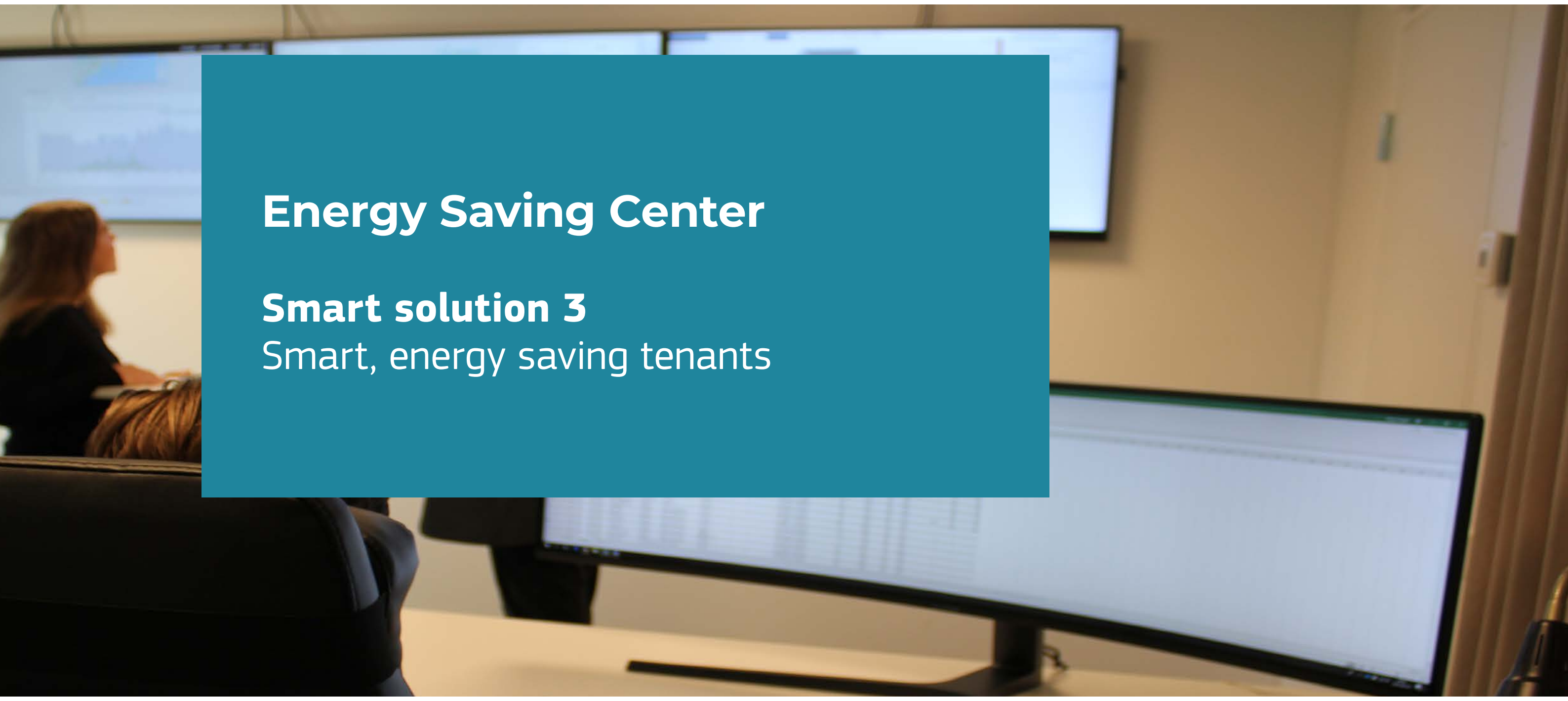

Energy Saving Center

Smart solution 3
Smart, energy saving tenants

Impacts

Controls
Installed equipment

Analyses
energy consumption

Optimises
energy consumption

Stockholm

Technical partners

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What is it?

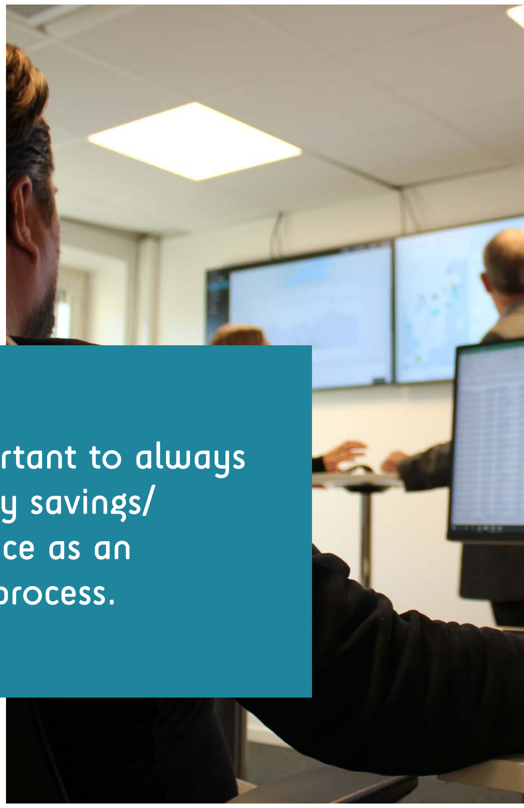
An internet-of-things platform that is to be used as a building energy management system (BEMS). The platform improves building energy performance by helping the decision-making process related to the application of energy efficient measures. The solution works for both tertiary and residential buildings. The Energy Saving Center (ESC) offers proactive monitoring of the customers' installations and a regular analysis of building energy consumption data for its optimal use, and includes an adaptive heating control system.

What did GrowSmarter do?

The service company L&T developed the tool 'Energy Saving Center' and implemented it in the GrowSmarter testing grounds of the residential buildings Brf Årstakrönet and Valla Torg, the office building Kylhuset and the cultural centre Slakthus 8.

The building's new, or existing control systems, were connected to the ESC while other smart meters, such as temperature-, CO_2 sensors and moisture-meters, were connected in order to make a platform for a smart building. Data was also 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 was made to regulate consumption 24/7.



It is important to always see energy savings/ surveillance as an ongoing process.

Lessons learnt

Working on a building level brings fewer privacy concerns compared to smart home systems. Depending on the type of building owner (e.g. corporative or public administration buildings), the collection of measurement data may present some challenges due to the required development of a communication chain through different networks (firewalls). This should be considered in implementation planning phase.

Upscaling & replication potential

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.

Including the energy surveillance tool in packages with other building services will reinforce the replication potential. The monitoring and decision-support software tool for the operation and maintenance of energy installations can also be sold together with other computer-based systems used to monitor and control services such as lifts, fire safety, ICT networks, or security systems.

How did the measure work?

Technical feasibility ●●●

All installations involved with energy saving should be supervised in some way to secure the result. Not doing so poses a risk for sub-optimization with different systems working in opposite ways. This can be avoided by central control.

Economic feasibility ●●○

The tool brings proven savings for the building owner: reduction of heat, electricity and water costs during building operation.

Replication potential ●●●

Developing the business model from B2C (Business-to-Consumer) to B2B (Business-to-Business) could be a good opportunity to upscale the solution.

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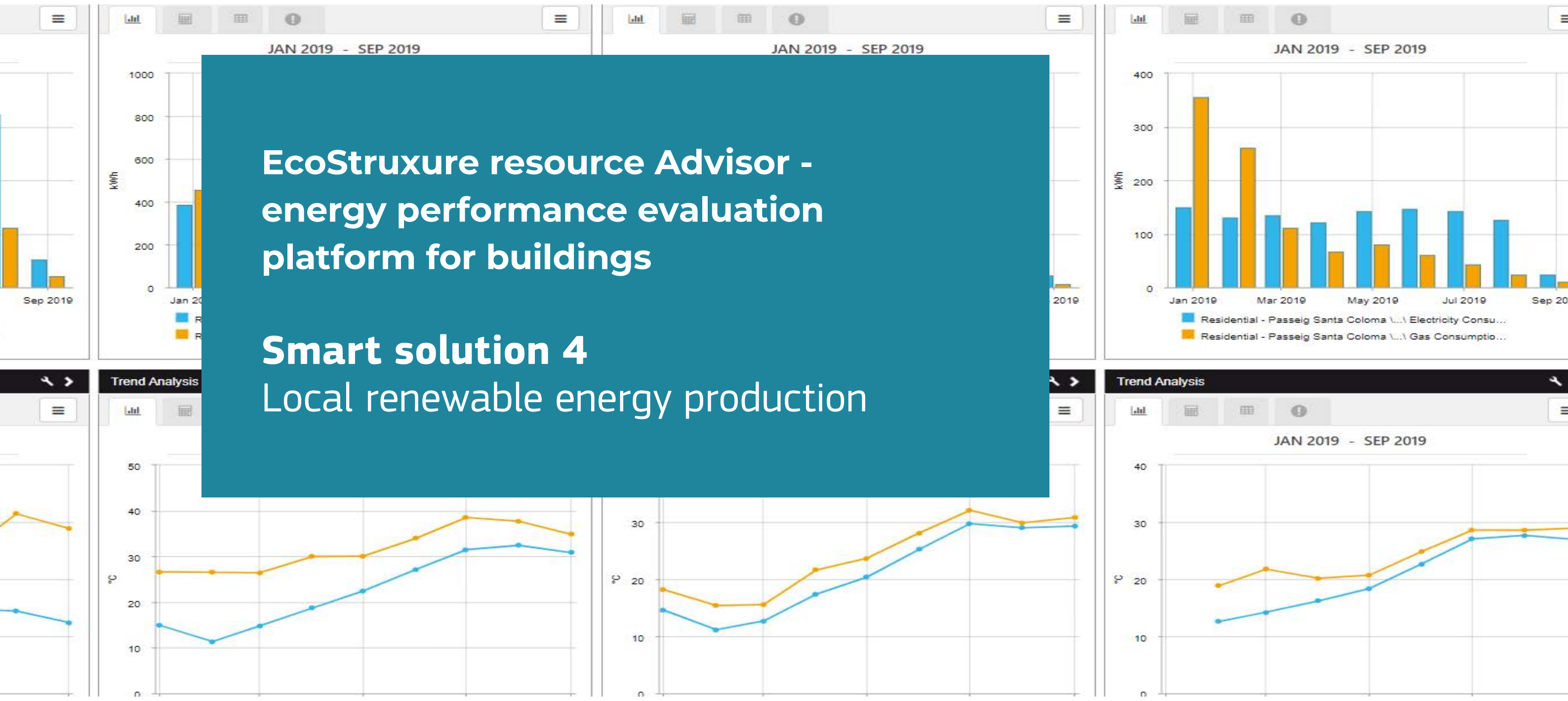

EcoStruxure resource Advisor - energy performance evaluation platform for buildings

Smart solution 4
Local renewable energy production

Estimated impacts

5%
reduction in CO_2 emissions

1
platform to manage results

+48.000
users of the EcoStruxure Energy Advisor (also outside GrowSmarter)

Barcelona

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What is it?

The EcoStruxure Resource Advisor is an Internet-of-things (IoT) platform fully aligned with the Clean Energy Package that empowers citizens to increase their sustainability by socializing energy preservation.

The EcoStruxure Resource Advisor aggregates multiple types of data from every part of a building in order to centralize information. This cloud-based software allows assessment of Key Performance Indicators (KPIs) to evaluate the impact of energy retrofitting works in a building. It identifies outliers and provide opportunities to increase energy efficiency in the building which ensures the projected energy savings can be achieved over time.

What did GrowSmarter do?

In Barcelona, Schneider Electric has used its cloud-based platform called EcoStruxure Resource Advisor to centralize the monitored data from some of the buildings retrofitted within the project. The tool shows KPIs based on the gathered data for the evaluation of the impact of energy retrofitting works in the buildings and informs citizens of the impact.

Lessons learnt

Automatic data gathering should start well before the retrofitting works to ease the creation and follow-up of the baseline and to avoid the strong dependence of monitoring systems with the finalization of retrofitting works.

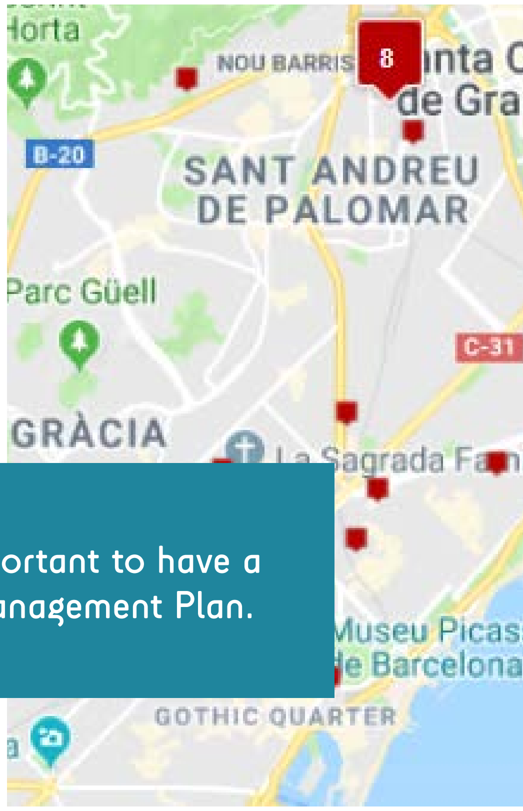
Also, clarity on who is responsible and accountable for Data Quality across the data transmission chain is necessary. Privacy as well as any Information technology (IT) security concerns should be tackled at the beginning of the project. The EU General Data Protection Regulation (GDPR) required additional security measures, software development and legal considerations, which resulted in an increased development cost and therefore selling prices – even for industrial-based applications such as this one.

User engagement is of critical importance when dealing with solutions such as the Ecostruxure Resource Advisor. The final consumer should be made aware of the real benefits of the measure, and the industry partner could highlight the potential economic savings that a building energy management system is able to provide. Schneider Electric estimated 15 percent CO_2 reducations are achievable. The public sector could promote the measure, with the purpose of fulfilling environmental targets.

Upscaling & replication potential

The integration of this type of monitoring platforms in Energy Performance Contracts (EPC) is regarded as a promising option to increase replication potential. The setup, use and maintenance of the software are subject to a contractual agreement.

In a commercial environment, this type of tool is usually necessary for the stakeholder responsible for guaranteeing the energy savings and becomes a regular tool to follow the sustainability performance and the goals achievement.



It is important to have a Data Management Plan.

How did the measure work?

Technical feasibility ●●●

The standardization of communication protocols would significantly facilitate the technical feasibility of the measure.

Economic feasibility ●●○

The platform is usually financed within a recurring services contract. As it is difficult to attribute savings to a monitoring platform, the measure is not intended to be self-financed as a standalone, but as a necessary part of self-financed solutions of active energy efficiency measures.

Replication potential ●●●

Improved and adequate regulatory frameworks for the energy management industry (in terms of standards and protocols) would enhance the replication potential.

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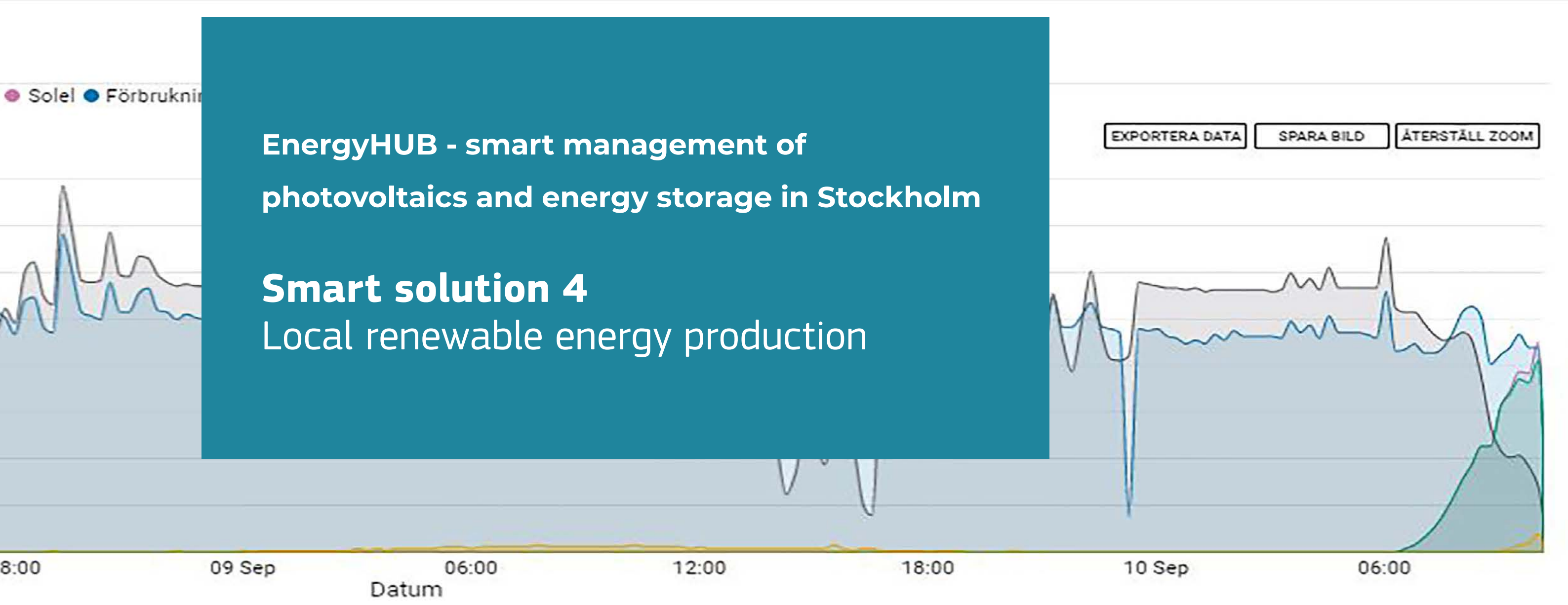

EnergyHUB - smart management of photovoltaics and energy storage in Stockholm

Smart solution 4
Local renewable energy production

Measured impacts

17% of Årstakrönet's electricity supplied by EnergyHub

9% of Kylhuset's electricity supplied by EnergyHub

5% of Slakhuset's electricity supplied by EnergyHub

Stockholm

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What is it?

Installation and management of photovoltaic units and electrical storage with smart energy management software in both tertiary and residential buildings. The management software gathers relevant information and optimizes the energy flow among solar panels, energy storage and the grid in order to maximize battery usage and perform peak shaving strategies.

What did GrowSmarter do?

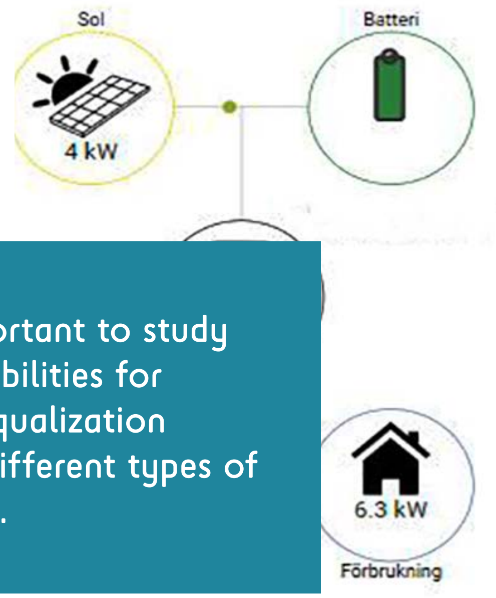
The service company L&T has installed photovoltaics, electrical storage and an inverter under the control of the so-called EnergyHUB management unit in both tertiary buildings retrofitted by the City of Stockholm (Slakthus 8 and Kylhuset) and in the private residential buildings of Brf Årstakrönet and the social housing of Valla torg.

Among several benefits the EnergyHUB works as a converter of electric current from DC to AC and AC to DC AC to DC and

Adaptive Current Equalization enables a lowering of the size of main fuses reducing the cost of the fixed fee.

Lessons learnt

The installation of the management software in different types of buildings (residential and tertiary) allows observation of how electrical power is used over time and finding possibilities for power equalization between different types of buildings. The analyses also provided information which was useful for the installation of the, photovoltaic cells ,in that they should be directed, not in the optimal direction, but where they can deliver optimal result when the use of electricity in the building reaches its peak, around 4pm.



It is important to study the possibilities for power equalization among different types of buildings.

The buildings had different groups of residents with different approaches to power consumption over time. Multi-family houses, industrial buildings and office buildings were all included in the Energy Hub. There is clear proof, that the power used in the multi Family house peaks at different times than the office buildings. This needs to be further analysed but show the potential for peak shaving between different types of building is large. This would enable an overall improved use of the power grid.

Upscaling & replication potential

One of the main goals of the energy optimization in this measure is peak shaving, which is considered to be a major topic in the near future due to the forecasted congestion of the electrical grids in cities. In this sense, it is expected that the measure has a high potential for upscaling and replication.

How did the measure work?

Technical feasibility ● ● ●

Using an EnergyHUB ensures that different systems involved in energy production consumption are synchronized. This optimizes the outcome of energy used and reduced the power load.

Economic feasibility ● ● ●

Reducing the amount of bought energy in combination with lower peak loads enable this technology to be self-financing. The need to lower peak loads is increasingly providing opportunities to share free loads between different types of buildings.

Replication potential ● ● ●

All buildings with the potential for and ambition to install PV cells, battery storage, EV charging stations and an interest of lowering the peak loads, could benefit from a solutions as EnergyHUB to monitor and control their energy use..

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Siedlungsmanagement - energy management system at neighborhood level

Smart solution 4
Local renewable energy production

Measured impacts

6000
data points every 15 minutes

36H
forecast of all systems

73
energy systems controlled

Cologne

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What is it?

The solution consists of a virtual power plant (intelligent management system) that connects local photovoltaic production, heat pumps and batteries to outside energy production. The system operates at neighbourhood level and optimizes energy and heat consumption by connecting internal energy producers (photovoltaic, heat pumps, and battery storage) and external ones (district heat). The project leads to a partly self-sufficient energy supply which results in less pressure on energy grids, lower carbon emissions, and better air quality.

What did GrowSmarter do?

The energy company RheinEnergie implemented the Siedlungsmanagement software to maximize the self-sufficiency of the Stegerwaldsiedlung neighbourhood (16 buildings) being retrofitted in GrowSmarter *(See factsheet 8: 'Energy efficient refurbishment..')*. The software manages the performance of 41 heat pumps, 1068 kWp of photovoltaics, district heating for peak loads, and 16 batteries . A charging station for electric vehicles (cars and pedelecs) is also integrated into the settlement.

Meters installed during the retrofitting of the Stegerwaldsiedlung measure and predict energy consumption patterns in each apartment. The system forecasts and optimizes energy consumption for the next 36 hours, updating every 15 minutes.

It is important to ensure that external control is possible before purchasing any equipment to be integrated with the software.

Lessons learnt

Connecting and controlling power systems to a new external control unit is a challenge. The manufacturers of the systems must provide access to the control unit and the necessary IT protocols.

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

Upscaling & replication potential

This measure is the first of its kind in Germany. Because of this, uncertainty about what must and must not be monitored in all energy flows in the settlement has been found. Discussions with expert lawyers to identify critical points to comply with the new Renewable Energy Act in terms of the interaction with the grid operator were carried out. The outcome of these discussions will be very useful for replication.

How did the measure work?

Technical feasibility ●○○

The electricity consumption forecast module of the smart energy management system will not provide so accurate results due to the impossibility of monitoring electricity consumption at dwelling individual level.

Economic feasibility ●○○

A larger implementation of this solution would increase the economic feasibility. The target groups are housing agencies and other energy providers. The software can be run based on minimizing energy costs for the settlement, which is beneficial for the settlement‘s manager in case it charges a fixed fee to its tenants.

Replication potential ●○○

Most of the manufacturers do not expect their devices to be part of such a complex energy management system. Intense discussions were required with the manufacturers on how their devices can be externally controlled. This should be accounted for replication purposes.

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Smart management of photovoltaics and energy storage

Smart solution 4
Local renewable energy production

Measured impacts

65%
of communal space power consumption at Sibelius covered by PVs and storage

20%
of power at Valldonzella covered by photovoltaics and storage

4%
Self consumption in BTC Naturgy Center

Barcelona

Technical partners

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What is it?

Installation of Photovoltaic units and electrical storage with smart energy management software in both tertiary and residential buildings, including different innovative PV cells (i.e. half-cell) and different urban integrations (i.e. PV pergola). The management software gathers relevant information and optimizes the energy flows based on the real-time operation and the forecasts of building consumption, weather and grid electricity prices.

What did GrowSmarter do?

The energy company Naturgy tested the viability of the business model as an ESCo that offers electricity self-consumption installations (PV and battery) to building owners. The research centre IREC developed the smart management software that controls the battery storage to optimize the performance of the system (usage of renewables, emissions, costs, etc.). These local electricity generation units were installed in the residential building Sibelius (electricity used for the common staircase electrical consumption), the youth day-care service centre Valldonzella and at Naturgy's headquarters in Barcelona. The inputs for the smart management system developed at IREC include: weather forecast affecting energy production, electricity prices forecast and building demand forecast in order to correctly balance the system in real time

It is important to have a favorable regulation for the installation of distributed energy resources that makes them economically attractive.

Lessons learnt

It is important to define a database maintenance procedure. The required accurate monitoring of smartly controlled self-consumption systems leads to a collection of very large amounts of data. Database maintenance is very important in order to have consistent data. Depending on the battery inverter manufacturer, the integration of energy management systems may be technically challenging.

Having regulation that facilitates the installation of distributed energy generation units is key for its replicability. New Spanish regulation (RD244) has allowed the collective self-consumption (i.e. various consumers associated to a photovoltaic generation installation) with different specificities. This use drastically reduces the payback period and is beneficial in case of multiple consumers with complementary load curves.

Upscaling & replication potential

It is only recently that the Spanish Government has approved a law that allows different consumers to own the same on-site energy generation unit as well as sell the surplus electricity to the grid. These kind of regulations increase the possibilities of applying smart management of local energy generation and enhances scalability.

How did the measure work?

Technical feasibility ● ● ●

Controlling the devices as planned in the energy management system definition may be challenging. Partnering with battery inverter manufacturers can be a good option to explore. The urban integration of photovoltaics is also an aspect to consider: Municipal Ordinances should ease the rooftop usages for photovoltaic generation.

Economic feasibility ● ● ●

Tax exemptions applied by Municipalities for PV installation shortens the payback periods and improves the ROI. For its economic feasibility, the acquisition of batteries by small/medium customers requires incentives from public institutions.

Replication potential ● ● ●

In order to reach the full replication potential of the solution, the two main drivers are a favourable regulation and a reduction of battery costs (through e.g. public incentives).

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MEET THE PROJECT TEAM:

GrowSmarter brought 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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www.grow-smarter.eu

STOCKHOLM

COLOGNE

BARCELONA