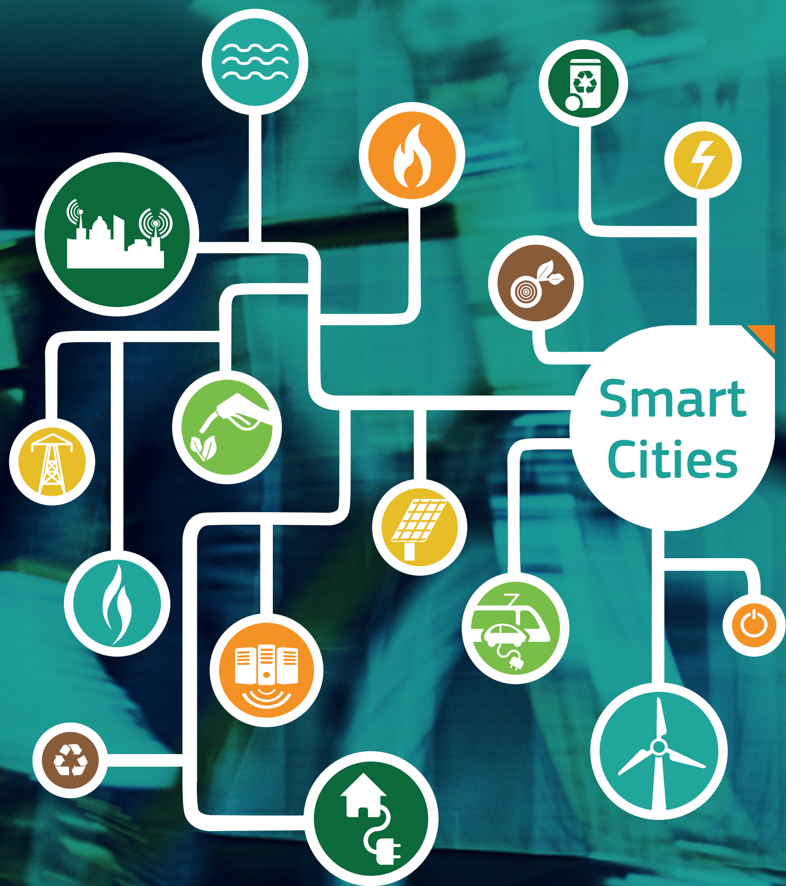
European Commission

The making of a smart city: **best practices across Europe**



EU Smart Cities Information System

EMPOWERING SMART SOLUTIONS FOR BETTER CITIES www.smartcities-infosystem.eu

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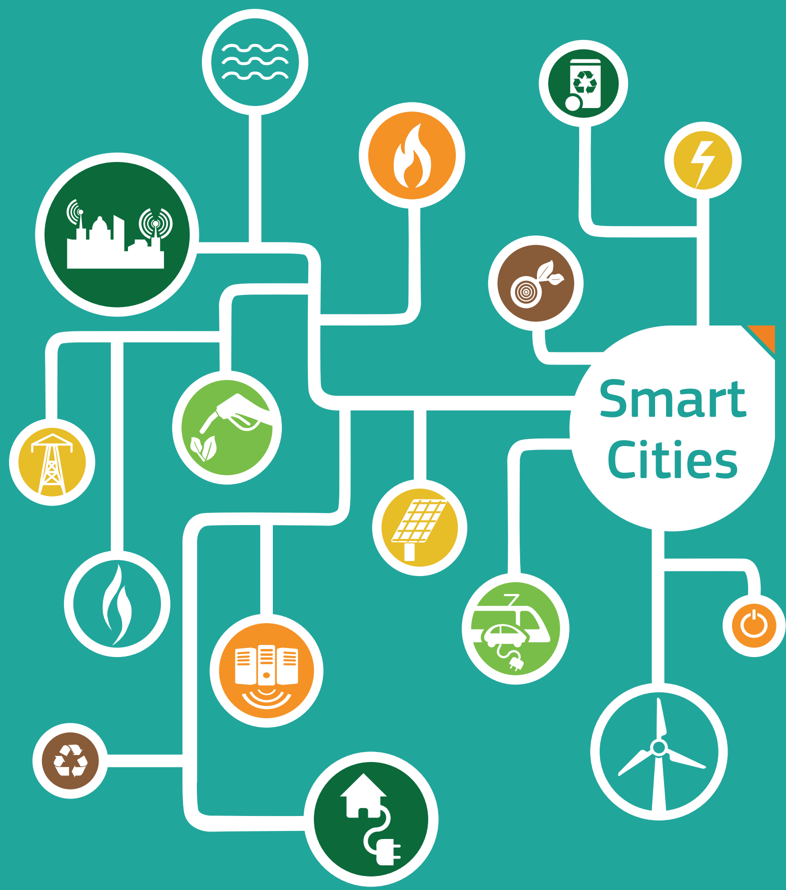
The making of a smart city: **best practices across Europe**



EU Smart Cities Information System

EMPOWERING SMART SOLUTIONS
FOR BETTER CITIES www.smartcities-infosystem.eu

Foreword

The making of a smart city

Ensuring a secure, sustainable and effective clean energy transition is one of the European Union's priorities and one of the key elements of the Energy Union.

Cities will play a key role in the transformation of the energy sector by changing the way they use energy. They are responsible directly or indirectly for approximately three quarters of all energy consumption and greenhouse gas emissions so cities have an important role in helping us meet the decarbonisation objectives of the EU for 2030 and 2050. Their influence goes far beyond their energy consumption and emissions. The commitment of cities and their inhabitants is also crucial to tackling the socioeconomic and environmental challenges facing Europe today. This is why in 2016 the EU launched the Urban Agenda to harness the growth potential, liveability and innovation of European cities through cooperation between cities, Member States and the European Commission.

The transformation of the way energy is produced, consumed and transported in the EU will require commitment, dedication and innovation with and between actors in many sectors. It will be a story of innovators and investors, as well of citizens adopting new ways of living and interacting. It is a collective movement built by big and small changes. Much will depend on the spread of good practices and learning of successes and mistakes. A key element will be sharing the knowledge gained from the many projects in cities to encourage the uptake of pilot solutions and discoveries made by pioneering cities.

The European Commission for its part supports many projects through funding programmes, such as in particular Horizon 2020, that are investing in technological solutions and socio-economic practices that lead to energy smart cities.

In this publication, the Smart Cities Information System has gathered together the best practices from over 80 cities from across 19 countries. These projects showcase how forward thinking on a grand scale can introduce technological advancements not only to buildings and districts, but also entire local communities. The cities presented here are using innovation to encourage wiser, more efficient and more effective energy use and smart living.

The creation of smart cities is a motivator for growth, new jobs and is a productive investment in Europe's future, leading to a sustainable, low carbon and environmentally friendly economy, as well as putting Europe at the forefront of renewable energy production.

I congratulate these energy pioneers for their achievements and encourage you to take up their best practices and bring innovation to your city, region and country.

Dominique Ristori

Director - General for Energy

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Introduction | Smart Cities Information System: Empowering smart solutions for better cities

Ensuring that successful innovative technologies tested in European cities are replicated in other budding projects lies at the heart of the Smart Cities Information System (SCIS). Bringing together project developers, cities, institutions, industry and experts from across Europe, SCIS encourages the exchange of data, experience and know-how to collaborate on the creation of smart cities and an energy-efficient urban environment.

SCIS encompasses data collected from ongoing and future smart city and energy-efficient projects co-funded by the European Union. The data is collected through digital tools and displayed on one website platform1, conveniently accessible for users, which encourages the input of data from city projects. From this stored information, analysis can be drawn and recommendations can be made to allow replication and the spread of good practice.

However, SCIS is more than just a database of projects and a list of project-specific problems or an inventory of high-level policies. Focusing on energy, mobility and transport, and ICT, SCIS showcases solutions in the fields of energy efficiency in buildings, energy system integration, sustainable energy solutions at district level, smart cities and communities, and strategic sustainable urban planning.

SCIS provides support to stakeholders through two key kinds of output. One is through technical information provided via a specially developed self-reporting tool and visualised on the website; the second is through the lessons and recommendations from the projects collected in surveys, which are collected and classified on the website.

With the aim of fostering replication, SCIS analyses project results and experiences to:

- establish best practices, which will enable project developers and cities to learn and replicate;
- identify barriers and point out lessons learned, with the purpose of finding better solutions for technology implementation and policy development;
- provide recommendations to policymakers on support and the policy actions needed to address market gaps.

As part of the initiative's ambitions to replicate the work of smart city projects, SCIS is producing three publications:

- The making of a smart city: policy recommendations for local, national and EU decision-makers will reach out to decision-makers at local, regional, national and European levels to advise them on analysis drawn from the data acquired through smart city projects.
- The making of a smart city: best practices across Europe will present EU-funded projects with the aim of profiling the best techniques and role models.
- The making of a smart city: replication and scale-up of innovation in Europe will present how key technologies and innovative solutions can be replicated and the steps necessary to achieve this.

'Empowering smart solutions for better cities' is the motto of the SCIS and lies at the heart of our ambition of creating a more secure and sustainable energy sector in Europe.

[1] www.smartcities-infosystem.eu

About The making of a smart city: best practices across Europe

In this publication, we present to you the success stories and the challenges: and, above all, the opportunities for replication that we believe can assist European cities on the way to becoming smarter. Some of the best practices of projects in cities from across Europe are showcased and their innovative technologies in energy, mobility and transport, and ICT are presented.

Replication is a key word in the smart city community. Replication builds up innovation and technological transfer. At the heart of a successful replication, lies the challenge of finding suitable financing and coming up with innovative business models, whilst sharing knowledge, good practices and lessons learned. In this publication we profile projects in 80 cities across Europe. We take a standardized approach in order to ensure that the information is easily read and understandable.

The projects have been clustered by themes reflecting the focus of their demonstrations and research activities:

- Smart Cities & Communities Lighthouse projects
- Strategic sustainable city planning
- Demonstration of very low-energy buildings
- Demonstration of optimized energy systems for high performance energy districts
- Demonstration of nearly zero-energy building renovation for cities and districts
- Large-scale energy systems for urban heating and cooling
- Sustainable energy solutions: the CONCERTO communities.

More detailed information can be found on the SCIS website[2] in easy-to-navigate sections where projects, technologies and lessons learned can be filtered and clustered in a variety of ways to meet the expectations of stakeholders with different expertise and interest.

Impact: key performance indicators

The following table has been used at city level as a summary of the main information about the project.

FACTS & FIGURES	
Geographical area	**name**
Demonstration area	**m^2**
Population in the area	**number of inhabitants**
Total investment	**€**
Funding from EU	**€**
Final energy savings	**kWh/yr**
Primary energy savings	**kWh/yr**
CO_2 emissions reduction	**tCO_2/yr**

- Geographical area: the name of the area where the project takes place.
- Demonstration area: size of the area affected by the high-efficient interventions. When the interventions concerns only buildings, this area corresponds to the sum of the newly constructed and/or renovated buildings. In the case of a city-level intervention, the demonstration area refers to the total estimated area affected, which includes the area of the buildings plus the area served by the mobility interventions.
- Population in the area: Population that is directly affected by the project actions. As before, when the actions concerns only buildings, this number corresponds to the occupants of newly constructed and/or renovated buildings. In the case of a city-level action, the population in the area refers to the total estimated inhabitants affected by the energy, mobility and transport and ICT measures.

[2] www.smartcities-infosystem.eu

- Total investment: total amount of money allocated for the whole intervention.

- Funding from EU: total amount of money covered by the European financial mechanisms.

- Final energy savings: this KPI indicates the yearly reduction of the delivered energy to end users in order to provide desired services (e.g. number of travels or comfort levels within a building) after the interventions carried out within the project. The savings take into consideration the energy consumption from the reference situation (according to the normative or to business as usual). These savings are calculated as an addition of the thermal (heating or cooling) energy and electricity in the whole demo site (lighting and appliances, e-mobility) to consider all savings.

- Primary energy savings: this KPI indicates the primary energy, this is, raw energy before any conversion, which is saved thanks to the interventions carried out within the whole project. It is calculated according to the primary energy factors either reported by the project or given by the relevant literature.

- CO_2 reduction: this KPI indicates the tonnes of CO_2 that are saved yearly thanks to the interventions carried out within the project. It is calculated according to the CO_2 factors either reported by the project or given by the relevant literature.

Technologies: key performance indicators

The following table has been used at city level as a summary of the main technical information of the project actions. Retrofitted area: net floor area of the energy efficient building/buildings renovated within the project.

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**m^2**
Newly built area	**m^2**
Investment	**€/m^2**
Payback period	**number of years**
Final energy demand (baseline)	**kWh/m^2/yr**
Final energy demand (after)	**kWh/m^2/yr**
CO_2 emissions reduction	**tCO_2/yr**
Energy supply	**list of technologies used to supply the building**

- Retrofitted area: net floor area of the energy-efficient building(s) renovated within the project.

- Newly built area: net floor area of the energy-efficient building(s) built within the project.

- Investment: total amount of money allocated for the intervention of the buildings reported.

- Payback period: time in which the initial cash outflow of investment is expected to be recovered from the cash inflows (savings) generated by the investment.

- Final energy demand (baseline): delivered energy to end users that is demanded to provide desired services within the building (e.g. comfort levels), taking into consideration the energy consumption from the reference situation (according to the normative or to business as usual). The total final energy demand is calculated as an addition of the thermal (heating or cooling) energy and electricity. In case more than one building is involved in the intervention, the average for the buildings is given.

- Final energy demand (after): delivered energy to end users that is demanded to provide the same services after the intervention. The total final energy demand is calculated as an addition of the final thermal (heating or cooling) energy and electricity delivered to the building. In case more than one building is involved in the intervention, the average for the buildings is given.

- CO_2 emissions reduction: this KPI indicates the tonnes of CO_2 that are saved yearly thanks to the intervention carried out in the buildings. It is calculated according to the CO_2 factors either reported by the project or found in literature. In case more than one building is involved in the intervention, the average for the buildings is given.

- Energy supply: list of technologies used to supply the building.

** Disclaimer*

The projects in scope of the Smart Cities Information System cover a broad list of topics and different timelines. While the CONCERTO projects have already provided data and the related work is considered finished, most of the Energy efficiency in buildings, Smart cities and communities and Lighthouse projects are still running and still updating their project information. Therefore, the current publication compiles the maximal amount of data that can be included at the moment of printing in order to present an overall picture based on projects' maturity. When monitoring data was not available, design data or expected results were used as source of information for the calculation of the KPIs. In these cases, individual disclaimers have been added in order to inform the reader that further information will be available at a later stage. When no information was available, the corresponding rows of the tables were not included.

** Disclaimer II*

Due to their innovative nature, some of the technologies presented in the publication show a payback that is longer than 30 years. This is attributed to the fact that the technologies are not fully mature, their production volumes are small and therefore initial investment is high. This, however, does not reflect the non-monetary benefits the implementation of these technologies has in the social and environmental sphere. Additionally, demonstration of innovative technologies that are far from market leads to an increase in their technology readiness level and is at the hearts of the projects, included in this publication.

Number of smart cities per country presented in this publication

Smart Cities & Communities

Lighthouse projects

Smart Cities & Communities Lighthouse projects are key role models at the district level. Lighthouse projects promote an integrated smart city approach, demonstrating effective solutions in the integration of sustainable homes and buildings, smart grid solutions (electricity, district heating, telecom, water, etc.), clever use of energy storage, electric vehicles and innovative charging infrastructures, as well as the latest generation ICT platforms. These projects are accompanied by energy-efficiency measures and the use of very high shares of renewables. Their goal is to facilitate a successful transformation towards intelligent, user-driven and demand-oriented city infrastructures and services.

Lighthouse cities develop and test integrated innovative solutions and act as exemplars for their region. They are committed to transfering knowledge and experience to facilitate successful replication adaptable to different local conditions.

Voted European Capital of Innovation 2014, Barcelona is a vast metropolitan hub with a long tradition of industry and entrepreneurship. Barcelona City Council encourages strategic initiatives aimed at generating international collaboration, and promoting a global and forward-looking vision to businesses and public bodies, as well as scientific and technological centres.

Barcelona's development towards a smart city began over 30 years ago when the city installed fibre optic cables to connect two municipal buildings. Currently, the City Council is using public-private partnerships to encourage innovation in areas such as transport, shopping, street lighting and environmental monitoring. Barcelona has been transformed into an urban laboratory, piloting projects and services that make the city more open, efficient and friendly.

The innovation zone, known as the 22nd District, has been chosen for Barcelona's implementation of the smart solutions within the GrowSmarter project. This multi-purpose area mixes residential, industrial and academic buildings in a lively, vibrant quarter bordering the Mediterranean Sea. Solutions being implemented in the 22nd District include introducing electric vehicles and installing charging infrastructure, refurbishing current buildings to create zero-energy blocks and installing district heating and cooling.

Impact*

The demonstration site in Barcelona consists of 10 refurbished buildings with an overall gross floor area of 33 110 m². The final energy demand of the site has been reduced by 2767 MWh every year thanks to the refurbishment.

According to SCIS calculations based on energy design data and the respective emission factors available (European factors – EN 15603), the primary energy savings go up to 5 729 MWh/yr while the carbon dioxide (CO_2) emissions reduction amounts to 1 610 tonnes every year

FACTS & FIGURES

Geographical area	**Barcelona, Spain**
Demonstration area	**33 110 m²**
Final energy savings	**2767 MWh/yr**
Primary energy savings	**5729 MWh/yr**
CO_2 emissions reduction	**1610 tCO_2/yr**

Technologies*

The solutions demonstrated in Barcelona are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Building services: heating, ventilation and air conditioning (HVAC) and lighting

Efficient lighting

Heat pumps

Heat pumps for heat storage in heating systems and hot water systems

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Electrical energy storage

Batteries for renewable energy storage

Smart street lighting

Lamp posts as bases for sensors, WiFi, mobile networks

Waste heat recovery

Recovering waste water heat from the drain

Open district heating with feed-in of waste heat

Waste heat from data centres and vacuum waste systems

Waste heat from fridges and freezers in supermarkets

ENERGY EFFICIENCY IN BUILDINGS*

Retrofitted area	**33 110 m²**
Final energy demand (baseline)	**170 kWh/m²/yr**
Final energy demand (after)	**92 kWh/m²/yr**
CO_2 emissions reduction	**1610 tCO_2/yr**

**Average values for the 10 buildings included in GrowSmarter*

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Developing charging infrastructure

Setting up refuelling facilities for alternative heavy duty fuels

Car sharing

Green parking index in combination with car-sharing pool with electric vehicles

Bicycle infrastructure

Electrical and cargo bike pool

Urban freight logistics

Integrated multi-mode transport for light goods

Micro distribution of freight

ICT

Building energy management system

Active house/home energy management systems/ smart home system

Energy visualisation

Smart meters

New adaptive control and regulation techniques for heating systems

Dynamic price models

Urban data platform

Big open data platform

Traffic control system

Smart guiding to alternative fuel stations and fast charging

Traffic signals synchronised to prioritise certain vehicle movements of goods

Travel demand management

ICT as planning support

Weather metering predicting the storage

i

GrowSmarter
Transforming cities for a smart, sustainable Europe

GrowSmarter

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Bristol, United Kingdom | REPLICATE

With its 442 500 inhabitants and the title European Green Capital 2015, Bristol is named alongside London as the UK's smart city leaders. As part of the REPLICATE project, Bristol will deploy a number of smart integrated energy, mobility and ICT solutions in the neighbourhoods of Ashley, Easton and Lawrence Hill. The pilot will explore how technology could help tackle inequalities, such as how smart homes could help ease fuel poverty, and how electric bikes could help people to be more active and have more choice on how to travel. The project will contribute towards Bristol's ambition to be carbon neutral and run entirely on clean energy by 2050.

Impact*

Led by Bristol City Council and partners, the Bristol pilot aims to explore how smart technology could be used to:

- reduce the cost, and amount, of energy consumed to help tackle fuel poverty;
- use more local clean renewable sources of energy to increase local resilience;
- enable greater sustainable mobility to increase health and wellbeing, as well as enable better access to training and employment;
- engage citizens in their energy use and travel patterns to enable them to make the changes they want;
- contribute to an overall aim to significantly help towards reducing the city's CO_2 emissions.

Technologies*

The solutions demonstrated in Bristol are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

240 households, including 150 smart homes (20 400 m²).

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Biomass boilers

Smart street lighting

Photovoltaics

photovoltaic will be installed both on residential and community scale

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Electric, hybrid and clean vehicles

E-bikes, electric car club vehicles, an on-demand electric mini-bus service and electric vehicle charging points in the district

ICT

Neighbourhood energy management system

The energy management system will work at city level.

Smart electricity grid

Urban data platform

Travel demand management

Strategic urban planning

Mobile applications for citizens

Travel planning and parking apps

* Detailed information regarding the technical and financial performance will be available at a later stage.

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC There were a number of unexpected changes to renewable energy subsidies and housing policy taken in the United Kingdom after the project was launched. This impacted on projects linked to the REPLICATE project in Bristol and particularly affected the business case on which the original district heating scheme was based, making the proposal no longer viable. The first significant policy change was the reduction in rent revenue from the Council's social housing, meaning that there was significantly less funds available to convert housing blocks from electric heating to a 'wet' system. This work was required for the original proposal.	**The result of this was a significant negative impact on the Council's Housing Business Plan and, as a consequence, the project had to undertake a major review of all spending to make the necessary cuts to expenditure.**
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC The second important legislative change was the 45 % reduction in the Renewable Heat Incentive (RHI) subsidy for this type of biomass boiler, thus making many projects no longer viable.	**As a result, the project had to generate a new proposal around district heating that involved augmenting and connecting several existing heat networks in the same district, rather than creating an entirely new one.**

CHALLENGES

REGULATORY & ADMINISTRATIVE, SOCIAL

There are a number of administrative challenges around electric vehicles and charge points, including:

- being able to grant parking permits for electric vehicles whilst keeping non-electric vehicles out. This is still being worked through;
- the backlog of Traffic Regulation Orders (TROs) for major infrastructure projects, which is impacting on the progress of the Bristol pilot. The pilot is currently tolerating this delay;
- the many old streets that have narrow pavements so are not suitable to have an electric vehicle charge point for health and safety reasons. To overcome this, a design for a connecting 'island' for the charge point was commissioned;
- it is difficult to predict the likely spread of electric vehicles, which makes matching the infrastructure to coincide with the rollout also challenging.

REGULATORY & ADMINISTRATIVE

Smart home technology is still a relatively new technology and integrating this with a wider Energy demand management system provides a number of challenges including most significantly the current differences in compatibility across the range of smart devices and ICT infrastructure.

BEST PRACTICES

SOCIAL

An in-depth citizen engagement plan has been developed for all of the interventions in Bristol. This involves road shows, demonstration homes, local champions and regular meet-ups to troubleshoot problems (particularly with the smart home pilot).

SOCIAL

Involving owners and tenants is key to ensuring buy-in and permission to carry out the retrofit and smart homes in the first place. This will be done by trusted local professionals, as well as a website and dedicated phone lines detailing the financial and environmental benefits. During the pilot, tenants/owners will be able to see how much they are saving financially and what the environmental benefits are through smart home technology.

REPLICATE

REPLICATE

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Cologne, Germany | GrowSmarter

Situated on the banks of the River Rhine, Cologne is the fourth largest city in Germany and home to key players in business and industry. The city is committed to the EU's goal of achieving a 20 % reduction in greenhouse gas emissions, a 20 % increase in the share of renewable energy and a 20 % increase in energy efficiency by 2020 based on 1990 levels. It aims to reduce CO_2 even further, with a 50 % reduction by 2030.

In order to achieve these goals, Cologne is looking to work closely with local industry. Areas of focus include sustainable mobility, energy efficiency of buildings, low-emission heating facilities and ensuring an integrated infrastructure as the city expands.

In this context within the GrowSmarter project, Cologne demonstrates 12 smart solutions in the fields of low-energy districts, integrated infrastructure and sustainable urban mobility in Mülheim, a vibrant area in the north-east of Cologne, which is currently undergoing a process of regeneration.

Impact*

The demonstration site in Cologne consists of two existing buildings with an overall gross floor area of 33 290 m². The final energy demand of the site has been reduced by 4 990 MWh every year thanks to the refurbishment.

According to SCIS calculations based on energy design data and the respective emission factors available (European factors – EN 15603), the primary energy savings go up to 6 203 MWh/yr while the CO_2 emissions reduction amounts to 1 844 tonnes every year.

Technologies*

The solutions demonstrated in Cologne are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

- Windows with extra low U-values

Building services (HVAC and lighting)

- Efficient lighting
- Heating renovation

Heat pumps

- Fuel cells as an add-on to air heat pumps
- Heat pumps for heat storage in heating systems and hot water systems

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Photovoltaics

FACTS & FIGURES

Geographical area	**Cologne, Germany**
Demonstration area	**33 290 m²**
Final energy savings	**4990 MWh/yr**
CO_2 emissions reduction	**1844 t CO_2/yr**

ENERGY EFFICIENCY IN BUILDINGS*

Retrofitted area	**33 290 m²**
Final energy demand (baseline)	**166 kWh/m²/yr**
Final energy demand (after)	**16 kWh/m²/yr**
CO_2 emissions reduction	**1844 t CO_2/yr**

**Average values for the two buildings included in GrowSmarter*

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

- Mobility hub
- Developing charging infrastructure

Electric, hybrid and clean vehicles

Car sharing

- Electrical and conventional car and bike sharing

Bicycle infrastructure

ICT

Building energy management system

- Active house/home energy management systems/ smart home system
- Energy visualisation
- Smart plugs, connected lighting and thermostats
- Smart meters

Urban data platform

- Big open data platform
- Semi-automatic instance mapping

Demand response

- Smart meter information analysis and actuators

ICT as a planning support

- Dynamic price models
- Urban models
- Virtual power plant
- Virtual power plant managed batteries for renewable energy storage

GrowSmarter
Transforming cities for a smart, sustainable Europe

GrowSmarter

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TRIANGULUM

Eindhoven is the centre of the Brainport Region, one of today's three top economic engines of the Netherlands, delivering about 14 % of the national gross domestic product (GDP). Two districts - Strijp-S and Eckhart Vaartbroek - will be transformed into sustainable living environments as part of TRIANGULUM.

The former Philips industrial complex in the Strijp-S neighbourhood will become a creative smart district. An innovative concept to clean up contaminated land will double as a means of producing energy. It is also planned to optimise the heat provision powered by renewable energies of the existing buildings. A district-wide ICT solution will allow residents to access different kinds of infrastructure, such as booking electric vehicles from a district car-sharing scheme or using smart parking concepts. In this way, the IT-based tool will help residents to develop sustainable patterns of energy and mobility behaviour. In addition, electric buses will make city traffic more eco-friendly.

A different set of challenges is posed by the Eckart Vaartbroek district, where energy efficiency renovations will be carried out on the social housing stock that predominates in this area. In order to precisely calculate energy savings, the project will use an IT-based instrument capable of modelling costs and providing a 3D visualisation of the district.

Impact*

The key impacts of TRIANGULUM's demonstration measures are:

- a significant increase in joint ownership of Smart City Eindhoven among users. Citizens and other relevant actors will be engaged in the process of investing into Eindhoven as a smart city;
- a new, smarter way of working for the city administration that allows true integration of smart city aims and objectives within and outside the municipal organisation;
- the implementation of innovative energy-saving technologies that will reduce energy bills and limit CO_2 emissions by 67 %;
- data infrastructure and sensor networks get a boost when the open data platform further facilitates smart city developments;
- people know they've been consulted and projects are being implemented in co-creation;
- there's been a sustainable transformation of public space and housing is still affordable;
- there's an uptake of smart solutions and a redefining of quality of life.

Technologies*

The interventions in Eindhoven include:

ENERGY EFFICIENCY IN BUILDINGS

Building envelope retrofitting

Renovation/refurbishment of dwellings: co-creation process with the tenants; use of energy saving visualisation platform (WoonConnect)

Building integrated renewable energy sources

Replacing heat provision utility (gas) with one powered by renewable energy (biomass)

Building services (HVAC & Lighting)

Smart energy-saving offices innovative concept (through the installation of sensors) for reducing an estimated 20 % of energy

ENERGY SYSTEMS INTEGRATION

Photovoltaics

Wind turbines

Smart street lighting

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Smart charging of electric vehicles by optimising the use of charging station

ICT

Traffic control system

Improved parking management

Detailed assessment for parking spaces (real time parking guide system)

Urban data platform

Smart city ICT open data platform

Transparency

Stimulate co-creation between government and partners in the city

ICT as planning support

Innovative ICT application (WoonConnect)

Interactive design and process for dwelling improvement (WoonConnect)

Stimulate investment in dwelling refurbishment

Strategic urban planning

Sensor network in the public space (fibre-optic data infrastructure)

Open WiFi

Sound, video and air quality sensors.

triangulum

DEMONSTRATE·DISSEMINATE·REPLICATE

TRIANGULUM

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With a population of 377 587 people and 12 million tourists per year, Florence is not only a place with an impressive artistic heritage and literary history, beautiful landscapes, high-quality fashion and lifestyle, agricultural and gastronomy products, but it also has efficient digital public services, high-level industries in innovation and technology, and excellent training institutes.

By becoming one of the lead cities in the REPLICATE project, Florence aims to implement an integrated smart city plan (co-created together with local stakeholders in the framework of the FP7 project STEEP and with the other two REPLICATE lighthouse cities) for the first smart district to be replicated and scaled up. The demonstration area is the Novoli urban park – a mixed-use area with residential and tertiary settlements with mobility infrastructure consisting of a highway, an airport, and a main station.

The actions to be implemented include energy efficiency and district heating with an innovative seasonal solar thermal storage for social housing, smart grid and energy-demand management with smart metering and mobile application for final users, public multivendor e-mobility infrastructures, advanced mobility services for citizens, data management and a smart city control room, smart lighting and intelligent systems (internet of things (IoT) pilot test on smart benches, smart waste and smart watering).

Impact*

The REPLICATE team is working to accelerate the deployment of innovative technologies, organisational and economic solutions in order to significantly increase the resource and energy efficiency, improve the sustainability of urban transport and drastically reduce greenhouse gas emissions in urban areas. The project therefore aims to enhance the transition process to a smart city in three areas:

- Energy efficiency: achieve energy savings in relation to the existing situation in building retrofitting and in district heating exploiting renewable energy sources integration;
- Sustainable mobility: integrate sustainable electric vehicles, recharging inftrastructure and information mobility systems;
- Integrated ICT infrastructures: develop a smart city platform delivering new sustainable and cost-effective services to citizens, while improving the efficiency and synergy in the use of local public resources and the delivery of public services.

Technologies*

The solutions demonstrated in Florence are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

The retrofitting measures will be implemented in social housing blocks

ENERGY SYSTEMS INTEGRATION

District heating and cooling

District heating is included in the interventions.

Thermal storage

Solar seasonal thermal storage is included in the interventions.

Smart street lighting

New intelligent lighting system based on light-emitting diode (LED) technology integrated with other services (traffic control, soft video surveillance, WIFI, environmental sensors,...)

MOBILITY & TRANSPORT

Electric, hybrid and clean vehicles

More than 100 electric taxis

Fast recharge infrastructure reserved for e-taxi fleet

228 public multivendor charging points in the city (40 in the district)

* Detailed information regarding the technical and financial performance will be available at a later stage.

ICT

Smart electricity grid

Urban data platform

ICT as a planning support

Innovative IoT services - smart benches, smart waste, smart watering

Mobile applications for citizens

Demand response

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC The legislative framework development has represented the main obstacle to the deployment of the pilot action in Florence. The regulations, which mostly affected the implementation, were the national procurement code, the excavated soils regulation and the national incentives framework. The new procurement code sets rules for the design and tendering procedures, thus causing a delay (and some additional costs to verify the design) in the scheduled activities. The excavated soils regulation affected the overall business model of the seasonal thermal storage.	In order to cut down on the delay caused by the new procurement code, the team separated the Piagge project (retrofitting buildings, district heating & renewable energy sources hybridisation) into three lots. This approach could also support the exploitation of the national incentives, the availability of which is uncertain and limited in time. With regards to the excavation soils regulation, the team resized the planned thermal storage, trying to balance the costs with the energy demand side and the expected performances.

CHALLENGES

FINANCIAL & ECONOMIC

It is possible for public administrations to access incentives for thermal insulation, which can contribute up to 40 % of the costs for wall and ceiling insulation, replacement of window enclosures, installation of solar shades, indoor lighting, building automation technologies and condensation boilers. The risk is that the Incentives framework conditions at national level can be reviewed and the intervention schedule would then not be on time to claim the economic contribution. This could affect the economic sustainability model at the core of the intervention.

CHALLENGES

FINANCIAL & ECONOMIC

There is a financial risk with respect to the e-taxi measure, where the infrastructure will be created without having any e-taxis circulating.

REGULATORY & ADMINISTRATIVE

The restrictions to landscape and historical areas have to be taken into account in each measure in Florence, finding a different solution for each specific implementation. For example, the seasonal thermal storage has to be built underground (but not too deep due to the aquifer legislation) and the technical rooms need to be limited as much as possible, to avoid building new visible volumes (according to the ZERO Volume structural plan). Furthermore, the lamp posts and other street furniture like the smart benches have to be approved by the art superintendence, as well as by the landscape authorities.

REGULATORY & ADMINISTRATIVE

With respect to the fast recharging stations for the e-taxi fleet, the permits procedure took more time and the action had to start in advance. The possibility of creating ‘recharging islands’ in order to exploit more of the locations already in use is also under consideration. On one hand, this will facilitate the search for recharging points; on the other, it will accelerate the building procedure.

BEST PRACTICES

SOCIAL

The model chosen for Florence foresees an internal steering group playing the role of the owner of the planning procedure and interacting with several ‘habitat teams’ formed by specific stakeholders and citizens. Every member of the internal steering group is in charge of a thematic: the internal referees coordinate the subgroups and refer to the steering team about the results. The coordination activities are carried out inside the internal group.

From the perspective of active participation, which describes how the current administration adopts all of its plans, the communication plan to engage stakeholders and citizens was created on the basis of two primary tools: non-stop institutional communication and direct participation. Citizens have been reached through social media activities and by interacting with associations and representatives. A public debate, the Maratona dell’Ascolto, was organised to close the development phase, while a previous one was focused on the district which is now interested in the pilot action. The event was open to anyone interested in providing feedback or receiving information and more than 130 people attended. Comments and contributions were collected after the Maratona and a final version of the plan has been developed and will be submitted for formal adoption.

SOCIAL

The energy efficiency action is going to involve the tenants of 300 flats in the Piagge buildings where the retrofitting and the district heating interventions will take place. A third party of the municipality in the project is Casa spa that manages the Piagge buildings, which is in daily contact with the tenants directly affected by the project activities. This will facilitate the communication and dissemination of the project and make the families more confident with the performed work and its impact.

The consistence of the interventions, timing, phases and expected results will be illustrated during on-site assemblies with the help of explaining totems/steles. An in situ info point will be provided by Casa spa to address technical questions in an empathic fashion. In addition, a sustainability helpdesk office is available for answering questions about incentives, and environmental and financial benefits.

SOCIAL

To address the necessary change of consumption behaviour, the project has planned a number of technological solutions to engage the tenants. All 600 families (300 in Piagge buildings and other 300 in the district) will be provided with the smart info device to control their electric demand, and a gaming app will be at their disposal to increase awareness and monitor the overall energy consumption of families. A little friendly competition provided by the app will stress the impact of their choices on their energy consumption and promote new sustainable behaviours.

REPLICATE

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Lisbon, the capital city of Portugal, has a smart city strategy that places its citizens and their needs at its core. Technology is just a means to an end. The city aims to become smart, sustainable, competitive, participatory, creative, innovative and citizen-centric. Lisbon has drafted an urban development strategy for the coming decades, and has committed to invest € 307 million in related projects (Programa Operacional Regional de Lisboa 2020). The strategy's main objectives are to attract more inhabitants by improving the quality of housing, and offering smart living services and smart ageing opportunities; to boost the economy and increase employment by investing in research and development, attracting more entrepreneurs and broadening access to higher education; and improving the quality of life in the city through measures for energy efficiency, mobility and social cohesion. Local regeneration and citizen participation are also priorities.

The demonstration area chosen for the SHARING CITIES project spreads over 10 km^2 and has 100 000 inhabitants. This strategic location stretches from the riverfront to the centre of the city, and includes the main historic and tourist districts. The area poses several challenges, ranging from its particular orography to the historic nature of its buildings, and its ageing population.

Impact*

Within the Sharing Cities project, Lisbon aims to:

- aggregate demand and deploy smart city solutions;
- deliver common and replicable innovative models;
- attract external investment;
- accelerate the take-up of smart city solutions;
- pilot energy-efficient districts;
- shift people's thinking irreversibly to local renewable energy sources;
- promote new models of e-mobility;
- successfully engage with citizens;
- exploit 'city data' to maximum effect;
- foster local-level innovation, creating new businesses and jobs.

Technologies*

The solutions being implemented in Lisbon include:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

High-performance new buildings

Smart street lighting

64 000 street lights

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Platform to manage e-vehicle charging points

540 e-vehicle public charging points from four providers

Electric, hybrid and clean vehicles

ICT

Traffic control system

Public transport platform

Urban data platform

63 sets of open data

* Detailed information regarding the technical and financial performance will be available at a later stage.

Sharing Cities

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Sharing Cities

The capital city of the United Kingdom unveiled the Smart London Plan in 2011. The Smart London Board is the city mayor's top line-up of academics, business representatives, infrastructure providers, and ICT and energy companies. It helps the Greater London Authority to shape and implement its strategy for how to apply technology to all areas of city policy (transport, energy, social and infrastructure policy). Smart technology and city data are becoming increasingly prominent in the urban planning discourse. The London Infrastructure Plan 2050 focuses on how technology and data can influence the future design and efficient operation of the city's assets, and how the related regulatory and market issues should be tackled. In parallel, it has developed the London DataStore, a hub for the city's growing ecosystem, which has generated numerous examples of how data can be used to manage and plan city operations.

The Greenwich demonstrator area is one of the most strategic locations in London. It stretches along the riverfront – from Maritime Greenwich, the UNESCO World Heritage Site, to Greenwich Peninsula – and spreads over 516 Ha. The site includes visitor attractions such as the O2 Arena, a new business start-up district, existing and new residential sites, and considerable water frontage.

Impact*

Within Sharing Cities, project London aims to:

- aggregate demand and deploy smart city solutions;
- deliver common and replicable innovative models;
- attract external investment;
- accelerate take-up of smart city solutions;
- pilot energy-efficient districts;
- shift thinking irreversibly to local renewable energy sources;
- promote new models of e-mobility;
- successfully engage with citizens;
- exploit 'city data' to maximum effect;
- foster local-level innovation, creating new businesses and jobs.

Technologies*

The solutions demonstrated in London are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

High-performance new buildings

ENERGY SYSTEMS INTEGRATION

Smart street lighting

23 000 street lights

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

12 low-capacity charging points

Autonomous vehicle tests

* Detailed information regarding the technical and financial performance will be available at a later stage.

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SMARTER TOGETHER

Lyon is one of the lighthouse cities in the SMARTER TOGETHER project. The demonstration area in focus is Lyon-Confluence, one of the largest urban redevelopment projects in France (150 ha – 600 000 m² existing floor area – 1 million m² of new buildings) and an area of many urban innovations. With SMARTER TOGETHER, Lyon-Confluence heads towards zero-carbon objectives, which means that after the implementation phase the annual greenhouse gases emissions of the buildings must not be superior to the level of emissions at the beginning of the project, despite an increase in built area (1 000 000 m² of new constructions), population and activities in the area.

FACTS & FIGURES

Geographical area	**Lyon-Confluence, Lyon, France**
Demonstration area	**35 000 m²**
Total investment	**€ 37 500 000**
Funding from EU	**€ 7 000 000**
Primary energy savings	**5477 MWh/yr**
CO_2 emissions reduction	**3534 tCO_2/yr**

Impact*

With SMARTER TOGETHER, Lyon aims to:

- refurbish 35 000 m² of existing buildings to reduce their energy consumption;
- develop local renewable energy generation: photovoltaic systems (1 MWp) and a wood-fired cogeneration power plant (2 MWe/4 MWth);
- reduce the use of conventional cars by providing alternative means of transport for inhabitants: smart charging stands, an electric vehicle car-sharing system and an autonomous driverless electric shuttle;
- feed the existing Grand Lyon smart data platform with news set of data to better monitor energy production and consumption in the area, and the actual effects and benefits of measures implemented to reach the zero-carbon objective;
- involve citizens in the redevelopment of the Lyon Confluence area and the implementation of new services (creation of an urban living lab to allow citizens and users to co-design the smart city solutions);
- increase the inhabitants' quality of life through the construction of comfortable and affordable dwellings and offices, convenient public spaces, easy access to the district, etc.

Technologies*

Some measures to be implemented in Lyon-Confluence within the SMARTER TOGETHER project are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Reducing energy consumption by refurbishing an area of 35 000 m² of existing buildings (private housing, social housing, office spaces and public buildings)

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Renewable district heating

Cogeneration (CHP)

SMARTER TOGETHER includes the construction of a wood-gas fired cogeneration power plant of 2 MWe/4 MWth, connected to the district heating

Photovoltaics

Four photovoltaic systems are constructed to achieve a total power of approximately 1 MWp, which comes in addition to the 1 MWp of photovoltaic systems already existing in the Lyon-Confluence area.

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Smart charging stands

Electric, hybrid and clean vehicles

Autonomous driverless electric shuttle

Car sharing

Electric vehicle car-sharing system

ICT

Building energy management system

Neighbourhood energy management system

Urban data platform

Provision of new sets of dynamic data to the Grand-Lyon data platform from the energy and sustainable mobility sector collected from various sources – smart power and heat meters, building energy management system, shared electric mobility services, energy production systems in the area, such as photovoltaic systems, and the district heating power plant plant - in order to monitor energy generation and consumption in the area and assess the actual energy performance of buildings

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE, & ECONOMIC The project in Lyon-Confluence is a complex endeavour, involving numerous players. One of the specificities is that the refurbishment targets mostly jointly privately owned buildings in a low income area and with high expectations regarding renewable energy sources, energy efficiency and data sets collected to better monitor the energy performance.	**The high level of complexity of the Lyon-Confluence urban project required a proper and skilful management team to successfully conduct and oversee the different dimensions, such as consent from owners and tenants, price competitiveness of renewable energy sources, regulatory issues (tenders which can delay the project), technical capabilities of the joint owners, connection of the building with the fully renewable district heating, quality and availability of the data sets needed for a better energy management of the district, behaviour, cooperation between the public departments, etc.** **There is not a one-stop shop solution but a steady process combining a clear long term vision and commitment of resources with short-term and pragmatic actions. The quality of the team and its expertise is a key factor of success to mobilise the complex district ecosystem.**
REGULATORY & ADMINISTRATIVE FINANCIAL & ECONOMIC The refurbishment of the buildings takes place in an area with strong constraints due to heritage protection. This impacts the type of works that are authorized with respect to the appearance of the buildings (external insulation, change of windows, etc.) and can also increase the cost of the eco refurbishment.	**The solution is that part of the team works closely with the public authorities in charge of heritage protection, and the design of the project features a proper balance between energy performance, cost and protection of the heritage.**
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC Renewable energy sources competitiveness, despite serious improvements is still not achieved.	**Lyon-Confluence has an important goal to achieve 1 MWp in photovoltaics. In order to make this happen given the current French regulation system, the local public redevelopment company SPL Lyon-Confluence obtained a feed-in tariff within national auctions.**

BARRIER	SOLUTION
SOCIAL Early inclusion of owners and tenants in the refurbishment works is also essential. Refurbishment of social housing is far easier as there competences and processes in place - consultation, tender, schedule, building site. It is far more complex with joint owners, who often don't have the necessary expertise to undertake large scale building works.	**Some of the solutions are to mobilise part of the team to work closely with the owners and tenants, to add financial incentives for the refurbishment in exchange for the connection to the fully renewable district heating which is currently being completed.**

CHALLENGES

FINANCIAL & ECONOMIC

Costs for IT development and maintenance with respect to collection, storage and use of data (public and private providers of data, city data platform, tool for data visulation and analysis) need to be taken into account in order to easily replicate the pilot action of SMARTER TOGETHER at a larger scale, in particular in the rest of Lyon Metropolis area.

REGULATORY & ADMINISTRATIVE

The project team encountered challenges with the access, collection and use of data from multiple public and private providers. For example, in order to assess the actual energy performance of buildings - either recently built or refurbished – the team had to secure access to data and complying with the data privacy regulations was a must.

REGULATORY & ADMINISTRATIVE

As this is a lighthouse project, scale is important and given the short timeline the ability to shift rapidly the refurbishing works from one building to another is crucial.

BEST PRACTICES

SOCIAL

Including citizens in the early stages of development is key and is carried out through variety of actions – setting up the so called House of the project, organising labs, providing the opportunity to participate in the prototyping. On one hand, this focuses on the involvement of local inhabitants (private groups of owners) in the eco refurbishment of their buildings. On the other, the inhabitants and the people working in the neighbourhood are engaged in the management of their energy consumption by means of data collection.

SMARTER TOGETHER

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The city of Manchester is one of 10 local authorities that make up the Greater Manchester conurbation, which has a total population of 2.6 million people and is the second largest economy in the United Kingdom. The innovation district, Corridor Manchester, will be the focus of TRIANGULUM's activities in the city – a 2 km long spine that contains two of the UK's largest universities and one of the largest medical research campuses in western Europe. Over the past five years, the partners have developed a joint strategy for the area and together will oversee capital investment predicted to be worth €3 billion. which makes up 20 % of the city's GDP. It employs 60 000 people in the knowledge economy sector, with a further 14 000 expected to be added in the next 10 years. There are 70 000 students in the Corridor, which is anticipated to reach 80 000 by 2020.

Manchester's approach is based upon an understanding that cities function as systems, involving a complex interaction between individuals, markets, infrastructure networks and public services. Every individual intervention has been chosen because it demonstrates the benefits of integration in different ways.

Building on the investments already made, the focus will be on the integration of energy, mobility and ICT systems around three core infrastructure assets within Corridor Manchester: Civic Quarter Heat Network, University of Manchester's (UoM) Electricity Grid and Manchester Metropolitan University's (MMU) Electricity Grid. These assets supply heat and power to the respective estates and buildings belonging to the Corridor partners. TRIANGULUM will build on the work already undertaken to establish a smarter, more independent infrastructure whereby energy generation, its supply, storage and use is managed in a much more demand-responsive manner. The primary focus for this is those buildings of heritage status value, a sector that until now has proved a major challenge in terms of carbon reduction.

All the new investments around renewable energy generation, supply and demand management will be connected through a new ICT infrastructure called the MCR-i. This platform will consist of a number of discrete layers, which will create two new knowledge environments. The first network of data and services that bridge the investments set out above will, in an integrated way, enable greater analysis and better-informed decision-making at both a strategic and operational level. This will improve energy efficiency, reduce carbon emissions and provide a greater ability to meet demand in a more cost-effective way. The second is the establishment of an open access marketplace from which innovative end-user and business applications can be developed and marketed independently. In addition, the city's programme to remove cars from the Corridor also provides the opportunity to develop a new mobility component focused specifically on logistics and freight distribution, whilst at the same time exploiting the opportunity to connect new modes of electric vehicle transport via the electricity infrastructure set out above.

Impact*

Manchester's overall objective is for Corridor Manchester to become one of the largest knowledge-rich low-carbon districts in Europe. In achieving these overall impacts, the aim is to decouple a reduction in carbon emissions whilst at the same time increasing economic activity. Very few cities have been able to exhibit this smart green growth but the Corridor has the right conditions and profile to demonstrate this. The rapidly increasing population growth which our urban cores are experiencing (Manchester is the fastest growing city in the UK) will put increased pressure on the way our cities deliver public services, such as housing, transport, energy, water and other basic services including health and education. The cities that compete most effectively in the future will be those that can deliver smart green growth against a backdrop of rapidly increasing urbanisation.

The implemented solution should impact the following targeted aspects:

- energy use (buildings and transport);
- energy costs;
- energy generated from renewable sources;
- mobility (i.e.: reduction of journeys);
- air quality (reduction of carbon emissions);;
- creation of new jobs;
- generation of added value (socio-economic impact);
- improved efficiency of doing business.

* Detailed information regarding the technical and financial performance will be available at a later stage.

Technologies*

The interventions in Manchester include:

ENERGY EFFICIENCY IN BUILDINGS

Building integrated renewable energy sources

Clean power generation (lower GHG)

Small energy storage

On-site generation, storage and its integration (renewable and conventional)

MOBILITY & TRANSPORT

Clean fuels and fueling infrastructure

Developing sustainable urban mobility schemes

Charging stations

Electric, hybrid and clean vehicles:

Replacement of diesel vehicles with electric ones

Bicycle infrastructure

Electric cargo bikes

ICT

Building energy management system

Energy Optimisation Initiative

Central controller connected to the energy infrastructure that recommend optimisations by responding to external signals for an optimised centrally controlled energy management

Urban data platform

Open data and service engine

Platform receiving data from a number of sources pertaining to different aspects of the city liveability: energy, transport, weather and air quality

Visualisation platform (Manchester-i)

3D visualisation platform as an interface of the data from the Open data and service engine

It serves as a tool for others to create apps and similar technology-based innovations

triangulum

DEMONSTRATE·DISSEMINATE·REPLICATE

TRIANGULUM

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Milan, Italy | Sharing Cities

Milan considers the idea of a smart city as being not technology-driven, but centred on its citizens. The concept 'smart city' for Milan covers smart mobility, smart environment, and smart inclusion and citizenship. This sets out a bold agenda, which will see the re-orientation of demand for transport services; the standardisation of payment technologies and efficiency solutions. In the chapters on smart economy and smart Europe, the city's smart city plan describes how the new sectors of the city economy should be developed to ensure economic vitality and competitiveness, and how these sectors can be enhanced via networks, resources and partnerships in Europe and across the world.

The demonstration of Sharing Cities' solutions will focus on the Porta Romana / Vettabbia area, which is under complete re-development. Its renewal will connect the historic centre of the city to its agricultural belt by joining together two geographically, economically and socially separated areas.

Impact*

Within Sharing Cities project Milan aims to:

- aggregate demand and deploy smart city solutions;
- deliver common and replicable innovative models;
- attract external investment;
- accelerate the take-up of smart city solutions;
- pilot energy-efficient districts;
- shift thinking irreversibly to local renewable energy sources;
- promote new models of e-mobility;
- successfully engage with citizens;
- exploit 'city data' to maximum effect;
- foster local-level innovation, creating new businesses and jobs.

Technologies*

The interventions taking place in Milan are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Retrofitting 21 000 m² of private buildings and 4000 m² of public buildings

ENERGY SYSTEMS INTEGRATION

Smart street lighting

300 smart lamp posts

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

60 charge points (20 rapid)

125 parking bays

Electric, hybrid and clean vehicles

62 e-cars, 150 e-bikes and 14 stations, 10 e-logistics vehicles

Car sharing

* Detailed information regarding the technical and financial performance will be available at a later stage.

Sharing Cities

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Munich, Germany | SMARTER TOGETHER

The Munich lighthouse demonstration area within the SMARTER TOGETHER project is located at the western edge of the city, and includes both the large urban redevelopment area Neuaubing-Westkreuz and the flagship new development area Freiham, set to become a model of low-carbon development for up to 20 000 new residents and 7 500 new jobs. With the aid of cutting-edge technology and the intelligent use of data, Munich's objectives are to cut CO_2 emissions by more than 20 %, raise the use of renewable energy to above 20 % and increase energy efficiency by more than 20 %. Neuaubing-Westkreuz/Freiham aims to be CO_2-neutral by 2050.

FACTS & FIGURES

Geographical area	**Munich, Germany**
Demonstration area	**42 000 m²**
Total investment	**€ 20 000 000**
Funding from EU	**€ 6 850 000**
Primary energy savings	**2785 MWh/yr**
CO_2 emissions reduction	**971 tCO_2/yr**

Impact*

Within the SMARTER TOGETHER project, Munich strives to:

- refurbish an area of 42 000 m² in order to reduce energy consumption;
- develop 109 kWp photovoltaic system and install a battery storage, both connected to the virtual power plant;
- construct multimodal mobility stations with multifunctional district sharing boxes that increase e-mobility and serve as exchange and delivery stations for goods;
- install smart street lamps that consume less energy and facilitate new services;
- implement open, secure and city-wide smart data platform acting as a virtual data backbone for collecting city data in the domains of mobility, energy, urban living and crowd data.
- measure and collect temperature and humidity data in up to 400 flats in the redevelopment area via smart home solution and provide users with an individual and secured access to their collected data via a mobile app (Wohlfühl-App);
- widen the use of the offerings described above.

Within the SMARTER TOGETHER project, the city of Munich will invest a total of € 20 million in the district. The EU will fund the project with € 6.85 million. The estimated savings amount to 2785 MWh of primary energy per year and an annual reduction of 971 tonnes of CO_2.

Technologies*

The planned implementations in Munich are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Holistic rehabilitation of housing stock in public and private ownership (energy-efficient, high-standard renovation of 42 000 m² floor space), while preserving current rent levels

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Construction of low-energy districts based on renewable district heating (geothermal and low-temperature district heating) and renewable energy

Near-to-surface geothermal energy

Smart street lighting

Smart lamppost connected to the urban data platform, which be available in two versions - 10 m for usage on road side and 3 m in green spaces and public parks. This should lead to more public services in the district, support safety, reduce energy consumptios. The lamps will offer sensor-based innovative solutions within the lighting infrastructure such as adaptive lighting, parking, free WiFi, etc.

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Construction of multimodal mobility stations to increase the use of e-mobility and serve as exchange and delivery stations for goods

Integration of 2 charging stations in lamp posts

Electric, hybrid and clean vehicles

E-trikes and cargo pedelecs in bike sharing scheme

Car sharing

Provision of e-cars for an existing car-sharing scheme.

ICT

Urban data platform

Upgrade of the city platform into a smart data platform

It will be the basis for a holistic view of city data and will be operated under the trustworthy control of the public authority to offer security and quality.

The platform will receive data, for example, from the sensor infrastructure installed with the open urban labs, and from sensors used within the smart home solutions of the refurbished flats, and can be used for developing smart services. To address the necessary regulations a so-called "data gatekeeper" concept is developed. It defines common usage, legal aspects (data privacy and security), operations and management process. The concept builds a framework for a trustworthy and open solution and is used as a blueprint to support replication and the development of an ecosystem of smart services.

Creation of integrated infrastructures for smart data management platforms and smart services (e.g. intelligent lamp posts, local goods distribution centres, shared economic services, apps, etc.).

Installation of 400 plug and play smart home solutions and connection to the data platform

Mobile applications for citizens

Smart city application giving access to services developed within the project, as well as standard functions like authentication, payment and access control. The app will allow users with smart home solutions to observe their individual data and to compare their own measured data with the average of the measured results of all project participants.

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE With regards to the new lampposts, due to city internal administrative standards, the project had to assure that they have a comparable external design like the existing ones.	**The team designed a new intelligent lamppost that internally complies with the technical requirements of a new generation of intelligent lampposts. From the external design it can almost not be distinguished from any standard lamppost used in Munich.**

CHALLENGES

REGULATORY & ADMINISTRATIVE

The preparation of the open call for innovative solutions based on the lampposts infrastructure and sensors is challenging as it has to be fully compliant with local regulations. The standard regulations foresee an official tender (in case e.g. a city wants to buy a well specified device or service) but do not precisely describe in detail the legal requirements when dealing with an open call that only offers the possibility to start-ups and other companies to test their innovative equipment like sensors in a city-owned infrastructure (such as lampposts) for a dedicated period of time (without an agreement to buy any of the tested equipment after the testing period) and share the raw data.

BEST PRACTICES

SOCIAL

The implementation of the new lampposts with innovative sensors that measure environmental and/or traffic related issues, require the involvement, on one side, of internal stakeholders engaged in the planning and building process, and on the other – the engagement of citizens, companies and experts, and administration.

Involving the citizens into the overall project activities in Munich was a crucial aspect in the SMARTER TOGETHER project. As local citizens are also potentially one of the main user groups of the generated data by the lampposts, it is important to engage them and to ask them about their expectations, ideas or needs. To address this issue the Technical University of Munich organized three collaboration workshops together with experts and citizens to develop and concretise ideas on which data should be generated by the sensors inside the lampposts. Another reason was to raise acceptance among the local residents. The results of the workshops were presented in the form of recommendations for the City of Munich to the local residents.

To communicate with the citizens, the project additionally used local newspapers, website, and a Smart City Interest Group - open group of interested people/companies/start-ups that are invited to meet on a regular base (e.g. twice a year) to exchange interesting news concerning learnings or new opportunities in the Munich smart city approach. Furthermore, they will create a local citizen team to keep in touch with the citizens that were involved in the co-creation phase.

On the other hand, the team has to engage potential companies and experts for the sensors, which should be implemented in the lampposts, in order to achieve suitable solutions. Therefore SMARTER TOGETHER is present at many events to discuss this issue with the target group of experts since the beginning of the project. It's a permanent process of ideas and feedback. To address the target group of potential companies, they are also working on an open call, which will be published after the lampposts are built, to be able to show a "living" example.

To complete this process they have also met with experts from the city administration of Munich to identify opportunities within the sensors and to discuss which data could be interesting or helpful.

SMARTER TOGETHER

SMARTER TOGETHER

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The area around Sneinton Road in Nottingham is considered to be the most appropriate for the development of the REMOURBAN demo site in the United Kingdom. The site is nearby the existing district heating and the pipeline reaches Bio City, situated very close to Sneinton Road. There is substantial Nottingham City Council housing in the area that needs upgrading to a much more energy-efficient state. Near the site is one of the famous city landmarks – George Green's Windmill – and the science centre.

With expected impacts of 50 % energy savings, 26 % CO_2 reduction and directly involving 8 100 citizens, Nottingham is implementing a variety of actions in the fields of low-energy districts, sustainable mobility, and an integrated infrastructure and society.

An intensive retrofitting programme will be developed in the Sneinton area in order to achieve a low-energy district. The district heating intervention will extend the existing district heating network (4 700 homes) by using the low-temperature return heating for the first time on this system, and maybe for the first time in the United Kingdom as a whole. As regards mobility and transport, the actions foreseen are going to reinforce the city's sustainable transport strategy by improving the transportation infrastructure, extending the city's fleet of electric buses and developing a small local consolidation centre for last-mile-delivery by using small electric vehicles for the transportation of goods at the city centre, thereby reducing the number of large vehicles used for domestic and business deliveries.

All these measures are complemented by ICT technologies and social actions, including a citizen engagement strategy, a social media strategy, a real-time integrated city model, a strategy for development of integrated urban plan, funding models to help private owners of retrofitted properties, a smart energy map and a common sustainable and smartness evaluation procedure.

Impact*

The overall gross floor area of 28 343 m² has been refurbished at the Nottingham demo site. The annual final energy saving through retrofitting is 2334 MWh per year.

FACTS & FIGURES

Geographical area	**Nottingham, United Kingdom**
Demonstration area	**28 343 m²**
Population in the area	**2567 inhabitants**
Final energy savings	**2334 MWh/yr**

Technologies*

The actions and measures being implemented in Nottingham within the REMOURBAN project are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Retrofitting: 28 343 m² district retrofitting of 465 dwellings with 2567 residents

Solid wall insulation and its use on a variety of substrates and property ages

'Room in the roof' insulation on properties that are over 100 years old

Horizon 2020 funding for these measures will be maximised with national Energy Company Obligation (ECO) funding

* Detailed information regarding the technical and financial performance will be available at a later stage.

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Connection with city-scale district heating

Within the individual blocks, the intervention aims to supply a low-temperature flow to go through class 2 or 3 meters into the individual properties and deliver low-temperature heating to the individual rooms by zone-activated control valves, operated by wireless room stats with individually set heating curves per property. The heat emitters will be skirting radiators, providing a healthier internal heating environment.

Cogeneration (CHP)

Electrically distributed generation with cogeneration

Photovoltaics

Photovoltaic installations will be positioned on five buildings with a total annual generated energy of 90.8kWh per year and total power capacity of 111 kWp

Storage in battery arrays

Waste heat recovery

Heating and cooling based on renewable energy sources such as waste heat

Waste-to-energy

The electricity to recharge the buses can be supplied by Enviroenergy, powered by burning the city's waste, representing further carbon savings of around 40 % compared to conventional diesel buses

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Transportation infrastructure – electric drive-lines and fast charging technology

Recharging by exploiting the waste from the city

2 fast charging points with photovoltaic panels

e-Buses charging depot

Electric, hybrid and clean vehicles

Fleet of 45 existing electric buses

13 e-Buses Urban freight logistics

Small local consolidation centre for last-mile-delivery with small electric vehicles

3 electrical vehicles

ICT

Building energy management system

Advanced building energy management system for monitoring district heating and building comfort controllers

ICT as planning support

Integrated Infrastructure City ICT Model that will combine online simulation models for each of the three building blocks, ICT for city architecture infrastructure, ICT for energy consumption infrastructure and ICT for transport infrastructure

Mobile applications for citizens

Citizens' engagement and empowerment – virtual 'games' and user apps

Energy chain – app for energy control at home

Traffic control system

Road systems – crowd-sourcing data connection (smart meter, traffic model)

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC The main financial risks of the project have been around matching the internal funding with the rising costs of project delivery.	**The team is constantly working to rework costs in order to ensure that the project can be delivered whilst also working under budget pressures.**
FINANCIAL & ECONOMIC, SOCIAL Attracting private investment was complicated due to the difficulties encountered when trying to explain the benefits of the project.	**The team pursued a strong communication campaign. They have sought to explain the benefits of the project by providing examples of best practices implemented in other similar projects.**
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC During the REMOURBAN works, resources have been a constant point of contention, with the number of personnel and cash resources required during the implementation of the project being different to those anticipated at the planning stage. This has largely been due to industry cost increases as well as staff reductions. Specifically, the project team has noticed equipment and goods costs increasing significantly between the initial bid and delivery stage, meaning that there have been financial pressures on achieving the required delivery activities of the project within the budget available. Government cuts and recruitment freezes have also put pressure on resources whereby changes in staff infrastructure have reduced the availability of personnel for the project.	**This was solved by hiring casual staff when necessary as well as consultants. However, such costs need to be anticipated and accounted for in funding budgets, and internal potential funding sources understood throughout the length of the project. It is essential also that the project has support throughout the organisational hierarchy, with an appointed project sponsor ensuring communication to management.**
REGULATORY & ADMINISTRATIVE The inefficient communication between the different departments of the municipality resulted in delays. In addition, there was administrative confusion over sharing the responsibility, especially between the financial and urbanism departments.	**A cross-cutting smart city department was created in the municipality, designed to aid the implementation of these projects. The department did not function perfectly, but it has proved helpful in dealing with the administrative burdens.**
SOCIAL Owners (usually the municipality) were aware of the merits of the project and they were committed to implementation. However, the tenants were used to doing smaller interventions (e.g. painting the walls) and did not immediately see the value for the community as a whole.	**The developers have tried to bridge the problems encountered with the tenants via communication campaigns, in which they sought to explain the benefits of this type of project by providing examples of best practices implemented in other, similar projects.**

CHALLENGES

REGULATORY & ADMINISTRATIVE, SOCIAL

In the main, this project has been able to move forward relatively smoothly, running well within the government's existing administrative and financial standards. However, some of the challenges noted have been specifically around the size and impact of such a project on organisational resources, as well as the style of language used and the requirements for partners to understand a varying level of complex and specialised knowledge, together with the unique Horizon 2020 processes, which not all project colleagues are automatically aware of. It is therefore essential that the local project coordinator acts as a conduit between colleagues and the project to support, 'translate' and motivate engagement. It is also essential that the coordinator has the time and resources available to be able to provide this service alongside the overall procedural management of the project. Key skills to support this role include academic understanding, project management experience and a thorough understanding of the organisational structure.

BEST PRACTICES

REGULATORY & ADMINISTRATIVE, SOCIAL

The Nottingham project coordination process has included the establishment of monthly team meetings, engaging with all local partners working within the project across all the various strands. It has been noted how important it is to ensure good communication and overall project understanding.

SOCIAL

Owners/tenants have been consulted throughout the project, in both planning and implementation stages. The team has worked to develop good relationships with the residents, holding fish and chip suppers, consultations within homes in the area and encouraging community champions to support the developments. The financial costs and benefits have always been discussed with the residents and their opinions sought. As the project requires their permission to be able to move ahead with the implementation, it has been essential to provide open and honest consultation throughout the project. This has been achieved through the community consultation meetings as well as printed information.

SOCIAL

An interesting outcome of the introduction of the electric bus scheme has been the impact on the working relationship between the bus drivers. It seems that the capacity for each vehicle to be driven in a way that can maximise emission savings has stimulated a healthy and positive competition between drivers to see which of them can drive the most efficiently and save the most energy. This has been good for team building and employee relationships.

REMOURBAN

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The Spanish city of San Sebastian has 186 062 inhabitants and was voted European Capital of Culture 2016. It is a touristic and commercial centre with strong emphasis on services and events. In recent years, San Sebastián has become one of the leading European cities in the context of smart and sustainable cities, largely because of its commitment to science, technology, economic development, sustainability and culture. The city is also an internationally recognized culinary destination.

San Sebastian has an integrated smart city strategy with the particular objective of becoming a nearly zero-energy city. San Sebastian wants to enhance the transition process to a smart city in three areas: energy efficiency, sustainable mobility and ICT infrastructures.

Impact*

The REPLICATE team is working to accelerate the deployment of innovative technologies, and organisational and economic solutions to significantly increase resource and energy efficiency, improve the sustainability of urban transport, and drastically reduce greenhouse gas emissions in urban areas. Therefore, the project aims to enhance the transition process to a smart city with the following:

- energy efficiency: achieve energy savings in relation to the existing situation in retrofitting buildings and in district heating;
- sustainable mobility: integrate sustainable electric vehicles, recharging systems and an Information Mobility System;
- integrated ICT infrastructures: develop new sustainable and cost-effective services to citizens providing integrated infrastructures that improve efficiencies in the use of local public resources and the delivery of public services

Technologies*

The solutions demonstrated in San Sebastian include:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

156 dwellings and 34 commercial premises spread over 18 350 m²

ENERGY SYSTEMS INTEGRATION

District heating and cooling

District heating system to give service to more than 1 500 new properties and 156 existing dwellings. The system is fired by a power plant with 7400 kW of power and two 1400 kW biomass boilers. It will lead to a reduction of 35 % in primary energy consumption, where 90 % of this energy is renewable, and 85 % reduction of CO_2 emissions.

Biomass boilers

Smart street lighting

MOBILITY & TRANSPORT

Electric, hybrid and clean vehicles

2 full electric and 2 hybrid buses for line 26, linking the district with the city centre

Public electric vehicle acquisition – 4 e-cars and 6 e-motos for the municipal fleet

Private electric vehicles: 12 e-taxis, 5 vehicles for the distribution fleet, as well as 12 vehicles and 20 e-motos

Charging infrastructure deployed in the city

* Detailed information regarding the technical and financial performance will be available at a later stage.

ICT

Building energy management system

A demand side platform will be developed for the monitoring of residents' consumption to foster sustainable behaviour

Urban data platform

Smart city platform with integrated services: Open Data and Citizen Participation services, IP services deployment in Poligono 27 and high-speed connectivity network deployment for the whole city.

Travel demand management

Mobility smart city platform and development of advanced mobility services

Traffic control system

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC In Spain, the Royal Decree-Act 1/2012 entered into effect, suspending procedures for the pre-allocation of payments and suppressing economic incentives for new power generation installations based on cogeneration, renewable energy sources and waste. However, section 3.3 of the aforementioned Royal Decree-Act states that a new specific regime will be developed for power generation installations that use biomass, waste and cogeneration technologies.	**As a result of this legislative change, some systems based on cogeneration are contemplating the prospect of not maintaining their installations. Hence, the waste heat that could be reused or is reused in other energy systems is not guaranteed and a project cannot be based on a model of recovering waste heat that has been called into question. In the San Sebastian pilot this legislative change has been taken into account to avoid potential problems related to reusing waste energy originated by cogeneration. As a result, self-sufficient projects should be considered as the main options.**
REGULATORY & ADMINISTRATIVE Local regulations and licences cause changes in the design of different implementations. In some cases, the licences need much more time to be managed because they involve various public administrations.	**Local regulations and licences should be analysed and taken into account from the very beginning of the project in order to design the implementations in accordance with the rules and avoid delays.**
REGULATORY & ADMINISTRATIVE The city of San Sebastian has historical buildings and areas covered by special protection, as well as protected green landscapes. Restrictions in some cases can be high.	**It is important to know which areas are affected by special protection and to plan accordingly to avoid problems during the project implementation.**

CHALLENGES

REGULATORY & ADMINISTRATIVE

The district heating installation is part of a major urban development in the neighbourhood, and obtaining the public and private funding to start the urban development was complicated. However, this initial financial risk has been overcome.

BEST PRACTICES

SOCIAL

With regards to the retrofitting intervention in San Sebastian, the team has been in contact with the owners' association since the early stages of the project to present and explain the proposal with the aim of engaging tenants and owners. Particularly important was to demonstrate that the municipality is an active part of the project, thus providing a form of reassurance and guarantee. As a result, the owners' association signed a letter of commitment that was submitted with the proposal.

During and after the implementation, the engagement process will be intensified. The owners' association will provide in-depth information about the financial and environmental benefits of the project to the owners and tenants. In addition, the municipality will have an open information point for all questions that can arise.

REGULATORY & ADMINISTRATIVE, SOCIAL

Almost 200 people participated in the definition of the Smart City Plan and an Action Plan in San Sebastian for 2016-2020. A review of the plan will take place in 2018 and stakeholder participation is foreseen.

SOCIAL

The REPLICATE project will develop a demand-side platform to allow residents to monitor how they are using their heating and to understand better how savings can be achieved. The residents will have the opportunity to learn about energy consumption and change their behaviour so as to reduce their energy bills and be more efficient.

REPLICATE

REPLICATE

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Sonderborg, Denmark | SmartEnCity

Sonderborg is a Danish municipality with 76 000 citizens committed to becoming a zero-carbon community by 2029, an objective pledged in the ProjectZero visionary project with a focus on sustainable growth and creating new green jobs. Energy efficiency and energy from the area's own renewable sources are the key means to turn the vision into reality. New thinking is essential and public policy and investments fuel this transition.

The activities of the SmartEnCity project are an important contribution to reaching Sonderborg's goal of CO_2 neutrality. Based on a baseline assessment of the current situation and an active involvement of citizens in all interventions, the project will implement renovations of multi-storey buildings, planning of coastal wind farms, heat pumps, electric cars and intelligent charging stations for electric cars.

Impact*

With the SmartEnCity project, Sonderborg seeks to:

- demonstrate ambitious electrification of Sonderborg's Roadmap 2020, including integration of wind energy from near coastal turbines and rooftop photovoltaic power production;
- integrate local green power production in district heating networks and green mobility solutions;
- retrofit the energy in existing buildings of a housing association in close cooperation with tenants;
- engage the citizens as co-designers of the Smart Zero Carbon Sonderborg's ambition to implement integrated solutions with comprehensive learning and introduce new ICT-based energy information.

Technologies*

The solutions demonstrated in Sonderborg include:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Altogether 45 multi-storey buildings (a total of 880 apartments with approximately 66 000 m^2 floor space) will be renovated

Heat pumps

A large heat pump will be installed which will use seawater as a heat source. It will provide heat to the district heating network.

ENERGY SYSTEMS INTEGRATION

Wind turbine

Photovoltaics

District heating and cooling

Thermal collectors

Solar thermal collectors will be installed on the buildings' rooftops

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Electric, hybrid and clean vehicles

18 new electric cars will be introduced into the area, 30 smart electric vehicle-charging stations will be installed, and city bus fleets will be extended by biogas buses

ICT

ICT as planning support

A new ICT system will be introduced, which will collect and analyse data to provide recommendations about the most appropriate energy source to use

Mobile application for citizens

* Detailed information regarding the technical and financial performance will be available at a later stage.

Lessons learned

CHALLENGES

REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC

Electric vehicles were exempt from registration fees in Denmark until 31 December 2015. The Government announced the gradual introduction of the registration fee over 5 years, after which point electric vehicles would be subjected to the same fees as conventional combustion engine vehicles. The introduction of this fee reduced the sales of electric vehicles markedly. According to Insero news, the number sold in 2016 equalled only 3 % of all vehicle sales. The lesson from this example is that future public subsidies should not be taken for granted, and the planning stage of project replication should include a preparation of Plan B for a changing regulatory environment that may impact the economic viability of the project.

REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC

In 2016, it was announced that the financial incentive for open-door wind turbines will end in 2018. Only the wind turbines connected to the national grid by 21 February 2018 are entitled to receive the incentive. This made the business case for many early-stage projects worse and endangers their entire feasibility. The change is especially burdensome due to the short time frame in which it is impossible to speed up wind projects to gain access to the incentive. Future public subsidies should not be taken for granted, and the planning stage of project replication should include a Plan B for a changing regulatory environment.

REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC

A national regulatory change announced in 2016 forced the cancellation of the programme where electricity from photovoltaics sold to the grid received a guaranteed price per kWh rather than the fluctuating spot market price. Options that may become more popular in the future are with the energy service companies (ESCOs) that take over the investments related to energy efficiency intervention. In exchange, they receive monthly payments from the energy cost savings., guaranteed for a set period of time.

REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC

A barrier to the smart mobility actions was the Danish tax system, which dictates that 'gifts free of charge' must be taxed by the receiver for the value of the gift. Therefore it was difficult to give away intelligent electric vehicle chargers, as had been the original plan. Private owners especially did not see the benefit of having to pay taxes for the combined value of the charger and the costs associated with installing the charger.

As a compromise, local businesses and car dealerships were targeted rather than private households. This, however, posed different challenges, because the intelligent e-vehicle chargers typically have the greatest benefit if left to charge overnight; however, vehicles parked at local businesses typically belong to employees or visitors and will not be parked overnight. The project team is treating this as an interesting case study to identify how the intelligent chargers perform in this setting.

SOCIAL

The project has a stakeholder engagement plan that includes how to and when to communicate what to whom. There is no matrix showing the importance/level of influence of each stakeholder, which is something that should be done for future projects. The project team tried to limit the number of people contacting each stakeholder so that time wouldn't need to be spent bringing SmartEnCity partners up to date on every occasion when they communicated with each other. However, this became more of a burden because the person contacting the municipality for smart mobility was unable to answer any ICT-related questions.

In general terms, stakeholders included Sonderborg project partners, local authorities, residents in affected housing associations, citizens in general, current and potential future e-vehicle owners, local businesses, SmartEnCity project partners and the project officer. Communication was done through various channels, but all stakeholders were met in person for the first few times to create a personal link and eradicate any misunderstandings. Email was used for complicated or extensive questions, and phone calls for quick and short questions and clarification. Furthermore the www.smartencity.dk website was set up for the local stakeholders to be able to find information in Danish about the initiatives in their immediate surroundings.

BEST PRACTICES

SOCIAL

So as to engage the tenants, the housing associations controlled the flow of information. The Danish housing associations are all set up similarly with residents/tenants from each department unit creating a board of residents that make decisions. Each department unit is typically made up of a few apartment buildings located next to one another on the same street. Decisions affecting the department unit in question must be brought to the board of residents which has to approve the decision and its consequences, unless it concerns safety or security; in that situation the national board of the housing association can overrule the board of residents' decision. In this case, the resident boards voted on whether to go forward with the retrofitting measures, whether to mount photovoltaics on top of the roof or have them integrated in the roofs, etc.

The residents were also engaged through the opportunity to voluntarily track their consumption of water, electricity and heat. A website was created especially for this and the residents could enter their consumption data into the website and see daily/weekly/monthly trends for their own apartment. This engagement activity was combined with educational workshops on the financial and environmental benefits of the project. Most people can relate to monetary savings, but this is difficult to use in this situation in Denmark. For example, even if a resident replaces all the lights with LEDs, the majority of the bill will stay the same due to various fees, e.g. transport fees, national fees, etc.

SOCIAL

Intelligent e-vehicle chargers mainly charge overnight when, generally, there is a surplus of renewable electricity in the grid. This may require some behavioural changes; however, so does driving an electric vehicle compared to a diesel car. The intelligent charging IT system is under development and so is the strategy for its successful adoption by users.

smart en. city

SmartEnCity

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The Stavanger region is regarded as one of the most innovative regions in Norway. For 10 consecutive years it has been appointed The Best Business Region in Norway (NHO) and is renowned for its close triple helix cooperation among businesses, academia and the public sector. The region aims at becoming one of Europe's foremost sustainable cities by integrating ICT, energy and mobility. In the Stavanger area, one district in particular – Paradis/Hillevåg – will be transformed into a living lab as part of the TRIANGULUM project. Within this area, substantial changes will take place in buildings, such as 100 private homes fitted with integrated solutions and smart generic gateways. Services include heat and light control, innovative video solutions, security/safety features and charging for electric vehicles. Stavanger sees smarter homes as a crucial part of building a smart city due to the opportunities in enabling the inhabitants to develop the smart city.

The interventions include:

- installing a renewable energy plant for three major municipal office buildings, making the energy supply for light and heating greener and reducing the CO_2 emission;
- developing and installing a smart generic gateway at a school and a nursing home, which will allow for the use of innovative video solutions, strengthened energy efficiency, building automation and smart charging of e-vehicles;
- developing a cloud data hub for gathering and analysing big data from the project;
- spreading knowledge on the new integrated solutions, as well as contributing towards the development of a business framework for smart cities.

Impact*

For the Stavanger region, TRIANGULUM means making a difference for its citizens and enabling new business and research to be spread, both in mature and new markets. The impact will be measured according to the following indicators:

- lowering emissions, both by enabling people to make the right choices and introducing equipment and infrastructure for electric mobility;
- improving the quality of public transportation and thus increasing its competitiveness compared to individual motorcar traffic;
- smarter houses make cities smart – decision support, energy control, safety and comfort;
- lowering energy consumption, both in dwellings and public buildings;
- 75 % of the heating requirement to be covered by renewable energy in the buildings that the municipality's new energy plant (centre) will serve;
- meaningful citizen involvement in everyday life;
- seeking business opportunities globally.

Technologies*

The measures being implemented in Stavanger include:

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Renovation of central energy plant for heating and cooling using renewable energy

MOBILITY & TRANSPORT

Clean flues and fuelling infrastructure

Electric vehicles charging infrastructure

Electric, hybrid and clean vehicles

Electric buses (demo project)

* Detailed information regarding the technical and financial performance will be available at a later stage.

ICT

ICT as planning support

Smart gateway for public and residential buildings

Innovative video solutions and visual communication tool

Urban data platform

Development of a cloud data hub for gathering and analysing big data

triangulum

DEMONSTRATE·DISSEMINATE·REPLICATE

TRIANGULUM

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Sweden's capital city, Stockholm, has been working on climate change mitigation and adaptation since the 1990s. The city is a real frontrunner with well implemented climate action plans and pioneering policies to ensure it meets its ambitious environmental targets. The carbon dioxide emissions have been cut by 25 % per citizen since 1990.

At the same time, Stockholm is growing rapidly and sometimes faces the challenges of both keeping and developing its unique city character. A key priority is to ensure that it remains a sustainable city, while offering an attractive and inspiring living and working environment. The implementation and monitoring of all climate actions undertaken in the city is coordinated by the climate action group. Their long-term aim is to become completely fossil fuel free by 2040.

In this context, within the GrowSmarter project, Stockholm demonstrates 12 smart solutions in the fields of low energy districts, integrated infrastructure and sustainable urban mobility in Årsta, a fast-growing district in the south of the city.

Impact*

The demonstration site in Stockholm consists of three refurbished buildings with an overall gross floor area of 36 307 m².

The final energy demand of the site is reduced by 3333 MWh every year thanks to the refurbishment. According to SCIS calculations based on energy design data and the respective emission factors available, the primary energy savings go up to 4918 MWh/yr while the CO_2 reduction amounts to 1187 tonnes every year.

Technologies*

The solutions demonstrated in Stockholm within the GrowSmarter project are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

- Windows with extra low U-values
- Air tightness

Building services (HVAC and lighting)

- Efficient lighting
- Energy quality assurance

Heat pumps

ENERGY SYSTEMS INTEGRATION

Waste heat recovery

- Recovering waste-water heat from the drain
- Waste heat from data centres and vacuum waste systems
- Waste heat from fridges and freezers in supermarkets

District heating and cooling

- Open district heating with a feed-in of waste heat

FACTS & FIGURES

Geographical area	**Stockholm, Sweden**
Demonstration area	**3307 m²**
Final energy savings	**3333 MWh/yr**
CO_2 emissions reduction	**1187 tCO_2/yr**

ENERGY EFFICIENCY IN BUILDINGS*

Retrofitted area	**36 307 m²**
Final energy demand (baseline)	**142 kWh/m²/yr**
Final energy demand (after)	**50 kWh/m²/yr**
CO_2 emissions reduction	**1187 tCO_2/yr**

**Average values for the three buildings included in GrowSmarter*

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Developing charging infrastructure

Setting up refuelling facilities for alternative heavy duty fuels

Electric, hybrid and clean vehicles

Car sharing

Green parking index in combination with car sharing pool with electric vehicles

Bicycle infrastructure

Electrical and cargo bike pool

Urban freight logistics

Integrated multi-modal transport for construction material /logistics centre

Integrated multi-modal transport for light goods

Micro distribution of freight

ICT

Building energy management system

New adaptive control and regulation techniques for heating systems

Active house/home energy management systems / smart home system

Open home net

Energy visualisation

Smart plugs, connected lighting and thermostats

Dynamic price models

Individual energy metering

CO_2 signal

Urban data platform

Big open data platform

Traffic control system

Traffic signals synchronised to prioritise certain vehicles for the movement of goods

Smart guiding to alternative fuel stations and fast charging

GrowSmarter

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Tartu, Estonia | SmartEnCity

Often called the intellectual capital of Estonia, Tartu is a town of intellectuals, scientists, creatives and students, making it a hotbed for creative and scientific culture. Estonia's most renowned university, the University of Tartu, hosts nearly 14 000 students, which makes up a good proportion of the whole population of the town – a total of 100 000. Also known as the city of good thoughts, Tartu already has a good track record as a smart city. It has been developing its e-services and paperless administration practices for decades and was one of the first in the world to implement many smart solutions – m-parking in 2000, public Wi-Fi throughout the city in 2000, local e-elections in 2005, city mobile applications in 2006, digital signatures in 2007, a fully electric taxi service in 2012, and participative budgeting in 2013, to name a few. Tartu ranks 15th in the European Smart Cities benchmark for smart people and joined the Covenant of Mayors in 2014 with the aim of promoting energy-efficient solutions, the use of renewable energy and citizens' awareness of environmental issues.

The selected pilot area for the SmartEnCity project spreads over 0.39 km^2 in the city centre and is surrounded by two streets in the so-called Khrushchev banks quarter. The demonstration activities include efficient renovation of buildings, innovative solutions for district heating, innovative solutions for transport, innovative solutions for street lighting, renewable energy, installation of sensors (noise, air pollution, temperature and humidity, as well as monitoring road conditions), and citizens' involvement in planning and implementation.

Impact*

With the SmartEnCity project, Tartu aims to:

- demonstrate a comprehensive approach to retrofitting out-dated panel buildings according to near zero-energy standards;
- boost the liveability of the town through intelligent street lighting, biogas buses, electric car and bike rentals, as well as charging stations and many ICT solutions;
- engage the citizens in creating a high-quality living environment that inspires environmentally aware decisions and new patterns of behaviour.

Technologies*

The solutions demonstrated in Tartu include:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

900 Khrushchev-era apartments (23 buildings) will be renovated, including greater energy efficiency

ENERGY SYSTEMS INTEGRATION

Smart street lighting

LEDs and sensor-based lighting

District heating and cooling

Waste heat recovery

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Installation of new charging points

Electric, hybrid and clean vehicles

Recycling old batteries used in electric vehicles

Car sharing

ICT

ICT as a planning support

An IT tool will be developed, which will enable residents to monitor, analyse and adjust home energy consumption. It will also promote the exchange of information in the community by providing real-time information about the availability of nearby shared cars and environmental conditions.

Smart district heating and cooling grids - demand

* Detailed information regarding the technical and financial performance will be available at a later stage.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC Cascade funding in the case of some mobility actions; for example, support for the purchase of electric vehicles was problematic.	**As the project did not find a solution to this barrier, they decided to change the planned activities.**
REGULATORY & ADMINISTRATIVE The biggest administrative burden for the project at this stage was to gain access to the electrical grid for the photovoltaic panels and the electric vehicle chargers.	**The access process was launched as soon as possible.**

BEST PRACTICES

SOCIAL

The SmartEnCity team in Tartu has developed a stakeholder engagement plan and especially in the refurbishing phase of the pilot area the focus of communication and engagement strategy is on the participation of the housing associations and residents belonging to these associations. All the buildings in the renovated district are privately owned and the collective decision by the owners is required for the renovation to take place. The SmartEnCity project supports this process but the final decision has to be made by the representative non-governmental organisation of the private owners. The main task is to include the associations in the renovation process and the single most important act of engagement will be the decision to renovate, made by the housing associations. Everything in the project has to support this decision and help its realisation.

The engagement strategy has several stages, including building up the necessary knowledge for entering into the renovation process via newsletter, website and forum; internal meetings of the housing associations to explain the planned renovation in detail, collecting feedback and trying to convince them to participate in renovations; supporting the housing associations in developing and implementing the renovation project designed by the contracted engineering company; providing knowledge to the people in renovated houses on the possibilities and ways of conserving energy in their everyday life.

SOCIAL

For Tartu, the major emphasis of the stakeholder engagement strategy is on learning, i.e. changing the existing socioeconomic practices. This requires a concentrated effort from all stakeholders as people must be taught how to adapt to and use the new technologies. The mutual learning practices will involve both peer-to-peer studying (current users of the technology will simultaneously promote and encourage other users to adapt to the technology), vision building (communicating the benefits and futuristic possibilities of smart cities and the specific technologies used), recruiting influential spokespeople, etc.

SmartEnCity

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Tepebaşı is a municipality located in Eskişehir in the mid-western side of Anatolia with a population of 320 000. Yaşamköyü is a district of approximately 30 000 m^2 with a built area of just under 10 000 m^2. The area was built on 2007 by TOKI, the governmental organisation responsible for mass housing in Turkey. Although relatively newly built, similar to most buildings built before the Energy Efficiency Law that came into force recently, the district building stock consists of inefficiently constructed buildings in energy consumption terms. The typology of buildings in the district are characteristic of the relatively recently built but energy-inefficient and poorly insulated type of mass housing, typical of TOKI construction, and highly inconsiderate of the climate zone. In this respect the retrofit intervention in the district, within the REMOURBAN project, is thought to be highly relevant and exemplary for hundreds of thousands of residential buildings with similar characteristics, both in Eskişehir and also across Turkey.

The main selected residential development axis for the city is in the west, towards the present demo site. It was given careful consideration regarding the integration of the demo site's mobility plans into the wider master plan. The highest population increase in Eskişehir, which is forecast to increase to around 950 000 by 2023 by the state statistical organisation, should happen in this axis. The selected demo site is in the middle of this development area and will present a smart and sustainable alternative to urban development in Eskişehir.

To achieve the expected impacts of 85 % of energy savings, 79 % reduction in CO_2 emissions and direct involvment of 600 citizens , the project in Tepebaşı will follow an integrated approach, combining actions in the fields of low-energy districts, sustainable mobility, integrated infrastructure and society.

In the area of building renovation, 'near-passive' buildings will be targeted by the interventions at the demo site, as well as the realisation of a central district heating/cooling and hot water system, bringing significant energy saving. With regards to mobility, among the measures that will be implemented is an additional 6.2 km expansion to the cycling lanes and organising municipally owned e-bikes. All these measures are complemented by ICT technologies and strategies, including a building energy management system, bike rental operation and 'City on Cloud' city management system with all the energy, mobility and other data on a cloud system, which will be monitored by the municipality. The success of the actions is ensured through social and non-technical measures such as a citizen engagement strategy, a social media strategy, a stakeholder platform, a strategy for development of integrated urban plan, and common sustainable and smart evaluation procedures.

Impact*

The overall gross floor area of 10 570 m^2 has been refurbished in the Tepebaşı demo site. The annual final energy saving is 1559 MWh. The total CO_2 emission savings amount to 476 tonnes of CO_2 per year.

FACTS & FIGURES

Geographical area	**Tepebaşı, Eskişehir, Turkey**
Demonstration area	**10 570 m^2**
Population in the area	**386 inhabitants**
Final energy savings	**1559 MWh/yr**
CO_2 emissions reduction	**476 tCO_2/yr**

Technologies*

The actions and measures being implemented in Tepebaşı within the REMOURBAN project are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Retrofitting 10 570 m^2 with 57 dwellings and 386 residents

Near-passive buildings will be targeted by the interventions

The most important component of the energy category interventions will be heating/cooling energy saving implementations on the building envelope via strong insulation in exterior walls, triple-glazed window units, pipe and attic insulation.

* Detailed information regarding the technical and financial performance will be available at a later stage.

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Renewable heating and cooling – air sourced heat pump and chiller

Biomass boilers

Cogeneration (CHP)

Polygeneration

Thermal storage

Electrical energy storage

Critical loads will be served via battery storage that will be housed in the same building as the central heating plant

Photovoltaics

Electricity distributed generation

An approximately 150 kWp photovoltaic system will generate around 70 % of the power needs of the demo site. The photovoltaic system consists of a 100 kWp rooftop building-integrated photovoltaic installation on the custom-made roof of the social centre, in addition to 50 kWp implemented on the car park area

Thermal collectors

Solar thermal collectors for domestic hot water (parabolic vacuum pipe)

27 kWt solar collectors

Smart street lighting

All lighting within buildings and street lighting in the district will be turned to low energy LED lighting with smart applications

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Incentives – integrated bike rental system, free parking for electric vehicles, municipality info kiosks for travel information

Electric, hybrid and clean vehicles

30 electric bikes

4 electric buses and minibuses for mass transit

22 electric hybrid vehicles for the municipality fleet

Bicycle infrastructure

An additional 6.8 km of cycling lanes will be established. The bicycle lanes will be integrated into the urban transportation network via nodes and bike parks at the city rail (ESTRAM) stations. A fleet of 30 e-bikes will be rented out by the Tepebaşı municipality, and the necessary charging infrastructures will be installed in the appropriate locations.

Intermodality

Door-to-door multimodality transport – advantageous ticketing options (bikes + public transport system), public transportation smartcard, smart debit card applications

The Tepebaşı municipality will purchase 4 e-buses operating to/from the demo site and its surroundings as well as 22 hybrid cars that will exploit the charging infrastructures to be established.

ICT

Building energy management system

Advanced building energy management system – energy monitoring system (automatic and occupancy control, CO_2 sensors, comfort controllers)

Neighbourhood energy management system

Energy monitoring and control system

Mobile applications for citizens

Advanced monitoring and energy performance visualisation ICT platform

Intelligent transport systems – smart phone app mobility, info interface to bike system

Strategic urban planning

Re-skilling centre in Tepebaşı, which will also act as a smart city and community demonstration site, with the smart and renewable energy urban management system in place

Urban data platform

City information platform – smart city monitoring portal

Shared infrastructure – energy data monitoring infrastructure access via the smart city monitoring portal

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC Legislation covering renewable energy grid connection, the type and number of permits, and government incentives are all in a state of flux in Turkey and subject to frequent changes. This issue has influenced photovoltaic system integration in the REMOURBAN demo site. Installed system capacities determine the specific, legally permitted procedures related to photovoltaic projects. These have also changed quite frequently and the authorities enacted a 'freeze' in 2016 while various issues were sorted out. As it stands, rooftop installations have been given an exemption from several steps in the procedures up to 50 kWp and it is thought that this value will be increased. All these issues have caused delays in applications and project flow.	**Unfortunately, it is not possible to involve this issue in risk maps prepared at the beginning of the project as the character of the change is not predictable. The only measure appropriate would be to start the procedural process as soon as possible into the project. One possible solution considered was to sub-divide the installed capacity so as to remain below a certain capacity, thus escaping over-complicated procedures. This however entails separate grid connection points and subscriptions, thus increasing the costs.**
REGULATORY & ADMINISTRATIVE The REMOURBAN interventions at Tepebaşı have been selected specifically to minimise outside interventions by alternate units of different administrations, such as ministries and metropolitan municipalities. The most important example of this is the selection of the demo site itself, which is owned by Tepebaşı municipality. However, it is important to realise that Tepebaşı, as a district municipality and not metropolitan municipality, has limited jurisdiction over important topics such as overall mobility planning and urban infrastructural decisions. The decisions regarding the path of the extended cycle routes for instance are one of the examples where there are overlapping authorities (metro municipality and Directorate of Highways under the Transport Ministry), and where up-front agreement is critical for the project.	**This has generally been solved by discussions early on in the project design.**
REGULATORY & ADMINISTRATIVE Silo mentality in large and multi-disciplinary institutions has been one of the major communication problems for the project. When interfaces include the metropolitan municipality of Eskişehir (hierarchically above Tepebaşı), relationships have not been satisfactory, especially where approval from the metro municipality is concerned.	**This problem had to be tackled carefully via a higher intervention by the project sponsors and champions in the municipality, who had influence in overcoming the communication difficulties.**
SOCIAL The almost full automation of the energy supply system requires significant behavioural changes by users. The extensive retrofit undertaken in the project not only radically reduces energy consumption in the buildings but also, through much better conditioning, significantly increases indoor air quality compared to before the project. Tenants' typical reaction to freshen the room had been to open the windows, even in the winter. This habit may continue despite the much higher quality of air indoors.	**Certain automatic controls and information interfaces on these aspects of the building will offset the previously explained behaviour gradually by providing information.**

CHALLENGES

FINANCIAL & ECONOMIC

Since REMOURBAN is focused on high performance, the interventions were planned to reach the expected over-standard performances. Although the equipment and materials have been chosen with consideration for the best value for money, it can be said that there would be a higher return on investment if the project did not have certain high-performance goals.

FINANCIAL & ECONOMIC

The project is funded 100 % by the European Commission since the owner of the demo site is a public institution, the Tepebaşı local government. However, the municipality has to make the necessary investments in the project before receiving funds from the Commission. Nevertheless, there is a large share of pre-financing, which was received at the beginning of the project.

BEST PRACTICES

SOCIAL

REMOURBAN has a specific task on citizen engagement. Through this deliverable, the relevant stakeholders that would be influenced by the project measures and the time and manner of their engagement have been noted. The university has carried out several inquiries and questionnaires regarding student evaluation of the proposed cycle routes and their usage.

SOCIAL

The tenants were consulted both at the beginning and during the implementation of the project. As extensive retrofits were planned to be undertaken, significant resident displacement was sure to take place. Tenant consultation was therefore imperative in the project. The procedure utilised was consultation meetings. As the demo site belongs to the municipality, there are no financial concerns on the part of the tenants. However, potential comfort and environmental benefits have been conveyed to residents via the above-mentioned meetings.

REMOURBAN

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Valladolid, Spain | REMOURBAN

Valladolid is the capital of the autonomous region of Castile and Leon in the north-west part of Spain, and with a population of 307 052 people it is the biggest city in the region. The demonstration site of the REMOURBAN project in Valladolid covers the FASA district, which has a surface of 3.5 km^2 and is part of the Delicias neighbourhood, located in the south-east of Valladolid. The district was designed and built at the beginning of the 1960s for workers of the FASA company. It consists of 19 blocks, a tower, a building for the central boilers, a park, some sports facilities and two car parks. With a total number of 398 dwellings, the FASA district has around 1180 inhabitants. The buildings in the area are of medium-poor constructive quality and progressively ageing. Its location at the traditional south entrance to the city makes the district part of a strategic area of the city regarding mobility.

With the aim to achieve 50 % energy savings, 80 % CO_2 reduction and to directly involve 5 700 citizens, a number of actions are underway in Valladolid in the fields of low-energy districts, sustainable mobility, integrated infrastructure and society.

An intensive building envelope retrofitting plan is to be deployed in all the buildings of the district, taking advantage of the homogeneity of the existing construction and aesthetic solutions. The second set of priority actions, planned to achieve a 'low energy district', is related to the district heating and domestic hot water systems, through the improvement of the existing thermal district heating (changing the energy source from gas to renewable energy and improving the system efficiency) and the integration of the current individual domestic hot water systems into this thermal network. With respect to mobility and transport, the actions foreseen for reducing the mobility impact, by means of reducing the energy consumption and CO_2 emissions, include the implementation and promotion of using clean powered (both public and private) vehicles, while improving the clean transport infrastructure.

All these measures are complemented by ICT technologies and strategies like the development of smart phone apps as an aid to mobility (AtM) and a ticketing system, or the implementation of unique contactless radio frequency infrared device (RFID) cards to enhance the intermodality among buses, rented bicycles and car sharing. Moreover, the success of the actions is ensured through social and non-technical measures such as a citizen engagement strategy, a social media strategy, a strategy for development of an integrated urban plan, an innovative strategy for building retrofitting in multi-owner property buildings, and common sustainable and smartness evaluation procedures.

Impact*

The overall gross floor area of 24 700 m^2 is to be refurbished in the Valladolid demo site. With respect to the energy and mobility measures , the expected annual final energy saving is 2222 MWh; the total CO_2 emission savings amount to 1147 tons per year.

FACTS & FIGURES

Geographical area	**Valladolid, Spain**
Demonstration area	**24 700 m^2**
Population in the area	**1181 inhabitants**
Final energy savings	**2222 MWh/yr**
Primary energy savings	**3365 MWh/yr**
CO_2 emissions reduction	**1147 tCO_2/yr**

Technologies*

The actions and measures being implemented in Valladolid within the REMOURBAN project are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Retrofitting 24 700 m^2 area with 398 dwellings and 1181 residents

Cost-effective retrofitting strategies related to the walls and roofs

Building integrated renewable energy sources

Building integrated photovoltaics

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Biomass district heating

Biomass boilers

Photovoltaics

Photovoltaic panels on façade (27,4 kWp)

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Charging infrastructure: 4 charging points for electric taxis, 1 fast charging point for taxis, and last mille fleets, 2 e-buses pantographs upgrade of 13 electric vehicle charging points, 20 charging points in parking areas and 20 new public charging points in private businesses

Electric, hybrid and clean vehicles

Full and hybrid electric vehicles: 40 full electric vehicle taxis, last mile, private businesses, 2 electric buses, 2 electric cars for the municipality car sharing fleet

Incentives: free parking for electric vehicles, tax reductions for electric vehicles, special lanes for electric vehicles

Intermodality

Door-to-door multimodality transport: ticketing system based on RFID cards, shared among users from buses, bicycles and the car-sharing fleet

ICT

Building energy management system

ICT platform for energy performance monitoring

Neighbourhood energy management system

Advanced building energy management systems for monitoring district heating and building comfort controllers

Urban data platform

The city information platform will collect and store the data from the district with regards to energy performance, comfort data, mobility aspects, etc. It will play a key role in the management of the improved infrastructures of energy and transport, being also part of the citizens' awareness strategy and enabling the evaluation the implemented measures results.

Mobile applications for citizens

Intelligent transport systems: smart phone app as an aid to mobility

Smart district heating and cooling grids: demand

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC There were legislative changes during the implementation phase of the project, which did not allow the project the use of cascade grants on the promotion of electric vehicles.	**It was necessary to make more effort to deal with this challenging change, but the final result was that Valladolid has an innovative public procedure of how to promote the purchase of e-vehicles through services data provider contracts with final 'companies' (taxis, last-mile companies and other companies with an EV fleet).**
REGULATORY & ADMINISTRATIVE Administrative procedures in public administration are complex, which becomes even more noticeable when dealing with innovation activities carried out by different departments.	**An important role in overcoming these administrative burdens was played by the Innovation Agency of the City Council of Valladolid. The agency has a transversal approach and is a key factor in the success of the project.**

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE The deployment of the charging infrastructure in Valladolid encountered delays due to the traditional tender procedure by contract.	**In order to overcome this administrative barrier, the team managed to change the traditional procedure and work towards a public-private partnership.**
SOCIAL There was an initial rejection by the tenants to the energy-efficiency activities in the FASA district.	**A detailed action plan was designed and launched to raise awareness and bring them on board.**

CHALLENGES

FINANCIAL & ECONOMIC

The main financial risk was the uncertainty surrounding the district owners signing the contracts with the companies awarded the project work.

FINANCIAL & ECONOMIC

The municipality of Valladolid provides local grants to more than 400 owners for the active and passive interventions; however this operation has become especially complicated. Supplementing EU funding with municipal subsidies means a complex administrative management, where the council must verify the legal and fiscal requirements of all the owners to grant the aid.

BEST PRACTICES

SOCIAL

The project In Valladolid has crafted a stakeholder engagement that maps the different stakeholders and plans the communication and dissemination activities tailored to each group during the different phases of the project.

The engagement activities include the distribution of a special informational leaflet among the tenants to raise the awareness of the financial and environmental benefits of the project, launch of a local website with a frequently asked questions section, and direct email and phone communication line with the project partners.

REMOURBAN

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Vienna, Austria | SMARTER TOGETHER

The SMARTER TOGETHER project demonstration area in Vienna is located in the central part of the south-eastern district of Simmering. In total, 21 000 inhabitants will benefit from smart project solutions within the fields of refurbishment, energy, mobility, and information and communication technologies. An emphasis is made on dialogue, in line with the Vienna Smart City Framework Strategy, where the human dimension of the smart city is the focus of attention. Dialogue includes all generations and backgrounds aiming at contributing to an integrated societal dynamic. The partnership includes all actors, from government to citizens to business players, where everyone has a specific responsibility towards achieving the common goals.

Impact*

Within the SMARTER TOGETHER project, Vienna strives to:

- refurbish three residential neighbourhoods with 1300 inhabitants and a total floor surface of 75 000 m^2;
- ensure total savings of 6000 MWh per year in all the refurbished housing complexes, which corresponds to the energy use of about 700 housing units;
- guarantee more sustainable and future-oriented energy supply with 9000 MWh provided by renewable energy sources (thermal as well as electric energy), which will result in considerable savings for the tenants in energy and heating costs;
- save about 550 tonnes of CO_2 annually;
- secure and/or create 900 jobs;
- promote an intensive governance learning process by involving eight departments of the City of Vienna's administration, ensuring that the experiences and results of the project will be integrated in a sustainable way all over the city.

FACTS & FIGURES

Geographical area	**Vienna, Austria**
Demonstration area	**75 000 m^2**
Population in the area	**3100 inhabitants**
CO_2 emissions reduction	**550 tCO_2/yr**

Technologies*

The measures that will be implemented include:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Residential and school buildings

Building services (HVAC & Lighting)

Installation of heat meters to measure heat consumption

ENERGY SYSTEMS INTEGRATION

District heating and cooling

More users are to be connected to the district heating

Thermal storage

Local shared heating: integration of solar thermal energy and heat storage

Photovoltaics

Thermal collectors

Waste heat recovery

Integrating solar thermal energy and waste heat to district heating

Smart street lighting

Innovative street lighting with free WLAN hotspots

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Electric, hybrid and clean vehicles

Development of a local e-mobility strategy

Design and installation of e-mobility point

Introducing e-mobility in the factory premises of the local Siemens plant and in mail delivery

Electric delivery in Austrian Post (vans and fast chargers)

Feasibility study of an e-taxi fleet station in Simmering

Car sharing

Exclusive e-car sharing system for tenants of a social housing block

Bicycle infrastructure

E-bike sharing scheme in Simmering

ICT

Urban data platform

Together with the other two lighthouse cities in SMARTER TOGETHER, Vienna will upgrade their urban data platform into a smart data platform by integrating new datasets from energy and mobility, as well as data analysis features

Postal reception boxes in the social housing blocks

Lessons learned

BARRIER	SOLUTION
SOCIAL The impact of engagement events in public areas only reached a too little people. In addition, tt was not possible to engage specific target groups sufficiently (e.g. full time working people and families with migration background).	**In order to reach more people, the project team implemented or plans to carry out the following actions:** • get in contact with the target groups via the pupils. A cooperation with "science pool" (private education provider) was established and the content of the teaching unit was coordinated with the SMARTER TOGETHER targets. • in addition, the cooperation with local clubs will be sought because it is assumed that it will be very helpful for reaching broad target groups. • the mobile info point Sim mobil was refined and different add-ons were installed (a solar panel on the roof, a bike generator, an energy quiz for making it more attractive. • the standard information process of the housing companies was enhanced. By installing a temporary information office on-site, the tenants had the possibility to talk to someone connected to the housing company to receive information about the refurbishment process and to express their wishes.

BARRIER	SOLUTION
SOCIAL The tenants of one of the refurbishment projects (Hauffgasse) were averse to the refurbishment.	**The team organised an information evening, and increased the opportunities for discussions in smaller groups.**
The tenants thought that all of them have to pay for the e-car sharing scheme regardless or the usage. The utilisations was not high enough to reach economic feasibility.	**Stronger communication efforts were necessary, including on-site support from independent people to answer questions and reduce the fear of something new. The use of a proven business model is very important.**

CHALLENGES

FINANCIAL & ECONOMIC

The investments for SMARTER TOGETHER in Vienna are more than € 50 million, mostly for refurbishment and construction work. Return on investment depends on the different project (e.g. 7% for energy investments to much lower for constructions). The main risks are probably associated with investments for new mobility services where the long-run revenue is difficult to foresee.

REGULATORY & ADMINISTRATIVE

A predesigned administrative procedure for installing a charging station does not exist. Therefore, the acquisition of permission takes longer, there is insecurity and a strong need for cooperation with relevant actors.

REGULATORY & ADMINISTRATIVE

The public bodies in Austria have stricter tender criteria than private companies, due to security reasons in public areas, thus all installations respectively products need a CE certificate. Furthermore, the tender and offer documents are accepted only in German. The solar bench product of the initial envisaged Serbian company did not have CE certifications and thus did not fit the Austrian tender criteria so an alternative company had to be found. This resulted in a delay. The lesson from this example was that the first question when dealing with an international company should be about the CE certification.

REGULATORY & ADMINISTRATIVE

With regards to school Enkplatz, one part of the building is under a preservation order, thus it cannot be used for renewable energy sources installations. The project team was aware of this from the beginning of the project. During the planning of the zero-energy gym, this had to be considered and the needed energy generation facilities will be installed on the gym only.

BEST PRACTICES

SOCIAL

A major focus of the project lies on the integration of the residents, and respectively the affected people of the target area in the district of Simmering. They can participate in different ways during the co-creation process, which accompanies the realisation projects. Quite a few engagement and co-creation activities took place, among which:

- low-energy districts - the tenants of the refurbishment building Lorystraße can decide about the colour of the façade and the balconies, as well as about the design of the community space and the garden.
- sustainable mobility - in order to select an e-bike model for the public mobility stations, a public e-bike testing was carried out. A mobility survey to support the mobility projects was also performed among the local tenants to gain knowledge about their mobility behaviour. The inhabitants also had the possibility to weigh in their wishes and ideas for the mobility point(s) during multiple events at the mobile info point Sim mobil.
- information and engagement: there were guided walks in the target area on project-related topics like mobility or energy. Bike days took place to inform about bike topics, while the sim mobil was used to inform tenants (in public areas, during the information events, etc). The practical support and experiences from the local urban renewal office was very helpful.

SMARTER TOGETHER

SMARTER TOGETHER

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Vitoria-Gasteiz is the capital of the Basque Country and one of the leading European cities investing in green economy. The city, which was the European Green Capital in 2012, has 240 000 inhabitants and a high proportion of green public areas, ensuring that the entire population lives within 300 metres of an open green space. Numerous tangible measures are in place to assist and increase biodiversity and ecosystem services. Vitoria-Gasteiz is committed to becoming smarter, using modern technologies to improve its citizens' quality of life. Citizens play a key role in the definition of strategies covering ICT, mobility, energy and the urban environment, working together with public bodies, the private sector and research agents.

The implementation area of the SmartEnCity project in Vitoria-Gasteiz is the Coronación neighbourhood, which is a highly vulnerable area from a social and energy-efficiency point of view. With the focus on neighbourhood regeneration, the actions in the demo site cover three main areas:

- energy rehabilitation of facade and building roofs in 1313 homes;
- installation of a central heating system and a wood-fired hot water boiler;
- rehabilitation of public spaces (streets, squares, pavement, benches, landscaping, etc.).

Impact*

The planned measures will reduce energy demand in the neighbourhood, increase the use of renewable energy, improve the comfort level of buildings, save costs on space heating and hot water and involve local residents in project planning.

Technologies*

The solutions being implemented in Vitoria-Gasteiz are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

750 dwellings (60 000 m²) in the Coronación district will be insulated

Existing energy systems will be replaced with a connection to the district heating

ENERGY SYSTEMS INTEGRATION

District heating and cooling

A new biomass (wood chip) district heating network will be deployed, and integrated energy management systems will optimise efficiency in homes, buildings and districts.

Biomass boilers

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Electric, hybrid and clean vehicles

Acquisition of electric vehicles (taxis and private cars) will be granted, and the recharge network will be extended

ICT

Building energy management system

Neighbourhood energy management system

* Detailed information regarding the technical and financial performance will be available at a later stage.

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC The Spanish electricity market has been running into deficit in recent years, known as a 'tariff deficit', largely as a result of the cost of running the country's electrical system exceeding the revenues generated by the sales of power. In 2016, the Spanish government proposed a new deficit reduction measure called the 'sun tax' that increases the price of self-generated solar power, largely based around photovoltaic technology. According to Spain's Photovoltaic Union (UNEF), the new law requires self-consumption photovoltaic system owners to pay the same grid fees that all electricity consumers in Spain pay, plus the so-called 'sun tax'.	**This regulation does not affect the project directly but it has removed the photovoltaic technology from the catalogue of possible technological solutions.**
REGULATORY & ADMINISTRATIVE The deployment of district heating is a relatively new concept in Spain, and ownership and exploitation of the system, which needs political decisions regarding the involvement of the public sector, can delay the project.	**The team has created a public-private management frame where several companies, together with the municipality of Vitoria Gasteiz, have signed an agreement for the management and exploitation of the district heating network.**
REGULATORY & ADMINISTRATIVE Energy data monitoring is an important part of the project but unfortunately this collides directly with the Data Protection Law.	**The solution would be to ask the owners to sign agreements that their energy monitoring data can be used for research, evaluation and energy management purposes.**
REGULATORY & ADMINISTRATIVE, SOCIAL The structure of ownership (mostly family-owned apartments) and property laws in Spain can also be barriers for the normal development of the project. Apartment owners in Coronación district have a decision-making power and an agreement from the community is needed before reaching any decision to undertake integral building refurbishment projects, and/or to connect to the district heating.	**To face this challenge the team has developed a direct intermediate strategy with the neighbours through multiple meetings to inform them and to be sure that any decision taken has been done with a thorough knowledge of the project.**
The project aims to develop a district heating network, so many of the tenants need to get used to a centralised heating system. Nowadays, many of the tenants use individual heating systems and this change of model will be a challenge, both for the tenants and for the project managers.	**The new public-private framework regarding the district heating network involves stakeholders from different backgrounds. Some of them come from important energy facility management companies and, taking advantage of this expertise, they will work to promote this new energy model , training programmes and ad hoc material with the tenants. Additionally, simulations will be shown to the tenants so that they can see, very specifically, which savings the new heating network will achieve and how this new model would positively affect their everyday budgets.**

CHALLENGES

FINANCIAL & ECONOMIC

Smart city projects normally implement relatively new technologies, thus increasing the financial risk due to the uncertainty of their success or impact. This sometimes makes it difficult to find the time and resources necessary to implement, test, launch and evaluate the results of these technologies. In spite of everything, in the last years, governments, private companies and investors are showing increasing interest in developing and financing this type of project, due to the impact they can have on cities in terms of environmental sustainability, economic competitiveness and improvement in citizens' quality of life. The public sector, in particular, is more willing to take on the financial risk of the uncertainty of the projects for the benefit of its citizens.

One important financial risk is not reaching the target of 750 homes adhering to the project in terms of connection to the new district heating infrastructure. This is the minimum in order to guarantee the economic feasibility of the business exploitation.

BEST PRACTICES

SOCIAL

The SmartEnCity project has developed a citizen engagement plan, taking into consideration the local conditions of each lighthouse city. As part of this, a qualitative research has been developed to map the citizen engagement reality of Vitoria Gasteiz, which is called the Citizen Engagement Strategy Model. The purpose of this model is to create a frame that can be useful for cities that are developing citizen engagement strategies involving the offer of innovative services and products. Additionally, the Communication and Citizen Engagement Committee was created within the governance structure of the Vitoria-Gasteiz's lighthouse project in order to promote and guarantee the community involvement and citizen engagement.

The engagement activities in Vitoria Gasteiz include the involvement of the neighbourhood associations; door-to-door invitations to a meeting presenting the project; an exhibition for the residents of the refurbishing typologies, as well as a demonstration of how the connection to the district heating will take place; identification of lead users or early adopters who will be offered some workshops where they can learn from the experiences of other renovation projects, and be given the opportunity to visit the projects.

The tenants are being continuously informed about the benefits of the project through the information office opened within the Coronación district, and through specific dissemination actions that take place periodically to strengthen neighbours' engagement. Ad hoc dissemination material has also been created and distributed among the tenants. Another important point related to communication with the stakeholders is that, as a rule, there is a single interlocutor with each community making the communication much easier and more direct, so that each community always talks with the same person to manage all the issues related to the project.

SmartEnCity

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Strategic sustainable city planning

Strategic urban planning adopts an all-encompassing view of the city and the metropolitan dynamics. Its general objectives include clarifying which city model is desired and working towards that collective vision of the future by coordinating public and private efforts, involving citizens and stakeholders, channelling energy, adapting to new circumstances and improving the living conditions of citizens affected. Furthermore, strategic planning provides a methodology, which helps cities identify their strengths and weaknesses, defining the main strategies for local development and prioritising the efficient allocation of resources.

A key added value of strategic planning is that it improves communication between the main actors and increases the commitment of the involved communities. A City Development Strategy is usually the identifiable result of strategy planning, which develops all aspects of the city, integrating technical, environmental, political, social and economic interests in the same territory.

InSMART

The InSMART project brought together cities and scientific and industrial organisations in order to implement a comprehensive model addressing a city's current and future energy needs through an integrative and multidisciplinary planning approach. This approach identified the optimum mix of short, medium and long-term measures for a sustainable energy future, addressing the efficiency of energy flows across various city sectors with regards to economic, environmental and social criteria, and paving the way towards the actual implementation of priority actions.

This has been tested in the cities of Trikala (Greece), Cesena (Italy), Evora (Portugal) and Nottingham (United Kingdom) with the support of technical specialists from the four countries. The process involved gathering local data, then using it in state-of-the-art computer modelling tools (for buildings and transport) to develop plausible future energy scenarios. The scenarios are tested and refined through a series of carefully weighted criteria to ensure they are economically, environmentally and socially acceptable.

Impact

InSMART approached the urban challenges of energy and climate by considering the city energy system as an integrated network of energy flows connecting energy providers with buildings, public spaces, transport and utilities, while taking into account spatial differentiation. Using a detailed characterisation of a local energy system, with simulation tools and the active participation of decision-makers and stakeholders, is the cornerstone of the InSMART Integrated City Energy Planning Framework.

InSMART has paved the way towards the implementation of an optimum mix of measures, using multi-criteria decision analysis involving different stakeholders from city planning bodies to private services in four European cities. The four cities involved, with specific and complex systems, received detailed insights about their own specific goals, through the application of the InSMART framework analysis.

The InSMART project tools, experiences and achievements may facilitate and support the deployment of local sustainable solutions and decision-making in cities across Europe, contributing to the realisation of the EU's energy and climate goals.

Tools

The InSMART project developed a new methodology for sustainable energy planning for municipalities in European cities. The methodology offers cities an integrated and participatory process to examine all the energy consumption sectors together with potential local energy generation options and come up with a smart development plan for energy that is supported by all stakeholders.

It consists of seven steps:

- Step 1: Include all the local stakeholders in the planning process.
- Step 2: Model building energy consumption.
- Step 3: Analyse urban mobility needs.
- Step 4: Deepen understanding of energy use in other sectors.
- Step 5: Use GIS technology to store and disseminate data.
- Step 6: Implement 'energy systems modelling' for integrated solutions.
- Step 7: Deliver and disseminate concrete medium-term action plans.

This common methodology was adopted by all while retaining each city's own specific opportunities and challenges. Along the implementation process, the collaboration among the four cities allowed the comparison of problems and solutions in a continuous learning process that proved effective for the conclusion of a technically robust and socially acceptable energy plan for each city.

The methodology is freely available to use in any city by the municipality and its local stakeholders. It can be integrated into the process of developing a Sustainable Energy Action Plan or a Sustainable Energy and Climate Action Plan by municipalities participating in the Covenant of Mayors for Climate and Energy, and offers the advantage of concrete scientific approaches in local energy planning.

Lessons learned

BEST PRACTICES

REGULATORY & ADMINISTRATIVE, SOCIAL

Active participation by municipal authorities, commercial and professional associations, private companies and citizens is key to the design of the future of a sustainable city's energy system.

SOCIAL

Combining household census data, door-to-door surveys, smart meter data (when available) and building dynamic simulation are essential in order to deliver sustainable options that take into account households' socioeconomic status.

SOCIAL

The mobility of people and goods makes the city a lively place but models and surveys are vital to find realistic ways to reduce its carbon footprint.

SOCIAL

Data availability and accessibility increases the awareness of all stakeholders to the new and innovative sustainable energy options.

REGULATORY & ADMINISTRATIVE

Cities can provide meaningful amounts of renewable energy at affordable cost.

REGULATORY & ADMINISTRATIVE

There are multiple configurations for a city's future energy pathway: integrated modelling tools assess which are the most promising.

REGULATORY & ADMINISTRATIVE

A detailed, realistic and applicable 10-year implementation plan, describing resources and monitoring requirements, is the best way to ensure the city's future energy sustainability.

INSMART
Integrative Smart City Planning

InSMART

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PLEEC

By connecting scientific excellence and innovative enterprises in the energy sector with ambitious and well-organised cities, the PLEEC project aimed to reduce energy use in Europe, contributing to the EU's 20-20-20 targets. The project followed a place-based approach to enforce endogenous urban development by considering local conditions in six cities: Eskilstuna (Sweden), Tartu (Estonia), Turku (Finland), Jyväskylä (Finland), Santiago de Compostela (Spain) and Stoke-on-Trent (United Kingdom).

By supporting a forward-looking and evidence-based strategic planning approach, cities have identified their strengths and potentials Based on the city profiles, technological, structural and behavioural energy efficiency solutions have been elaborated for each PLEEC city, demonstrating that urban energy efficiency should be seen in the transition to a fully sustainable urban energy system. The Energy Efficiency Action Plans developed by the cities have integrated the individually best matching solutions into a strategic approach, guiding the cities on their way to become energy smart.

Impact

Within the PLEEC framework, five key fields of urban development have been identified: green buildings and land use, mobility and transport, technical infrastructure, production and consumption, and energy supply. Based on this, each city created an individual Energy Efficiency Action Plan (EEAP) on how to improve their energy efficiency in a strategic and holistic way, considering their technological, structural and behavioural capabilities.

Tools

In order to make their knowledge available to other European cities, the project developed the PLEEC model for energy efficiency and sustainable urban planning, which is a guide for European city planners on how to successfully develop an EEAP. The PLEEC tool has gathered the experiences from all 18 partners of PLEEC in their efforts to study energy-efficiency planning in cities and to develop the EEAPs for the six partner cities. The EEAP is a document where goals and actions in energy efficiency are clearly stated. The EEAP is also a valuable tool for communications to stakeholders, who improve the chances of successful implementation of energy-efficiency measures. On what should we focus? What pitfalls should we avoid? How do we choose actions to reach our goal?

Lessons learned

BEST PRACTICES

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE, SOCIAL

Understanding local conditions in different cities is key to developing an EEAP that can be successfully implemented. No action can be copied from one city to another but by sharing experiences we can come a long way towards a more energy-efficient future.

REGULATORY & ADMINISTRATIVE, SOCIAL

The integration of technology, structures and behaviour is a crucial aspect for a sustainable transition into a truly energy-efficient smart city.

PLEEC

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STEEP

STEEP (Systems Thinking for Comprehensive City Efficient Energy Planning) was an innovative European project delivered in partnership between the cities of San Sebastian (Spain), Bristol (United Kingdom) and Florence (Italy). These cities decided to join together adopting a 'systems thinking' methodology in combination with open-data sourcing to improve efficiency along all the key aspects of their energy value chain, by applying smart city concepts in an integrated manner while learning from each other's expertise in applying sustainable practices.

Integral to the STEEP project is the concept of open source information sharing and creation of a methodology that could be utilised and applied by any city.

Impact

The STEEP project used an innovative open source methodology to develop smart city plans for each pilot city and help them achieve their carbon-reduction targets. The local authorities took a lead role in this process, coordinating the activity of relevant stakeholders.

STEEP has made available a background of knowledge that can be extended to wider areas (metropolitan) and to other cities that are approaching the smart city thematic.

Tools

The STEEP project created a process model of systems-based thinking for district energy master planning, which was to be applied to three city districts to better understand the systems that impact upon energy use, and the interventions that can be taken to meet the ambitious energy and carbon targets.

These models were enriched and validated through open innovation methodologies applied with the stakeholders. The learning obtained from the process model for district energy master planning was then applied when defining a specific action plan (timeline, costs and payback periods) at city level. With the knowledge gathered in this process, a replicable open source methodology and key performance indicators were produced for developing and screening integrated Smart City Plans.

The key performance indicators will also allow other cities to use the STEEP methodology to produce their own energy and Smart City Plans and carry out benchmarking analysis.

Lessons learned

BEST PRACTICES

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE

The key learning is that the district energy planning process developed within the STEEP project has been successful and has become an important part of the future city development. Each city used the STEEP methodology in a different way demonstrating that it can be adaptable to different needs. The STEEP methodology simplified the complex planning system and thus made it more effective.

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE, SOCIAL

The systems thinking approach was very helpful in the management of working groups with the attendance of various stakeholders, allowing a clear visualisation of complex problems. The optimal stakeholder selection and efficient management of their contributions are fundamental to the production of a good plan.

BEST PRACTICES

REGULATORY & ADMINISTRATIVE

Smart city planning is a process that needs to be continuously managed. It is necessary to set up a proper structure with all necessary resources to ensure collaboration and coordination of the activities. Multi-departmental and cross-sectorial involvement is required; a proper internal flow chart is the right tool for 'breaking the silos' and making smart concepts more real and affordable in terms of time, efforts and resources needed.

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE, SOCIAL

The large ICT presence in the planning is not a surprise. The concept of smart city is always linked to the use of innovative communication technologies, however it is interesting to notice that the role of ICT is different than expected - it is not the final purpose but a powerful enabler for other objectives.

SOCIAL

A common denominator in the three STEEP plans is the 'accessibility' as a recurrent factor - the concept is related to open data, but also to services, transport and mobility, affordability of energy, etc. A smart city should make things available to those who need them, because this efficiency is not an end in itself, rather it is aimed at improving the quality of life. From this point of view, the attention paid to customer (citizen or city user) satisfaction became fundamental in the smart city strategies, developed within STEEP.

STEEP
SYSTEMS THINKING FOR EFFICIENT ENERGY PLANNING

STEEP

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STEP-UP

The STEP-UP project brought together four European cities – Glasgow, Ghent, Gothenburg and Riga, along with research organisations and businesses – with the aim to improve the integration of energy and urban planning, to help cities enhance their Sustainable Energy Action Plans, as developed under the European Commission's Covenant of Mayors initiative, and to develop innovative projects at the intersection of the transport, energy and ICT sectors. STEP-UP took an integrated approach to energy planning, project design and implementation by addressing three themes together: energy and technology, economics, and organisation and stakeholders.

Impact

STEP-UP drew on the partner cities' existing experience of integrated energy planning, building on this through learning and adapting experience from other cities and partners to create a coherent and easy-to-use model for energy planning. This model was adopted in multiple cities to deliver faster and greater impacts for Europe's 2020 energy targets.

Tools

The STEP-UP project produced two guidebooks: 'Developing enhanced Sustainable Energy Action Plans' and 'Developing sustainable energy projects'. The first one aims to provide guidance and recommendations, using examples from demonstration sites, and sets out the key steps, tools, approaches and methods, and advice for each step of the process. The second one presents key points for cities to consider in the planning stages of a new low-carbon or sustainability project. It may be useful for city planners, municipalities, energy strategists and business developers in the European context.

In addition, as part of the STEP-UP project, the University of Strathclyde has developed a new Master programme, which draws on real-world experiences and outputs from STEP-UP. The MSc in Global Sustainable Cities is an innovative programme focused on tackling major urban opportunities and issues.

Lessons learned

BEST PRACTICES

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE, SOCIAL

In the STEP-UP project, maintaining and promoting an integrated approach to energy planning and project development has been crucial. By adopting an integrated approach, a project is able to achieve more holistic solutions to complex problems by bringing together different kinds of stakeholders, sectors and technologies, and by combining the three dimensions of sustainability in order to deliver environmental, social and economic benefits to the city and its inhabitants.

FINANCIAL & ECONOMIC

A key challenge for cities lies in structuring projects in the right way to successfully attract investors and reduce risk, in order to increase their scale and impact. Business models should be appropriate to the local context. However, many of the STEP-UP lighthouse initiatives organised their business models around public-private partnerships so that the public sector can reduce the costs of capital investment and borrowing required, and the private sector can assume an element of financial, technical and operational risk and control in the project.

REGULATORY & ADMINISTRATIVE

Strong leadership is vital due to a local authority's unique position to influence other actors in the city. STEP-UP's research shows that successful projects have local political leaders who can champion projects and act as enablers to make a concept become reality. As sustainable energy projects can last for decades, it is important that the approach taken has a long-term focus and the ability to look beyond short-term political cycles.

BEST PRACTICES

REGULATORY & ADMINISTRATIVE

The low-carbon energy and sustainability agenda should not be perceived to be solely targeted towards environmental objectives. Instead it should be aligned with the wider policies and strategies of the local authority so as to gain support from, and offer benefits to, as many areas as possible. The ability of a project to fit with the overall city vision, address multiple city challenges and deliver on many policy fronts is therefore seen as a key winning element for sustainable energy projects, in order for them to help the city achieve a low-carbon and sustainable future.

SOCIAL

Continued communication and collaboration with stakeholders is a key winning element for many projects. As integrated projects tend to involve cooperation across various sectors, such as transport, energy and ICT, and utilise a variety of technologies, it is vital that organisations are able to keep an open dialogue going between them in order to secure support and involvement throughout the duration of the project, and enable effective communication, knowledge and information exchange. This can lead to improved project outcomes, enhancing potential for future expansion, replication or further collaboration.

STEP-UP

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TRANSFORM

TRANSFORM was a collaboration involving six European cities – Amsterdam (the Netherlands), Copenhagen (Denmark), Genoa (Italy), Hamburg (Germany), Vienna (Austria) and Lyon (France) – and 13 partners working together to improve their policy and programmes to lower carbon dioxide emissions.

The project's integrative approach brought operational plans to a strategic level, including strong stakeholder processes and data analytics, and took into account all relevant energy flows, environmental aspects, urban mobility, and the interrelation of possible measures and their costs. This integration of elements created win-win business models for stakeholders who initially had different interests.

Impact

The TRANSFORM project:

- supported cities with implementation plans embedded in integrated planning;
- improved insight into stakeholder processes and financial strategies;
- improved insight on the use of data, and the possibility to find better economics by using analytics.

Tools

TRANSFORM developed several tools, methods, instructions and formats to support energy transition in cities, which were designed and tested:

- 'Definition of a Smart Energy City', including KPIs with a special focus on the integration of physical planning and energy flows, utility infrastructure, the use of data and behavioural aspects;
- in-depth analysis (state of the art) of TRANSFORM cities, including the following aspects: local climate, local energy resources, development history, relation to and control over region, state of economic development, prosperity and social issues, institutional capacity, structure and level of civil society involvement in energy and planning issues, degree of control over energy generation, production and distribution assets (structure of ownership of utility companies, etc.) and energy consumption, transportation patterns, etc.;
- blank questionnaire that could be used by any city to make a self-assessment on its state of the art in relation to becoming a Smart Energy City;
- 'Generic Transformation Agenda' (Quantitative Decision Support Tool), which supports cities and decision-makers striving towards integrated energy planning. It summarises the experiences and invites other cities to use this Generic Transformation Agenda to develop their specific City Transformation Agenda;
- Decision Support Environment (DSE): a web-based tool providing the relevant stakeholders in cities with information facilitating informed decision-making, a model for quantitative assessment of the state and progress of Smart Energy City development;
- TRANSFORM Virtual Handbook.

Lessons learned

CHALLENGES

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE, SOCIAL

It is challenging to design and build tools to support the energy transition of cities. Moreover, together with the tools and methods TRANSFORM developed, it is far from easy to change an existing city to low-carbon if it comes to energy use and production. The team learned that energy transformation is a complex process with many stakeholders, huge financial investments, and legal, political, societal, organisational constraints. Transformation influences the life of citizens, politicians and businesses.

REGULATORY & ADMINISTRATIVE, SOCIAL

In most TRANSFORM cities, collecting the data appeared to be far more difficult than expected at the beginning of the project. Fear for legal and privacy issues are the most important boundaries to not being able to gather all the data needed. It is impossible to produce an Energy Atlas without the data provided by third parties and energy providers, therefore collaboration is needed. The sharing of data and gaining insight into each other's interests and considerations is of huge importance to making energy transition a reality. While there are numerous instances of the ways in which open data is already creating both social and economic value, we don't know yet which new things will become possible. New combinations of data can create new knowledge and insights, which can lead to whole new fields of application.

BEST PRACTICES

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE, SOCIAL

Within the TRANSFORM project, an online integrated urban energy planning tool, the Decision Support Environment (DSE) was developed, which supports cities by providing quantitative insights on possible sustainability measures that can be taken and implemented.

The DSE utilises city data and analytics to calculate the impact of multiple low-carbon measures on CO_2 emissions (such as district heating and retrofitting), energy consumption, renewable energy systems and costs. Through data, measures, targets and locations, the city is able to simulate multiple scenarios, completely customised to their areas of interest and targets. The aim of the DSE is to support the private and public stakeholders involved in urban planning to go through a transparent and structured decision-making process.

The DSE serves as a common platform where ideas and proposals can be exchanged and analysed in a transparent way. The security of the uploaded city data can be customised. It can range from the data being fully open, allowing access for everyone, to being completely secured. The tool aims to contribute to the EU's 2020 targets, and hence there are the key KPIs to analyse the impact of possible sustainability measures for a city in the DSE. The Decision Support Environment will help achieve your city's sustainability goals!

BEST PRACTICES

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE, SOCIAL

The spatial matching of relevant KPIs is essential for a successful climate protection strategy. This relates particularly to the alignment of energy consumption and energy supply, as well as to the social background and the implementation options of specific urban areas. Accordingly, to provide a holistic approach for a transformation process, the technical and social data should be joined. Only an appropriate analysis, which includes the qualification of the sociotechnical system, the urban structure and the system of agents/actors for a particular form of energy, can lead to an energy-optimised design.

Within TRANSFORM, the cities of Amsterdam and Hamburg created an Energy Atlas. Both atlases present a compilation of all kinds of information, some of it directly related to energy, others indirectly. They provide information about the city as a whole, but also focus specifically on the district of the TRANSFORM Smart Urban Lab. Because of the detailed level of information in the Energy Atlas it is possible to make all various types of calculations and measurements on energy. How does the city's current energy consumption compare to the possibilities for the generation of sustainable energy in the city? Are there greater or more limited possibilities for specific areas within the city? Which potential energy source presents the greatest opportunities? The Atlas provides insight into these questions.

TRANSFORM TRANSFORMATION AGENDA FOR LOW CARBON CITIES

TRANSFORM

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Demonstration of very low-energy new buildings

Projects aim to create the right framework to demonstrate and disseminate innovative and cost-effective energy-efficiency technologies for the achievement of very low-energy new buildings. This involves the analysis of suitable energy-efficiency technologies (including their technical and economic viability), demonstrates the activity in several new buildings and provides the activities for dissemination and replication at a European level.

NEXT-BUILDINGS

Houthaven used to be a harbour and timber handling area, situated close to Amsterdam city centre, where many wood factories and related companies were located. After a long history of industrial activities, Houthaven is being transformed into a residential area. In total, seven islands are under development, providing space for 2200 dwellings, 70 houseboats and 50 000 m^2 facilities. In the NEXT-BUILDINGS project, 30 000 m^2 of net zero-energy buildings were realised within Houthaven in the area named Blok 0. What is special about Blok 0 is that consortia of future residents took the lead in developing this area. In total about 250 dwellings were foreseen, as well as about 700 m^2 of other building uses such as ateliers and studios. A collective car parking was realised, and additional parking is possible at some of the plots.

The construction works finished in April 2016 and by June 2016 Blok 0 was almost completely occupied. Part of the project is also the Brede School, which is an excellent example of linking climate neutral building to education. The roof of the school is equipped with a large array of high-performance photovoltaic modules. Monitoring devices have been installed in a sample of the dwellings to ensure that useful energy data from the neighbourhood is available; the approach is based on smart meters and web-based data collection.

Impact*

Blok 0 consists of 9 buildings with a total area of 25 400 m^2 with the energy supply provided by photovoltaic modules and district heating. According to design data, the final energy demand of the building is to be reduced by 1778 MWh/year, while the primary energy demand is to be reduced by 2844 MWh per year and the CO_2 by 611 tonnes per year. The integrated photovoltaic modules are designed to produce 270 MWh/year with a payback of 7 years.

Brede School has an overall area of 6000 m^2, where the energy supply is provided by photovoltaics and district heating. According to design data, the objective is a reduction of final energy demand by 450 MWh/year, while the primary energy demand is to be reduced by 612 MWh per year and the CO_2 by 53 tonnes per year. The integrated photovoltaic is designed to produce 113 MWh/year with a payback of 7 years.

FACTS & FIGURES

Geographical area	**Houthaven, Amsterdam, the Netherlands**
Demonstration area	**31 400 m^2**
Final energy savings	**2228 MWh/yr.**
Primary energy savings	**3367 MWh/yr.**
CO_2 emissions reduction	**664 tCO_2/yr**

Technologies

The following array of interventions was implemented as part of the NEXT-BUILDINGS project in Amsterdam:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

High-performance new buildings

Building services (HVAC & lighting)

Building integrated renewable energy sources

Photovoltaic: the roof is equipped with a large array of high-performance solar modules

ENERGY SYSTEMS INTEGRATION

District heating and cooling

ENERGY EFFICIENCY IN BUILDINGS	BLOK 0
Newly built area	**25 400 m^2**
Final energy demand (baseline)	**100 $kWh/m^2/yr$**
Final energy demand (after)	**30 $kWh/m^2/yr$**
CO_2 emissions reduction	**611 tCO_2/yr**
Energy supply	**Photovoltaics, district heating and cooling**

* The KPIs for the new building are compared with the baseline of a reference building and reference energy suppliers.

ENERGY EFFICIENCY IN BUILDINGS	BREDE SCHOOL
Newly built area	**6000 m²**
Final energy demand (baseline)	**103 kWh/m²/yr**
Final energy demand (after)	**28 kWh/m²/yr**
CO_2 emissions reduction	**53 tCO_2/yr**
Energy supply	**Photovoltaics, district heating and cooling**

ICT

Building energy management system

Monitoring devices are installed to ensure that useful energy data from the neighbourhood is available. The approach is based on smart meters and web-based data collection.

Mobile applications for citizens

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC High upfront capital costs	**Several financial instruments were introduced to cover for the extra costs of the first net zero-energy buildings in Houthaven demo site Blok 0:** • the sustainable district heating and cooling system is partly financed by the fee that builders need to pay to connect to the grid. The remaining part is financed by the energy service company Westpoort Warmte, which will exploit the heating and cooling system in order to obtain a return on their investment; • homeowners and builders could take advantage of the existing regulations and grants to lower the extra costs of the net zero-energy buildings; • no split incentives for developers. The City of Amsterdam compensates developers for the remaining extra costs of the net zero-energy buildings by adjusting the price of the building plots.
FINANCIAL & ECONOMIC Due to the global financial crisis, the project realisation had to be postponed as the financing, through the municipality of Amsterdam became problematic.	**Professional investors, like banks, had to be involved.**
FINANCIAL & ECONOMIC To cover the financial risk, the municipal Amsterdam Development Company introduced a requirement that at least 80 % of dwellings had to be sold before the construction could begin. Due to the economic crisis, this requirement could not be complied with.	**The municipal Amsterdam Development Company took the risk and the construction started anyway. However, the required number of apartments has already been sold.**

BARRIER	SOLUTION
FINANCIAL & ECONOMIC Power markets for renewable energy are quite new and are governed by traditional large energy companies.	**The municipal Amsterdam Development Company had to prepare new types of contracts that were tailored to the given situation and to engage new parties.**

CHALLENGES

FINANCIAL & ECONOMIC

According to the research by the city of Amsterdam, the extra costs for an energy-neutral house can be roughly € 7000. Buyers are willing to invest an additional € 5000 to € 10 000 for the measures. Moreover, there is a European grant of approximately € 5000 per house available. As a result, most builders will add these costs to the selling price. However, about half of the builders have experienced that the measures actually exceed the mentioned limit of € 10 000, so when the European grant runs out, builders in the future may become hesitant to realise an energy neutral house in Houthaven.

BEST PRACTICES

REGULATORY & ADMINISTRATIVE, SOCIAL

The Collective Self-organised way of development was used. Through this method, the future inhabitants can decide about many aspects of their still-to-be-built houses and commission the construction to the builder. Within the approach, private persons are raising money for their future house. Due to the financial crisis and in order to be able to streamline this process, the first building block Blok 0 was divided into smaller parts of 8-9 building plots or units. These building plots were then advertised for purchase in the newspapers and the actual buyers were drawn by lot from those who applied. The City Council of Amsterdam accepted the role of an umbrella organisation, acting on behalf of the private individuals. As the City Council has the competencies needed for such a role, this proved to be a success.

REGULATORY & ADMINISTRATIVE

The City of Amsterdam's local policy was that all new building developments should be carbon neutral by 2015. Before this date, the city was aiming for carbon neutral development in 40 % of the building projects. The Houthaven demo site is one of the test projects with the objective to build carbon neutral dwellings and set the standard for cost-effective carbon neutral development in the city area after 2015.

REGULATORY & ADMINISTRATIVE, SOCIAL

Houthaven's Blok 0 area was specially designed so that no real estate developer had the lead in developing this area, but a consortia of future residents are the protagonists. The future residents had to agree in their consortium on the architecture of the building and the energy concept, and were responsible for the submission of the building permits. Milestones were part of the agreement with the consortium, with the risk of losing their reservation for the plot to other interested parties, in case milestones were not met.

NEXT-BUILDINGS

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Bilbao, Spain |
BUILDSMART

The demonstration building is a three-block residential building located in the Portugalete municipality in Greater Bilbao and is developed by the Basque Government's Department of Housing, Public Works and Transport. The implemented technologies had to be energy-efficient in order to achieve the target value but at the same time low-cost, because the developer couldn't afford expensive technology. The social scope of the project is also important as it is oriented towards social housing. Therefore, the building will be low-cost in order to be affordable for tenants of low-medium income.

Impact*

This residential building serves for social housing oriented to low-income residents. It has been designed as a passive solar house with a targeted annual energy use of 42 kWh per m². The design of the building aimed to minimise its environmental impact by using materials with low embodied energy and low environmental toxicity wherever possible.

Technologies*

Several energy efficiency measures were implemented in the building:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Parietodynamic wall, integrated with the building ventilation system, to maximise the energy storage in the facade

An insulating painting with nanotechnology, which is designed to insulate and waterproof the walls

Green roofs, which provide insulation in winter and prevent overheating in summer

ICT

Building management system

An energy display screen was installed in each of the buildings, providing information on heating, lighting and electric energy consumption. This is a tool for communicating with the residents, making them aware of their energy consumption to help improve users' behaviour.

BUILDSMART
Energy efficient solutions ready for market

BUILDSMART

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* Detailed information regarding the technical and financial performance will be available at a later stage.

Helsingborg, Sweden | NEXT-BUILDINGS

The city of Helsingborg had adopted an ambitious climate action plan by which the city had already achieved 88 % CO_2 emissions reductions (compared with the 1997 level) and a less than 20 % share of fossil fuel, the final goal being carbon neutrality, or even exporting carbon-neutral energy to neighbouring areas. With this aim, the NEXT-BUILDINGS project realised very low-energy buildings as the first phase of a huge and very ambitious 311 000 m^2 ecodistrict development. The new dwellings comprised not only of passive houses or zero-energy buildings, but also include active houses (a new category of houses that generate electricity and heat, and include user involvement and demand control), together forming a more sustainable new neighbourhood.

Impact*

The new buildings were established as fill-in buildings in between the eco-rehabilitated buildings. They are active houses with a space heating demand of less than 16 kWh/m^2/yr.

Active houses are active as they generate electricity (exchange/export of electricity to grid) and heat (exchange/export of solar to district heating). Moreover, they feature user involvement, behaviour and demand control, and thus have an important role for the development of the total adjacent area.

Technologies*

The implemented measures include:

ENERGY EFFICIENCY IN BUILDINGS

High-performance new buildings

Building integrated renewable energy sources

100% green electricity

Waste sorting

ENERGY SYSTEMS INTEGRATION

Waste heat recovery

Heat recovery from waste water

Photovoltaics

Thermal collectors

District heating and cooling

Renewable district heating

ICT

Building energy management system

i

NEXT buildings

NEXT-BUILDINGS

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* Detailed information regarding the technical and financial performance will be available at a later stage.

The Turkish demonstration site of NEED4B is on the Özyeğin University campus, located in Nisantepe, Istanbul, north-west Turkey. The Nisantepe region is a newly developed residential site situated very close to the residential and financial region of Ümraniye. The building in focus is in part of the campus buildings that host the School of Languages (ScOLa). The total building area is 17 756 m^2 spread across seven levels. It has a south-north direction and connects the campus valley and the quad level with an internal void situated in the south facade, which acts as a buffer zone to reduce the heating and cooling capacity.

The master plan and architectural design work of the campus started in the last quarter of 2009 and until now several buildings have been constructed in different phases. The whole campus was designed and constructed with the aim of becoming an example of sustainability and energy efficiency. The university aims to provide hands-on education to its students by giving them facilities that teach by example. All the campus buildings are candidates for the internationally known LEED (Leadership in Energy & Environmental Design) certification, but the new faculty building's goal is to go a step further in energy efficiency issues.

NEED4B took advantage of the big impact that this demonstration case had on students attending classes there, making them more conscious and knowledgeable about green buildings and the environment. Another important issue is that energy efficiency is monitored and studied by the students very closely. This is a big opportunity for their education, as they can learn first-hand about the real performance of an energy-efficient building.

The Turkish demo site takes part in the Zero Istanbul 2050 initiative. This initiative is coordinated by Özyeğin University and increases the visibility of the demo site, while facilitating the spread of NEED4B results.

Impact*

The demonstration building has a total surface of 17 756 m^2. It integrates photovoltaic panels designed to generate 160 000 kWh/year, and solar thermal panels. According to the design data, the final energy demand of the building is to be reduced to 35 kWh/m^2/yr, and the primary energy demand is to be reduced by 621 MWh per year.

Technologies*

The implemented technologies include:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Reinforced concrete frame construction

Optimised solar shading with perforated horizontal louvres in the south and partially east facades, and vertical perforated aluminium shades in the west and partially east facades

Internal curtains where necessary

Building integrated renewable energy sources

Photovoltaics

ENERGY SYSTEMS INTEGRATION

Thermal collectors

Near-to-surface geothermal energy

Earth tubes used for partial cooling/heating

ICT

Building energy management system

The building has a multi-dimensional energy performance monitoring, visualisation and optimisation platform

* Detailed information regarding the technical and financial performance will be available at a later stage.

NEED4B

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The NEED4B pilot site in Lecce (Italy) is located in a central and strategic part of the city, a few metres away from the historic centre and in front of a recreational space for students. It is a mixed-use building composed of four floors above ground and three floors underground. The first floor underground and the ground floor consist of shops and commercial spaces, while the first, second and third floors above ground are for offices. The building is surrounded by green spaces, a private parking area for the offices, and a bus stop.

One of the main concerns in NEED4B was reducing the cooling demand in those buildings situated in the Mediterranean area. This demo site located in the south of Italy provides the opportunity to address this topic and provide an example of best practices in terms of energy efficiency during the warm seasons. Lecce is one of the most visited cities in the south of Italy. The urban area where the pilot is located has a large historical and architectonical value and it is currently under refurbishment. This enhances the visibility of the zone, where tradition meets innovation, and both the new building and the retrofitted ones represent the icons of energy-efficient technology and research.

The building has a high replication potential since it represents a high energy-efficient building with structural and technical characteristics that can be easily transferred and adapted to different built environment contexts. In this case, the new building aims to be perfectly integrated in a historic district, but its structural and technical aspects might be also reproduced in a new development area of the city.

Impact*

The demonstration site in Lecce includes a multifunctional building with a total surface of 5214 m^2. According to the monitoring data, the primary energy consumption is 45 kWh/m^2/yr, where the reference (normal practice) is 81 kWh/m^{2}yr, thus reducing the energy consumption of the building by 187 MWh/yr.

Technologies*

The implemented measures include:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

The envelope integrated advanced insulation, double skin coating, and high-performance glazing

The main frame was made of steel-reinforced concrete, while the envelope was made of components that were assembled on site

Building integrated renewable energy sources

Photovoltaics (on the roof)

Heat pumps

Heating and cooling was provided by a highly efficient heat pump (COP 4 for heating and COP 3.5 for cooling)

ICT

Building energy management system

All the available data were uploaded and managed using a building information modelling tool in order to coordinate the various phases in the most efficient way. Future data will be uploaded as it becomes available.

* Detailed information regarding the technical and financial performance will be available at a later stage.

NEED4B

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Ljubljana, Slovenia | EE-HIGHRISE

The objective of the EE-HIGHRISE project was to demonstrate and validate new technologies, concepts, and systems in order to test and assess the technological and economic feasibility of innovative energy solutions for high-rise buildings. The project used the Eco Silver House in Ljubljana (Slovenia) as a demonstration site.

The building is located in the city centre of Ljubljana, in the heart of a business, commercial and recreational area. The demonstration was implemented in the residential part of the building (12 870 m² out of a total net area of 23 455 m²), which consists of 11 floors with 128 passive-house-standard apartments. The Eco Silver House was designed to fulfil the requirement for the passive standard (PHPP07).

The fundamental principles of sustainable development of a high-rise building were reflected in EE-HIGHRISE through comprehensive planning of energy-efficient savings, along with renewable energy sources, thermal insulation, wall soundproofing, an air conditioning system, sun protection, air-conditioning appliances, intelligent control and management of electric and mechanical devices, machinery and tools, ecological materials, use of rainwater, solar power station on the roof and a green roof.

Within the project timeline, an interactive model of the Eco Silver House was created as a virtual building and made available online. It enables stakeholders in the sustainable buildings field to visit the Eco Silver House demonstration building via the internet for free, providing extensive information about the design, construction and operation stage of the Eco Silver House as well as the different sustainable systems, processes and outcomes, the knowledge and practices gathered within the EE-HIGHRISE project.

Impact*

As a result of the energy efficiency, the space heating in Eco Silver House was reduced from 105 kWh/m²/yr (business as usual) to 21 kWh/m²/yr, while electricity consumption was reduced from 28 kWh/m²/yr (business as usual) to 23 kWh/m²/yr. Together with the domestic hot water, the total consumption went from 143 kWh/m²/yr to 51 kWh/m²/yr, representing a decrease of more than half in comparison to a reference building. This makes for 2109 MWh/yr of final energy savings. According to the primary energy and CO_2 factors of Slovenia, the primary energy savings go up to 2239 MWh/yr while the CO_2 reduction amounts to 937 tonnes every year.

FACTS & FIGURES

Geographical area	**Eco Silver House, Ljubljana, Slovenia**
Demonstration area	**12 870 m²**
Population in the area	**300 000 inhabitants**
Total investment	**€ 17 148 078**
Funding from EU	**€ 1 226 000**
Final energy savings	**2109 MWh/yr.**
Primary energy savings	**2239 MWh/yr.**
CO_2 emissions reduction	**937 tCO_2/yr**

Technologies*

The most important innovations of EE-HIGHRISE are the integration of the building envelope, HVAC system, intelligent integrated control system and renewable energy sources, fulfilling the passive standard for a high-rise building. The implemented measures include:

ENERGY EFFICIENCY IN BUILDINGS

High-performance new buildings

- Thermal isolation and sound isolation of walls
- Sun protection measures
- Intelligent Control Centre for the management of electric and mechanical devices, machinery and tools
- Use of ecological materials for a healthy environment and high living comfort
- Air-conditioning with time-defined operations
- Use of rainwater for toilet flushing to save drinking water
- Green roof

Building integrated renewable energy sources

- Solar power station on the roof, which produces 33 MWh of electricity per year

* The KPIs for the new building are compared with the baseline of a reference building.

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Each apartment has its own heat substation for space heating and domestic hot water

Waste heat recovery

High-quality ventilation system by a recuperator, which enables the restoration of the waste heat. System efficiency of 85 % heat recovery was achieved, which is reflected in cutting the heating costs by half, compared to the reference value, and ensuring high living comfort and good air quality.

ENERGY EFFICIENCY IN BUILDINGS

Newly built area	**39 064 m²**
Payback period	**16 years**
Final energy demand (baseline)	**143 kWh/m²/yr**
Final energy demand (after)	**51 kWh/m²/yr**
CO_2 emissions reduction	**937 tCO_2/yr**
Energy supply	**Photovoltaics, district heating and cooling**

ICT

Building energy management system

Intelligent Control Centre for management of electric and mechanical devices, machinery and tools

The total investment for the EE-HIGHRISE building amount to EUR 17 148 078, whereas the reference building costs are estimated at EUR 15 922 077. The energy-related higher investments that are included amount to EUR 1 226 000. The total energy savings add up to EUR 77 900 per year, which means that the higher investment can be paid off by the energy savings in 16 years.

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE The first design of the building, especially the aspects regarding airtightness, did not fulfil the European Standards for fire safety.	**Minor changes were done to the design, which fulfilled the required standards.**
REGULATORY & ADMINISTRATIVE There was an obligation to connect to the district heating that had to be taken into account.	**This was implemented and turned out to be beneficial for the project.**
FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE There was an obligation to install photovoltaics on the roof. The space for the photovoltaic installation was not enough to cover the demand of the building, especially in this high-rise building. It wasn't economically and technically compatible with the normal use of the building.	**A contract was signed with e-cars company to sell the electricity produced by the photovoltaic installation.**

CHALLENGES

FINANCIAL & ECONOMIC

The project based their business models on funding from the Slovenian Government (ECOFUNDS). In the meantime, the funding scheme changed and therefore the building did not receive the subsidies on completion.

FINANCIAL & ECONOMIC, SOCIAL

The apartments took longer to sell than expected.

EE-HIGHRISE

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Lyon, France | NEXT-BUILDINGS

The goal of the demonstration project was to build a 12 300 m² zero-energy building in the Lyon-Confluence area in Lyon, France. The public company in charge of the urban project had had previous experience with its involvement in a demonstration project for the construction of the first buildings of this major urban regeneration project (CONCERTO Renaissance project). Given that the first demo project has had a significant impact on the other buildings constructed in that area, the public company wanted to build a new demonstration building with improved energy-efficient targets.

Impact*

After an international design competition, the local public redevelopment company SPL Lyon-Confluence selected a group of real estate developers, Bouygues Immobilier and SLC, which are associated with the Japanese architect Kengo Kuma, who has designed a group of three buildings called HIKARI. In addition, a specific partnership has been set-up with the New Energy and Industrial Technology Development Organisation of Japan and Toshiba for the design and the construction of HIKARI.

This group of buildings, with offices, apartments and shops, was completed and officially commissioned in September 2015. Monitoring is ongoing and SPL Lyon-Confluence is already replicating the zero-energy building concept to new housing blocks of the Lyon-Confluence area under construction.

Technologies*

The interventions implemented in the HIKARI building include:

ENERGY EFFICIENCY IN BUILDINGS

High-performance new buildings

Reinforced insulation of building envelope (u-values of walls between 0,15-0,18 W/m².K)

Triple glazing made of wood and aluminium (u-value of 0,75) for dwellings

High-quality air tightness (N50 < 0.6 ACH)

Automatic sun shading

ENERGY SYSTEMS INTEGRATION

Photovoltaics

168 kWp photovoltaic system on the roof of each of the 3 buildings

21 kWp see-through photovoltaic façade for the apartments building on the MINAMI

Cogeneration (CHP)

75 kW CHP powered by locally produced rapeseed oil to provide heat and domestic hot water

Absorption chiller powered by the heat from the CHP and the heat from ground water to cool down office places

Thermal storage

63 m³ of water storage for heat

20 m³ of phase-changed material (PCM) made of paraffin for cold

Heat/cold storage used to reduce the size of energy production systems

Electrical energy storage

100 kWh battery storage system to self-consume the electricity powered by the CHP

* Detailed information regarding the technical and financial performance will be available at a later stage.

ICT

Building energy management system

The system is used to improve the indoor comfort of users

Sensors

10 000 sensors have been installed including image-based motion sensors, temperature, CO_2 and humidity sensors, etc.

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE Insurance companies are not willing to let construction companies use innovative, custom-made building products such as the see-through photovoltaic facade.	**A specific approval test procedure with a complex administrative process has been undertaken in order to actually build the see-through photovoltaic facade.**

NEXT buildings

NEXT-BUILDINGS

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Malmö, Sweden | **BUILDSMART**

The city of Malmö participated in the BUILDSMART project with the construction of four different types of new buildings – a hotel, office and two residential buildings – with a focus on their sustainability. The buildings are located in two areas of the city – Malmö Live, in central Malmö, and in the south-east part of the city, known as Hyllie.

Malmö Live is a new concert, congress and hotel complex situated within walking distance from Malmö central station, between the old city centre and the new modern district of Western Harbour. BUILDSMART developed two of the associated buildings – the hotel and the residential part of the complex.

Klipporna, an office building, and the Roth Residential building are situated in the district of Hyllie, which is the largest growth area in the city, developed around a new railway station with connections to central Malmö and Copenhagen. The ambition of the city of Malmö is for the next phase of the Hyllie development to become an example of showing the way towards climate-neutral development.

Impact*

The four new buildings in Malmö have a combined gross floor area of 51 789 m². As a result of the energy efficiency, the total final energy consumption went from 138 kWh/m²/yr (national regulation) to 70 kWh/m²/yr, representing ca. 50 % decrease in comparison to the reference building.

This constitutes 3014 MWh/yr of final energy savings. According to the primary energy and CO_2 factors provided by the project, the primary energy savings go up to 3366 MWh/yr while the CO_2 reduction amounts to 2227 tonnes every year. Thanks to the integration of two innovative systems – deep green cooling and a geothermal plant with heat pumps – the demonstration buildings save an additional 43 and 382 tonnes respectively per year.

FACTS & FIGURES

Geographical area	**Malmö, Sweden**
Demonstration area	**51 789 m²**
Population in the area	**286 535 inhabitants**
Total investment	**€ 62 795 000**
Funding from EU	**€ 4 074 580 (7 %)**
Final energy savings	**3014 MWh/yr**
Primary energy savings	**4448 MWh/yr**
CO_2 emissions reduction	**2625 tCO_2/yr**

Technologies

These large-scale demonstration buildings are characterised by a number of innovative techniques such as energy-efficient building envelopes with high airtightness and low energy losses, energy-efficient installations resulting in minimised energy use, techniques for minimising cooling needs, e.g. efficient windows and shading equipment, close connections to the surrounding infrastructure, such as energy systems that optimise energy use and reduce peak loads for both heating and cooling, a waste management system created for maximum recycling and energy recovery, including treatment of the biological waste fraction. The technologies and interventions include:

ENERGY EFFICIENCY IN BUILDINGS

High-performance new buildings

- Low u-value windows, automatic sun shading
- Green roofs
- Energy-efficient white goods

Building services (HVAC and lighting)

- Mechanical ventilation system with heat recovery
- Low-energy LED lighting

Building integrated energy renewable sources

- Photovoltaic

Heat pumps

* The KPIs for the new building are compared with the baseline of a reference building.

ENERGY SYSTEMS INTEGRATION

Deep geothermal energy

Deep green cooling: The BUILDSMART project has also integrated and demonstrated an innovative cooling technology based on geothermal energy. This system has a maximum cooling output of 133 kWh, using the relatively constant annual ground temperature of 10 to 12 °C to cool the building through 70 boreholes approximately 220 m deep. The pipes are part of a water-filled closed-loop system that supplies the building's chilled beams and the air handling units via a heat exchanger. The system was designed to meet Klipporna's entire cooling demands in the summer and pre-warms the outdoor air for the air handling units in the winter.

Geothermal plant integrated with heat pumps to supply heating and cooling. The maximum heating output is 800 kW, the same as the cooling output.

Waste-to-energy

Wood waste will be used for biogas production at the local biogas plant

Thermal collectors

Thermal storage

Ice storage, which will increase the cooling capacity needed for large events

ENERGY EFFICIENCY IN BUILDINGS	
Newly built area	**51 789 m²**
Investment	**€ 79/m²**
Final energy demand (baseline)	**138 kWh/m²/yr**
Final energy demand (after)	**70 kWh/m²/yr**
CO_2 emissions reduction	**2227 tCO_2/yr**
Energy supply	**Biogas, deep green cooling, geothermal plant with heat pumps, photovoltaics**

ENERGY SYSTEM INTEGRATION DEEP GEOTHERMAL ENERGY	DEEP GREEN COOLING
Technology before	**Electrical chillers**
Investment	**€ 1 200 000**
Energy carriers (baseline)	**Electricity**
Energy carriers (current situation)	**Water, electricity**
CO_2 emissions reduction	**43 tCO_2/yr**

ENERGY SYSTEM INTEGRATION DEEP GEOTHERMAL ENERGY	GEOTHERMAL PLANT WITH HEAT PUMPS
Area served	**20 000 m²**
Technology before	**Electrical chillers**
Investment	**€ 2 500 000**
Energy carriers (baseline)	**Electricity**
Energy carriers (current situation)	**Water, electricity**
CO_2 emissions reduction	**382 tCO_2/yr**
Primary energy savings	**1882 MWh/yr**

ICT

Smart electricity grid

Building energy management system

Lessons learned

BARRIER	SOLUTION
SOCIAL Low energy costs do not motivate users to make an extra effort and pursue energy savings.	**The team organised training sessions on conscious environmental behaviour in energy consumption for the residents and the people working in the office building. It is important that this training is repeated, especially for new residents moving into the building.**

BUILDSMART
Energy efficient solutions ready for market

BUILDSMART

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Munich, Germany | **DIRECTION**

The city of Munich participated in the DIRECTION project that aimed at demonstrating how the use of very innovative and cost-effective energy efficiency technologies can lead to the achievement of very-low-energy new buildings. This objective, along with the effective adoption of low-energy buildings, was achieved by switching to a model whereby energy efficiency provides value to the market and represents an attractive asset across the whole of the value chain.

The demonstration site, known as NU-office, has 11 000 m² of floor space dedicated to offices and shops. The building was awarded with an international Platinum LEED certificate in Green Building, which for a non-private housing is a unique example. Essential concept components are targeted on the use of environmentally compatible building materials, high-quality ambient air, maximum flexibility of the system reacting to occupancy, and high energy efficiency for heating, cooling, ventilation and lighting.

Impact*

As a result of the energy-efficiency and renewable energy sources interventions, the thermal energy decreased by 40 % while the electricity consumption decreased by 9 % compared to the reference building. The biggest share is space heating, which accounts for 32 kWh/m²/yr for the reference building and 19 kWh/m/yr for the DIRECTION building.

The total primary energy demand for the reference building is 70 kWh/m²/yr while the consumption of primary energy for the NU-office building is 42 kWh/m²/yr. This shows a saving of 38 % of primary energy in NU-office – 308 MWh/yr. With regards to the primary energy of electricity, there is a mismatch between the design data based on simulation and the real performance, where the monitoring data shows one-third higher consumption (29 kWh/m²/yr) compared to the design data (19 kWh/m²/yr).

The CO_2 emissions are calculated on the basis of CO_2 factors provided by the Council Information System of Munich (RIS). The monitored CO_2 emissions amount to 133 tonnes per year (12 kgCO_2/m²/yr). As a result of interventions undertaken, a total annual amount of 207 tonnes of CO_2 can be saved in comparison to the reference building. In relative numbers this is an emissions reduction of 60 %.

FACTS & FIGURES

Geographical area	**NU-office, Munich, Germany**
Demonstration area	**11 000 m²**
Population in the area	**1.5 million inhabitants**
Total investment	**€ 5 918 000**
Funding from EU	**ca. 63 %**
Final energy savings	**143 MWh/yr**
Primary energy savings	**308 MWh/yr**
CO_2 emissions reduction	**207 tCO_2/yr**

Technologies*

The technological approach to the NU-office in Munich included the implementation of the following solutions:

ENERGY EFFICIENCY IN BUILDINGS

High performance new buildings

- Improved insulation of exterior walls
- Innovative systems engineering
- Optimised daylight concepts
- Triple-glazed windows with highly efficient framing
- External and internal shading systems
- Highly efficient lighting using LED technology

Heat pumps

- Absorption heat pump, powered by district heat, where the heat is extracted from groundwater

Building integrated renewable energy sources

- Photovoltaics on all roof areas

Building services (HVAC and lighting)

- Mechanical ventilation and heat recovery: semi-decentralised ventilation units that permit high heat recoveries were implemented, while natural ventilation is also possible with openable windows in the whole building

* The KPIs for the new building are compared with the baseline of a reference building.

ENERGY SYSTEMS INTEGRATION

District heating and cooling

The district heating and cooling is used in combination with the absorption heat pump, and in cooling periods groundwater is also used for passive cooling

ENERGY EFFICIENCY IN BUILDINGS

Newly built area	**11 000 m²**
Investment	**€ 538/m²**
Payback period	**19 years**
Final energy demand (baseline)	**45 kWh/m²/yr**
Final energy demand (after)	**30 kWh/m²/yr**
CO_2 emissions reduction	**207 tCO_2/yr**
Energy supply	**Heat pumps, district heating and cooling, photovoltaics (roof)**

The investment costs associated with energy efficiency and renewable energy sources interventions amount to € 5 918 000 and are distributed across the interventions but mainly in windows (€ 1.2 million), thermal insulation on the outside walls (€ 1.3 m), building automation system (€ 0.6 m), highly efficient lighting (€ 1 m) and the heating system (€ 1.3 m).

The total final energy savings compared to the reference building are 143 MWh per year. The respective energy cost savings are € 29 581 per year with the reference building as baseline. This results in a payback period of 19 years. The calculation of the payback period ignores the financial gains due to differences in rent, which can result in a lower payback period.

Lessons learned

BARRIER	SOLUTION
SOCIAL Owners are reluctant to invest because it is the tenants who pay the energy bills, while tenants don't directly intervene in the building development phase as they don't own the building.	**A way of approaching this problem is by showing that energy-efficiency benefits can trigger owner demand. Energy-efficient solutions need to be demonstrated to building companies and owners so that they can understand the advantages brought about, and how future earnings can offset investment costs. The NU-office implemented several energy-saving measures with a predicted energy consumption below that of the average office building consumption, thus offering tenants a 'flat-rate charge' on consumption costs and generating a marketing advantage for the building.**

DIRECTION

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Stambruges, Belgium |
NEED4B

The demonstration site is located in Stambruges, 24 km from the city of Mons. It consists of a wood-based envelope house aimed at demonstrating the construction of passive house. The key design strategies are a wood-based structure, large insulation, efficient glazing and a passive house concept. The house might be further developed to be a positive energy house thanks to the installation of photovoltaic panels. The energy performance of the building is determined by a complete measurement system with data acquisition and treatment.

The construction started in February 2015 and finished in November 2015. The building monitoring started in December 2015, when the occupants arrived.

Impact*

The building in Stambruges has a total surface of 219 m^2. The energy demand is mostly electrical but a wood-burning stove installed in the house provides the space heating. According to the monitoring data, the current primary energy consumption of the building is 34 $kWh/m^2/yr$.

Technologies*

ENERGY EFFICIENCY IN BUILDINGS

High-performance new buildings

- Wood-based structure
- Large insulation
- Efficient glazing
- Passive house concept

Building integrated renewable energy sources

- Photovoltaics

ICT

Building energy management system

- Complete measurement system with data acquisition and treatment

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* Detailed information regarding the technical and financial performance will be available at a later stage.

The city of Valladolid, located in central Spain with a Mediterranean continental climate, participated in the DIRECTION project that aimed at demonstrating how the use of very innovative and cost-effective energy-efficient technologies can lead to the achievement of very-low-energy new buildings. This objective, along with the effective adoption of low-energy buildings, was achieved by switching to a model whereby energy efficiency provided value to the market and represented an attractive asset across the whole of the value chain.

This innovative approach was demonstrated in the new building CARTIF III, which has 4075 m² of floor space and will be used for CARTIF Technology Centre research activities, with both offices and test facilities.

Impact*

As a result of the energy-efficient and renewable energy sources interventions, the consumption of both thermal energy and electricity are cut in half compared to the reference building. The reference building in this region has 75 kWh/m²/yr as a total final energy consumption whereas the CARTIF III achieved a monitoring consumption of less than 35 kWh/m²/yr. Therefore, in comparison with business as usual, the final energy savings amount to 53 %.

As a result of the interventions undertaken, a total annual amount of 277 MWH/yr of primary energy can be saved in comparison to the reference building. This reduction on primary energy is translated into 101 tonnes of CO_2 (25 $kgCO_2/m^2/yr$) that can be saved in comparison to the reference building. In relative numbers, this is an emissions reduction of 70 %. The monitored CO_2 emissions amount to 46 tonnes per year (11 $kgCO_2/m^2/yr$).

FACTS & FIGURES

Geographical area	**CARTIFF III, Valladolid, Spain**
Demonstration area	**4075 m²**
Population in the area	**310 000 inhabitants**
Total investment	**€ 544 660**
Final energy savings	**163 MWh/yr**
Primary energy savings	**277 MWh/yr**
CO_2 emissions reduction	**101 tCO_2/yr**

Technologies

CARTIF III, as a very-low-energy building, implemented innovative interventions that enhanced the overall energy efficiency of the building in order to achieve a consumption (primary energy) that was lower than 60 kWh/m²/yr. These include:

ENERGY EFFICIENCY IN BUILDINGS

High-performance new buildings

The building envelope minimises thermal energy demand

The building envelope minimises electricity demand for lighting through glass walls and louvre blinds that improve solar gain

High-efficiency lighting

Waste heat recovery: mechanical ventilation and heat recovery, with a free cooling system for the entire building that allows a considerable reduction in cooling requirements

Building integrated renewable energy sources

Photovoltaics: 45 kWp photovoltaic, which allows a contribution of 15 kWh/m²yr

Heat pumps

Geothermal heat pump with seasonal performance for the office area, which transfers energy to and from the ground to ensure balance. The annual thermal requirement to heat this area therefore is zero.

ENERGY SYSTEMS INTEGRATION

Biomass boilers

A very-high-performance biomass boiler (> 90 %) provides all the necessary thermal energy for the industrial buildings and the domestic hot water.

* The KPIs for the new building are compared with the baseline of a reference building.

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**4075 m^2**
Investment	**€ 134/m^2**
Payback	**>30 years**
Final energy demand (baseline)	**75 kWh/m^2/yr**
Final energy demand (after)	**35 kWh/m^2/yr**
CO_2 emissions reduction	**101 tCO_2/yr**
Energy supply	**Photovoltaic (45 kWp), heat pumps, biomass boilers**

ICT

Building energy management system

The investment costs associated with energy-efficiency and renewable energy sources interventions amount to € 544 660. The largest share of this budget goes on the installation of shading devices (€ 155 000) and the geothermal system (€ 135 000). The energy cost savings are € 18 181 per year with the reference building as a baseline.

Based on the calculated energy savings, the payback period for design and monitoring data is determined to be more than 30 years. This result considers a discount rate of 3 % and an inflation rate for the energy carriers of 3 %. On the one hand, this value is higher than the average payback period of 30 years for eligible costs related to energy efficiency measures as stated in the European Commission decision from 2013. On the other hand, the longer payback period reflects the core energy efficiency measures with a longer life cycle, such as energy-efficient insulation and other facade parts.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC In Spain there was a change to the photovoltaic and self-consumption legislation that deeply affected the viability of the project. Controversial changes in the support schemes in Spain in 2010, 2013 and 2014 first abolished the feed-in-tariff and later introduced an access toll to the electricity grid. Over-production is no longer a revenue-generating option and it has made the project economically non-viable.	**Since the buildings have no energy storage capacity, the consortium saw it necessary to install regulators on the panels in order to limit electricity production, a solution that meant losing energy and revenue. The Valladolid demonstration site had also attempted to divert some of the extra energy for other uses, such as making sure in advance that the building would not overheat during the summer.**
SOCIAL Fully-centralised room control systems tend to generate a sense of frustration among users.	**Involving tenants in the design process and giving them some flexibility in adjusting the environmental parameters is therefore important. Motivating and empowering users to change their behaviour towards sustainability requires obtaining the right balance between centralised control and user freedom.**
SOCIAL A new building's potential in energy saving can only be fully exploited when everyday users get taught how to actively deal with these aspects and systems.	**The opportunities for energy savings should be promoted as a personal green contribution; users should be encouraged through incentives and training to save energy.**

DIRECTION

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The NEED4B demonstration site in Sweden features two buildings, which represent pre-fabricated low-energy wooden framed villas of between 140 and 200 m^2. The houses were manufactured beforehand and then assembled at the selected locations. One building was assembled in a new attractive residential area near Varberg and used as display house for a time. The second building of the same kind was assembled at a research facility in Borås and used as a full-scale test lab for energy-efficient technologies and construction details, with artificial user-behaviour loads. Different HVAC equipment performance was tested and evaluated, as well as the impact of different user-behaviours and construction details. The building was used in parallel for smart grid research and as a showcase for journalists and visitors.

The strength of their construction aimed to show how the future would deal with the issue of energy in private homes and strive for zero-energy buildings. The buildings also went beyond the issue of energy waste management and water management adapted to the region. Renewable energy sources were the focus in the construction of these buildings.

Pre-fabricated villas are a mass-market product. The house model is not a prototype, but a real solution to become part of the standard catalogue. It was constructed and equipped with energy solutions that work in various climates and countries from Helsinki to Strasbourg, including the United Kingdom, Germany and other countries with a similar climate.

Impact

The two buildings have a total area of 310 m^2. They integrate photovoltaic panels, designed to generate 3000 kWh/yr, and solar thermal panels. According to the design data, the primary energy consumption of the building is to be reduced to 50 kWh/m^2/yr.

Technologies

The two buildings feature the following technological measures:

ENERGY EFFICIENCY IN BUILDINGS

High-performance new buildings

Building services (HVAC and lighting)

Building integrated renewable energy sources

Photovoltaics

ENERGY SYSTEMS INTEGRATION

Thermal collectors

Near-to-surface geothermal energy

Deep geothermal energy

ICT

ICT as planning support

Smart monitoring system with 100 measuring points in Borås and 30 measuring points in Varberg

Smart electricity grid

Smart internal power grid

NEED4B

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Demonstration of optimised energy systems for high performance energy districts

Projects set out to demonstrate, at the level of cities or districts, an innovative integrated energy system, optimised both in terms of an increase in energy efficiency and CO_2 reduction. This might be achieved with a balance of supply-side measures based on a high share of renewables and demand-side measures to reduce consumption, or match consumption with production (demand management) as well as energy storage.

Projects address through their work the retrofitting of a district towards zero-energy buildings, proposing innovative solutions for a medium and low voltage electricity distribution grid, as well as for district heating and cooling energy supply. As a value added measure, successful projects have shown particular attention to assess the benefits for industry, customers and end-users. Through integrated actions and the development of partnerships, the projects also demonstrate their viability as new innovative market solutions and replication potential for large-scale market deployment before 2020.

Aarhus, Denmark | READY

Aarhus is the second biggest city in Denmark with 300 000 inhabitants. With the aim to become carbon neutral by 2030, the city moves forward with its climate and smart city strategy with a number of sustainable actions and projects, amongst which is READY.

With demonstration measures in the fields of retrofitting buildings, integrated energy systems, ICT and mobility and transportation, Aarhus aims to showcase how the demand for energy and particularly the need for fossil fuels and the release of CO_2 can be considerably reduced to nearly zero, and show a sustainable way forward for other European cities.

Impact*

The demo site of Aarhus accounts for a total primary energy reduction of 10 938 MWh with 2706 tonnes of savings of CO_2 emissions.

FACTS & FIGURES

Geographical area	**Aarhus, Denmark**
Demonstration area	**306 650 m²**
Total investment	**€ 14 700 000**
Primary energy savings	**10 938 MWh/yr**
CO_2 emissions reduction	**2706 tCO_2/yr**

Technologies*

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Several retrofit areas are planned in connection with the social housing of Ringgården, the administrative building of Ringgården and private single-family houses.

The retrofitting demonstration will meet the demands of the low-temperature district heating energy supply to the area.

ENERGY SYSTEMS INTEGRATION

District heating and cooling

A low-temperature district heating energy supply is to be demonstrated for the area.

The residential area included in the demonstration project is located nearby the new University Hospital. The hospital will have a local district cooling system installed, based on a compressor. Surplus heat from the cooling system will be supplied to the local district heating system through installed heat storage (in order to supply surplus heat at the right time). In this way, energy for cooling and heating is utilised in the most efficient way, and the hospital becomes self-sufficient in heat supply by utilising waste heat from cooling. Such a system has considerable potential for replication , both in Aarhus and in other cities.

Photovoltaics

Thermal collectors

Innovative types of low-cost, large-size photovoltaic-thermal modules. The new highly efficient photovoltaic-thermal elements in a frameless module can be used as roofing material and thereby recover heat losses.

Waste heat recovery

The heat in the wastewater from the buildings is to be used for domestic hot water preparation. With prefabricated installation manholes, a new modular system with buffer, heat pump and smart grid control are planned for buildings with more than 10 apartments.

Electrical energy storage

Development and testing of (second-life) battery solutions.

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Establishment of charging stations in demonstration settlements and at the New University Hospital in Skejby

Electric, hybrid and clean vehicles

Innovative technical solutions and business models of battery electric vehicles and the interaction with the low-voltage grid

Reinforcement of the introduction and roll-out concepts of electrical vehicles as part of the solutions provided

Intermodality

Further measures on reduction of private car commuting and internal transportation in the Skejby industrial area – introduction of awareness and benefit measures, public transportation improvements, etc.

Car sharing

Demonstration of vehicle sharing and vehicle-pooling service integrated with public transportation, company commuting, residential areas, etc.

ICT

Smart electricity grid

READY

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Amsterdam, the Netherlands | **City-zen**

The city of Amsterdam has 825 000 residents from 180 different countries, who own over 600 000 bicycles. The wider Amsterdam Metropolitan Area has 2.1 million inhabitants. The city has a strong commitment to encourage green research, development and investment in sustainable initiatives. As a result, the area is enjoying a rapid uptake of electric transportation and a growing number of companies are developing sustainable products that influence global business. Amsterdam is exceptionally well connected, both physically and digitally.

The city is acting in line with the EU's 20-20-20 climate targets and has the ambitious goal to reduce CO_2 by 40 % compared to 1990 by the year 2025. The City-zen project is one of the major projects in which the city is working with its partners to scale up innovative energy solutions and open networks.

The demonstration objectives of City-zen in Amsterdam are focused on retrofitting existing housing, making the e-grid smarter, and improving and expanding the heat grid.

Impact*

The total CO_2 emission savings amount to 7 500 tonnes per year.

FACTS & FIGURES

Geographical area	**Amsterdam, Netherlands**
CO_2 emissions reduction	**7400 tCO_2/yr**

Technologies*

The interventions being implemented in Amsterdam within City-zen project are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

700-900 dwellings are to be retrofitted to ensure affordable total living costs (rent and energy) for tenants now and in the future, while at the same time establishing better comfort

Empowering tenants and home-owners to save energy and involving them in the co-design with other stakeholders of innovative approaches for energy-efficient retrofitting

A lab home demonstrating hybrid heat pump

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Sustainable heat network: the waste-to-energy plant is to be optimised and new heat sources are to be connected to the district heating network, such as innovative daylight collectors. Existing multi-family buildings will be connected to the heat grid.

Cooling with water: a cold network will be installed in a large business area, which makes conventional air conditioning systems redundant. Next to that, 300 newly built homes will get comfortable cooling from surface water. This solution has not been applied before on this scale in the Netherlands.

Waste-to-energy

Recovery of waste heat at bio refinery

Increase of overall efficiency of waste to energy plant by redesign of turbine set-up

Large scale storage

Off-grid heat from the sewer system will be added to an underground storage.

Cooling with water: before raw water is transported to the dunes for purification, the cold will be extracted and stored underground.

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Batteries in houses and cars will ensure that energy can be stored and used at a later time. Owners of these batteries can trade their energy and their storage capacity on the energy market.

Electric, hybrid and clean vehicles

Demonstrate vehicle to grid (V2G) applications and technology on the Amsterdam New West smart grid

ICT

Demand response

Current and voltage are monitored continuously to provide more accurate monitoring and control functions

The residents will gain more control over their energy use. If, for instance, a citizen wants to sell the energy of his solar panels to a neighbour, this becomes technically possible.

Batteries in houses will ensure that energy can be stored and used at a later time.

Smart electricity grid

10 000 dwellings connected to a smart grid

Intelligent electricity network equipped with computer and sensor technology at key nodes

The existing network power has been increased in key areas and the network structure has been improved. In the future, slumbering power outages will be visible on the smart grid and thus can be prevented.

Lessons learned

BEST PRACTICES

SOCIAL

Although the City-zen demonstration projects take place in the frontrunner smart cities of Amsterdam and Grenoble, the project's focus is sharing its knowledge and experience with other European cities, not only by demonstrating to others how it can be done in the Netherlands and France but by going 'glocal' – combining specialist global expertise with local stakeholder energy and knowledge of the context and lifestyle on location. This is achieved by a unique methodology called the City-zen Roadshow. Over a 4-year period, the City-zen Roadshow team will visit 10 cities that are seeking expert guidance on how to become more sustainable and move towards energy neutrality. The team will help these cities and their neighbourhoods to develop a sustainable agenda or, in other words, a sustainable City Vision.

The Roadshow spends 5 days in each hosting city to deliver energy and urban design workshops in which all local stakeholders are welcome and encouraged to join and to take ownership of the final outcomes. These outcomes will allow each city's resources, people, knowledge and renewable energy potential to be directed effectively over a realisable timescale that will meet their energy transition. The process starts by identifying a neighbourhood's urban lifestyle and energy challenges. Then, on the final day of the event model, a definitive sustainable City Vision is presented to the city that responds to all levels of their built and natural environment.

The City-zen Roadshow team has so far visited Belfast (United Kingdom), Izmir (Turkey), Dubrovnik (Croatia) and Menorca (Spain). The team is currently in preparation talks with Seville (Spain), Roeselare (Belgium) and Klaipeda (Lithuania).

City-zen

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Bolzano, Italy | SINFONIA

Since 2005, the Italian city of Bolzano (100 000 inhabitants) has developed an ambitious investment plan for large-scale urban refurbishment in collaboration with both public and private stakeholders. The work undertaken in the SINFONIA project is part of this plan, and aims to achieve 40 % to 50 % primary energy savings in the demo sites, and to increase the share of renewables in the district of Bolzano SW (south-west) by 20 %.

Within SINFONIA, the city of Bolzano and the Institute for social housing (IPES) aim to refurbish 9 buildings in the Don Bosco and Oltrisarco-Aslago districts. A total of 345 social housing apartments from the 1950s to the 1970s covering a surface area of approximately 31 000 m² are to be renovated to consume less energy and improve the comfort of their tenants, but also to enhance the neighbourhoods where they are located. The project includes renovation of the building's envelope, installation of power plants running on renewable energy sources to supply the building's demand, new windows and doors, a mechanically controlled ventilation system as well as district heating system optimisation and improved energy distribution control.

Impact*

As a result of the energy efficiency, the final energy consumption in the buildings (considering heating, ventilation, lighting, domestic hot water and renewable energy production) that are part of the project SINFONIA in Bolzano will be reduced from 189 kWh/m²/yr (business as usual) to 38 kWh/m²/yr. This amounts to 4508 MWh/yr of final energy savings. The total primary energy savings for the project go up to 5879 MWh/a while the CO_2 reduction is 1462 tonnes every year.

Technologies*

The implemented measures in Bolzano are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

31 000 m² of social housing from the 1950s to the 1970s are to be retrofitted to achieve high energy performance and improved interior comfort while ensuring cost-effectiveness and minimal impact on tenants.

Building integrated renewable energy sources

Integration of renewable energy sources for electricity, heating and domestic hot water

ENERGY SYSTEMS INTEGRATION

Cogeneration (CHP)

Organic Rankine cycle with biomass

District heating and cooling

The district heating network will be extended and optimised to reduce both the CO_2 and the nitrogen equivalent emissions.

Waste heat recovery

A study will be carried out on the recovery of wasted energy from the local industrial park.

FACTS & FIGURES	
Geographical area	**Bolzano, Italy**
Demonstration area	**31 150 m²**
Population in the area	**1014 inhabitants**
Final energy savings	**4508 MWh/yr**
Primary energy savings	**5879 MWh/yr**
CO_2 emissions reduction	**1462 tCO_2/yr**

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**31 000 m²**
Final energy demand (baseline)	**189 kWh/m²/yr**
Final energy demand (after)	**37 kWh/m²/yr**
CO_2 emissions reduction	**1462 tCO_2/yr**
Energy supply	**Photovoltaics, solar thermal collectors, district heating**

* Detailed information regarding the technical and financial performance will be available at a later stage.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Recharge points for vehicles and bicycles

ICT

Demand response

Real time monitoring and forecasting of peak loads and energy demand

Smart electricity grid

Bolzano will implement an Urban Service-Oriented Sensible Grid (USOS-grid) system in the south-west district for improved energy distribution control

Smart street lighting

Smart retrofitting of the public lighting system

SINFONIA

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Grenoble, France | City-zen

As a major player in the Local Climate Plan since 2004 and as a Covenant of Mayors' member since 2008, the city of Grenoble is committed to reducing energy consumption, encouraging the use of renewable energies, promoting social solidarity, setting up alternative forms of transport and developing environmental, architectural and urban quality. The main objectives of the Grenoble Local Climate Plan, launched in 2004, and revised in 2009, remain the reduction of local greenhouse gas emissions by factor 4 by 2050.

Between 2005 and 2010, energy consumption decreased by 5,4 % and greenhouse gas emission were reduced by 18 %.. The final energy consumption per inhabitant in 2011 was 19.7 MWh. To go further and turn Grenoble into a true smart city for its inhabitants, the municipality has launched the Éco-cité project in the north side of the town. Eco-cité is gathering private and public stakeholders around demonstration projects for which political decisions have already been taken in the fields of mobility, building and energy.

The overall objective of the City-zen project is to transform the Éco-cité area into a positive energy and carbon neutral district through retrofitting private co-owned buildings and social housing, creating a low-temperature heating and cooling network, and to develop a territorial monitoring system to monitor and manage all energy flows in order to save energy and assess the systems' and policies' efficiency.

Impact*

The total CO_2 emission savings amount to 10 900 tonnes per year.

FACTS & FIGURES	
Geographical area	**Grenoble, France**
CO_2 emissions reduction	**10 900 tCO_2/yr**

Technologies*

The interventions being implemented in Grenoble within the City-zen project are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

363 dwellings are to be retrofitted with the objective of reaching the level of current thermal regulation for new buildings, leading to a saving of 9600 tonnes of CO_2 per year.

Experiment with specific supporting actions to ensure the achievement of co-ownership retrofitting (non–technical drivers)

Involvement of end-users or the so called consumer focused renovation to prevent the disqualification of their dwelling, to increase comfort and health and control the energy expenses

High-performance new buildings

The new buildings are designed to be energy-efficient with a CO_2 reduction target of 1300 tonnes per year.

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Adapting the grid's heat to this new energy-efficient buildings' needs, by designing a low pressure district heating loop in order to avoid heat losses compared with the traditional district heating in Grenoble

Waste heat recovery

Improvement of the overall district energy efficiency by connecting the loop to a heat recovery system from sewage water coupled with heat pumps

Thermal storage

Demonstration of seasonal storage solutions with dry geothermal boreholes

Centralised phase change materials storage to help meet peak demand for heating

Solar thermal generation, coupled with PCM storage solutions

* Detailed information regarding the technical and financial performance will be available at a later stage.

ICT

Neighbourhood energy management system

Demonstration of smart management of various energy flows, providing an optimised and rational use of local resources

Demonstration of a multi-utilities vision through an innovative multi-energy real-time territorial monitoring system, with a user-friendly approach

Smart electricity grid

Implementing innovative solutions to optimise the electric system

Lessons learned

BEST PRACTICES

SOCIAL

Although the City-zen demonstration projects take place in the frontrunner smart cities of Amsterdam and Grenoble, the project's focus is sharing its knowledge and experience with other European cities, not only by demonstrating to others how it can be done in the Netherlands and France but by going 'glocal' – combining specialist global expertise with local stakeholder energy and knowledge of the context and lifestyle on location. This is achieved by a unique methodology called the City-zen Roadshow. Over a 4-year period, the City-zen Roadshow team will visit 10 cities that are seeking expert guidance on how to become more sustainable and move towards energy neutrality. The team will help these cities and their neighbourhoods to develop a sustainable agenda or, in other words, a sustainable City Vision.

The Roadshow spends 5 days in each hosting city to deliver energy and urban design workshops in which all local stakeholders are welcome and encouraged to join and to take ownership of the final outcomes. These outcomes will allow each city's resources, people, knowledge and renewable energy potential to be directed effectively over a realisable timescale that will meet their energy transition. The process starts by identifying a neighbourhood's urban lifestyle and energy challenges. Then, on the final day of the event model, a definitive sustainable City Vision is presented to the city that responds to all levels of their built and natural environment.

The City-zen Roadshow team has so far visited Belfast (United Kingdom), Izmir (Turkey), Dubrovnik (Croatia) and Menorca (Spain). The team is currently in preparation talks with Seville (Spain), Roeselare (Belgium) and Klaipeda (Lithuania).

City-zen

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The city of Innsbruck in Austria (120 000 inhabitants) defined its 2025 Energy Plan back in 2009. In this context, and as part of the SINFONIA project, the city has selected its eastern district to demonstrate the large-scale implementation of energy-efficient measures, with the objective of achieving on average 40 % to 50 % primary energy savings in the demo sites, and to increase by at least 30 % the share of renewables in the district's energy mix.

Impact*

As a result of the energy efficiency, the final energy consumption in Innsbruck will be reduced from 99 kWh/m²/yr (business as usual) to 47 kWh/m²/yr, according to design data. This amounts to 535 MWh/yr of final energy savings for the two buildings reported by the project so far. The total primary energy savings go up to 607 MWh/yr while the CO_2 reduction is 164 tonnes every year. These positive environmental values represent the expected results of the project and are likely to increase when more information is reported.

FACTS & FIGURES	
Geographical area	**Innsbruck, Austria**
Demonstration area	**66 000 m²**
Final energy savings	**535 MWh/yr**
Primary energy savings	**607 MWh/yr**
CO_2 emissions reduction	**164 tCO_2/yr**

Technologies*

The implemented measures in Innsbruck are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

66 000 m² of residential and public buildings from the period 1930 to 1980 are to be retrofitted to dramatically improve indoor quality and energy performance, and reduce the final energy demand by up to 80 %

Building integrated renewable energy sources

Integration of renewable energy sources on-site (photovoltaics, solar thermal)

Heat pumps

ENERGY SYSTEMS INTEGRATION

District heating and cooling

The district heating network is to be extended and optimised to increase the use of renewable energy sources by 95 % and reduce the use of fossil fuel by 22 %. Solar energy and innovative biomass gasification are to be integrated into the network.

Polygeneration

Waste heat recovery

Recovery of heat/cold from local industries, waste-water and geothermal heat from the Brenner Tunnel

ENERGY EFFICIENCY IN BUILDINGS*	
Retrofitted area	**10 294 m²**
Final energy demand (baseline)	**99 kWh/m²/yr**
Final energy demand (after)	**47 kWh/m²/yr**
CO_2 emissions reduction	**164 tCO_2/yr**
Energy supply	**Photovoltaics, solar thermal collectors, district heating**

** The project is still ongoing and so far the refurbished area is 10 294 m², therefore the KPIs above apply only to this area. Further information will be available at a later stage.*

* Detailed information regarding the technical and financial performance will be available at a later stage.

ICT

Smart electricity grid

Smart grids and smart home applications are planned to combine demand and supply-side measures to reduce the overall electricity demand by 3 %. Buildings are to be transformed to smart urban model houses. Measures include the smart load control for refrigerators, water boilers and heat pumps, and the involvement of customers.

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SINFONIA

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Laguna de Duero is one of the municipalities surrounding the metropolitan area of the city of Valladolid, the administrative capital of the Castile and León region. Throughout the centuries, what was distinctive about the area was its natural lagoon, which dried out during the 1970s. This turn of events, however, determined the future of the city in a significant way. Laguna de Duero went through a period of growth and expansion, including the creation of the Torrelago district, which is the focus of the CITyFiED project activities.

The Torrelago district was built in two phases, each one involving a district heating network and the following numbers of buildings and dwellings:

- Phase 1: 12 buildings of 12 floors, with 4 apartments per floor, for a total of 576 dwellings with an average area of 100 m^2. These buildings were constructed in 1977.
- Phase 2: 19 buildings of 12 floors, with 4 apartments per floor, for a total of 912 dwellings with an average area of 100 m^2. Eleven buildings were constructed in 1979; the remaining eight were constructed in 1981.

Nowadays, this metropolitan area is established under the spatial planning directive of Valladolid and its surroundings, as all municipalities in the region have similar urban characteristics and mobility problems. A total of 416 000 residents live across a total area of about 1000 km^2.

Impact

The overall gross floor area of 140 000 m^2 that has been refurbished in the Laguna de Duero demo site affects more than 4000 residents. The annual final energy saving estimate is 6598 MWh with respect to thermal energy savings (reduction of 38,65%) and 137.2 MWh/yr regarding electric energy savings associated with the district heating (reduction of 63.64%). The total CO_2 emission savings estimate amounts to 212 tonnes per year.

FACTS & FIGURES

Geographical area	**Laguna del Duero, Spain**
Demonstration area	**140 000 m^2**
Population in the area	**4000 inhabitants**
Final energy savings	**6735 MWh/yr**
CO_2 emissions reduction	**212 tCO_2/yr**

Technologies*

The key energy-efficiency measures implemented in the demonstration site are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Interconnection of the two original district heating networks in order to increase the overall performance of the whole system.

Twelve new heat exchange substations at building level in Phase I have been built. In addition, a variable flow pumping system has been installed, as well as two buffer tanks of 25.000 L, smart control and management systems to adapt energy production and distribution, smart thermal energy meters at home level and individual smart thermostats and cut-off valves in each dwelling.

Biomass boilers

Three new high efficiency biomass boilers have been installed at the demonstration site. Works have included the construction of an underground boiler room, a biomass silo of 427 m^3, installation of two buffer tanks, a smart metering system and the implementation of various substations.

Cogeneration (CHP)

Heat energy used for domestic hot water system

ICT

Neighbourhood energy management system

Monitoring platform and visualisation platform

Smart electricity grid

Electricity generated by the CHP, used for the district heating facilities and the electrical vehicles recharging points.

ICT as planning support

Adaptative control and monitoring system

* Detailed information regarding the technical and financial performance will be available at a later stage.

Lessons learned

BEST PRACTICES

FINANCIAL & ECONOMIC, SOCIAL

It is clear that investing to improve energy efficiency has profound environmental impacts. The CITyFiED demonstration site in Laguna de Duero is showing the economic and societal benefits as well, with 50 unemployed Laguna residents due to receive training and work on the renovation implementation of the building facades. More than 400 résumés reached CITyFiED partner 3IA, the company responsible for placing the new Torrelago building facades, when 50 new positions were advertised. Previously unemployed residents have been prioritised in the recruitment and the new hires will receive an extensive training programme, lasting around 2 weeks, to ensure a high-quality delivery of tasks on the facades and to prepare a talent base for future implementations in the project.

SOCIAL

In a truly cooperative approach, CITyFiED representatives carried out a workshop with the residents about the visualisation side of the district's renovation. Participants had the opportunity to address various technological and non-technological solutions designed to cut energy consumption, and the effects that these could have on residents. The approach seeks to take account of user perspectives, and places residents at the heart of the decision-making process. For long-term success in green energy, projects like CITyFiED need residents to fully buy into the planned retrofitting and development. Such an approach raises awareness of energy challenges and increases the prospect of replicability through citizen engagement.

CITyFiED
RepliCable and InnovaTive Future Efficient Districts and cities

CITyFiED

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Lund is a medium-sized university city with a research-intensive industry. The town dates back a thousand years, but the number of inhabitants has grown, largely during the last century, and a great number of the buildings from the 1960s and 1970s now need retrofitting. Almost 90 % of the heat demand in the city is supplied by district heating, and the hospital and some office buildings are connected to a district cooling network.

The focus of the CITyFiED project are 16 houses in the Linero district spread over 40 400 m². The retrofitting aims to reach a higher energy standard with maintained affordability for the tenants. Simulations of the energy-efficient measures included in the retrofitting strategy were carried out during the first part of the project. They showed that the original final energy savings targets not only can be accomplished but will be surpassed.

The first round of analysis showed that the total final energy savings in Linero would reach approximately 58 kWh/m²/yr. This value is better than the project's original target of achieving a reduction of 31 %. Primary energy savings at the site have been established at 19 % of the original primary consumption and greenhouse gas emissions are to be reduced by 26 %. Four indicators for indoor environmental quality in the buildings were analysed – operative temperature, relative humidity, CO_2 levels and the Predicted Percentage Dissatisfied (PPD) index to measure ambient climate dissatisfaction. None of the indicators show critical levels in the current buildings and no negative effect has been observed from the calculations of the renovation measures. At the heart of reaching these performance targets are the research, planning and efficiency of the extensive renovation strategy.

Impact

The overall gross floor area of 40 400 m² has been refurbished in the Lund demo site affecting 1150 people. The annual final energy saving estimate is 2343 MWh. The total CO_2 emission savings estimate amounts to 404 tonnes per year.

FACTS & FIGURES	
Geographical area	**Lund, Sweden**
Demonstration area	**40 400 m²**
Population in the area	**1150 inhabitants**
Final energy savings	**2343 MWh/yr**
CO_2 emissions reduction	**404 tCO_2/yr**

Technologies*

The key measures implemented in Lund are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Building services (HVAC and lighting)

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Smart district heating

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

Fast charging points for electric vehicles

ICT

Building energy management system

Monitoring systems for providing best indoor comfort conditions and energy savings

ICT as planning support

Demand response

Numerous full-scale concept solutions to complement structural advantages will include smart grid monitoring initiatives – with visualisation tools and demand responsive meters

* Detailed information regarding the technical and financial performance will be available at a later stage.

Lessons learned

BEST PRACTICES

SOCIAL

The Swedish partners have established structures for working together to safeguard the systemic approach that characterises the project. These are a steering committee ensuring a high-level awareness of the CITyFiED actions and methodology, a communications group to speak with a united voice and engage with residents, and collaborative working days.

SOCIAL

Great efforts were invested in improving the living conditions (both indoor and outdoor) in the Linero district in an economically sound way so that the tenants can remain in the area. Frequent meetings with the tenants have been carried out to ensure high acceptance of the measures.

CITyFiED

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Soma is located in the Manisa province, western Turkey and has a population of about 90 000 people. The town has grown around the lignite mining industry and the lignite-fired thermal power plant. The pilot demonstrator district consists of a total gross area of 64 971 m², of which 41 158 m² is a conditioned area. The total population in the demo site is around 2000 people.

In general, buildings in the area are heated by coal-based heating systems, where old-fashioned stoves heat around 70 % of dwellings and only 30 % of buildings are heated by central heating boilers with their own radiator systems. As a result, the air quality in the region has suffered greatly. To tackle this, the local government has placed district heating implementation at the top of their agenda.

Taking into account these conditions, two different retrofitting strategies were implemented:

- application of passive design strategies on the building envelope adding defined building elements such as insulation;
- integration of active design strategies such as building-integrated photovoltaic and solar thermal collectors as a renewable technology, innovative integration of monitoring systems for providing best indoor comfort conditions and energy savings.

Impact

The overall gross floor area of 41 158 m² will be refurbished in Soma within the CITyFiED project. The annual final energy saving estimate is 4320 MWh. The total CO_2 emission savings estimate amounts to 1083 tonnes of CO_2 per year.

FACTS & FIGURES

Geographical area	**Soma, Turkey**
Demonstration area	**64 971 m²**
Population in the area	**2000 inhabitants**
Final energy savings	**4320 MWh/yr**
CO_2 emissions reduction	**1083 tCO_2/yr**

Technologies*

The key energy efficiency measures implemented in Soma are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

ENERGY SYSTEMS INTEGRATION

District heating and cooling

District heating based on waste heat recovery from a thermal power plant

Photovoltaics

Waste heat recovery

Thermal collectors

ICT

Smart grid

Building energy management system

Monitoring platform

* Detailed information regarding the technical and financial performance will be available at a later stage.

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE The tender process for publicly owned buildings is proving to be time-consuming and intricate.	**The local teams are on a tight schedule to complete the renovations on all the intended dwellings within the project's duration.**
REGULATORY & ADMINISTRATIVE A number of political and financial changes and events in Soma delayed the start of the works. One of the major risks for the project is the government's decision to privatise SOMA Electricity Generation & Trading Joint Stock Company (SEAŞ). This has influenced decision-making, prioritisation, budgeting and resource allocation for the company, which is at the centre of the interventions at the demo site and the related investments. In addition, these changes have led to new requirements for the buildings in the Soma demonstration site in terms of seismic testing.	**The risk is gradually being overcome. However, there are some concerns that SEAŞ will become a significantly smaller enterprise in the process, affecting current resource arrangements. Given the social aspects and attractiveness of the project, the local team is assessing the progress of the situation and acting accordingly.**

CITyFiED
RepliCable and InnovaTive Future Efficient Districts and cities

CITyFiED

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Växjö, Sweden | READY

Växjö municipality, together with its inhabitants, businesses, organisations and university, are all working towards a better environment and a smaller carbon footprint. The city has high ambitions to make itself sustainable, energy-efficient, fossil fuel-free and with a large proportion of wooden buildings. Växjö aims to be at the forefront and therefore participates in various EU projects, among which is the READY project, that demonstrates how the demand of energy and particularly the needs for fossil fuels and release of CO_2 can be considerably reduced to nearly zero, and show a sustainable way forward for other European cities.

The project has a whole-city approach, which includes interventions in the fields of retrofitting buildings, integrated energy systems, ICT, and mobility and transportation.

Impact

The demo site of Växjö accounts for a total primary energy reduction of 8020 MWh with total savings of CO_2 emissions amounting to 1778 tonnes.

FACTS & FIGURES

Geographical area	**Växjö, Sweden**
Demonstration area	**54 192 m²**
Total investment	**€ 12 000 000**
Primary energy savings	**8020 MWh/yr**
CO_2 emissions reduction	**1778 tCO_2/yr**

Technologies

The implemented measures in the demo site of Växjö within the READY project are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Refurbishment of 376 apartments in the Araby housing district (the sub-areas of Alabastern and Bärnstenen) as well as the City Hall building located in central Växjö, which covers 11 162 m²

Small energy storage

Some renovated buildings are to be tested as a pilot, being equipped with smart district heating sub-centrals in order to use the building as accumulator.

ENERGY SYSTEMS INTEGRATION

District heating and cooling

The READY project further develops and enhances the existing district heating and cooling systems in order to increase the overall energy efficiency in the city. Two existing district cooling networks are to be connected so as to increase the renewable energy sources production and increase the amount of waste heat used in the system. The integration of the district heating network and the district cooling network is to be performed with absorption cooling machines, making it possible to produce cooling with heat when the electricity price is high and produce cooling with electricity when the prices are low.

Waste heat recovery

Connection of waste heat sources from more local industries. The waste heat is either to be recovered in the heating system and used as an energy source or used to produce electricity. In both cases, local cooling machines will not cool the waste and therefore the electricity consumption at the local industries will decrease as well.

The Green Operating Centre in Växjö is progressing, where an innovative cooling system with an integrated piping system is connected to the computer centre to cool down the server hall with district cooling return water.

This centre is also designed with efficient hot and cold aisles, making it possible to utilise the heat from servers that would otherwise have been wasted. In this way the PUE (power usage effectiveness) value goes down from 2.2 to 1.2.

MOBILITY & TRANSPORT

Clean fuels and fuelling infrastructure

A number of pilot charging stations will be realised in cooperation with the electric utility service provider EON

Electric, hybrid and clean vehicles

Carpooling

ICT

Neighbourhood energy management system

The retrofit of the sub-areas Alabastern and Bärnstenen will include a number of innovative utility services – all of them connected to the advanced ICT management system, with the purpose of optimising the overall performance and reducing energy consumption.

Smart electricity grid

Control of the supply and demand and optimisation of the use/re-use of energy across the integrated energy systems (electricity and electric vehicles, as well as district heating)

Urban data platform

Växjö uses a common and open ICT platform enabling all the required types of services and communication. The communication platform will benefit from the existing open broadband network (provided by Wexnet) inside each building, which is supplemented with support for a digital low-power sensor network provided via a smart communication node installed in each apartment. The smart node is planned to communicate with measuring devices, individual appliances and other sources of information. The software platform is to integrate the utility services and enable real-time visualisation of services on various platforms such as web, tablet, smart phone and television.

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READY

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Demonstration of nearly zero-energy building renovation for cities and districts

Through the demonstration of innovative technical, economic and financial solutions, the main target for these projects is to renovate a district of existing buildings, with the priority placed on retrofitting residential homes, ensuring economies of scale and cost-effectiveness. This will be achieved by optimising a large number of buildings in one district in a fully integrated way, with an extension of the building energy management system to the whole district, and including an efficient urban design that allows significant savings.

Mixed societies bringing together living with working, leisure and consumer activities will result in reduced needs for transportation, and will enable a better peak management of energy (energy peaks in offices happen at different times of the day to private homes), water, waste, etc.

A systemic approach is a key aspect of these projects. All the building elements that contribute to improved energy efficiency and sustainability through integrated design and planning are presented. This includes heat recovery technologies and very efficient water/waste management, enhanced systems for energy behaviour monitoring, and demand response and load control systems, as well as ICT tools at district level.

Aachen, Germany | # EU-GUGLE

The city of Aachen has 248 000 inhabitants and is situated at the western border of Germany with Belgium and the Netherlands. The district Aachen-North, which is the focus of the EU-GUGLE project, is a heterogeneous area with a mixture of recent and old industrial and residential buildings. It is spread over 300 hectares and has 15 500 inhabitants. The urban planning focuses on revitalising and improving the attractiveness of the district. Most recently, Aachen-North was part of a multi-year urban development programme called Social City, where energy was one of the aspects covered, along with green spaces, housing, living quality, leisure, places for culture, social institutions, and the integration of industry and road space.

The model site of the EU-GUGLE project includes 391 dwellings for renovation, which cover an area of 41 688 m^2 with 1500 inhabitants. The buildings are mainly settlements from the 1920s and 1930s and multi-storey buildings from the 1970s.

Impact*

The expected primary energy savings in the EU-GUGLE pilot district in Aachen are up to 65 %. The activities are also aiming to reduce energy demand by increasing the information and transparency of energy use. The envisaged actions are eligible examples of energy-efficient retrofitting and have great potential for immediate replication.

FACTS & FIGURES

Geographical area	**Aachen-North, Aachen, Germany**
Demonstration area	**41 688 m^2**
Population in the area	**1500 inhabitants**

Technologies*

The implemented measures are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Insulation measures on facades, roofs, cellar ceilings, windows

Building services (HVAC and lighting)

Technical control systems for heat, electricity and lighting

Presence detectors for lighting

ENERGY SYSTEMS INTEGRATION

Waste heat recovery

Heat recovery from the sewage and heat pumps integrated in a low exergy heat network

Thermal collectors

District heating and cooling

ICT

Building energy management system

Smart metering

* Detailed information regarding the technical and financial performance will be available at a later stage.

EU-GUGLE

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Alingsås, Sweden | **BEEM-UP**

The Swedish demo site of the BEEM-UP project is located in Alingsås and known as Brogarden. The area consists of multi-dwelling buildings built in the period 1971 to 1973, comprising a total of 300 apartments, divided into 16 houses with 2 to 4 floors each. All apartments have a balcony or patio.

Overall, a gross floor area of 14 860 m² has been refurbished in the project. The houses were stripped down to the frame and rebuilt using passive house techniques. While doing this, the layout of the apartments has been changed slightly to ensure better accessibility and to provide an increased number of large apartments that suit the modern way of living better than the old layout.

Brogarden is classified by the municipality as an area of conservation value. The building materials have therefore been chosen to resemble those of the original building.

Impact*

The energy consumption figures amounted to 210 kWh/m²/yr before the project and 90 kWh/m²/yr after the interventions were implemented. The total thermal consumption was reduced by two thirds, from 170 kWh/m²/yr to 58 kWh/m²/yr thanks to the passive strategies deployed in the building, such as the highly efficient insulation. These results show that the interventions led to a reduction in the thermal energy consumption of over 100 kWh/m²/yr.

The results from the Swedish demo site show that the anticipated savings regarding space heating are largely achieved, while the expectation on the reduction of domestic hot water consumption is not met. The 45 % savings in energy for domestic hot water seemed to be too ambitious, especially as the consumptions are very much dependent on the tenants' behaviour. The discrepancies could be explained by the fact that the calculations were made with the assumption that the heating and ventilation systems would be functioning perfectly.

The electricity consumption (sum of domestic and common consumptions) that includes lighting consumption showed a decrease of 33.7 %. The discrepancy between this result and the objective of the project on lighting (42 %) could be explained by the tenants' habits.

The BEEM-UP project did not set any goals regarding the reduction of CO_2 emissions, but reached a reduction of 61 tonnes of CO_2. Regarding the overall primary energy saving, the objective was saving 75 % on heating consumption and 45 % on domestic hot water. The monitored results show that the primary energy savings have been reduced by 75 % and 12 % respectively.

FACTS & FIGURES

Geographical area	**Alingsås, Sweden**
Demonstration area	**14 860 m²**
Population in the area	**ca. 300 inhabitants**
Total investment	**€ 22 250 000**
Final energy savings	**1783 MWh/yr**
Primary energy savings	**2229 MWh/yr**
CO_2 emissions reduction	**61 tCO_2/yr**

Technologies

The refurbishment included:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

New walls containing several layers of insulation and slotted steel studs with a total of 440 mm insulation

100 mm expanded polystyrene extending 1 m below ground level was added to the basement, along with 100 mm drainage panel downwards to the ground floor

400 mm new mineral wool insulation was fitted in the roof space

The windows were replaced with triple pane windows with insulated glass

Building integrated renewable energy sources

Photovoltaic panels on the roof and/or walls were installed on three of the buildings

Building services (HVAC and lighting)

Optimised lighting: low-energy fittings in the apartments and low-energy or halogen lighting and LED lighting in stairwells

Balanced ventilation with heat recovery, where single unit serves entire building

* Please note that there is no design data for the electrical consumption of the demo site.

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**14 860 m²**
Investment	**€1500/m²**
Payback period	**>30 years**
Final energy demand (baseline)	**210 kWh/m²/yr**
Final energy demand (after)	**90 kWh/m²/yr**
CO_2 emissions reduction	**61 tCO_2/yr**
Energy supply	**District heating, photovoltaic**

ICT

Building energy management system

ICT energy management was installed including smart meters. Electricity is measured individually, hot water is monitored remotely for each apartment, and heating is measured for each staircase.

The investment cost for the intervention was € 1500/m², which represents a total of € 22.25 million. According to the data provided and SCIS calculations, the annual cost savings for energy come to € 361 633, from a total cost of € 394 613. Therefore the annual costs after renovation equal € 32 980.

With regard to the payback period, an inflation rate of 3 % for the energy prices has been assumed while the discount rate has been assumed to be 3 %. The resulting payback period is 30 years.

The financial analysis shows that the profitability of the project is not given due to the high investments in comparison to the low energy cost savings. This however does not reflect non-monetary benefits that might occur through implementation.

Lessons learned

BEST PRACTICES

FINANCIAL & ECONOMIC

The extensive renovation and sharp energy focus mean that future financial risks are reduced, as operation and maintenance costs will be significantly lower following the retrofit. There is also a transaction of future behaviour-related risks of energy costs from the building owner to the tenant, as the tenants take charge of their own energy bills and possible savings after the renovations (before, the costs were included in the rent, which did not encourage energy saving). The improvement of quality in the buildings and the status of the neighbourhood will also minimise future financial risks such as vacancies.

SOCIAL

A crucial element of the successful implementation of the project was the continuous dialogue with the tenants and the good collaboration within the procured partnership. The developer created a showroom apartment and together with the Swedish Union of Tenants held an open house every week for the tenants of the housing complex. A newsletter was distributed once a month with contributions from the building owners Alingsåshem, the Tenants' Union and the construction company Skanska. In addition, understanding that these were not merely houses but people's homes, where they tried to continue living their daily lives despite the renovation works, made a difference.

SOCIAL

In general, the project has been very successful and this is, according to many of the partners, largely thanks to the extensive involvement and the partnership model of the project. Every project member contributed, shared their experiences and ideas, and helped each other at a much deeper level than in normal retrofitting projects because of the shared objective and incentives, the positive dialogue and the team spirit.

BEEM-UP

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Augsburg, Germany | **E2REBUILD**

The E2REBUILD demonstration site in Augsburg (southern Germany) consists of two multi-storey residential buildings with typical post-war characteristics from 1966. The buildings are a three-storey block with 12 apartments and a six-storey block with 48 apartments. They have been fully retrofitted including building services and bathrooms, with residents remaining in their apartments during the construction work.

The demo site has received numerous prestigious awards, including the Holzbau Plus Prize and the Deutscher Holzbaupreis Anerkennung, Deutscher Bauherrenpreis 2013, and is attracting more and more public interest in its holistic refurbishment method.

Impact

The demonstration site Grüntenstrasse in Augsburg consists of an original overall gross floor area of 4499 m² that has been increased to 4724 m² by the refurbishment.

An energy performance of 170 kWh/m²/yr and 90 kWh/m²/yr were monitored before and after the renovation works. The results show that the heating demand for space heating exceeded 144 kWh/m² per year, which represents the largest energy consumption. The interventions for retrofitting reduced the thermal energy demand to around 40 kWh/m²/yr.

The objective was to reach a reduction of over 80 % in CO_2 emissions. The final reduction is over 90 % due to the large use of biomass, with a total reduction of 113 tonnes of CO_2 per year. Overall the reduction aimed for with the primary energy savings was 15 % of the previous consumption. The monitored results show that the primary energy savings have been reduced by almost 50 %, with a total reduction of 472.4 MWh/yr.

FACTS & FIGURES	
Geographical area	**Grütenstrasse, Augsburg, Germany**
Demonstration area	**4724 m²**
Total investment	**€ 5 555 000**
Final energy savings	**377 MWh/yr.**
Primary energy savings	**472 MWh/yr.**
CO_2 emissions reduction	**113 tCO_2/yr**

Technologies

The demonstration in Augsburg included the following measures:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

The envelope has been retrofitted using a prefabricated envelope system based on TES EnergyFacade.

The project serves as a pilot example for the implementation of prefabricated timber elements (U-value 0.13 W/m²K) with modern highly insulated windows.

Thermal bridges have been almost eliminated by integrating the balconies into the heated space.

The existing balconies were converted into winter gardens and a new outdoor space between the former concrete balcony structures was created. Hence the apartments gain extra space with an additional room acting as a thermal buffer zone and an additional exterior platform.

Building services (HVAC and lighting)

Mechanical ventilation system with heat recovery

ENERGY SYSTEMS INTEGRATION

Biomass boilers

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**4724 m²**
Investment	**€1176/m²**
Payback period	**30 years**
Final energy demand (baseline)	**170 kWh/m²/yr**
Final energy demand (after)	**90 kWh/m²/yr**
CO_2 emissions reduction	**236 tCO_2/yr**
Energy supply	**Biomass boilers**

The investment cost for the intervention has been € 1176/m², adding up to a total of € 5 555 000 including VAT. According to the provided data, the annual cost saving for energy is € 41 612, with annual costs after renovation of € 26 692. The resulting payback period is 30 years. The financial analysis shows that a profitability of the project is not given due to the high investments in comparison to the low energy cost savings. This however does not reflect non-monetary benefits that might occur as a result of the implementation.

Lessons learned

BARRIER	SOLUTION
SOCIAL A multidisciplinary approach was planned for the refurbishment, which posed a challenge for the different players (engineers, architects, scientists, etc.) who had to engage in interdisciplinary discussions.	**In order to integrate the different approaches and points of view and to work better together, the consortium:** • developed holistic retrofit strategies with high added value and high replication potential for each relevant building type; • created a formalised process for early integration of production planning, cost estimation, design and socio-architectural parameters; • elaborated on different types of collaboration models. Retrofitting strategies will be matched with the requirements of users and different ownership structures, as well as different financing schemes; • created a decision tool which allows evaluation of simple repair measures, sustainable retrofitting concepts or building reconstruction in an early design stage.

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E2ReBuild

E2REBUILD

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Ballerup, Denmark | SCHOOL OF THE FUTURE

Hedegaards School is located in Ballerup, Denmark, in a cold temperate climate. The school is positioned in a relatively open urban area with mainly low-rise buildings and is one of 10 schools in the town. In this area, the annual mean temperature has increased from 8 °C in 1980 to 8.7 °C today. The number of heating degree days is 2900 and the number of hours with bright sunshine is about 1700 – this has also increased over the last 30 years from about 1500 hours.

Part F of Hedegaards School, with a building age of more than 35 years, was in need of refurbishment as the roof and the windows were leaky and the thermal insulation of the walls and attic was insufficient. The electric lighting installations in the corridors were technically obsolete, causing high electricity consumption. This part has an overall floor area of 3850 m^2, which includes 15 ordinary classrooms, two rooms for science, one auditorium, one teachers' room and a student cafeteria in the basement.

Impact

Retrofitting included the thermal insulation of the building envelope, new windows, the installation of more efficient lighting fixtures in the corridors and two classrooms, photovoltaics and a high-quality building energy management system. According to the design data of the demonstration site, the energy demand could be reduced by around 75 % due to the interventions taken by the project, accounting for a total thermal demand reduction of 70 %.

The final results of the monitoring data show that the thermal energy savings could almost be achieved compared to the design values. The total energy reduction has been 67 % based on the real data monitored under real conditions of use, from 210 kWh/m^2/yr to 90 kWh/m^2/yr. If this result is compared to the 7 % reduction that was calculated based on design data, the result shows a good agreement between simulation and real performance. Regarding the photovoltaic system, the energy generation exceeded the expectation. Since the electricity produced by the photovoltaic system has been used on-site, the grid electricity consumption has also been reduced.

The calculated energy savings of Hedegaards School are in agreement with the project target values. The measurements performed in 2014 were adjusted with regard to climate. Final energy savings for heating were 60 % (lower than predicted) while electricity savings were 29 %, thus slightly exceeding the planned values. The total savings of delivered energy achieved in the project are 123 kWh/m^{2}yr or 57 %. It should be noted that the set point of the indoor temperatures now is about 3 degrees higher than before the retrofitting. Calculations prove that this influence corresponds approximately to the missing percentage of the savings.

The assessment regarding the reduction in primary energy consumption and CO_2 emissions showed that 539 MWh of primary energy and 58 tonnes of CO_2 are saved every year post refurbishment.

FACTS & FIGURES	
Geographical area	**Hedegaards school, Ballerup, Denmark**
Demonstration area	**3850 m^2**
Population in the area	**49 000 inhabitants**
Total investment	**€ 551 000**
Funding from EU	**ca. 70 %**
Final energy savings	**462 MWh/yr**
Primary energy savings	**539 MWh/yr**
CO_2 emissions reduction	**58 tCO_2/yr**

Technologies

A comprehensive planning of the energy-efficient project savings was carried out, which included the retrofit of building construction elements and building service systems.

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

The existing, contaminated windows (the old windows were found to contain lead and polychlorinated biphenyls - PCB) were replaced with new triple-glazed windows mounted in insulated frames.

The external masonry work and the existing insulation layer were removed from the double-leaf masonry facade.

The walls were insulated with 33 cm of mineral wool and provided with a new exterior layer (masonry or facing shell). Due to these measures, previously existing thermal bridges could be significantly reduced.

The roof was sealed and an additional insulation layer of 25 cm mineral wool was applied, which increased the total insulation thickness to 45 cm.

Building services (HVAC and lighting)

As the existing lighting solutions in the classrooms already employed rather efficient T5 luminaires, retrofitting was restricted to two classrooms where two different LED systems were tested side-by-side. Here, the blackboard lighting was replaced with LED strips in a reflector.

The corridors were supplied with two rows of LED downlights that use daylight-dependent controls.

Mechanical ventilation and heat recovery: a high-quality ventilation system was installed with a recuperator, enabling the restoration of waste heat. A system efficiency of 85 % heat recovery was achieved.

Building integrated renewable energy sources

152 m² of photovoltaic panels were installed on the roof of one of the school. With a total installed power of 22.5 kWp the annual electricity generation amounts to approx. 22.5 MWh/yr.

ENERGY SYSTEMS INTEGRATION

District heating and cooling

The connection to the district heating supply was maintained. The local district heat is mainly generated by waste incineration.

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**3850 m²**
Investment	**€ 143/m²**
Payback period	**13 years**
Final energy demand (baseline)	**210 kWh/m²/yr**
Final energy demand (after)	**90 kWh/m²/yr**
CO_2 emissions reduction	**58 tCO_2/yr**
Energy supply	**Photovoltaics**

ICT

Smart grid

The total investments for the demonstration site are € 551 000 including interventions for the envelope (€ 430000), lighting (€ 67 000) and the photovoltaic system (€ 54 000). Based on the provided monitoring data, the energy cost savings come to € 42 804 per year. The calculated payback period is 13 years.

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE Mismatch between planned activities and real implementation.	**Some planned actions had to be modified due to this mismatch.**

CHALLENGES
FINANCIAL & ECONOMIC There was a mismatch between the budget and the real costs of implementation due to unexpected additional costs and/or improper budget calculations.

SCHOOL OF THE FUTURE

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Bratislava is the capital of Slovakia and the country's largest city with a population of about 475 000. Located in south-western Slovakia, the city occupies both banks of the Danube River (centre of the city) and the left bank of the Morava River (west part of the city).

The apartment buildings selected for the EU-GUGLE project demonstration are located in two districts: the wider city centre and the western part of the city. The total area to be renovated is 40 000 m², and features a wide range of different building types with different construction systems and construction materials from 1960s onwards, representing a typical city building composition. Almost all of the selected buildings were characterised by high-energy demands and diverse technical difficulties. The envelope had insufficient thermal protection and required a high amount of energy for space heating and domestic hot water preparation. Most of the buildings were connected to a district heating network.

The selection of pilot private apartment buildings aimed to identify the wide spectrum of issues and problems that could occur in the renovation process of housing stock in the city.

Impact*

The energy consumption figures amount to around 165 kWh/m²/yr before the project and less than 50 kWh/m²/yr after the interventions will be implemented. The energy saving measures are expected to result in 60 to 75 % reduction of energy use in buildings In addition, the interventions will improve the quality of life of the inhabitants and raise their awareness of a correct renovation of properties, regardless of historical or contemporary buildings and environmental issues in general. The measures will be replicated in other apartment buildings, located in different city districts with similar building types in terms of construction materials and construction systems.

FACTS & FIGURES

Geographical area	**Bratislava, Slovakia**
Demonstration area	**40 000 m²**

Technologies*

The measures implemented in Bratislava are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Improvement to the energy performance of buildings through renovation and retrofitting measures, such as thermal protection of peripheral constructions, roofs, replacement of existing windows with triple-glazed windows

Building services (HVAC and lighting)

Retrofitting of the building's technical system components and thermal insulation of distribution system pipes

Mechanical ventilation system with heat recovery

Heat pumps

ENERGY SYSTEMS INTEGRATION

Thermal collectors

New energy source after disconnection from district heating

Photovoltaics

Cogeneration (CHP)

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**3 786.30 m²**
Investment	**€ 189,37/m²**
Payback period	**7.8 years**
Final energy demand (baseline)	**93,32 kWh/m²/yr**
Final energy demand (after)	**8,91 kWh/m²/yr**
CO_2 emissions reduction	**117 tCO_2/yr**
Energy supply	**Photovoltaics, heat pumps**

* Detailed information regarding the technical and financial performance will be available at a later stage.

ICT

Building energy management system

Introduction of metering and regulation control systems

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE Achieving the proposed primary energy factor was impossible with the current energy delivery system (district heating).	**Disconnection from the district heating and building new heating room with renewable energy system.**
REGULATORY & ADMINISTRATIVE Change in the law concerning fire protection during the construction.	**Adaptation of the project to the new law requirements.**
SOCIAL Prolonged construction work of the deep renovation due to problems with the building company was very stressful for the inhabitants.	**Regular controls and check-ups at the building site to prevent further delays.**

EUGUGLE

EU-GUGLE

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SCHOOL OF THE FUTURE

The Tito Maccio Plauto School, which was part of the SCHOOL OF THE FUTURE project, is located in Cesena in north-east Italy, close to the Adriatic Sea. The school, built in the 1960s, is an L-shaped building on three levels with a basement, part of which is used for music labs and the canteen. It has classrooms, labs, an administration area and a music hall, as well as a gym adjacent to the main building. The building hosts about 400 pupils and 40 to 50 teachers and caretakers.

Impact

The focus for the school in Cesena was on reducing the final energy consumption for space heating. The expected impact was estimated to achieve a total reduction of 84 %. The domestic hot water supply has not been changed and was estimated to be 1 kWh/m²/yr. The monitoring results show that the heating demand was 148 kWh/m²/yr before the implementation and 30 kWh/m²/yr after the interventions were deployed.

The electricity consumption of the school before the implementation was 11 kWh/m²/yr. By installing a photovoltaic plant on the roof the expected consumption of electricity from the grid would be zero in a yearly balance. The monitoring results show that due to the lower electricity consumption after the implementation (10 kWh/m²/yr), an additional annual energy use of 3 kWh/m²/yr from the photovoltaic plant has been fed into the grid.

The analysis of the results shows that only a minor part of the energy consumption is used for electricity. The major part is used for space heating: 148 vs. 11 kWh/m²/yr before the intervention and 30 vs. 10 kWh/m²/yr after refurbishment.

The calculations for primary energy and CO_2 emission factors for gas and electricity show that both have been drastically reduced. While the primary energy for thermal heat has been reduced by 84 %, the primary energy for electricity has been reduced by 100 % due to the electricity produced from the photovoltaic plant. The reduction of the CO_2 emissions adds up to 48 tonnes every year.

FACTS & FIGURES

Geographical area	**Tito Maccio Plauto School, Cesena, Italy**
Demonstration area	**6420 m²**
Population in the area	**100 000 inhabitants**
Total investment	**€ 954 769**
Funding from EU	**ca. 70 %**
Final energy savings	**192 MWh/yr**
Primary energy savings	**339 MWh/yr**
CO_2 emissions reduction	**48 tCO_2/yr**

Technologies

The interventions deployed in the school in Cesena include:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

- Envelope insulation for the whole building
- Installation of new windows and shading devices
- Thermostatic valves and thermostats.

Building services (HVAC and lighting)

- Mechanical ventilation system with heat recovery

Building integrated renewable energy sources

- Photovoltaics on the roof

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**6420 m²**
Investment	**€ 795/m²**
Payback period	**11 years**
Final energy demand (baseline)	**165 kWh/m²/yr**
Final energy demand (after)	**45 kWh/m²/yr**
CO_2 emissions reduction	**48 tCO_2/yr**
Energy supply	**Photovoltaics (roof)**

ICT

Smart grid

The overall investment for energy-related work was € 950 000, where the largest share of € 706 580 covers the civil works (new windows, insulation of the building, etc.), followed by the new boilers with remote control worth € 114 000. According to the SCIS calculations based on the energy prices for gas and electricity taken from EUROSTAT data for Italy (year 2014), the school achieved savings of € 92 000 per year.

A payback period of 11 years has been calculated, taking into consideration the energy-related investment and the energy cost savings. However, considering the surplus electricity produced from the photovoltaic plant, this period could be reduced even further.

Lessons learned

BARRIER	SOLUTION
SOCIAL The extensive renovation works affect the use of the building and its occupants.	**To overcome these barriers, a common understanding and coordination between the developers responsible for the works and the school management was essential.**
SOCIAL One of the main barriers encountered was the lack of information on similar projects in Italy, as well as a shortage of skilled workers.	**The presence of scientific and industrial partners who have been working on similar projects for years and have experience in dealing with these issues was of great value.**
SOCIAL Highly insulated and airtight buildings bring new requirements, especially in terms of cooling, indoor air quality and functionality (e.g. moisture).	**Passive solutions such as solar protection and extra/night ventilation must be adopted to avoid thermal discomfort.**

CHALLENGES

FINANCIAL & ECONOMIC

Very ambitions retrofitting projects are expensive, and therefore dependent on the economic situation. The economic crisis affected the contractors and the original work plan and as a result the works were delayed.

SCHOOL OF THE FUTURE

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Delft, The Netherlands | **BEEM-UP**

The BEEM-UP building site in the Netherlands is located in the north-west of Delft, approximately 2.5 km from the city centre. The group of buildings is called Complex 5 and consists of 108 dwellings distributed over 3 types in 8 blocks constructed in 1958. The area has a specific identity as the surrounding buildings share the typical Dutch brick facade, a remarkable architectural quality.

Impact*

An overall area of 9 128 m^2 was refurbished in Delft. The monitored energy consumption accounted for 191 kWh/m^2/yr before the renovation and 139 kWh/m^2/yr on the first year of monitoring after the retrofitting. The space heating represents the highest share of the load, with 137 kWh/m^2/yr before the works and 75 kWh/m^2/yr after. The domestic hot water increased its value from 21.5 to 33 kWh/m^2/yr although a reduction had been expected. From the data provided by the project, it can be observed that the simulations did not have enough data to properly model the demand, and therefore the design results before the retrofitting are on the whole higher than that monitored. This is the main reason behind the growth of domestic hot water consumption after the works.

The total primary energy for the design and monitoring have been calculated using the data provided by BEEM-UP, resulting in 2418 MWh/yr. The BEEM-UP project did not set any goals regarding the reduction of CO_2 emissions.

Technologies

The tenants in Delft had the possibility of choosing a specific energy reduction refurbishment package according to their preferences. Measures included: solar panel, floor insulation and home energy management with a feedback system. The refurbishment has resulted in a substantial energy demand reduction for space heating.

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Thermal envelope was improved

High-performance windows (HR++ with layer of metal foil) were installed providing 1.6 times better insulation than double-glazing

Building services (HVAC and lighting)

Optimised lighting: LED lighting was installed in the common areas

Mechanical ventilation system with heat recovery: improved mechanical ventilation system with heat recovery was connected to the living room.

ENERGY SYSTEMS INTEGRATION

Thermal collectors

Solar boiler was installed in 50 of the dwellings for warm water and heating

FACTS & FIGURES

Geographical area	**van der Lelijstraat, Delft, the Netherlands**
Demonstration area	**9128 m^2**
Population in the area	**100 046 inhabitants**
Total investment	**€ 3 540 000**
Final energy savings	**2194 MWh/yr**
Primary energy savings	**2418 MWh/yr**
CO_2 emissions reduction	**658 tCO_2/yr**

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**9128 m^2**
Investment	**€ 388/m^2**
Payback period	**>30 years**
Final energy demand (baseline)	**191 kWh/m^2/yr**
Final energy demand (after)	**139 kWh/m^2/yr**
CO_2 emissions reduction	**658 tCO_2/yr**
Energy supply	**Thermal collectors**

* Please note that there is no design data for the electrical consumption of the demo site besides the lighting.

ICT

Building energy management system

ICT energy management system was installed in 34 of the dwellings, including smart meters. The feedback system gives occupants a real-time insight into their electricity and gas consumption, as well as weekly and monthly statistics. It provides the user with a tool to control the heating in the house via an application on their smart phone.

The investment cost for the intervention has been € 388/m² making a total of € 3.54 million. According to the data provided, the annual cost savings for energy are € 77 259 on a total cost of € 103 012. Therefore, the annual costs after renovation are equal to € 25 753.

The resulting payback period is more than 30 years. The financial analysis shows that a profitability of the project is not given due to the high investments in comparison to the low energy cost savings. This however does not reflect the non-monetary benefits that might occur through the implementation.

Overall, the BEEM-UP project achieved substantial improvements. The energy consumption in the Delft project is 15 % lower for gas (heating, hot water and cooking) than the average Dutch household and even 30 % lower than the average electricity consumption. Also comfort conditions have been apparently reached thanks to the refurbishment according to the tenants' positive comments, which were collected during interviews with them.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC, SOCIAL The project encountered a problem with multiple families living in the same building. Only 40 % of the tenants were interested in the solar boiler technology that the project sought to implement. The reason for this was that numerous tenants had already fitted their own individual private heating installations.	**In order to overcome the low interest in the product among tenants and to avoid the implementation of two different energy sources for different tenants in the same building, the existing private installations were bought by the project and improved. Following this, these tenants rented the system for the same price that was offered to the others. This method guaranteed that all tenants were treated in the same way and were able to still own their own system.**
REGULATORY & ADMINISTRATIVE Dutch tenant protection regulation demands that 70 % of the tenants must agree to a physical improvement of the houses in case the landlord wants to increase the rent, thus reclaiming the costs of the improvement. This can result in the tenants disagreeing with the necessary refurbishments and blocking the project.	**This was avoided as the envelope refurbishments and other improvements were implemented without adding extra costs to the rent.**

CHALLENGES

SOCIAL

The results from the Dutch demo site were quite different from the predictions. The expected demand regarding space heating was met, but since the simulations expected a higher energy demand prior to the refurbishment, the expectation on savings was not achieved. The discrepancies could be explained by the fact that the calculations were made with the assumption that the heating and ventilation systems were functioning perfectly, as well as the way tenants used them. Also, the energy saving percentage did not include the rebound effects. For example, before the refurbishment, the tenants would only heat one room, thus keeping the consumption quite low. After the works were performed, more spaces were heated and therefore the savings were not that high. This is especially true because the calculations were made based on the whole building being heated, and not just one room, and therefore the simulations anticipated greater energy consumption.

SOCIAL

The improvement of the insulation value of the envelope is quite modest and does not change the heating habits. For the envelope to have an effect, a much higher thermal resistance and sealing is needed with side effects, such as the need for balanced flow ventilation. In the Delft project, the renovation led to an up-to date performance of the envelope, but the improvement to the heating zone, i.e. the living room and kitchen, is minimal. The main conclusion is that dwellings with sober installations before the renovation will not save much energy with modern installations that provide much more comfort. The involvement of the tenants has had a positive impact on the quality of the community and the acceptance of upheaval during the renovation.

BEST PRACTICES

SOCIAL

The project developers pursued a strong communication campaign aiming to engage the tenants. They had numerous open-house sessions to inform the tenants on planned and ongoing renovations and created a tenants' feedback group to exchange opinions on the necessary renovations. The tenants were asked to fill in several questionnaires on their energy behaviour and consumption, which led the organisation of informational sessions to promote more sustainable energy consumption patterns.

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BEEM-UP

BEEM-UP

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Drammen, Norway | SCHOOL OF THE FUTURE

The Norwegian demo site of the SCHOOL OF THE FUTURE is known as Brandengen Primary School. It is situated in a housing area in the outskirts of Drammen, 40 km south-west from the capital city of Norway. The school's facilities consist of three brick buildings linked together with arcades – the main building, the activity building for gym, arts and crafts, and a small building for leisure time. The buildings, designed by the famous Norwegian architect Arnstein Arneberg, are of historical value. Drammen municipality emphasised that the restoration of the facades had to be close to the original historic look, in accordance with the request from the conservation authorities.

Impact

The comparison of the final energy demand before and after the interventions shows that the final energy demand was reduced by 72 % due to the retrofitting and the installation of the ground-source heat pump system. While the electricity consumption for lighting and ventilation increased by 5 kWh/m²/yr, the electricity consumption for the heat pump is lower than expected. The only energy carrier that is delivered to the building is electricity from the grid. Due to the high share of renewable energies in Norway in the electricity production, both the CO_2 emission and primary energy can be reduced drastically. Compared to grid electricity (51 gCO_2/kWh) the CO_2 emission factor for oil heating (330 gCO_2/kWh) is six times higher. This leads to a drastic reduction in the CO_2 emissions of up to 94 % with 68 tonnes of CO_2 less every year. The primary energy savings are also substantial. Overall the primary energy demand and consumption has been reduced by 75 %, saving 174 MWh/yr.

FACTS & FIGURES

Geographical area	**Brandengen primary school, Drammen, Norway**
Demonstration area	**7072 m²**
Population in the area	**65 000 inhabitants**
Total investment	**1 093 000**
Funding from EU	**ca. 70 %**
Final energy savings	**162 MWh/yr**
Primary energy savings	**174 MWh/yr**
CO_2 emissions reduction	**68 tCO_2/yr**

Technologies

In order to reduce the energy consumption and to increase the indoor comfort, a two-step strategy was carried out. Firstly, energy-efficiency measures were applied to reduce heating and cooling demand. Secondly, the remaining demand was covered with an effective energy supply system, utilising new renewable energy resources to a large extent based on a geothermal heat pump.

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Additional insulation in the attic, mansard walls and basement walls

Replacement of windows as an energy upgrading measure applied to the facades

ENERGY SYSTEMS INTEGRATION

Near-to-surface geothermal energy

19 energy wells for collectors were drilled in the schoolyard, each about 250 m deep

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**7072 m²**
Investment	**€ 154/m²**
Payback period	**25 years**
Final energy demand (baseline)	**200 kWh/m²/yr**
Final energy demand (after)	**55 kWh/m²/yr**
CO_2 emissions reduction	**68 tCO_2/yr**
Energy supply	**Geothermal energy wells (19 in total, 25 m deep)**

ICT

Smart grid

The overall investments for the demonstration site was € 1 093 000 (excl. VAT), which corresponds to a specific investment of € 154/m². Based on the SCIS calculations and the information available, the resulting total savings are € 42 870 per year for the monitoring data. While the cost for delivered energy for heat has been reduced by € 94 575, the cost of electricity increased by around € 50 000 per year. Based on this, the resulting payback period is 25 years.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC The investment costs for passive house windows were seen as too high.	**The contractor and the window manufacturer were involved in the development of the demonstration building, making Brandengen School a showcase of the windows' performance.**

CHALLENGES

REGULATORY & ADMINISTRATIVE

The technical solutions were limited due to the historical value of the building. Drammen municipality emphasised the need to restore the facades close to the original historic look, in accordance with a request from the conservation authorities.

School of the Future

SCHOOL OF THE FUTURE

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Eibar, Spain | ZENN

The Mogel neighbourhood in Eibar has been going through an integral renovation project since 2006. A lift installation and an energy-efficiency improvement to the residential buildings have been developed using diverse financing sources, including EU funding through the ZENN project.

Impact

Retrofitting works have been performed in several stages in all of the buildings in the community, which has completely transformed the neighbourhood. The residents are pleased, feel more comfortable at home and their quality of life has increased.

Lessons learned

BEST PRACTICES

FINANCIAL & ECONOMIC

The continuity of the ZENN project together with the Renove Programme of the Basque Government provided the residential community with important financial aid that can provide the economic viability of the comprehensive retrofitting works.

SOCIAL

An important success factor is that the residents have been kept well informed about the technical and economic aspects of the project throughout the whole process. The information was distributed at general assemblies with the neighbours, meetings with the presidents of the communities, meetings in the residential blocks and an information tent in the neighbourhood, as well as via mailing and press relations.

Technologies*

ENERGY EFFICIENCY IN BUILDINGS

- Retrofitting the building envelope
- Building services (HVAC and lighting)

ZENN

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Genoa, Italy | R2CITIES

The R2CITIES implementation site in Genoa is the social housing district of Lavatrici, developed between 1980 and 1990. Located in the west part of the city, the site consists of more than 500 dwellings. It is divided into four main blocks, each of which is composed of three different buildings – a high block, a lower block, and a centre block of apartments. The complex has one common area, ample parking and is served by a public bus line.

The demonstration focuses on passive and low-cost solutions, drawing on available natural resources such as solar power, natural ventilation and natural daylight. The activities performed within the R2CITIES project aim to turn the district into a quasi-zero-energy district according to national regulations.

Impact

The overall gross floor area of 18 000 m² has been refurbished at the R2CITIES demo site in Genoa. The annual final energy saving is 571 MWh. The total CO_2 emission savings amount to 562 tonnes per year. The investment cost for all the interventions totals € 767 542.

FACTS & FIGURES

Geographical area	**Genoa, Italy**
Demonstration area	**18 000 m²**
Population in the area	**1000 inhabitants**
Total investment	**€ 767 542**
Final energy savings	**5715 MWh/yr**
CO_2 emissions reduction	**562 tCO_2/yr**

Technologies*

The implemented measures in Genoa with R2CITIES include:

ENERGY EFFICIENCY IN BUILDINGS

- **Retrofitting the building envelope**
- **Building services (HVAC and lighting)**

R2CITIES

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The E2REBUILD demonstration in Halmstad, Sweden is a multi-storey building from 1963 with the typical features of that period, such as a reinforced concrete load-bearing frame and facade elements. The building contains 91 apartments. The retrofit included a complete exchange of main pipes (water and sewage) as well as new kitchens and bathrooms, energy-efficient measures such as new, highly insulated windows, improved adjustments of control systems, new high performance extraction air, new outdoor air heat pumps and increased airtightness. Residents remained in their apartments during the retrofit construction work, which allowed the team to evaluate their communication with tenants.

Impact

The demonstration site in Halmstad consists of an overall gross floor area of 6178 m² that has been refurbished in the project.

The energy consumption figures for the demonstration site were monitored before and after the works, resulting in respectively 200 and 110 kWh/m²/yr of primary energy consumption. The monitoring values show that the heating demand for space heating exceeded 130 kWh/m²/yr before the project and represented the largest energy consumption. After the refurbishment, this primary energy consumption was reduced to 96 kWh/m²/yr.

The CO_2 emissions and total primary energy have been calculated using the national electricity factors provided by the project and literature. The CO_2 emissions were reduced by 45 tonnes of CO_2 every year and the primary energy savings were 624 MWh.

FACTS & FIGURES	
Geographical area	**Halmstad, Sweden**
Demonstration area	**6178 m²**
Total investment	**€ 3 900 000**
Final energy savings	**599 MWh/yr**
Primary energy savings	**624 MWh/yr**
CO_2 emissions reduction	**45 tCO_2/yr**

Technologies

The refurbishment measures implemented in Halmstad included:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

- Highly insulated windows
- Increased airtightness

Building services (HVAC and lighting)

- Improved adjustments of control systems
- Occupant-controlled lighting in the garage
- Low-energy lighting in stairwells

Heat pumps

- Outdoor and extraction air heat pumps

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**6178 m²**
Investment	**€ 631/m²**
Payback period	**18 years**
Final energy demand (baseline)	**210 kWh/m²/yr**
Final energy demand (after)	**110 kWh/m²/yr**
CO_2 emissions reduction	**45 tCO_2/yr**
Energy supply	**Heat pumps, district heating**

The investment cost for the intervention was € 624/m². According to provided data, the yearly cost savings for energy result in € 32 348 for monitored values. The payback period according to the data provided and the SCIS calculations is 18 years.

Lessons learned

BARRIER	SOLUTION
SOCIAL Extensive renovation works affect the use of the building and its occupants.	**Residents remained in their apartments during the retrofit construction work, making it possible to investigate and evaluate tenant-installer communication during the period of extensive renovation work.**

E2REBUILD

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R2CITIES

The Yakacik neighbourhood in the Kartal district in Istanbul is one of the selected pilot sites for the R2CITIES project. The implementation area is located between the Sea of Marmara to the south and the TEM motorways to the north. Despite being far from the city centre it is one of the best-connected parts of Istanbul with motorways, ferries, suburban railways and metro. The presence of the International Sabiha Gökçen Airport, Formula 1 track and Sabancı University contribute to the economic structure of the area, together with small-scale commerce and manufacturing.

Renovation measures in combination with efficient strategies are taking place in three residential buildings with different building characteristics. Passive design, heating and cooling sources and an integration of renewables for the building envelope are being implemented. The retrofitting plan aims at improving the quality of life in the neighbourhood by developing a strong social, environmental and economic sustainable area based on public participation and respect of the natural and cultural heritage.

Impact

The overall gross floor area of 18 113 m² has been refurbished in the demonstration site in Istanbul. The annual final energy saving is 12 538 MWh and the total CO_2 emission savings amount to 992 tons per year. The total investment cost for all the interventions is € 4 245 750.

FACTS & FIGURES	
Geographical area	**Istanbul, Turkey**
Demonstration area	**18 113 m²**
Total investment	**€ 4 245 750**
Final energy savings	**3967 MWh/yr**
CO_2 emissions reduction	**992 tCO_2/yr**

Technologies*

The interventions in Istanbul within the R2CITIES project feature:

ENERGY EFFICIENCY IN BUILDINGS

- Retrofitting the building envelope
- Building services (HVAC and lighting)
- Building integrated renewable energy sources

ENERGY SYSTEMS INTEGRATION

- District heating and cooling

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**18 813 m²**
Investment	**€ 234/m²**
Final energy demand (baseline)	**344 kWh/m²/yr**
Final energy demand (after)	**125 kWh/m²/yr**
CO_2 emissions reduction	**20 tCO_2/yr**
Energy supply	**District heating**

R2CITIES

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Milan, the second-largest city in Italy and the capital of Lombardy has a population of about 1.35 million people. The area included as the Italian demonstrator of the EU-GUGLE project us called Zona 4 and is one of the nine administrative districts of Milan, located at the southeast border. With a surface of about 21 km^2 the district has a population of 152 300 inhabitants. The project covers public residential buildings used for social housing and one public school.

For all the renovations carried out in the buildings in Milan, the action plan has three steps - improvement of building envelope to reduce the energy needs for heating and cooling of the building and reach higher levels of indoor comfort, improvement of the efficiency of the mechanical systems and production of energy from renewable sources to satisfy the remaining energy use. This approach would allow to obtain the optimal results in terms of energy savings, environmental impact and economic costs during the service life of the building and also to create a large and stable market with important volumes of activity for all the construction actors and building aspects. The EU-GUGLE project and the collaboration with the end-use Efficiency Research Group of Politecnico di Milano has motivated the City of Milano to create a new Technical office for energy efficiency.

Impact*

The targeted primary energy savings in Zona 4 are up to 82%. The design and implementation of the activities are a perfect case for devising, testing and fine-tuning innovative solutions to be replicated at the scale of the entire city.

FACTS & FIGURES	
Geographical area	**Milan, Italy**
Demonstration area	**18 000 m^2**

Technologies*

The refurbishment measures implemented in Milan included:

ENERGY EFFICIENCY IN BUILDINGS

Building envelope retrofitting

A great attention has been paid both by researchers and the technical staff in order to enhance the energy performance of the envelope of the buildings, for example checking insulation strategies, identifying and correcting thermal bridges, reviewing building systems control strategies and monitoring.

The already carried out works show a reduction of the primary energy demand for heating and domestic hot water of the building, from more than 250 kWh/m^2/yr to about 35 kWh/m^2/yr

A child care center building will be retrofitted to passive house standard with prefabricated envelope elements, which will include thermal insulation, new high performance windows, automated external solar protections, automated night ventilation via windows and the two re-designed atria, room by room mechanical ventilation with winter heat recovery. The above technologies will allow to achieve summer comfort without mechanical compression cooling, good IAQ and winter comfort with energy needs lower than 15 kWh/m^{2}y. Presently the building shows very poor comfort and IAQ levels.

Building services (HVAC & Lighting)

Savings obtained by the envelope retrofit are complemented by savings due to heat recovery on exhaust air and photovoltaic system

Building integrated renewable energy sources

ENERGY SYSTEMS INTEGRATION

Photovoltaics

District heating and cooling.

* Detailed information regarding the technical and financial performance will be available at a later stage.

ICT

Building energy management system

Sensors for measurement - illuminance, CO_2, temperature and humidity

Actuators for operation - lights dimmer and on/off switches, mechanical ventilations and winter heat recovery systems, upper windows openings for summer night ventilation, external solar protections and thermostat valve for heating system

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Munich, Germany | E2REBUILD

The E2REBUILD demonstration in Munich, Germany consisted of two blocks of residential multi-storey buildings in the suburb of Sendling, built in 1954. The buildings, owned by the public housing company GWG München, represented uniform standard blocks built in the post-war decade of the 1950s to fulfil urgent housing needs, with three storeys and accessed by inner staircases. The resources were quite poor concerning material, construction and design, resulting in a lack of variability, technical facilities, daylight and comfort inside the buildings. Heating was provided before the refurbishment individually.

The Munich demonstration project was completed in a year and fully occupied in the summer of 2012. The building has been fully retrofitted, including the replacement of the attic by an additional floor to create more rental space. Residents were moved out during the renovation process.

Impact

The Munich demonstration site consists of an overall gross floor area of 2012 m² before the refurbishment and 3323 m² afterwards.

The energy consumption figures for the demonstration site were monitored before and after the works resulting in 292 and 75 kWh/m²/yr, respectively. The monitoring values show that the heating demand for space heating exceeded 280 kWh/m²/yr before the project and represented the largest energy consumption. After the refurbishment, this consumption was reduced to 50 kWh/m²/yr. In this case, no data for electricity consumption was provided.

The CO_2 emissions and total primary energy have been calculated using the national electricity factors provided by the project and literature. The CO_2 emissions were reduced by 265 tonnes every year. The primary energy savings were 780 MWh.

FACTS & FIGURES

Geographical area	**Munich, Germany**
Demonstration area	**3323 m²**
Total investment	**€ 7 760 000**
Final energy savings	**724 MWh/yr**
Primary energy savings	**780 MWh/yr**
CO_2 emissions reduction	**265 tCO_2/yr**

Technologies

The refurbishment measures implemented in Munich featured:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Additional layer of prefabricated insulated timber elements (U-value 0.14 W/m²K) with modern, highly insulated windows

Thermal bridges were eliminated by cutting off the cantilevering concrete balconies and replacing them with free-standing balconies

Facades were renovated

Building services (HVAC and lighting)

Optimised lighting

Mechanical ventilation system with heat recovery

ENERGY SYSTEMS INTEGRATION

Cogeneration (CHP)

Thermal collectors

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**3323 m²**
Investment	**€ 2337/m²**
Payback period	**>30 years**
Final energy demand (baseline)	**292 kWh/m²/yr**
Final energy demand (after)	**75 kWh/m²/yr**
CO_2 emissions reduction	**265 tCO_2/yr**
Energy supply	**Cogeneration (CHP), thermal collectors**

The investment cost for the intervention was € 2337/m², adding up to a total of € 7.76 million. According to provided data, the yearly cost savings for energy result in € 76 435 for monitored values. Therefore, the annual costs after renovation equal to € 24 697. The payback period according to the data provided and SCIS calculations is more than 30 years.

The financial analysis shows that the profitability of the project is not given due to the high investments in comparison to the low energy cost savings. This however does not reflect non-monetary benefits that might occur through the implementation.

Lessons learned

BARRIER	SOLUTION
SOCIAL The planning team and the building contractor discovered that the theoretical innovation potential of construction methods and processes is absolutely case-specific and can only succeed if done step by step, according to the competence, will and potential of the contractors.	**Together, the owners, tenants and planning partners have to improve in:** • arranging and developing innovative methods and details with partner companies and craftsmen; • measurement sequences in complex conversion processes; • finding ways to establish new regulations in order to get the right partners, not only with regards to competence but also professionalism. • A fundamental change in human awareness and the quality of communication plays a vital role in accomplishing the desired standards in the future. Truly sustainable architecture in the renewal of existing building stock cannot be achieved by using standard methods, standard processes or a standard amount of time and money.

E2ReBuild

E2REBUILD

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Oslo, Norway | **ZENN**

Oslo participated in the ZENN project with the renovation works in the Økern nursing home, which was built in 1975 and contains 140 dwellings for senior citizens. The demonstration site is one of four buildings connected to each other, the rest of which were renovated in the period 2000-2010. The retrofitting plan has been completed and the tenants moved in in October 2014. The project used well-known and tested techniques and products with regards to technological solutions, while implementing innovative processes and novel collaboration with research institutes during the design and execution of the work.

Impact*

Major activities carried out included additional insulation, minimising the thermal bridges and the construction of a building with a lower air infiltration rate. These measures have reduced the energy demand for heating by 80 %, and now all energy for heating comes from district heating rather from direct electricity as before. The HVAC system has been altered and variable air-volume control was introduced in relevant spaces, resulting in a heat recovery of 85 % and a maximum specific fan power (SFP) of 1.5 kW/(m^3/s). This has reduced the energy demand for ventilation (except heating) by 70 %. A photovoltaic plant on the roof was installed, the largest in Oslo. It is expected to produce 105 MWh annually and will cover 10 % of the buildings' energy demand.

In addition to this, the lighting system was changed to a system with low-energy consumption and motion sensors, reducing the energy demand for lighting by 38 %. The total energy demand for Økern Sykehjem has thus been reduced by 66 % – from 357 kWh/m^2/yr to 120 kWh/m^2/yr.

FACTS & FIGURES

Geographical area	**Oslo, Norway**
Population in the area	**140 inhabitants**
Final energy savings	**237 kWh/m^2/yr**

Technologies*

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

- Additional insulation
- Minimising thermal bridges
- Lower air infiltration rate

Building services (HVAC and lighting)

- Altered HVAC system with variable air-volume control
- Lighting system with low energy consumption and motion sensors

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Photovoltaics

- Installation of large photovoltaic plant on the roof

ICT

Building energy management system

* Detailed information regarding the technical and financial performance will be available at a later stage.

ZENN

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Oulu, Finland | E2REBUILD

The pilot building in Oulu, Finland is one of five student apartment buildings with communal facilities in a housing cooperation. The building was completed in 1985 according to a Finnish industrialised building system developed in the 1970s, using prefabricated concrete units for residential buildings, called the BES system. The building was in need of a complete refurbishment and reconfiguration to new-built standards. The building renovation, which finished in February 2013, included a comprehensive refurbishment of indoor spaces and a facade renovation with the TES method, utilising timber-based prefabricated elements for the renewal of the building envelope.

Impact

The demonstration site in Oulu consists of an overall gross floor area of 680 m² that has been refurbished in the project. The energy consumption was monitored before and after the works, resulting in 166 and 87 kWh/m²/yr, respectively. The results show that the heating demand for space heating reached 100 kWh/m²/yr before the intervention, which accounts for the largest energy consumption. The interventions for the retrofit reduced the total thermal energy demand below 55 kWh/m²/yr, which is a more than 45 % reduction.

The CO_2 emissions and total primary energy for the design and monitoring have been calculated using the national electricity factors provided by the project. The final reduction of CO_2 emissions is 23 %, with 43 less tonnes of CO_2 emitted every year. Overall, the aim was to reduce the primary energy savings to 40 %. The monitored results show that the expected primary energy savings have been achieved with 32 MWh less primary energy consumed every year.

FACTS & FIGURES

Geographical area	**Oulu, Finland**
Demonstration area	**680 m²**
Total investment	**€ 1 650 000**
Final energy savings	**53 MWh/yr**
Primary energy savings	**32 MWh/yr**
CO_2 emissions reduction	**43 tCO_2/yr**

Technologies

The interventions in Oulu included:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Total refurbishment of indoor spaces and a facade renovation with the TES method utilising timber-based, prefabricated elements for the renewal of the building envelope

New windows, doors and highly insulated roof and ground floor slab

Low-flow showers, energy efficient kitchen appliances

Building services (HVAC and lighting)

Optimised lighting with LED lighting in stairwells and apartments

Mechanical ventilation system with rotating heat recovery

ENERGY SYSTEMS INTEGRATION

District heating and cooling

District heating is included in the project.

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**608 m²**
Investment	**€ 2431/m²**
Payback period	**>30 yr**
Final energy demand (baseline)	**166 kWh/m²/yr**
Final energy demand (after)	**87 kWh/m²/yr**
CO_2 emissions reduction	**43 tCO_2/yr**
Energy supply	**District heating**

The investment cost for the intervention was € 2431/m^2, making a total of € 1.65 million. According to the provided data, the annual cost savings for energy result in € 8631, from a total cost of € 24 304. The resulting payback period exceeds 30 years.

The financial analysis shows that the profitability of the project is not given due to the high investments in comparison to the low energy cost savings. This however does not reflect non-monetary benefits that might occur through implementation. The result was an energy efficient building to the standard of a new building with a renewed 50 year life expectancy, achieved with lower embodied energy due to the recycling of existing structures.

Lessons learned

BARRIER	SOLUTION
SOCIAL The owners did not anticipate the amount of disturbance that was created by the phasing of ongoing renovations around the building's exterior, and received complaints from tenants due to unexpected remedial work after the refurbishment.	**The post-occupancy tenant questionnaires provided valuable insight into understanding the disturbance during the refurbishment process. Residents gave feedback on noise and dust from the renovations of adjacent buildings. The need for improved communication with tenants throughout and after the refurbishment process was demonstrated.**

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E2REBUILD

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The French demonstration site of the BEEM-UP project is located in the centre of Paris. The demonstration building is surrounded by buildings of similar height and is composed of 87 dwellings built around 1950. In 1993, the building was renovated (outer insulation, double-glazed windows, boilers), but it needed a major upgrade to become a pilot and an example for bringing the rest of the housing park to the low energy standard for renovated buildings, with a consumption target of less than 104 kWh/m²/yr for HVAC, hot water and lighting.

Impact

The demonstration site in Paris consists of an overall gross floor area of 5759 m² (heated area: 4352 m²) that has been refurbished in the project. The monitored energy values before the intervention were 351 kWh/m²/yr and 149 kWh/m²/yr after the project. The results show that the heating demand for space heating exceeded 234 kWh/m² per year and represented the largest energy consumption. The interventions for the retrofit reduced the space heating demand to below 73 kWh/m²/yr, and the electricity needs were cut by more than half, from 100 kWh/m²/yr to 47 kWh/m²/yr.

The CO_2 emissions and total primary energy for the design and monitoring were calculated using the LCA Ecoinvent database, although the BEEM-UP project did not set any goals regarding the reduction of CO_2 emissions. The reduction of CO_2 amounts to 161 tonnes per year. Regarding the overall primary energy saving, the objective of BEEM-UP was saving 75 % on heating consumption and 45 % on domestic hot water. The monitored results show that the primary energy savings add up to 2044 MWh/yr.

Important differences were found between the expected savings and the real performance of the systems. The following explanation can account for these differences:

- no savings were achieved for the domestic hot water consumptions due to the large amount of energy lost in the domestic hot water distribution circuit;
- the air exchange rates before refurbishment were not measured (they could have been higher or lower than assumed) and this parameter can have a large influence on the calculated results, particularly in terms of heating consumptions;
- the ICT savings were based only on assumptions;
- the room temperatures before refurbishment could have been lower than calculated, because in some cases not all the rooms were heated;
- the efficiency of the old building services could not be calculated precisely; only assumptions could be made (no information was available about the efficiency of the old components: boiler, distribution losses, uncertainty about the air-change rates);
- the consumption of warm water may differ considerably from the calculations (before and after) because the consumption is very much dependent on tenants' behaviour. More knowledge on behavioural issues could have enabled a better estimation.

Future projects need to take these issues into account in order to help improve the estimate impact and improve the output.

FACTS & FIGURES

Geographical area	**Contentin Falguière, Paris, France**
Demonstration area	**5759 m²**
Total investment	**€ 4 251 000**
Final energy savings	**1157 MWh/yr**
Primary energy savings	**2044 MWh/yr**
CO_2 emissions reduction	**161 tCO_2/yr**

Technologies

The implemented measures feature:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Thermal envelope was improved, including increased insulation on walls, basement ceiling and roof

New photovoltaicC double-glazed windows

Building services (HVAC and lighting)

Optimised lighting: all public spaces were fitted with low-energy light systems and the tenants were encouraged to switch to low-energy lighting

New controlled mechanical ventilation system was installed

Building integrated renewable energy sources

Photovoltaics

ENERGY SYSTEMS INTEGRATION

Thermal collectors

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**5759 m²**
Investment	**€ 738/m²**
Payback period	**>30 years**
Final energy demand (baseline)	**351 kWh/m²/yr**
Final energy demand (after)	**149 kWh/m²/yr**
CO_2 emissions reduction	**161 tCO_2/yr**
Energy supply	**District heating and cooling, thermal collectors, photovoltaics**

ICT

Building management system

ICT energy management system was installed including cost optimal control solutions, from individual solutions like chronostat, radiator zone control and meter data for individual billing to full home automation

The investment cost for the intervention was € 738/m², making a total of € 4 251 000 excluding VAT.

The financial return for the project is more than 30 years. This is relatively long, but as a demonstration for a non-mature innovation under testing it can in fact be considered as short and could improve using the lessons learned. The rental value after refurbishment would also positively affect the return on investment, which was not taken into account in the calculation.

Lessons learned

CHALLENGES

SOCIAL

The consumption of warm water may differ considerably from the calculations (both before and after), especially as the consumption is very much dependent on the tenants' behaviour.

BEST PRACTICES

SOCIAL

The developer decided to involve the tenants in the whole process of refurbishment, in order to make them accept the works more easily. The project indicated that when the tenants are involved, they are more aware of the environmental issues and consequently contribute to the successful implementation of the project.

Main measures used in the pre-retrofitting phase: employment of a person in charge of the tenants' engagement; interviews about the occupation of the dwellings, use of common spaces in the building and creating interest in the environment; letters to tenants informing them of the forthcoming renovations and questionnaire on the technical state of the building; two information meetings with the tenants; two workshops on specific topics: energy consumption commitment and renovation of outdoor spaces.

Main measures used during the renovation period: demonstration of a showcase apartment to the tenants; open communication channel with tenants through the housekeeper; information website, providing information about the schedule of works; one person at the construction company dedicated to interaction with tenants.

BEEM-UP

BEEM-UP

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The E2REBUILD demonstration in Roosendaal, the Netherlands, consists of 112 identical, single family terrace houses built in 1960 in the area of Kroeven. The whole area underwent a transformation, which included renovation of existing houses and new construction. The retrofit of 50 of the houses was part of the E2REBUILD project and was completed at the beginning of 2011.

The renovation in the Roosendaal pilot buildings took place with the tenants remaining in their homes throughout the entire renovation work, which required consideration from both sides and continuous dialogue.

Impact*

The demonstration site in Roosendaal consists of an overall gross floor area of 460 m² that has been refurbished in the project.

As a result of the energy efficiency, the space heating was reduced from 109 kWh/m²/yr (business as usual) to 28 kWh/m²/yr, while electricity consumption was reduced from 37 kWh/m²/yr (business as usual) to 32 kWh/m²/yr. Together with the domestic hot water, the total consumption went from 173 kWh/m²/yr to 76 kWh/m²/yr, representing a decrease of more than half when compared to the reference building.

This makes a total 45 MWh/yr of final energy savings. According to the primary energy and CO_2 factors provided by the project, the primary energy savings go up to 48 MWh/yr while the CO_2 reduction amounts to 46 tonnes every year.

FACTS & FIGURES	
Geographical area	**Roosendaal, Kroeven, Netherlands**
Demonstration area	**460 m²**
Population in the area	**77 000 inhabitants**
Total investment	**€ 509 220**
Final energy savings	**45 MWh/yr**
Primary energy savings	**48 MWh/yr**
CO_2 emissions reduction	**46 tCO_2/yr**

Technologies

The refurbishment measures implemented in Roosendaal included:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelop

New 350 mm timber frame element with cellulose insulation for the walls

Triple-glazed passive house window frames

Prefabricated timber roof elements, filled with 350 mm insulation

External facade cladding made of natural slate

Building services (HVAC & Lighting)

Heat recovery ventilation

ENERGY SYSTEMS INTEGRATION

Thermal collectors

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**460 m²**
Investment	**€ 1107/m²**
Payback period	**>30 yr**
Final energy demand (baseline)	**173 kWh/m²/yr**
Final energy demand (after)	**76 kWh/m²/yr**
CO_2 emissions reduction	**46 tCO_2/yr**
Energy supply	**Thermal collectors**

The investment cost for the intervention was € 1 107/m², making a total of € 509 220. According to the provided data, the yearly cost savings for energy result in € 4 622 for monitored values. The payback period according to the data provided and SCIS calculations exceeds 30 years.

* The KPIs for the new building are compared with the baseline of a reference building.

The financial analysis shows that the profitability of the project is not given due to the high investments in comparison to the low energy cost savings. This however does not reflect non-monetary benefits that might occur during implementation. The life time of the buildings is extended with 50 years, without the need for investing in new buildings and replacing tenants.

Lessons learned

BARRIER	SOLUTION
SOCIAL Extensive renovation works affected the use of the building and its occupants.	**The renovation in the Roosendaal pilot buildings took place with the tenants remaining in their homes throughout the work. This required both a fast and non-intrusive renovation process and a continuous dialogue between the housing company and the tenants.**

E2REBUILD

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Sestao, Spain | EU-GUGLE

Located 11 km from Bilbao, Sestao is a municipality with a strong post-industrial character. It has an area of 3.5 km^2 where only 0.9 km^2 are devoted to residential use and the rest is used for industrial purposes.

The demonstration district included in the EU-GUGLE project is located in the lower area of Sestao and is the most affected by the de-industrialisation process, with high unemployment rates. There is a mixture of local and immigrant populations with limited economic resources and a low academic level. The building stock consists of residential buildings, most of which have private owners, but there are a few public buildings. Most of them were built between 80 and 100 years ago in wood resulting in poorly ventilated interior rooms and no natural light distribution. The renovation area covers 24 509 m^2 and is made up of 258 dwellings with 1 300 inhabitants.

Impact*

Since most of the buildings in the demonstration are privately owned, energy-efficient refurbishment measures will not have a significant impact on rent prices. However, these energy-efficient measures will raise the value of the homes in terms of their market price and impact on the residents' energy bills.

Furthermore, to carry out the rehabilitation work it was necessary for the public administration to assume ownership of some of the homes then, once they were renovated, these homes would be sold or leased to private parties with protection criteria of public housing. This does not just mean a change in ownership of dwellings but also a renewal and rejuvenation of the population living in the district. The allocation of housing to protection criteria of publicly-owned buildings not only guarantees the arrival of new families, but also the possibility of elderly people and people with mobility problems getting secure housing in the area.

FACTS & FIGURES

Geographical area	**Sestao, Spain**
Demonstration area	**24 509 m^2**
Population in the area	**1300 inhabitants**

Technologies*

The measures implemented in Sestao are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Rehabilitation resulting in reduction of waste, costs and CO_2 emissions, with the use of sustainable materials such as wood, plasterboard, prefabricated panels, etc.

Building services (HVAC and lighting)

Planned rooms with natural light and airy spaces, achieving an improvement to the houses' ventilation conditions

ENERGY SYSTEMS INTEGRATION

Biomass boilers

Biomass centralised boilers for the production of hot water and heating (20 %)

Thermal collectors

Renewable thermal energy through solar panels for hot water and space heating (80 %)

Waste heat recovery

Lifts with excess energy recovery system

ICT

Building energy management system

Programmable thermostats for heating systems

* Detailed information regarding the technical and financial performance will be available at a later stage.

EU-GUGLE

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Stuttgart, Germany | SCHOOL OF THE FUTURE

The aim of the SCHOOL OF THE FUTURE project was to design, demonstrate, evaluate and communicate shining examples of how to achieve the high-performance building of the future with a focus on school buildings. One of the project's demonstration sites was the Solitude-Gymnasium, which is located in the north-west of Stuttgart, the capital of the federal state Baden-Württemberg (south-western Germany).

The secondary school consists of five buildings with a mix of central and side corridors. Overall, a gross floor area of 9918 m² (heated area: 8924 m²) has been refurbished in the project. The school has around 710 students and 60 employees. The existing buildings have been constructed during different phases between the 1960s and the early 1990s.

Before the renovation, the school consisted of several solid constructions with high-energy consumption – the main building, the science building, the big pavilion and the gym. Some interventions to address this had already taken place prior to this project: the boilers and the south-facing windows of the big pavilion were replaced, and the roofs of the main building and the gym were refurbished.

Impact

The total energy demand for the Solitude-Gymnasium in Stuttgart amounted to 175 kWh/m²/yr for monitoring consumption before the refurbishment. The monitored values following the end of the project were 125 kWh/m²/yr, which was higher than expected. The main reason behind this is the use of the gymnasium as a shelter for refugees, which led to an increase in the energy consumption that could not have been foreseen by the project. Excluding the gym, the monitored energy consumption after the refurbishment is 77 kWh/m²/yr.

The reduction in energy consumption following the refurbishment and use of energy sources with lower primary energy factors led to an annual reduction of 605 MWh in the final use of energy and 935 MWh in the use of primary energy. This represents more than 50 % of the use of primary energy before the refurbishment. Accordingly, CO_2 emissions are down by 55 tonnes, which is a reduction of 60 % from before the refurbishment.

FACTS & FIGURES

Geographical area	**Solitude Gymnasium, Stuttgart, Germany**
Demonstration area	**9918 m²**
Population in the area	**625 000 inhabitants**
Total investment	**€ 13 290 120**
Funding from EU	**ca. 70 %**
Final energy savings	**605 MWh/yr**
Primary energy savings	**935 MWh/yr**
CO_2 emissions reduction	**55 tCO_2/yr**

Technologies

The refurbishment measures implemented included:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Intensive retrofitting plan for the building envelope: walls, roofs, and windows (triple-glazed)

Building integrated renewable energy sources

Photovoltaics

Building services (HVAC and lighting)

Mechanical ventilation system with heat recovery

ENERGY SYSTEMS INTEGRATION

Cogeneration (CHP)

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**9918 m²**
Investment	**€ 1340/m²**
Payback period	**>30 years**
Final energy demand (baseline)	**175 kWh/m²/yr**
Final energy demand (after)	**77 kWh/m²/yr**
CO_2 emissions reduction	**55 tCO_2/yr**
Energy supply	**Photovoltaics, Cogeneration (CHP)**

ICT

Building energy management system

Installation of sensors to monitor daylight, temperature, humidity and CO_2 as well as meters to measure the operating hours of electrical lighting

The investment cost for the interventions was € 1 340/m², which makes a total of over € 13 million. Due to this high investment cost, the payback period according to the design data exceeds 30 years.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC Several solar renewable energy installations were planned for the gymnasium. Due to shading, space limitation or structural restraints, only one photovoltaic installation was realised.	**The photovoltaic system consisting of 30 modules and a total power of 7.65 kWp was installed on the main building. The modules are oriented east-west with a tilt-angle of 10 degrees.**

CHALLENGES

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE

On the south facade of the gym a photovoltaic plant had been planned with a total power of 24 kWp with 164 m². The project was tendered in 2014 but the outcomes of the tender were way off budget and the profitability was not given. In the end the photovoltaic system could not be realised.

FINANCIAL & ECONOMIC

Space limitations or structural restraints can prevent the implementation of efficiency measures in the refurbishment of buildings. In this case it was the installation of the initially planned additional photovoltaic panels and the heat recovery in the gym.

FINANCIAL & ECONOMIC

The heating system could not be changed completely because of the existing gas boilers dating from 2004, but the additional installation of a CHP unit seemed possible and economically feasible. Although there are examples of refurbishments available, every retrofit brings new challenges and many results from previous projects cannot be used.

CHALLENGES

FINANCIAL & ECONOMIC

Initially solar thermal installations were planned on the roof of the gym. During the planning phase for the heating system, the economic analysis showed that the solar thermal collectors would decrease the full load hours of the micro CHP installation. Due to the counter-productive effects on the efficient work of the micro CHP, the solar thermal plants were not installed at the site.

SOCIAL

The gym has been used as refugee accommodation so the usage profile of the predicted energy savings for the gym could not be achieved.

SCHOOL OF THE FUTURE

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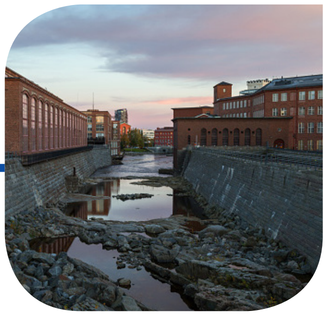
Tampere, Finland |

EU-GUGLE



Tampere is located on the banks of the Tammerkoski rapids, between two lakes, Näsijärvi and Pyhäjärvi. It is the third biggest city in Finland, and the biggest inland city in the Nordic countries with 215 168 inhabitants.

The EU-GUGLE demonstration takes place in Tammela, a sparsely built traditional residential area beside the city centre and the railway. The district characteristics feature a traditional square plan with building stock, a vivid market square and parks. The building stock consists of apartment buildings mostly built between 1960s and 1980s. Buildings and sites are owned by private households via Limited Liability Housing Company system. 440 dwellings are to be renovated with an area of 32 300 m^2 and 660 inhabitants.

Impact*

The energy efficiency measures implemented in Tampere led to to 1930 MWh/yr of final energy savings. The total primary energy savings go up to 920 MWh/yr, while the CO_2 reduction is 382 tonnes every year. The reason behind the low primary energy savings is the primary energy factor of the district heating network used in Tampere: 0.7 kWhPE/kWhFE.

These positive environmental values are likely to increase when more information is reported by the project.

FACTS & FIGURES	
Geographical area	**Tampere, Finland**
Demonstration area	**32 300 m^2**
Population in the area	**660 inhabitants**
Funding from EU	**€ 1 137 000**
Final energy savings	**1930 MWh/yr**
Primary energy savings	**920 MWh/yr**
CO_2 emissions reduction	**382 tCO_2/yr**

Technologies*

The measures implemented in Tampere are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Rehabilitation focuses on adding insulation to the walls, renewal of the windows and balcony doors, glazing of the balconies

Heat pumps

Exhaust air heat pump

Building services (HVAC and lighting)

Energy-efficient lighting

Lower water pressure and water saving faucets

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Thermal collectors

Solar panels

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**32 300 m^2**
Final energy demand (baseline)	**159 kWh/m^2/yr**
Final energy demand (after)	**99 kWh/m^2/yr**
CO_2 emissions reduction	**382 tCO_2/yr**

ICT

Building energy management system

Advanced building automation

Remote monitoring of the properties

* Detailed information regarding the technical and financial performance will be available at a later stage.

EU-GUGLE

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Valladolid, Spain | R2CITIES

A complete retrofit based on facade improvements, ICT and renewable energy systems is being implemented in the Cuatro de Marzo district, the demo site chosen for the R2CITIES project in Valladolid.

The district of Cuatro de Marzo is located in the southern part of the city's urban area. Built between 1955 and 1960 as a suburb, the residential area is now right in the commercial centre of the city. It consists of 1941 dwellings, distributed across a total of 190 buildings, considered to be of medium-to-poor constructive quality and progressively ageing. In addition, there are four schools, one church and 25 business premises. The district is characterised by a high population density (200 inhabitants/ha) and high construction density.

The city of Valladolid has been actively supporting and promoting urban restoration projects in the district. When it comes to R2CITIES, the municipally-owned company VIVA plays the role of coordinator and supervisor of the refurbishment works, encourages apartment owners to join the retrofitting urban plan, and negotiates with commonhold associations to secure approval for the renovation works.

Before the intervention of the project, Cuatro de Marzo dealt with common problems such as heating loss, residents' discomfort and very high energy consumption. As a result, energy-efficient measures within R2CITIES aimed at reducing thermal consumption through insulation, shade improvements and ICT implementation, and electrical consumption through the installation of occupancy sensors in common areas, more efficient lighting equipment and the provision of detailed billing. Another objective was to reduce CO_2 emissions by means of renewable energy systems such as photovoltaics and thermal collectors.

Impact

Overall, the gross floor area of 21 000 m² has been refurbished in the demo site in Valladolid. The annual final energy saving is 1816 MWh and the total CO_2 emission savings amount to 575 tonnes of CO_2 per year. The total investment cost for all interventions is € 2 068 274.

FACTS & FIGURES	
Geographical area	**Valladolid, Spain**
Demonstration area	**21 000 m²**
Population in the area	**4000 inhabitants**
Total funding	**€ 2 068 274**
Final energy savings	**1816 MWh/yr**
CO_2 emissions reduction	**894 tCO_2/yr**

Technologies*

The interventions in Valladolid included:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Building services (HVAC and lighting)

More efficient lighting equipment

ENERGY SYSTEMS INTEGRATION

Thermal collectors

Photovoltaics

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**21 000 m²**
Investment	**€1340/m²**
Payback period	**>30 years**
Final energy demand (baseline)	**175 kWh/m²/yr**
Final energy demand (after)	**56 kWh/m²/yr**
CO_2 emissions reduction	**635 tCO_2/yr**
Energy supply	**Biomass, photovoltaics**

ICT

Building energy management system

ICT as planning support

Demand response

Occupancy sensors in common areas

Monitoring platform for detailed billing

R2CITIES

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* Detailed information regarding the technical and financial performance will be available at a later stage.

Vienna, Austria | EU-GUGLE

The EU-GUGLE demonstration district in Vienna is named Penzing or the 14th district. The smart Viennese gate to western Austria and to the Natura 2000 area – the Biosphärenpark Wienerwald – covers about 3374 hectares with an open area covering 60 %, including parts of the forest surrounding Vienna. The district has about 84 362 inhabitants, predominantly between 40 and 50 years of age.

All the envisaged demonstration buildings – 1038 dwellings with 3592 inhabitants – had poor energy performance values and urgently needed the planned renovation. The buildings in the district are residential and social housing, used by tenants and apartment owners.

The private buildings serve as a viable space for tackling the different apartment ownerships that exist in Vienna. Special appointments with house representatives were organised to countercheck baseline data of the social housing company Wiener Wohnen and other partners, as well as to map building particularities during the preparation phase of the realisation.

Impact*

As a result of the energy efficiency, the final energy consumption for the six buildings reported so far by the project partners in Vienna was reduced from 170 kWh/m²/yr (business as usual) to 89 kWh/m²/yr. This amounts to 1996 MWh/yr of final energy savings. The total primary energy savings go up to 6499 MWh/yr while the CO_2 reduction is 1299 tonnes every year. These positive environmental values are likely to increase when more information is reported by the project.

FACTS & FIGURES

Geographical area	**Penzing, Vienna, Austria**
Demonstration area	**53 086 m²**
Population in the area	**1711 inhabitants**
Funding from EU	**€ 2 244 291**
Final energy savings	**1996 MWh/yr**
Primary energy savings	**6323 MWh/yr**
CO_2 emissions reduction	**1255 tCO_2/yr**

Technologies*

The implemented measures in Vienna are:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

The main focus is on the efficient refurbishment of 68 783 m² gross floor area, partly in one object with prefabricated facade elements. The expected energy efficiency savings for all refurbished buildings are about 55-65 %

Building integrated renewable energy sources

Intelligent integration of renewable energy in buildings (photovoltaics) and realisation of suitable accompanying measures to create a high-quality city district

ENERGY SYSTEMS INTEGRATION

District heating and cooling

Optimising the centralised heating plant

ICT

Building energy management system

Smart metering

ICT as planning support

During the project, data on the planning and implementation details are to be collected to provide information about building physics, refurbishments and HVAC of the realised demonstration objects. Monitoring data will also be collected, in order to compare the measured results with the calculated yields.

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**24 736 m²**
Investment	**€ 192/m²**
Final energy demand (baseline)	**89 kWh/m²/yr**
Final energy demand (after)	**170 kWh/m²/yr**
CO_2 emissions reduction	**1255 tCO_2/yr**

* Detailed information regarding the technical and financial performance will be available at a later stage.

EU-GUGLE

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Voiron, France | E2REBUILD

The Voiron demonstration site of E2REBUILD project is a multi-storey building in the department of Isère. The building was made of concrete with no insulation, it had natural ventilation and the windows were first-generation photovoltaicC double-glazing 4-6-4. All dwellings had an individual gas boiler for domestic hot water production, but each dwelling had its own different heat production – either electric heaters (ca. 29 dwellings with an energy demand of 529 kWh/m² year) or fossil fuel boilers (c. 43 dwellings with an energy demand of 202 kWh/m² year). The building's average consumption was 265 kWh/m²/yr.

The retrofitting programme reduced the energy consumption to 95 kWh/m²/yr and created a structured heat and domestic hot water production through a collective heating system (gas boiler) and solar thermal panels for hot water. Mechanical ventilation was installed and the roof, floor and walls were insulated. Furthermore, balconies were closed using prefabricated elements.

Impact*

The demonstration site in Voiron consists of an overall gross floor area of 3646 m² that has been refurbished in the project. As a result of the energy efficiency, the space heating was reduced from 210 kWh/m²/yr (business as usual) to 59 kWh/m²/yr, while the consumption for domestic hot water was reduced from 48 kWh/m²/yr (business as usual) to 32 kWh/m²/yr. Together with electricity, the total consumption went from 265 kWh/m²/yr to 95 kWh/m²/yr, representing a decrease of more than half in comparison to the reference building.

This represents 594 MWh/yr of final energy savings. According to the primary energy and CO_2 factors provided by the project, the primary energy savings rises to 1020 MWh/yr while the CO_2 reduction amounts to 127 tonnes every year.

FACTS & FIGURES	
Geographical area	**Voiron, France**
Demonstration area	**3646 m²**
Total investment	**€ 3.2 000 000**
Final energy savings	**594 MWh/yr**
Primary energy savings	**1020 MWh/yr**
CO_2 emissions reduction	**127 tCO_2/yr**

Technologies

The refurbishment measures implemented in Voiron included:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

- Insulation of the whole building envelope
- Closing of balconies using prefabricated elements
- Reduction of thermal bridges

Building services (HVAC and lighting)

- Highly efficient centralised heating system
- Renewal of the electrical system
- Heat recovery in ventilation system

ENERGY SYSTEMS INTEGRATION

Thermal collectors

- Production of domestic hot water

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**3646 m²**
Investment	**€ 905/m²**
Payback period	**28 years**
Final energy demand (baseline)	**265 kWh/m²/yr**
Final energy demand (after)	**60 kWh/m²/yr**
CO_2 emissions reduction	**127 tCO_2/yr**
Energy supply	**Thermal collectors**

The investment cost for the intervention was € 869/m², which amounts to € 3.2 m in total. According to the provided data, the annual cost savings for energy result in € 116 070 for monitored values. The results show that the payback period according to the data provided and SCIS calculations is 28 years.

* The KPIs for the new building are compared with the baseline of a reference building.

Lessons learned

BARRIER	SOLUTION
SOCIAL The implementation process was slowed down by the tenants.	**The subsequent involvement of the tenants during the implementation process, as well as the participation of different stakeholders, ensured a well-accepted and smooth project, even though sometimes tenants experienced disturbances.**
REGULATORY & ADMINISTRATIVE Difficulties were encountered when implementing prefabrication: unfavourable regulations, as well as problems discovered on-site (e.g. need for reinforcement of the balconies).	**A better preparation during the design phase was necessary, possibly using building information modelling as in some other demonstration projects. In Voiron, the use of prefabrication was too limited and the site didn't fully benefit from its added values.**

E2REBUILD

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Large-scale energy systems for urban heating and cooling

These projects present research, development and demonstration of a portfolio of technologies and devices including storage technologies to increase the potential of active and passive heating and cooling from renewable energy sources in order to contribute to sustainable energy.

The aim is to achieve substantial cost reductions, increase efficiencies, further reduce environmental impacts and optimise the use of technologies in different regional conditions where sufficient economic and technical potential can be identified.

Research and demonstration include new systems and components for industrial applications, district and/or dedicated space heating and cooling, building integration and energy storage.

Brescia, Italy | PITAGORAS

The city of Brescia in northern Italy is part of the PITAGORAS project, which aims to develop highly replicable, cost-effective and high energy-efficient large-scale energy generation systems that will allow the sustainable urban planning of very-low-energy city districts. The project's concept for waste heat recovery system is demonstrated in a real-scale pilot plant.

Impact

During the winter period, the pilot plant produces district heat (10 MWh), which is delivered via the local district heating network. During the summer season, the pilot plant uses the waste heat to produce around 1.8 MWel of electricity through an Organic Rankine Cycle. The set temperature of heat into the district heating network is 107 °C.

Compared to reference systems, this amounts to a reduction of 39 057 MWh/yr of primary energy demand and a reduction of 7220 tonnes of CO_2/yr thanks to the low primary energy (0 kWh of primary energy for every kWh of final energy) and the CO_2 factor (0 gCO_2/kWh).

FACTS & FIGURES	
Geographical area	**Brescia, Italy**
Demonstration area	**265 000 m²**
Total investment	**€ 12 million**
Funding from EU	**€ 2.5 million (20 %)**
Primary energy savings	**39 057 MWh/yr**
CO_2 emissions reduction	**7220 tCO_2/yr**

Technologies

The implemented solutions include:

ENERGY SYSTEMS INTEGRATION

- District heating and cooling
- Polygeneration
- Waste heat recovery
- Waste-to-energy

ENERGY SYSTEMS INTEGRATION	WASTE HEAT REVALORISATION PLANT
Area served	**265 000 m²**
Technology before	**Gas boilers**
Investment	**€ 12 million**
Payback	**12 years**
Energy carriers (before)	**Gas, electricity (grid)**
Energy carriers (current situation)	**Waste heat**
CO_2 emissions reduction	**7220 tCO_2/yr**
Primary energy reduction	**39 057 MWh/year**

The investment cost for the intervention was a total of € 12 million, with € 2.5 million as funding from the European Union. The revenues are € 400 000 for the electricity fed into the grid and € 500 000 for the delivered heating energy, resulting in a return on investment of 12 years.

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC The Italian Regulatory Authority for Electricity Gas and Water (AEEG) established the payment of surcharge costs for the self-generation systems (Decision AEEG 12 December 2013, 578/2013/REEL). This obligation created a barrier to the development of Organic Rankine Cycle applications to the recovery of waste heat from industrial processes. Indeed, this rule reduces the value of the electricity produced by a heat recovery system from an industrial process with Organic Rankine Cycle technology, prolonging investment payback times up to 100 %.	**In order to transpose the Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services into its national system, the Italian authorities introduced the concept of Efficient User Systems. According to the Italian Decree No 115 of 2008, the Efficient User Systems are defined as renewable or high-efficiency cogenerative plants. As such, the Efficient User Systems benefit from the reduction on tariffs for electricity transmission, distribution and dispatch, as well as from the discount of surcharge costs. Today waste heat recovery for power generation systems is not included in the definition of Efficient User Systems despite their multiple benefits, together with the non-utilisation of fossil fuels and reduction of carbon emissions through the recovery of excess heat, which is otherwise dispersed into the environment.** **Because of their proved benefits, waste heat recovery systems should be assimilated to high-efficiency cogeneration plants or renewable systems and included in the definition of Efficient User Systems.** **The economic obstacle is a key issue: investment payback times for the implementation of technologies related to waste heat recovery are longer than the 3 to 4 years, which is the usual timeframe considered acceptable by industrial players. For this reason, creating ad hoc incentive mechanisms or including them in existing supporting schemes could help in overcoming this barrier.**

BEST PRACTICES

REGULATORY & ADMINISTRATIVE

The successful implementation process of the project was a result of the joint programming of the developers with the relevant local authorities and public utilities company. The municipality joined the promotion of the smart cities approach, while the utilities company was involved in evaluating the project payback time.

SOCIAL

Communication and promotion of the environmental impacts and benefits in order to promote awareness and acceptance of the demonstrated interventions.

PITAGORAS

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In large cities such as Cologne, heat generation accounts for more than two-thirds of stationary energy consumption. This is why it is necessary to consider ways to make more efficient use of non-fossil energy sources and create more sustainable heating systems in metropolitan areas. One idea is to recover heat from wastewater systems that is currently simply flushed away. Within the CELSIUS project, the city of Cologne focused on using wastewater along with geothermal energy, solar energy and wood pellets as a sustainable source of heat for large buildings – a sensible addition to an economically viable mix of energy sources that includes natural gas, district heating systems and local heating sources.

Wastewater systems promise major heat recovery potential. Studies have shown that around 20 % of all buildings in Germany could be heated using this technology. However, so far most projects have failed in the face of technical and/or financial obstacles. The CELSIUS project seeked to identify the most effective methods so as to increase the success rate of future projects. The potential of this technology is demonstrated in two locations in Cologne: the districts of Wahn and Mulheim.

Furthermore, as part of CELSIUS Cologne tested an additional way to use a district heating network – for the operation of certain household appliances (white goods) – and in so doing reduce electricity demand and related carbon emissions. This is achieved by replacing the vast majority of the electricity used to operate household appliances with energy in the form of hot water.

The other field of action in Cologne was the delivery of district heating to white goods to reduce the use of electricity. Currently, 75 % of the electricity used by white goods is for heating purposes.

Impact

The works performed in Cologne as part of CELSIUS were focused on the implementation of heat recovery system from a sewage network in order to use the heating in a decentralised local network for the Wahn and Mulheim sites. The Wahn demo site has a total capacity of 200 kW, with a set temperature into district heating of 60 °C and a yearly production of 1000 MWh. The total primary savings amount to 330 MWh/yr and 20 tonnes of CO_2/yr. For the Mulheim site, the total capacity is 158 kW, with a set temperature into district heating of 60 °C and a yearly production of 700 kWh. The total primary savings amount to 167 MWh/yr and 22 tonnes of CO_2/yr.

FACTS & FIGURES

Geographical area	**Cologne, Germany**
Demonstration area	**30 000 m²**
Total investment	**€ 1 060 000**
Funding from EU	**€ 530 000 (50 %)**
Primary energy savings	**497 MWh/yr**
CO_2 emissions reduction	**42 tCO_2/yr**

Technologies

ENERGY SYSTEMS INTEGRATION

District heating

Delivery of district heating to white goods to reduce the use of electricity

Waste heat recovery

Heat recovery system from a sewage network in order to use the heating in a decentralised local network

ENERGY SYSTEMS INTEGRATION	WASTE HEAT RECOVERY (WAHN)
Area served	**20 650 m²**
Technology before	**Gas boilers**
Investment	**€ 530 000**
Payback period	**19 years**
Energy carriers (baseline)	**Gas**
Energy carriers (current situation)	**Waste heat, district heating**
CO_2 emissions reduction	**20 tCO_2/yr**
Primary energy savings	**330 MWh/yr**

ENERGY SYSTEMS INTEGRATION	WASTE HEAT RECOVERY (MULHEIM)
Area served	**11 199 m²**
Technology before	**Gas boilers**
Investment	**€ 530 000**
Payback period	**35 years**
Energy carriers (baseline)	**Gas**
Energy carriers (current situation)	**Waste heat, district heating**
CO_2 emissions reduction	**22 tCO_2/yr**
Primary energy savings	**167 MWh/yr**

ICT

Demand response

Demand response is used with the aim of understanding how decentralised energy capacity can contribute to electricity network capacity and resilience. The demonstrator engages in such activities in order to contribute to developing enhanced systems for optimising the contribution that decentralised energy can make to demand response and load control systems.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC The heat price required for recovering the investment has to be higher than the heat price of standard solutions (gas-boiler).	**The potential solutions can be:** • optimal technical dimensioning to cut the investment to the inevitable; • convincing the customer to pay the higher price for the sustainable solution.
SOCIAL The demonstrations in Cologne were implemented in school buildings, therefore the stakeholders had to be involved throughout the development.	**The refurbishment of the heating systems within the schools was discussed with the head teachers and caretakers, and they were kept informed of the developments.**

BEST PRACTICES

REGULATORY & ADMINISTRATIVE

The Renewable Heat Law in Germany regulates that certain amounts of the heat supply should be covered by renewable energy sources. Heat recovery is accepted as a renewable.

CELSIUS

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Genoa, Italy | CELSIUS

The city of Genoa is one of the first Italian cities to commit to the implementation and promotion of the smart city holistic approach and has invested efforts into involving diverse stakeholders to work together with the objective of making a real change in sustainability.

As part of their smart city strategy, Genoa participated as a demonstrator in the CELSIUS project with the aim of increasing the overall energy efficiency associated with the industrial gas distribution activity. A local energy system connected to the nearby industrial park has been developed within an important area of the city. The main components are an expansion turbine by which mechanical energy is recovered from the pressure drop between the gas transmission and distribution pressures, a combined heat and power (CHP) plant and a control system for both electricity and gas consumption.

The implemented measures in Genoa allow shifting from the current use of low-efficiency independent heating systems, which are still widespread in the city of Genoa, to higher efficiency heating solutions, thus reducing the overall fuel consumption and CO_2 emissions.

Impact

The maximum thermal output of the CHP plant of Genoa is 300 kW and 1076 kW of power. The heating generated by the internal combustion engine will be fed into the district heating network at 70 °C.

According to the design data, the final energy input fed to the system equals 7 million kWh/yr of gas with an overall system performance of 21 %, and 7 million kWh/yr of electricity with an overall system performance of 73 %.

This results in a primary energy reduction of the area of 6100 MWh/year, while the CO_2 is reduced by 1336 tonnes per year.

FACTS & FIGURES	
Geographical area	**Genoa, Italy**
Total investments	**€ 3 021 000**
Funding from EU	**€ 1 497 000 (49.5 %)**
Primary energy savings	**6100 MWh/year**
CO_2 emissions reduction	**1336 tCO_2/yr**

Technologies

The approach in Genoa includes the following measures:

ENERGY SYSTEMS INTEGRATION

Cogeneration (CHP)

The expansion turbine is interfaced with a gas-fired CHP plant that will service the heat that is used in the expansion process. The CHP plant services a small heating network as well, which supplies several buildings inside the industrial park, including the fire fighters' station outside the park. The control and fine regulation of gas consumption for pre-heating, as well as the programming of the electricity to be distributed to the district, are implemented in association with this plant, in order to achieve a more rational use of both gas and electricity within the industrial park and the district.

Waste-to-energy

Installation of a turbo-expander able to recover the mechanical energy inherent in the pressurised natural gas (currently wasted) in order to generate electricity

ENERGY SYSTEMS INTEGRATION	COGENERATION (CHP)
Technology before	**Individual gas boilers, electricity grid**
Investment	**€ 3 021 000**
Payback period	**10 years**
Energy consumption (current situation)	**7000 MWh/yr**
CO_2 emissions reduction	**1336 tCO_2/yr**

The total investment costs are € 3021 million with a total of € 1497 million in grants. The calculated payback period is 10 years.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC The costs of the technological components and in particular the turbo-expander were higher than foreseen. Therefore the payback period and return on investment (ROI) are longer than commercially acceptable.	**Replicability could contribute to a gradual decrease in the price of the turbo-expanders.**
FINANCIAL & ECONOMIC Due to the innovative nature of the turbo-expander technology and its installation, it took more time to customise the equipment according to the specific need of the Genoa demonstration site.	**When defining the project's timeline and costs, the team has to take into account the customisability needs for the technological solutions and carefully select the machine vendor.**

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CELSIUS

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Gothenburg took part in the CELSIUS project with several fields of action focusing on the construction of 900 new apartments, which are to be connected to the district heating system and used as small short-term thermal storage, for connecting ships to the district heating system when docked in the harbour, and for feeding cold water from the river into the district cooling network.

A total of 900 apartments were constructed and these buildings are used as short-term thermal energy storage. When the demand in the global system is low, the buildings are charged. When there is a demand peak, the heat stored in the buildings is discharged and released into the system to partially cover the demand and therefore balance it. This will lead to a reduction in the size of the energy production peaks in the district heating production system whilst still meeting the overall heat demand on the network at peak times. The reduction in energy production will lead to a decrease in the use of fossil fuels and consequently the amount of CO_2 emissions produced.

In addition, a ferry that docks in Gothenburg several times a week, the Stena Danica, was connected to the district heating system when in harbour. There are already possibilities available to connect ships at the quayside to the electrical grid, but the heating equipment on board still needs to be used. When using district heating from the city to heat the ship, no emitting machines on board ships would be required when moored in the harbour.

Finally, cold water from the Göta Älv River is fed into the district cooling network. The benefits of district cooling are a decreased use of harmful cooling agents, no noise from cooling towers or compressors, an efficient use of energy and resources, and reduced electricity consumption.

Impact*

The 900 newly constructed apartments, which are connected to the district heating system, cover approximately 75 000 m² of living area.

With regards to connecting the ship to the district heating and using it instead of burning bunker oil in the ship generators and heaters, it is expected that this measure will reduce the CO_2 emissions by 172 tonnes (62 %) per year and ship.

The river cooling has a capacity thermal cooling output of 30 MW with a set temperature of the cooling into the cooling circuit of 6 °C. The overall system performance for this system is 5 %.

FACTS & FIGURES	
Geographical area	**Gothenburg, Sweden**
Demonstration area	**75 000 m²**

Technologies*

ENERGY EFFICIENCY IN BUILDINGS

Small energy storage

The thermal capacity of the structural elements of the new buildings will be exploited for heat storage and demand management.

ENERGY SYSTEMS INTEGRATION

District heating and cooling

District heating for ships in harbour

River cooling

Large-scale storage

Waste heat recovery

ENERGY SYSTEMS INTEGRATION	COGENERATION (CHP)
Technology before	**Electrical chillers**
Payback period	**20 years**
Energy carriers (baseline)	**Electricity**
Energy carriers (current situation)	**Water, electricity**

* Detailed information regarding the technical and financial performance will be available at a later stage.

CELSIUS

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* Detailed information regarding the technical and financial performance will be available at a later stage.

London, United Kingdom | # CELSIUS

The London Underground's mid-tunnel ventilation shaft and UK Power Network's electricity substation have been identified as sources of waste heat that could be utilised within the local Bunhill Heat and Power Network. As part of the CELSIUS project, the city investigated into how these sources of waste heat can be captured and integrated into this local district heating system. Thus, the city developed knowledge and expertise on how to optimise an approach to laying district-heating pipework in a highly urbanised, mixed-use environment that already has highly congested subterranean utility supplies. The demonstrator clarified how to further develop existing networks, how to implement waste heat capture and utilisation from multiple local sources, and explore lower temperature operating systems.

Impact

Before the expansion, Bunhill Heat and Power Network supplied heat to around 700 homes and 2 leisure centres. After the interventions were implemented, 500 more homes were connected, as well as 2 new developments and additional existing buildings in the vicinity. The heating system is more carbon- and financially-efficient than London's district heating systems were traditionally designed, specified and built to be.

The underground infrastructure for heat recovery from the tube ventilation shaft has a total capacity of 1160 kW, with a set temperature into district heating of 80 °C and a yearly production of 9000 MWh. The total primary savings amount to 6.7 MWh/yr and 1 tonne of CO_2/yr.

FACTS & FIGURES	
Geographical area	**London, United Kingdom**
Total investment	**€ 2 000 000**
Funding from EU	**€ 1 000 000 (50 %)**
Primary energy savings	**7 MWh/yr**
CO_2 emissions reduction	**1 tCO_2/yr**

Technologies*

ENERGY SYSTEMS INTEGRATION

District heating

Waste heat recovery

ENERGY SYSTEMS INTEGRATION	
Technology before	**Individual gas boilers**
Investment	**€ 2 000 000**
Payback period	**3.5 years**
Energy carriers (baseline)	**Gas**
Energy carriers (current situation)	**Waste heat**
CO_2 emissions reduction	**1 tCO_2/yr**
Primary energy savings	**7 MWh/yr**

ICT

Demand response

* Detailed information regarding the technical and financial performance will be available at a later stage.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC The UK Government's ECO scheme is designed to partially fund district heating network expansions as a low carbon solution. However, the Government has repeatedly altered the scheme, leading to uncertainty over the level of funding available or even whether this project fulfils the criteria for applying.	**The project has worked closely with an ECO broker to explore the opportunity of securing such funding. The results of these efforts haven't been reported on yet.**
REGULATORY & ADMINISTRATIVE The project wanted to x-ray the pipe welding in order to examine its quality. However, UK regulations require you to send a nuclear incident plan to local residents if you wish to do this.	**Instead, an ultrasound was used to check the welds.**
REGULATORY & ADMINISTRATIVE As Islington is a densely populated and historic borough, planning controls are very restrictive, which was a problem when building an energy centre directly adjacent to a residential tower block.	**The team worked closely with the planning department to work out what materials would be deemed acceptable.**

CHALLENGES

SOCIAL

Lack of skilled district heating pipework welders in the UK.

CELSIUS

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The city of Rotterdam participated in the CELSIUS project with a focus on two interventions: development of an energy system in the vertical city of De Rotterdam and the creation of a heat hub aiming to increase the effectiveness of the waste heat transportation network.

De Rotterdam is a 160 000 m^2 mixed-use building with housing, commercial and recreational functions. The implemented measures as part of the CELSIUS project include a high-temperature hot water heat distribution system, which supplies water to the residential and hotel sections, and a low-temperature heating system, which allows for heat to be supplied to the offices, commercial premises and shops. Cooling is centrally generated through three water-cooled compression chillers connected to the New Meuse River by a cold-water inlet. The apartments in the building have comfortable floor heating and cooling, while the renewable energy saves space because there are no radiators and boilers, and air conditioning is unnecessary. Also, the building re-uses the heat recovered from exhaust air from the ventilation systems. Part of the electricity and heat demand is produced in a biomass-fired CHP, which is integrated in the building.

The heat hub is a physical structure placed at a strategic location near the waste heat transportation infrastructure and the district heating system in Rotterdam. It focuses on increasing the effectiveness of the waste heat transportation network of Warmtebedrijf Rotterdam with buffering, heat balancing, smart ICT and forecasting. It allows for an increase in total heat delivery of the waste heat network without any additional investments in a new transport infrastructure or by means of additional heat sources.

Impact

The heat hub has a storage temperature of 185 °C with a return temperature of 60 °C. The total amount of heating energy fed into the storage is 4000 MWh/yr, which reduces the use of primary energy to 3400 MWh per year and the CO_2 emissions to 800 tonnes per year.

FACTS & FIGURES

Geographical area	**Rotterdam, the Netherlands**
Demonstration area	**160 000 m^2**
Total investment	**€ 1 046 292**
Funding from EU	**€ 523 146 (50 %)**
Primary energy savings	**3400 MWh/yr**
CO_2 emissions reduction	**800 tCO_2/yr**

Technologies*

The interventions in Rotterdam include:

ENERGY SYSTEMS INTEGRATION

District heating

The heat hub, operational since the last quarter of 2013, acts as a distribution station and connects the existing district heating systems in the south and north of Rotterdam.

Large-scale storage

Thermal storage

The heat hub has a well-insulated buffering tank. The capacity of the buffer is 185 MWh and the discharge capacity is 30 MWth. By placing the tank in the middle of the distribution network, instead of at the traditional location in the vicinity of the production facilities, Warmtebedrijf Rotterdam increases the effectiveness of the buffering capacity because the buffered heat is closer to the end-consumer. There is also a positive effect on the local air quality because less gas-fired boilers are needed for peak load.

Waste heat recovery

Cogeneration (CHP)

ENERGY SYSTEMS INTEGRATION

Investment	**€ 1 046 292**
CO_2 emissions reduction	**800 tCO_2/yr**
Primary energy savings	**3400 MWh/yr**

* Detailed information regarding the technical and financial performance will be available at a later stage.

ICT

Demand response

For better forecasting and heat balancing, a smart ICT system is under development. The system is a crucial element to further optimise heat sources, buffers, new connections and pumping stations in the waste heat transportation infrastructure of Warmtebedrijf Rotterdam and the entire district heating system.

Lessons learned

BARRIER	SOLUTION
REGULATORY & ADMINISTRATIVE Since the heat hub is in a district near the city centre, the municipality of Rotterdam prescribed some dos and don'ts for the heat hub. They didn't allow the hub to be placed near the quayside, in order to leave open space for the construction of a future promenade. As a result, no fences were built to keep out nuisances and vandalism.	**To prevent vandalism, the team put in place permanent night-time surveillance. If needed, there is a process for immediate reaction, such as cleaning off graffiti, for example.**

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celsius smart cities

CELSIUS

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Sustainable energy solutions: the CONCERTO communities

CONCERTO is a European Commission initiative within the European Research Framework Programme (FP6 and FP7), which aims to demonstrate that the optimisation of the building sector of whole communities is more efficient and cheaper than the optimisation of each building individually when all the relevant stakeholders work together and integrate different energy-technologies in a smart way. Special focus is placed on buildings and industry, which use 40 % and 25 % of total energy respectively in the EU.

The CONCERTO initiative demonstrates on a large scale how to reduce the consumption of fossil fuels by substitution with renewable energy sources and demand management.

This publication looks at the results of the third generation CONCERTO projects. For information regarding first and second generation, please visit the SCIS website*.

* www.smartcities-infosystem.eu/content/concerto-publications-archive

The community of Cernier in the canton of Neuchâtel in Switzerland is one of four pilot communities within the SOLUTION project. It is a typical Swiss community (most municipalities do not have more than 10 000 inhabitants), which makes it a good national role model and the experiences can be transferred to other Swiss cities of similar size.

SOLUTION's demonstration site in Cernier consists of 1 new and 6 refurbished buildings, including a nursery school, a primary school, a multi-family house and a farmhouse. The renewable energy systems implemented in Cernier included biogas cogeneration, heat pumps, wood boilers, solar thermal collectors and photovoltaic installations. A key development project at Cernier was the construction of an agricultural biogas plant for district heating and cogeneration.

Impact*

Overall a gross floor area of 12 744 m² has been refurbished during the project and 5148 m² have been newly constructed. The final energy consumption, according to monitoring data, has been measured before and after the interventions for all the refurbished buildings on the demo site. The results show that the average value for heating energy consumption exceeds 290 kWh/m²/yr before the retrofitting measures. The planned interventions for retrofitting reduced the total energy consumption for heating to 150 kWh/m²/yr. With regard to the new buildings, the reference value is 45 kWh/m²/yr and 28 kWh/m²/yr for the SOLUTION building.

This represents 1615 MWh/yr of final energy savings. The primary energy savings go up to 2540 MWh/yr while the CO_2 reduction amounts to 398 tonnes every year.

FACTS & FIGURES

Geographical area	**Cernier, Switzerland**
Demonstration area	**17 892 m²**
Population in the area	**2200 inhabitants**
Total investment	**€ 2 291 157**
Final energy savings	**1615 MWh/yr**
Primary energy savings	**2540 MWh/yr**
CO_2 emissions reduction	**398 tCO_2/yr**

Technologies

The interventions in Cernier include:

ENERGY EFFICIENCY IN BUILDINGS

Building integrated renewable energy sources

Photovoltaics

Heat pumps

Building services (HVAC and lighting)

Individual reduction of consumption thanks to awareness tools, including access to instantaneous consumption, visit from energy advisor, implementation of saving tools such as those avoiding standby-mode

ENERGY SYSTEMS INTEGRATION

District heating

Cogeneration (CHP)

Construction of an agricultural biogas plant for district heating and cogeneration, which enables treating 7500 tons of organic waste, and feeding 740 MWh/yr of electricity to the grid and about 700 MWh/yr of heat to the district heating. Beyond creating additional revenue for the farmer operating the plant, the facility also allowed for the creation of necessary storage volume for the collected pig manure, as no manure can be brought out to the fields during the winter. These two factors ensure the ongoing continuity of the farm's operation. The decomposed manure creates a fertiliser that is easier to absorb for the plants and avoids the release of methane into the atmosphere.

Biomass boilers

Thermal collectors

Smart street lighting

* The KPIs for the new and refurbished buildings are compared with the baseline of a reference building.

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**12 744 m^2**
Newly built area	**5148 m^2**
Payback period	**7 years**
Final energy demand (baseline)	**290 kWh/m^2/yr (business as usual for old buildings) 45 kWh/m^2/yr (business as usual for new buildings)**
Final energy demand (after)	**150 kWh/m^2/yr (business as usual for old buildings) 28 kWh/m^2/yr (business as usual for new buildings)**
CO_2 emissions reduction	**398 tCO_2/yr**
Energy supply	**Biogas, solid biomass, photovoltaics**

The investment cost for the intervention was € 2.3 million in total, which includes the costs of methanisation equipment (€ 1 million), cogeneration (€ 225 000) and technical building (€ 275 000). The remuneration for electricity fed to the grid is CHF 0.427/kWh (excl. VAT), based on an average yearly power production of 93 kW el. The payback period is 7 years.

Lessons learned

CHALLENGES

FINANCIAL & ECONOMIC

There was a high investment cost for replacing the existing energy system with renewables. The replacement of an old heating system is often complicated and the financial support is insufficient. In order to get the support for renewable heating, the building's envelope has to be very efficient, i.e. it requires a concurrent building retrofit.

FINANCIAL & ECONOMIC

With regards to implementing district heating, there weren't enough consumers to make the project secure and provide a cheaper cost of heating. The density of suitable buildings is not very high, even in the city centre.

REGULATORY & ADMINISTRATIVE

Cernier is too small an area and lacks the human resources to have an energy service, so the responsibility for the energy supply and management is not in the hands of the town's authorities.

REGULATORY & ADMINISTRATIVE

There are heavy administrative requirements with small, individual projects, which unnecessarily reduce the economic interest in the technological solution implemented.

REGULATORY & ADMINISTRATIVE

There were difficulties in obtaining long-term contracts with suppliers of co-substrates for biogas cogeneration.

SOCIAL

The main challenge was motivating people due to the poor financial advantage of the power savings.

SOLUTION
Cernier Hartberg Hvar Lapua Preddvor

SOLUTION

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Galanta, Slovakia | GEOCOM

Galanta is situated in the south-western part of Slovakia, near Bratislava. Spread over 396 ha, the town has 16 500 residents. The exploration of geothermal energy in Galanta began back in the 1980s when drilling works for geothermal wells were initiated. Since the mid-1990s, these wells have been used for heating the energy supply via district heating.

The focus of the interventions in Galanta as part of the GEOCOM project was on the complete refurbishment of designated buildings (residential and public), including photovoltaic installations and the connection of additional buildings to the district heating network.

Impact

Overall a gross floor area of 18 183 m² was refurbished by applying insulation to outer walls, and replacing doors and windows. As a result of the energy efficiency, 850 MWh/yr of final energy are being saved in the buildings that underwent retrofitting activities.

Three multi-storey residential buildings, an elderly care home and a medical laboratory were connected to the district heating network, with a total consumption of 1983 MWh/yr. From the point of view of primary energy demand, an average total primary energy savings of 714 MWh is achieved every year from this connection.

According to SCIS calculations based on the energy monitoring data and the respective emission factors, the total CO_2 emission savings due to the refurbishment measures amount to 424 tonnes of CO_2 per year, and the CO_2 emission savings resulting from adding new buildings to the district heating network amount to 388 t/yr. The total CO_2 emission savings are 812 t/yr.

FACTS & FIGURES

Geographical area	**Galanta, Slovakia**
Demonstration area	**18 183 m²**
Population in the area	**16 500 inhabitants**
Total investment	**€ 1 080 826**
Funding from EU	**ca.30 %**
Final energy savings	**850 MWh/yr**
Primary energy savings	**2594 MWh/yr**
CO_2 emissions reduction	**812 tCO_2/yr**

Technologies

The following interventions were implemented in Galanta as part of the GEOCOM project:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

- Retrofitting the walls
- Replacement of windows and doors

Building integrated renewable energy sources

- Photovoltaic installations on roofs

ENERGY SYSTEMS INTEGRATION

District heating and cooling

- Additional connections to geothermally-driven district heating network

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**18 183 m²**
Investment	**€ 60/m²**
Payback period	**28 years**
Final energy demand (baseline)	**151 kWh/m²/yr**
Final energy demand (after)	**104 kWh/m²/yr**
CO_2 emissions reduction	**424 tCO_2/yr**
Energy supply	**Photovoltaics (roof), geothermal district heating network**

The investment cost for the intervention was € 60/m², making a total of € 1 million. According to the provided data, the yearly cost savings for energy result in € 116 070 for the monitored values. The costs saved by the interventions amount to € 38 927.

The resulting payback period is 28 years for the whole project. The payback period for all the refurbishment measures is 22 years. The elementary school has the shortest payback period with 15 years, the kindergarten the longest with 25 years.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC The payback periods are relatively long.	**This project is unlikely to attract interest from private investors unless a cost-benefit analysis allows factoring in environmental and social benefits that can be monetised and charged. This can be done in one of two ways: by introducing fees to parents of pupils or the tenants for example, which is not legally possible in many countries either for public schools or because of tenant protection; or by introducing concession systems from the state with public-private partnerships, grants or energy subsidies through feed-in tariffs.**
REGULATORY & ADMINISTRATIVE Difficulties with the complicated legislation in Slovakia were encountered during the implementation works. In the case of the photovoltaic installations, the return on investment is not cost-effective due to the administrative obstacles and national legislation.	**The legislation for renewable energy seems to require a review and needs to be further researched.**
SOCIAL The environmental benefits of using already-existing geothermal wells for the supply of heating energy did not seem to have an influence on the decision-making of the buildings' tenants. There was an overall lack of awareness or interest from the general public on the sustainability needs.	**The inhabitants of the refurbished buildings were informed about all the technologies used, such as the photovoltaic system. The technologies used also became part of the school's curriculum.**

GEOCOM

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In the Hartberg eco-region in Austria, the SOLUTION project has served as a catalyst for the development of advanced communal demonstrations using an implemented bottom-up approach. Targeted activities included improvements in the energy efficiency of buildings with 70 % energy savings, the construction of new commercial buildings with an energy performance close to zero-energy consumption, decentralised district heating systems and polygeneration, large-scaled implementation of small and medium renewable energy systems applications, symbiotic integration of novel solar electricity storage units, improvements in the framework for potential private investors, and the promotion of innovative integration aspects of renewable energies.

Impact*

The demonstration site in Hartberg consists of 6 refurbished and 8 new buildings. Overall a gross floor area of 5679 m² has been refurbished in the project and 4609 m² have been newly constructed.

The energy consumption figures were monitored before and after the works, and were 250 kWh/m²/yr and 93 kWh/m²/yr respectively as average for the buildings included in the project.

The CO_2 emissions were reduced by 185 tonnes of CO_2 every year. The primary energy savings were 3292 MWh per year.

FACTS & FIGURES

Geographical area	**Hartberg, Austria**
Demonstration area	**10 288 m²**
Population in the area	**6350 inhabitants**
Final energy savings	**1748 MWh/yr**
Primary energy savings	**3292 MWh/yr**
CO_2 emissions reduction	**41 tCO_2/yr**

Technologies

The implemented measures in Hartberg included:

ENERGY EFFICIENCY IN BUILDINGS

Heat pumps

ENERGY SYSTEMS INTEGRATION

Biomass boilers

Thermal collectors

District heating and cooling

- Biomass
- District heating extension in Hartberg/Neusafenau and in Kaindorf
- Heat exchanger system for cooling

Photovoltaics

- Combined with battery units

Cogeneration (CHP)

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**5679 m²**
Newly built area	**4609 m²**
Final energy demand (baseline)	**250 kWh/m²/yr**
Final energy demand (after)	**93 kWh/m²/yr**
CO_2 emissions reduction	**41 tCO_2/yr**
Energy supply	**District heating and cooling, cogeneration (CHP), solid biomass, heat pumps**

* The KPIs for the new and refurbished buildings are compared with the baseline of a reference building.

ICT

Building energy management system

Mechanical heating and ventilation system

According to the design data, the yearly cost savings for energy come to € 51 211. Based on the available financial data and the lack of investment costs, a payback calculation is not possible.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC The two biogas CHPs in the Ecopark Hartberg have been in operation since 2004 and needed renovation as the plant's efficiency faced challenges with the hydraulic system and the connected cooling absorption device, which is used for summer operations. The use of waste heat represented the most critical parameter.	**In order to optimise the operation of the CHP applications, a continuous and rather constant heat demand at the plant's location was envisaged in order to run the plant economically.**
FINANCIAL & ECONOMIC With crystalline silicon (c-Si) module technologies clearly dominating the worldwide market, some thin film modules are not always compatible with all the inverter types available on the market.	**The whole set-up, including market availability, needed to be checked and considered in the planning phase.**
SOCIAL There is a lack of social awareness on the impact of individual behaviours on energy consumption.	**One very effective way is to give people periodic feedback on their energy consumption. Such feedback can be delivered in a variety of ways, of which the best but most expensive is to use installed in-home displays. Another possibility is to use internet portals that the consumer can log on to and have all their data displayed. The simplest way to deliver feedback is by using an ordinary letter every month with an overview of last month's energy consumption.**

CHALLENGES

FINANCIAL & ECONOMIC

Difficulties occur in the building integration of photovoltaic systems due to limited spaces and/or difficult interchangeability with standard building components.

FINANCIAL & ECONOMIC

There is a strong dependency on public funds.

FINANCIAL & ECONOMIC

In comparison with conventional bulk electricity prices, the costs for solar power are still higher.

REGULATORY & ADMINISTRATIVE, FINANCIAL & ECONOMIC

The team faced challenges trying to access funding for renewable energy sources (solar energy, wind power and hydropower) because each programme had different criteria for eligibility and different payment modalities, which do not facilitate the process.

SOCIAL

Many mistakes were made by the workers due to a lack of routine and skills.

SOLUTION
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Høje-Taastrup, Denmark | ECO-Life

The ECO-Life community Høje-Taastrup is located in the western area of the municipality and includes the suburbs of Hedehusene, Fløng and Gammelsø. There is a population of 12 000, which is expected to increase due to further development in the area.

The demonstration site showcases 23 refurbished buildings with a total gross floor area of 19 494 m² and 5 new buildings with a floor area of 9917 m². The integration work included 10 heat pumps, 3 solar thermal systems and 16 photovoltaic systems as part of the refurbishment and construction activities. In addition, 10 energy systems ranging from charging ports for electric vehicles to electricity generation via wind turbines were installed.

Impact*

As a result of the energy efficiency, the total final energy consumption for the new buildings is estimated to be reduced by 609 MWh/yr when compared with the reference building. In the case of the refurbished buildings, the savings of final energy are estimated to be 1857 MWh/yr.

This makes a total 2466 MWh/yr of final energy savings, taking into account the renovation of the old buildings and the construction of the new ones, which corresponds to 48 % of final energy savings.

According to the primary energy and CO_2 factors provided by the project, the primary energy savings rise to 4295 MWh/yr, which is 45 % of the primary energy use in the reference situation. The total amount of primary energy savings from the energy system integration is 8480 MWh/yr. In total, 12 775 MWh/yr (56 %) of primary energy are saved in Høje-Taastrup.

The refurbishment measures and high-performance new buildings yielded a CO_2 savings for electricity and thermal energy of 806 tonnes per year (67 %). The total CO_2 savings due to the integration of energy systems are 1101 tonnes per year. Overall there is a saving of 1907 tonnes per year (82 %) of CO_2 emissions following the interventions.

FACTS & FIGURES

Geographical area	**Høje-Taastrup, Denmark**
Demonstration area	**29 411 m²**
Population in the area	**48 853 inhabitants**
Total investment	**€ 52 100 000**
Final energy savings	**2466 MWh/yr**
Primary energy savings	**12 775 MWh/yr**
CO_2 emissions reduction	**1907 tCO_2/yr**

Technologies

The measures in Høje-Taastrup, realised as part of the ECO-Life project, featured:

ENERGY EFFICIENCY IN BUILDINGS

- Retrofitting the building envelope
- High-performance new buildings
- Building services (HVAC and lighting)
- Building integrated renewable sources
- Heat pumps

ENERGY SYSTEMS INTEGRATION

- Photovoltaics
- Wind turbine
- Thermal collectors

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**19 494 m^2**
Newly built area	**9917 m^2**
Investment	**€ 1768/m^2**
Final energy demand (baseline)	**138 kWh/m^2/yr**
Final energy demand (after)	**70 kWh/m^2/yr**
CO_2 emissions reduction	**1907 tCO_2/yr**
Energy supply	**Heat pumps, photovoltaic, thermal collectors, wind turbine**

The total investment costs for interventions in Høje-Taastrup according to the SCIS calculations are € 52 million. This includes costs for new buildings, building refurbishment, building integrated renewable energy systems and energy system integrations. The total energy cost savings are € 511 700/yr (32 %).

According to the project's reported information, the payback period is 4 years for the total energy system integration and the building's integrated renewable energy systems, and 14 years for the new and refurbished buildings.

Lessons learned

BARRIER	SOLUTION
SOCIAL It is difficult and time-consuming to persuade homeowners to carry out energy refurbishment.	**Homeowners who at first were hesitant to be part of the change could be persuaded through competent guidance on a one-to-one basis from a trustworthy person. This person (e.g. from the municipality) can highlight the added values like the increased market value of a house and the improved comfort as an added value of the energy savings.** **In terms of social impact these interactions serve as groundwork for future engagement with the general public on measures connected with energy efficiency and environmental protection.**
SOCIAL User awareness and communication with tenants about the refurbishment was a challenge.	**This was overcome by highlighting the added value of the interventions.**

CHALLENGES

SOCIAL

For low-energy buildings and houses that underwent extensive renovation, users' habits can influence the final energy consumption negatively. Inhabitants believe that the energy costs are lower in comparison to a normal renovated building, so they don't pay attention to good housekeeping (e.g. venting through open windows and maintaining a higher room temperature).

ECO-Life project

ECO-Life

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The island of Hvar is located approximately 40 km off the Dalmatian coast in Croatia, and is the fourth largest Croatian island with a total area of 297 km². The SOLUTION demonstration area comprises the whole island.

The objective of Hvar was to make the energy supply 20 % self-sufficient by 2020 with improvements to the energy efficiency of existing buildings, as well as constructing new energy-efficient buildings as a primary measure. Altogether, 10 buildings were refurbished during the SOLUTION project – 5 private buildings and 5 public buildings (3 schools and 2 kindergartens), and 4 buildings were newly constructed.

In view of the abundant solar resources and the mild climate on the island, the demonstration site integrated solar thermal collectors and small and large-scale photovoltaic installations, as well as solar cooling. In addition, since there is a great deal of agricultural and kitchen waste on the island, biogas production was chosen as a solution to the problems linked with landfills and future waste management.

Impact*

The demonstration site Hvar in Croatia consists of an overall gross floor area of 8506 m², which has been refurbished, and 3168 m² that has been newly constructed.

As a result of energy efficiency, the total energy consumption of the renovated buildings was reduced from an average of 110 kWh/m²/yr (business as usual) to 35 kWh/m²/yr representing a decrease of more than 65 % in comparison to the reference building. The reference building's consumption exceeds 60 kWh/m²/yr year, while the total energy demand of the new buildings in Hvar is 38 kWh/m²/yr.

This means there are 638 MWh/yr of final energy savings for the renovation and 70 MWh/yr of final energy savings for the new buildings when compared to the reference values. According to the primary energy and CO_2 factors provided by the project, the primary energy savings go up to 850 MWh/yr for the renovation and 126 MWh/yr for the new construction, while the CO_2 reduction amounts to 289 tonnes per year for the renovation and 41 tonnes for the new construction every year.

FACTS & FIGURES	
Geographical area	**Hvar, Croatia**
Demonstration area	**11 674 m²**
Population in the area	**2200 inhabitants**
Final energy savings	**708 MWh/yr**
Primary energy savings	**876 MWh/yr**
CO_2 emissions reduction	**330 tCO_2/yr**

Technologies

The implemented measures in Hvar feature:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Specific refurbishment measures had to be applied to the buildings on Hvar Island according to their period of construction and their characteristic construction materials (historic buildings from the 19th century to the 1950s, buildings from the 1950s to the 1980s, buildings from the 1980s to 2000)

Building integrated renewable energy sources

Photovoltaics

ENERGY SYSTEMS INTEGRATION

Waste-to-energy

Biogas from olive oil waste. Since there is a lot of agricultural and kitchen waste on the island, biogas production was chosen as a solution to the problems linked with landfills and future waste management. The waste is processed by extracting energy; high-quality compost is also obtained.

Thermal collectors

The best example from Hvar is the complete refurbishment of the school in Svirče, where the building was improved by thermal insulation to the external walls and the roof along with replacing the windows and doors. The boiler room was reconstructed and the fuel was switched to wood pellets.

* The KPIs for the new and refurbished buildings are compared with the baseline of a reference building.

A heat pump, solar thermal system, 23 kW photovoltaic system and energy monitoring system were installed.

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**8506 m²**
Newly built area	**3168 m²**
Final energy demand (baseline)	**110 kWh/m²/yr (business as usual for old buildings)** **60 kWh/m²/yr (business as usual for new buildings)**
Final energy demand (after)	**35 kWh/m²/yr (business as usual for old buildings)** **38 kWh/m²/yr (business as usual for new buildings)**
CO_2 emissions reduction	**330 tCO_2/yr**
Energy supply	**Photovoltaics, biogas, thermal collectors**

According to the design data, the yearly cost savings for energy result in € 52 475. Based on the poor financial data and lack of investment costs in the project documents, the payback calculation is not possible.

Lessons learned

BARRIER	SOLUTION
SOCIAL Limited experience in the field of energy efficiency and large-scale photovoltaic operation.	**National and international initiatives to train local architects, installation companies and construction companies on energy-efficient building development were launched. The topics included how to become a passive house planner, details and rules in passive house construction, etc.**

CHALLENGES

FINANCIAL & ECONOMIC

There are high investment costs when refurbishing the envelopes of buildings, and on an island these are even greater due to high transportation costs.

FINANCIAL & ECONOMIC

The testing phase of the biogas plant and the developments related to that caused delays in the (economically feasible) operation.

REGULATORY & ADMINISTRATIVE

Changes to photovoltaic feed-in tariffs in Croatia have a negative impact on the feasibility of larger-scale photovoltaic plants.

SOLUTION

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Kortrijk, Belgium | **ECO-Life**

The ECO-Life demonstration site in Belgium is in Kortrijk, a city located in the Flemish province of West Flanders. The wider municipality comprises the city of Kortrijk and the seven surrounding towns with a total of 74 700 inhabitants, which makes it the seventh largest city in the Flemish region.

A large number of the housing units in Kortrijk date from before 1960. They are not adapted to changed living standards, or to higher energy standards. In striving for innovation and a higher quality of life for residents, the Council of Kortrijk decided to improve the building stock through refurbishment and new construction.

Impact*

An overall area of 24 700 m² was included in the ECO-Life project in Kortrijk. As a result of the energy efficiency, the monitored yearly energy balance was found to be 117 kWh/m²/yr on average. This amounts to 1127 MWh of final energy saved every year.

On the supply side, the following production of renewable energy has been achieved:

- Photovoltaics: 210 MWh/yr
- Heat pump: 163 MWh/yr
- Biomass plant: 1346 MWh/yr

According to the primary energy and CO_2 factors provided by the project and the SCIS database, the primary energy savings go up to 5463 MWh/yr, which is 70 % of the primary energy used in the reference situation. The intervention within ECO-Life yielded 464 tonnes per year CO_2 savings under full operation (40 % in comparison to national regulations). Additionally, 346 tonnes of CO_2 have been displaced by the savings from the renewable energy system.

There was a mismatch between design values and monitored values. This was mainly due to high network heat losses in district and collective heating networks, low production efficiencies, and higher energy demand for space heating in some demonstration buildings.

FACTS & FIGURES

Geographical area	**Kortrijk, Belgium**
Demonstration area	**24 700 m²**
Population in the area	**48 853 inhabitants**
Total investment	**€ 4 214 000**
Final energy savings	**1127 MWh/yr**
Primary energy savings	**5463 MWh/yr**
CO_2 emissions reduction	**710 tCO_2/yr**

Technologies

The following interventions were implemented in Kortrijk as part of the ECO-Life project:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope:

The demonstration buildings in the Venning district replaced a neighbourhood of single-family social houses built in the 1950s. Some of the houses were demolished, while others were renovated to meet higher standards.

Building integrated renewable energy sources

Photovoltaics

ENERGY SYSTEMS INTEGRATION

Biomass boiler

District heating

The main heating generation system in the Venning district is a biomass boiler with a capacity of 950 kWth.

* The KPIs for the new and refurbished buildings are compared with the baseline of a reference building.

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**24 700 m²**
Investment	**€ 170/m²**
Final energy demand (baseline)	**162 kWh/m²/yr**
Final energy demand (after)	**106 kWh/m²/yr**
CO_2 emissions reduction	**2227 tCO_2/yr**
Energy supply	**Biomass boiler + district heating, photovoltaics**
Innovative solutions	**Smart grid**

The total investment costs for the interventions in Kortrijk are € 4 million. This includes costs for building refurbishment, building integrated renewable energy systems and energy systems integration.

The reduction of fuel costs is calculated by comparing the heat costs of the households with the heat use (for space heating and domestic hot water) of a reference building that complies with Flemish energy standards for new buildings in 2010. With such a comparison, ECO-Life calculated that the reduction of fuel costs in the ECO-Life dwellings is significant – more than € 450 per year for an average household.

The simple payback times found in the cost analysis show a large variation between the buildings included in the demonstration site, ranging from 10 to 73 years. When EU grants are considered, the payback drops to 9 for the lowest and 33 years for the highest.

The simple payback time for the total photovoltaic and heat pump system is 1 year with the EU grant and 12 years without the grant. The heat pump shows 1 year of payback compared to a reference system (in this case a condensing boiler).

ECO-Life project

ECO-Life

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The SOLUTION city Lapua is located in the South Ostrobothnia region in western Finland and has a population of approximately 14 000 inhabitants. The total area of Lapua is 751 km², of which the core city area that incorporates all of the Lapua demonstration site measures about 40 km².

Before the SOLUTION project, the core centre of the city was already equipped with a district heating system and a bio-CHP-production; building automation system provided a central access to data for city-owned buildings.

The project activities focused on the construction of 18 new buildings and the refurbishment of 1 existing building – the Niittypuisto care home.

Impact*

Overall a gross floor area of 5983 m² was newly constructed and the total refurbished area was 3174 m². As a result of the energy efficiency, the total energy consumption was reduced from an average of 160 kWh/m²/yr (business as usual) to 80 kWh/m²/yr for the renovated building, representing a decrease of 50 % in comparison to the reference building.

The total energy demand of the new buildings was calculated to be 38 kWh/m²/yr, while the figure for the reference building exceeded 60 kWh/m²/yr. This resulted in 479 MWh/yr of final energy savings for the new buildings based on the design data. With regard to the monitoring data, no savings were achieved at Niittypuisto as the occupation level and the functional status of some areas within the building changed significantly after the refurbishment. At the request of the project, this building's detailed data is not included in the present publication.

With regards to the refurbished buildings, the primary energy savings increase to 850 MWh/yr, while the CO_2 reduction amounts to 395 tonnes per year.

FACTS & FIGURES

Geographical area	**Lapua, Finland**
Demonstration area	**5983 m²**
Population in the area	**14 628 inhabitants**
Primary energy savings	**850 MWh/yr**
CO_2 emissions reduction	**395 tCO_2/yr**

Technologies

The following interventions were implemented in the new buildings in Lapua as part of the SOLUTION project:

ENERGY EFFICIENCY IN BUILDINGS

Heat pumps

ENERGY SYSTEMS INTEGRATION

District heating

Thermal collectors

Heat from the system will be used for domestic hot water and an underfloor heating system, while excess heat will be fed to the small-scale district heating network.

Geothermal cooling

Cogeneration

Wind power

Heat pump

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**5983 m²**
Final energy demand (baseline)	**160 kWh/m²/yr (business as usual)**
Final energy demand (after)	**80 kWh/m²/yr**
CO_2 emissions reduction	**395 tCO_2/yr**
Energy supply	**Heat pump, district heating, thermal collectors, geothermal cooling (cogeneration, wind power, heat pump)**

ICT

Building energy management system (BEMS):

* The KPIs for the new and refurbished buildings are compared with the baseline of a reference building.

There is a remote control for the energy management system, which monitors and analyses energy consumption, and controls the lighting and HVAC systems.

According to the design data, the annual cost savings for energy total € 621 354. Based on the poor financial data and lack of investment costs in the deliverables, the payback calculation is not possible.

Lessons learned

CHALLENGES

FINANCIAL & ECONOMIC

One of the demo sites, Ritamaki School, was dropped from the project in 2013 because achieving the requirements for this renovation would not have been economically feasible. As a result the school did not go through the renovation plans that were set to increase energy efficiency, apart from connecting the school to the district heating network.

REGULATORY & ADMINISTRATIVE

Fossil fuels are still used for district heating, which negatively affects the CO_2 emission balance within the project. This is something the team cannot influence but it does affect the project's results.

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Montieri is situated in central Italy, about 2 hours' drive from Florence. The well-preserved historical town stretches over 108 km² and has a population of 1216 people. It features a number of very old buildings with distinctive characteristics, such as stone masonry walls (filaretto natural stonework) and unusual arches and openings. These buildings are listed by the local authority as important cultural and historical symbols of Montieri. As a result, the town needed to develop innovative solutions to reduce the primary energy consumption of these buildings without carrying out major retrofitting works.

The focus of the interventions in Montieri was on the construction of a new district heating system based on geothermal energy, with a total capacity of 6 MW. Refurbishments, photovoltaic and solar thermal installations were additional measures carried out in the scope of the GEOCOM project.

Impact

Overall a gross floor area of 1986 m² was refurbished in Montieri. As a result of the energy-efficiency interventions, the energy needs were reduced from 214 kWh/m²/yr (business as usual) to 75 kWh/m²/yr.

The data provided by the project showed that the refurbishment of the buildings resulted in final energy savings amounting to 96 MWh/yr. According to SCIS calculations, the change to the energy carriers, together with the buildings' upgrade, achieved 148 MWh/yr of primary energy savings for those interventions affecting the buildings. The primary energy savings for all the interventions within the demo site increase to 4950 MWh/yr while the CO_2 reduction amounts to 3507 tonnes each year.

FACTS & FIGURES	
Geographical area	**Montieri, Italy**
Demonstration area	**1986 m²**
Population in the area	**1216 inhabitants**
Total investment	**€ 6 920 934**
Funding from EU	**ca. 30 %**
Final energy savings	**96 MWh/yr**
Primary energy savings	**4950 MWh/yr**
CO_2 emissions reduction	**3507 tCO_2/yr**

Technologies

The following interventions were implemented in Montieri as part of the GEOCOM project:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

- Retrofitting the walls
- Replacing windows and doors

Building integrated renewable energy sources

- Photovoltaics
- Thermal collectors

ENERGY SYSTEMS INTEGRATION

Deep geothermal energy

- Construction of a geothermal district heating network

ENERGY EFFICIENCY IN BUILDINGS	
Retrofitted area	**1986 m²**
Final energy demand (baseline)	**214 kWh/m²/yr**
Final energy demand (after)	**75 kWh/m²/yr**
CO_2 emissions reduction	**82 tCO_2/yr**
Energy supply	**Thermal collectors, photovoltaics, deep geothermal district heating**

The payback period calculated by SCIS for the whole demonstration site of Montieri is 28 years. Regarding just the new geothermal district heating network, the payback period exceeds 30 years. The financial analysis shows that a profitability of the project is not given due to the high investments in comparison to the low-energy cost savings. This however does not reflect non-monetary benefits that might occur during the implementation.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE The procedures of the environmental impact assessment report, including the time needed for its preparation and the duration until an agreement was met with the authorities and public consultants, was considered to be too long by the investors.	**The long payback periods require considerable public support to attract private investments for any part of the project.**
SOCIAL Significant retrofitting measures could not take place because the owners of the private properties regarded them as not cost-effective compared to the new geothermal district network.	**The energy-demand target to be reached by the retrofitting measures had to be reduced to gain acceptance amongst the buildings' owners. In addition, the local administration had committed to implementing an extensive energy renovation on one or more of the public buildings in the Montieri municipality if the penetration of retrofitting measures on private buildings proved to be low.**

CHALLENGES

FINANCIAL & ECONOMIC

Efforts by the municipality to promote energy-retrofitting measures had little impact. GEOCOM funding could not be combined with national incentives for retrofitting works, which made promoting those measures and their profitability more difficult. One additional financial solution found was the funding of solar thermal applications outside the area of the geothermal network in order to increase the use of renewable energy sources, but private investment was difficult to attract for such measures.

The projects produced a considerable number of benefits, particularly from the geothermal sources for citizens. However, it is unclear to what extent such benefits can be transformed into a clear monetised value that citizens would be willing and able to cover.

REGULATORY & ADMINISTRATIVE

The main challenges were the civil works in the narrow streets of the historic town centre and all the related interferences (structural damage and modification of building foundations, temporary blocking of entrances, placement of geothermal pipework equipment). As the municipality had to renovate other infrastructures at the same time there was an increased administrative and coordination effort.

BEST PRACTICES

SOCIAL

With regard to geothermal energy use it was favourable that no new boreholes had to be drilled. Consequently, concerns about the risk of water and soil contamination among the general population could be avoided.

GEOCOM

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GEOCOM

Mórahalom is a small community in Hungary known for its thermal baths. The balneological use of geothermal wells has a long tradition. A study from 2007 states that '87 % of the municipality's energy use is based on natural gas which translates into 59 % of all annual municipal costs'. Based on these findings with innovation potential, the integration of renewable energy sources, and in particular geothermal heating and electricity generation, took centre stage in the town's strategy and vision.

One of the specific developments that reflected this was the GEOCOM project, launched in 2010 with the objective to increase the visibility of direct heat applications of geothermal energy throughout Europe. The demonstration site in Mórahalom consisted of two refurbished buildings (an elementary school and kindergarten) that included an increase in the net heated area after the project implementation, two cogeneration facilities using free waste gas from geothermal wells for electricity and thermal energy generation, and public street lighting.

Impact

The total area covered in Mórahalom within the GEOCOM project is 11 275 m^2. The implemented measures and mainly the cogeneration resulted in a reduction of the final energy demand of the site by 105 MWh per year. This is especially important since the project activities in fact increased the net heated area.

The street lighting system consumed 30 MWh/yr of grid electricity in 2013 before the renovation took place. In 2015 after the renovation, 93 % of the electricity was provided from a photovoltaic system, and due to the increase in efficiency the final energy consumption dropped by 57 % to 13 MWh/yr.

Due to the increased net heating area, there was an increase in the final energy demand for the buildings. However, the deployment of cogeneration combined with geothermal energy led to a total primary energy decrease for the buildings of 120 MWh/yr.

According to SCIS calculations based on energy monitoring data and the respective emission factors available, the primary energy savings go up to 650 MWh/yr while the CO_2 reduction amounts to 167 tonnes every year for the whole demo site.

FACTS & FIGURES

Geographical area	**Mórahalom, Hungary**
Demonstration area	**11 275 m^2 (6103 m^2 refurbished buildings)**
Population in the area	**5800 inhabitants**
Total investment	**€ 924 348**
Funding from EU	**€ 308 116 (30 %)**
Primary energy savings	**650 MWh/yr**
CO_2 emissions reduction	**167 tCO_2/yr**

Technologies

The implemented measures in Mórahalom include:

ENERGY EFFICIENCY IN BUILDINGS

Retrofitting the building envelope

Replacement of windows and doors

Building integrated renewable energy sources

Photovoltaic installations on roofs (36 kWp for elementary school, 9.6 kWp for kindergarten)

Thermal collectors (81.2 m^2 for elementary school, 40.6 m^2 for kindergarten) for domestic hot water, including preheating water for kitchen services in educational institutions

Switch from natural gas boilers to district heating network

Building services (HVAC and lighting):

Optimised street lighting powered by photovoltaics

Heat pumps

Additional heating energy once new consumers are available.

ENERGY SYSTEMS INTEGRATION

Deep geothermal energy combined with CHP:

The goal of the heat pump operation is to use the return water from the primary thermal circle of the geothermal system with a temperature of 40 °C in a low-energy system, cooling the water to 20 °C before re-injection. The approximate electrical demand of the heat pumps is 90 kW.

Cogeneration (CHP)

Use of free waste gas from geothermal wells for electricity and thermal energy production at two CHP plants.

ENERGY EFFICIENCY IN BUILDINGS

Retrofitted area	**6103 m²**
CO_2 emissions reduction	**167 tCO_2/yr**
Energy supply	**Solar thermal, photovoltaic, deep geothermal energy, heat pump, cogeneration (CHP)**

The investment cost for the intervention was a total of € 924 348. Based on the data available, the SCIS financial assessment shows that the costs saved by the interventions amount to € 116 070. As a result, the payback period is calculated to be 16 years for all the implemented measures. The results for the individual interventions show that there is no feasible payback period for the refurbishment and street lighting interventions, while the payback period for the energy system integration is 3 years.

Lessons learned

BARRIER	SOLUTION
FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE There are a number of risks linked to geothermal energy system operations that may have an impact on the environment: • exploitation of geothermal wells can lead to a drawdown of groundwater; • drilling operations can lead to freshwater hazards and well blowouts; • as part of the operation of geothermal systems, solved solids and geothermal brine are brought to the surface water.	**This can be resolved by re-injecting groundwater after the thermal energy is transferred. There are already examples of injection techniques applied in Hungary to reduce the risks. Furthermore, an injection of geothermal fluid is neither financially incentivised, nor legally obligatory. The establishment of an overarching national policy on injection as part of a sustainable operation of geothermal systems is advised. Injection would also replace expensive and complex water treatment processes.**
SOCIAL The biggest barrier was the dependence on fossil fuels in the form of natural gas, which, coupled with a lack of awareness about alternative energy sources, led to a resistance to change.	**A great deal of consultation and planning was required before the first geothermal energy system was operational in 2011. Once finished, it not only saved costs for additional interventions, but also served as a best practice example for industry and tourism.**

CHALLENGES

FINANCIAL & ECONOMIC, SOCIAL

One of the interventions at the demonstration site in Mórahalom is the installation of a heat pump to further increase the independence from natural gas as the main energy carrier. According to the project partners, the heat pump will not be running at full capacity for a few years due to the rather warm winters recently and the smaller energy demand. Further residential building construction is planned, thus providing potential consumers in the future. Nevertheless, the maintenance of the heat pump is currently causing unintended annual expenditures. On the other hand, a heat pump system coupled with geothermal water use is an innovative approach with a possible high-efficiency level. Currently, this kind of system configuration can neither be found in Hungary nor elsewhere in central eastern Europe.

REGULATORY & ADMINISTRATIVE

Regulatory barriers in relation to fiscal policy include the increase and yearly fluctuation of water fees, as well as the preference to use geothermal water for medicinal rather than energy purposes, according to the Ministry of Environmental and Water Conservation Affairs.

FINANCIAL & ECONOMIC, REGULATORY & ADMINISTRATIVE

Financial barriers to the introduction of additional uses of geothermal energy are the weak Hungarian economy caused by global economic recession, an unstable legal environment concerning land concessions and energy policy, and missing sector-specific financial measures. A difficulty arises with the fact that if the geothermal system is set up in a sustainable way, including injection wells, the drilling costs are higher compared to a business-as-usual situation, which can reduce the value for investors.

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GEOCOM

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Technologies

ENERGY EFFICIENCY IN BUILDINGS

City | Project	Retrofitting of the building envelope	High-performance new buildings	Building services (HVAC and lighting)	Small energy storage	Building integrated renewable energy sources	Heat pumps
Smart Cities & Communities Lighthouse projects						
Barcelona, Spain | GrowSmarter	●		●			●
Bristol, United Kingdom | REPLICATE	●					
Cologne, Germany | GrowSmarter	●		●			●
Eindhoven, the Netherlands | TRIANGULUM	●		●		●	
Florence, Italy | REPLICATE	●					
Lisbon, Portugal | Sharing Cities	●	●				
London, United Kingdom | Sharing Cities	●	●				
Lyon, France | SMARTER TOGETHER	●					
Manchester, United Kingdom | TRIANGULUM				●	●	
Milan, Italy | Sharing Cities	●					
Munich, Germany | SMARTER TOGETHER	●					
Nottingham, United Kingdom | REMOURBAN	●					
San Sebastian, Spain | REPLICATE	●					
Sonderborg, Denmark | SmartEnCity	●					●
Stavanger, Norway | TRIANGULUM						
Stockholm, Sweden | GrowSmarter	●		●			●
Tartu, Estonia | SmartEnCity	●					
Tepebaşı, Turkey | REMOURBAN	●					
Valladolid, Spain | REMOURBAN	●				●	
Vienna, Austria | SMARTER TOGETHER	●		●			
Vitoria-Gasteiz, Spain | SmartEnCity	●					

City | Project	Retrofitting of the building envelope	High-performance new buildings	Building services (HVAC and lighting)	Small energy storage	Building integrated renewable energy sources	Heat pumps
Demonstration of very low-energy new buildings						
Amsterdam, the Netherlands | NEXT-BUILDINGS	●	●	●		●	
Bilbao, Spain | BUILDSMART	●					
Helsingborg, Sweden | NEXT-BUILDINGS		●			●	
Istanbul, Turkey | NEED4B	●				●	
Lecce, Italy | NEED4B	●				●	●
Ljubljana, Slovenia | EE-HIGHRISE		●			●	
Lyon, France | NEXT-BUILDINGS		●				
Malmö, Sweden | BUILDSMART		●	●		●	●
Munich, Germany | DIRECTION		●	●		●	
Stambruges, Belgium | NEED4B		●			●	
Valladolid, Spain | DIRECTION		●			●	●
Borås & Varberg, Sweden | NEED4B		●	●		●	
Demonstration of optimised energy systems for high performance-energy districts						
Aarhus, Denmark | READY	●					
Amsterdam, the Netherlands | CITY-zen	●					
Bolzano, Italy | SINFONIA	●				●	
Grenoble, France | CITY-zen	●	●				
Innsbruck, Austria | SINFONIA	●				●	●
Laguna de Duero, Spain | CITyFiED	●					
Lund, Sweden | CITyFiED	●		●			
Soma, Turkey | CITyFiED	●					
Växjö, Sweden | READY	●			●		

ENERGY EFFICIENCY IN BUILDINGS

City | Project	Retrofitting of the building envelope	High-performance new buildings	Building services (HVAC and lighting)	Small energy storage	Building integrated renewable energy sources	Heat pumps
Demonstration of nearly zero-energy building renovation for cities and districts						
Aachen, Germany | EU-GUGLE	●		●			
Alingsås, Sweden | BEEM-UP	●		●		●	
Augsburg, Germany | E2REBUILD	●		●			
Ballerup, Denmark | SCHOOL OF THE FUTURE	●		●		●	
Bratislava, Slovakia | EU-GUGLE	●		●			●
Cesena, Italy | SCHOOL OF THE FUTURE	●		●		●	
Delft, The Netherlands | BEEM-UP	●		●			
Drammen, Norway | SCHOOL OF THE FUTURE	●					
Eibar, Spain | ZENN	●		●			
Genoa, Italy | R2CITIES	●		●			
Halmstad, Sweden | E2REBUILD	●		●			●
Istanbul, Turkey | R2CITIES	●		●		●	
Milan, Italy | EU-GUGLE	●		●		●	
Munich, Germany | E2REBUILD	●		●			
Oslo, Norway | ZENN	●		●			
Oulo, Finland | E2REBUILD	●		●			
Paris, France | BEEM-UP	●		●		●	
Roosendaal, the Netherlands | E2REBUILD	●		●			
Sestao, Spain | EU-GUGLE	●		●			
Stuttgart, Germany | SCHOOL OF THE FUTURE	●		●		●	
Tampere, Finland | EU-GUGLE	●		●			●
Valladolid, Spain | R2CITIES	●		●			
Vienna, Austria | EU-GUGLE	●				●	
Voiron, France | E2REBUILD	●		●			

City | Project	Retrofitting of the building envelope	High-performance new buildings	Building services (HVAC and lighting)	Small energy storage	Building integrated renewable energy sources	Heat pumps
Large-scale energy systems for urban heating and cooling						
Brescia, Italy | PITAGORAS						
Cologne, Germany | CELSIUS						
Genoa, Italy | CELSIUS						
Gothenburg, Sweden | CELSIUS				●		
London, United Kingdom | CELSIUS						
Rotterdam, the Netherlands | CELSIUS						
Sustainable energy solutions: the CONCERTO communities						
Cernier, Switzerland | SOLUTION	●		●		●	●
Galanta, Slovakia | GEOCOM	●				●	
Hartberg, Austria | SOLUTION						●
Høje-Taastrup, Denmark | ECO-Life	●	●	●		●	●
Hvar, Croatia | SOLUTION	●				●	
Kortrijk, Belgium | ECO-Life	●				●	
Lapua, Finland | SOLUTION						●
Montieri, Italy | GEOCOM	●				●	
Mórahalom, Hungary | GEOCOM	●		●		●	●

ENERGY SYSTEMS INTEGRATION

City | Project	District heating and cooling	Large-scale storage	Biomass boilers	Co-generation (CHP)	Poly-generation	Thermal storage
Smart Cities & Communities Lighthouse projects						
Barcelona, Spain | GrowSmarter	●					
Bristol, United Kingdom | REPLICATE	●		●			
Cologne, Germany | GrowSmarter	●					
Eindhoven, the Netherlands | TRIANGULUM						
Florence, Italy | REPLICATE	●					●
Lisbon, Portugal | Sharing Cities						
London, United Kingdom | Sharing Cities						
Lyon, France | SMARTER TOGETHER	●			●		
Manchester, United Kingdom | TRIANGULUM						
Milan, Italy | Sharing Cities						
Munich, Germany | SMARTER TOGETHER	●					
Nottingham, United Kingdom | REMOURBAN	●			●		
San Sebastian, Spain | REPLICATE	●		●			
Sonderborg, Denmark | SmartEnCity	●					
Stavanger, Norway | TRIANGULUM	●					
Stockholm, Sweden | GrowSmarter	●					
Tartu, Estonia | SmartEnCity	●					
Tepebaşı, Turkey | REMOURBAN	●		●			
Valladolid, Spain | REMOURBAN	●		●			
Vienna, Austria | SMARTER TOGETHER	●					●
Vitoria-Gasteiz, Spain | SmartEnCity			●			

Electrical energy storage	Photo-voltaics	Wind turbine	Thermal collectors	Deep geo-thermal energy	Near-to-surface geo-thermal energy	Smart street lighting	Waste heat recovery	Waste-to-energy
●						●	●	
	●					●		
	●							
	●	●				●		
						●		
						●		
						●		
	●							
						●		
					●	●		
	●						●	●
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	●	●	●					
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						●	●	
●	●		●			●		
	●							
	●		●			●	●	

ENERGY SYSTEMS INTEGRATION

City | Project	District heating and cooling	Large-scale storage	Biomass boilers	Co-generation (CHP)	Poly-generation	Thermal storage
Demonstration of very low-energy new buildings						
Amsterdam, the Netherlands | NEXT-BUILDINGS	●					
Bilbao, Spain | BUILDSMART						
Helsingborg, Sweden | NEXT-BUILDINGS	●					
Istanbul, Turkey | NEED4B						
Lecce, Italy | NEED4B						
Ljubljana, Slovenia | EE-HIGHRISE	●					
Lyon, France | NEXT-BUILDINGS				●		●
Malmö, Sweden | BUILDSMART						●
Munich, Germany | DIRECTION	●					
Stambruges, Belgium | NEED4B						
Valladolid, Spain | DIRECTION			●			
Borås & Varberg, Sweden | NEED4B						
Demonstration of optimised energy systems for high performance-energy districts						
Aarhus, Denmark | READY	●					
Amsterdam, the Netherlands | CITY-zen	●	●				
Bolzano, Italy | SINFONIA	●			●		
Grenoble, France | CITY-zen	●					●
Innsbruck, Austria | SINFONIA	●				●	
Laguna de Duero, Spain | CITyFiED	●		●	●		
Lund, Sweden | CITyFiED	●					
Soma, Turkey | CITyFiED	●					●
Växjö, Sweden | READY	●					

Electrical energy storage	Photo-voltaics	Wind turbine	Thermal collectors	Deep geo-thermal energy	Near-to-surface geo-thermal energy	Smart street lighting	Waste heat recovery	Waste-to-energy
	●		●				●	
			●					
							●	
●	●							●
			●	●				
			●	●	●			
●	●		●				●	
								●
							●	
							●	
							●	
	●						●	
							●	

ENERGY SYSTEMS INTEGRATION

City | Project	District heating and cooling	Large-scale storage	Biomass boilers	Co-generation (CHP)	Poly-generation	Thermal storage
Demonstration of nearly zero-energy building renovation for cities and districts						
Aachen, Germany | EU-GUGLE	●					
Alingsås, Sweden | BEEM-UP						
Augsburg, Germany | E2REBUILD						
Ballerup, Denmark | SCHOOL OF THE FUTURE	●					
Bratislava, Slovakia | EU-GUGLE				●		
Cesena, Italy | SCHOOL OF THE FUTURE						
Delft, The Netherlands | BEEM-UP						
Drammen, Norway | SCHOOL OF THE FUTURE						
Eibar, Spain | ZENN						
Genoa, Italy | R2CITIES						
Halmstad, Sweden | E2REBUILD						
Istanbul, Turkey | R2CITIES	●					
Milan, Italy | EU-GUGLE	●					
Munich, Germany | E2REBUILD				●		
Oslo, Norway | ZENN	●					
Oulo, Finland | E2REBUILD	●					
Paris, France | BEEM-UP						
Roosendaal, the Netherlands | E2REBUILD						
Sestao, Spain | EU-GUGLE			●			
Stuttgart, Germany | SCHOOL OF THE FUTURE				●		
Tampere, Finland | EU-GUGLE	●					
Valladolid, Spain | R2CITIES						
Vienna, Austria | EU-GUGLE	●					
Voiron, France | E2REBUILD						

Electrical energy storage	Photo-voltaics	Wind turbine	Thermal collectors	Deep geo-thermal energy	Near-to-surface geo-thermal energy	Smart street lighting	Waste heat recovery	Waste-to-energy
			●				●	
	●		●					
			●					
					●			
	●							
			●					
	●							
			●					
			●					
			●				●	
			●					
	●		●					
			●					

ENERGY SYSTEMS INTEGRATION

City | Project	District heating and cooling	Large-scale storage	Biomass boilers	Co-generation (CHP)	Poly-generation	Thermal storage
Large-scale energy systems for urban heating and cooling						
Brescia, Italy | PITAGORAS	●				●	
Cologne, Germany | CELSIUS	●					
Genoa, Italy | CELSIUS				●		
Gothenburg, Sweden | CELSIUS	●	●				
London, United Kingdom | CELSIUS	●					
Rotterdam, the Netherlands | CELSIUS	●	●		●		●
Sustainable energy solutions: the CONCERTO communities						
Cernier, Switzerland | SOLUTION	●		●	●		
Galanta, Slovakia | GEOCOM	●					
Hartberg, Austria | SOLUTION	●		●	●		
Høje-Taastrup, Denmark | ECO-Life						
Hvar, Croatia | SOLUTION						
Kortrijk, Belgium | ECO-Life	●		●			
Lapua, Finland | SOLUTION	●					
Montieri, Italy | GEOCOM						
Mórahalom, Hungary | GEOCOM				●		

Electrical energy storage	Photo-voltaics	Wind turbine	Thermal collectors	Deep geo-thermal energy	Near-to-surface geo-thermal energy	Smart street lighting	Waste heat recovery	Waste-to-energy
							●	●
							●	
								●
							●	
							●	
							●	
			●			●		
	●		●					
	●	●	●					
			●					●
			●					
				●				
				●				

MOBILITY & TRANSPORT

City | Project	Clean fuels and fuelling infra-structure	Electric, hybrid and clean vehicles	Car-pooling	Car sharing	Bycicle infra-structure	Inter-modality	Urban freight logistics
Smart Cities & Communities Lighthouse projects							
Barcelona, Spain | GrowSmarter	●			●	●		●
Bristol, United Kingdom | REPLICATE	●	●					
Cologne, Germany | GrowSmarter	●	●		●	●		
Eindhoven, the Netherlands | TRIANGULUM	●						
Florence, Italy | REPLICATE	●						
Lisbon, Portugal | Sharing Cities	●	●					
London, United Kingdom | Sharing Cities	●						
Lyon, France | SMARTER TOGETHER	●	●		●			
Manchester, United Kingdom | TRIANGULUM	●	●			●		
Milan, Italy | Sharing Cities	●	●		●			
Munich, Germany | SMARTER TOGETHER	●	●		●			
Nottingham, United Kingdom | REMOURBAN	●	●					●
San Sebastian, Spain | REPLICATE		●					
Sonderborg, Denmark | SmartEnCity	●	●					
Stavanger, Norway | TRIANGULUM	●	●					
Stockholm, Sweden | GrowSmarter	●	●		●	●		●
Tartu, Estonia | SmartEnCity	●	●		●			
Tepebaşı, Turkey | REMOURBAN	●	●			●	●	
Valladolid, Spain | REMOURBAN	●	●				●	
Vienna, Austria | SMARTER TOGETHER		●		●	●		
Vitoria-Gasteiz, Spain | SmartEnCity	●	●					

City | Project	Clean fuels and fuelling infra-structure	Electric, hybrid and clean vehicles	Car-pooling	Car sharing	Bycicle infra-structure	Inter-modality	Urban freight logistics
Demonstration of optimised energy systems for high performance-energy districts							
Aarhus, Denmark | READY	●	●		●		●	
Amsterdam, the Netherlands | CITY-zen	●	●					
Bolzano, Italy | SINFONIA	●						
Grenoble, France | CITY-zen							
Innsbruck, Austria | SINFONIA							
Laguna de Duero, Spain | CITyFiED							
Lund, Sweden | CITyFiED	●						
Soma, Turkey | CITyFiED							
Växjö, Sweden | READY	●	●	●				

ICT

City | Project	Building energy management system	Neigh-bourhood energy management system	Urban data platform	Traffic control system	Travel demand management
Smart Cities & Communities Lighthouse projects					
Barcelona, Spain | GrowSmarter	●		●	●	●
Bristol, United Kingdom | REPLICATE		●	●		●
Cologne, Germany | GrowSmarter	●		●		
Eindhoven, the Netherlands | TRIANGULUM			●	●	
Florence, Italy | REPLICATE			●		
Lisbon, Portugal | Sharing Cities			●	●	
London, United Kingdom | Sharing Cities					
Lyon, France | SMARTER TOGETHER	●	●	●		
Manchester, United Kingdom | TRIANGULUM	●		●		
Milan, Italy | Sharing Cities					
Munich, Germany | SMARTER TOGETHER			●		
Nottingham, United Kingdom | REMOURBAN	●			●	
San Sebastian, Spain | REPLICATE	●		●		●
Sonderborg, Denmark | SmartEnCity					
Stavanger, Norway | TRIANGULUM			●		
Stockholm, Sweden | GrowSmarter	●		●	●	
Tartu, Estonia | SmartEnCity					
Tepebaşı, Turkey | REMOURBAN	●	●	●		
Valladolid, Spain | REMOURBAN	●	●	●		
Vienna, Austria | SMARTER TOGETHER			●		
Vitoria-Gasteiz, Spain | SmartEnCity	●	●			

Demand response	Smart electricity grid	ICT as planning support	Mobile applications for citizens	Smart district heating and cooling grids – demand	Strategic urban planning
		●			
	●		●		●
●		●			
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		●			
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			●		●
			●	●	

ICT

City | Project	Building energy management system	Neigh-bourhood energy management system	Urban data platform	Traffic control system	Travel demand management
Demonstration of very low-energy new buildings					
Amsterdam, the Netherlands | NEXT-BUILDINGS	●				
Bilbao, Spain | BUILDSMART	●				
Helsingborg, Sweden | NEXT-BUILDINGS	●				
Istanbul, Turkey | NEED4B	●				
Lecce, Italy | NEED4B	●				
Ljubljana, Slovenia | EE-HIGHRISE	●				
Lyon, France | NEXT-BUILDINGS	●				
Malmö, Sweden | BUILDSMART	●				
Munich, Germany | DIRECTION					
Stambruges, Belgium | NEED4B	●				
Valladolid, Spain | DIRECTION	●				
Borås & Varberg, Sweden | NEED4B					
Demonstration of optimised energy systems for high performance-energy districts					
Aarhus, Denmark | READY					
Amsterdam, the Naetherlands | CITY-zen					
Bolzano, Italy | SINFONIA					
Grenoble, France | CITY-zen		●			
Innsbruck, Austria | SINFONIA					
Laguna de Duero, Spain | CITyFiED		●			
Lund, Sweden | CITyFiED	●				
Soma, Turkey | CITyFiED	●				
Växjö, Sweden | READY		●	●		

Demand response	Smart electricity grid	ICT as planning support	Mobile applications for citizens	Smart district heating and cooling grids – demand	Strategic urban planning
			●		
	●				
	●	●			
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	●				

ICT

City | Project	Building energy management system	Neigh-bourhood energy management system	Urban data platform	Traffic control system	Travel demand management
Demonstration of nearly zero-energy building renovation for cities and districts					
Aachen, Germany | EU-GUGLE	●				
Alingsås, Sweden | BEEM-UP	●				
Augsburg, Germany | E2REBUILD					
Ballerup, Denmark | SCHOOL OF THE FUTURE					
Bratislava, Slovakia | EU-GUGLE	●				
Cesena, Italy | SCHOOL OF THE FUTURE					
Delft, The Netherlands | BEEM-UP	●				
Drammen, Norway | SCHOOL OF THE FUTURE					
Eibar, Spain | ZENN					
Genoa, Italy | R2CITIES					
Halmstad, Sweden | E2REBUILD					
Istanbul, Turkey | R2CITIES					
Milan, Italy | EU-GUGLE	●				
Munich, Germany | E2REBUILD					
Oslo, Norway | ZENN	●				
Oulo, Finland | E2REBUILD					
Paris, France | BEEM-UP	●				
Roosendaal, the Netherlands | E2REBUILD					
Sestao, Spain | EU-GUGLE	●				
Stuttgart, Germany | SCHOOL OF THE FUTURE	●				
Tampere, Finland | EU-GUGLE	●				
Valladolid, Spain | R2CITIES	●				
Vienna, Austria | EU-GUGLE	●				
Voiron, France | E2REBUILD					

Demand response	Smart electricity grid	ICT as planning support	Mobile applications for citizens	Smart district heating and cooling grids – demand	Strategic urban planning
	●				
	●				
	●				
●		●			
		●			

ICT

City | Project	Building energy management system	Neigh-bourood energy management system	Urban data platform	Traffic control system	Travel demand management
Large-scale energy systems for urban heating and cooling					
Brescia, Italy | PITAGORAS					
Cologne, Germany | CELSIUS					
Genoa, Italy | CELSIUS					
Gothenburg, Sweden | CELSIUS					
London, United Kingdom | CELSIUS					
Rotterdam, the Netherlands | CELSIUS					
Sustainable energy solutions: the CONCERTO communities					
Cernier, Switzerland | SOLUTION					
Galanta, Slovakia | GEOCOM					
Hartberg, Austria | SOLUTION	●				
Høje-Taastrup, Denmark | ECO-Life					
Hvar, Croatia | SOLUTION					
Kortrijk, Belgium | ECO-Life					
Lapua, Finland | SOLUTION	●				
Montieri, Italy | GEOCOM					
Mórahalom, Hungary | GEOCOM					

Demand response	Smart electricity grid	ICT as planning support	Mobile applications for citizens	Smart district heating and cooling grids – demand	Strategic urban planning
●					
●					
●					

Investment

Co-funded by the Horizon 2020 Research and Innovation Programme of the European Union		
PROJECT	**TOTAL INVESTMENT**	**FUNDING BY EU**
SMART CITIES & COMMUNITIES LIGHTHOUSE PROJECTS		
GrowSmarter	€ 34 846 533	€ 24 820 974
REMOURBAN	€ 24 793 451	€ 21 541 949
REPLICATE	€ 29 250 564	€ 24 965 263
Sharing Cities	€ 28 068 094	€ 24 753 945
SmartEnCity	€ 32 201 606	€ 27 890 139
SMARTER TOGETHER	€ 29 119 448	€ 24 742 978
TRIANGULUM	€ 29 501 431	€ 25 420 602

Co-funded by the 7th Framework Programme for Research of the European Union		
PROJECT	**TOTAL INVESTMENT**	**FUNDING BY EU**
STRATEGIC SUSTAINABLE CITY PLANNING		
InSMART	€ 2 629 866	€ 2 145 450
PLEEC	€ 4 490 718	€ 3 827 064
STEEP	€ 2 622 651	€ 2 197 398
STEP-UP	€ 4 641 595	€ 3 749 593
TRANSFORM	€ 7 186 700	€ 5 611 852
DEMONSTRATION OF VERY LOW-ENERGY NEW BUILDINGS		
BUILDSMART	€ 6 704 255	€ 4 074 580
DIRECTION	€ 6 958 677	€ 4 369 546
EE-HIGHRISE	€ 3 245 535	€ 2 193 504
NEED4B	€ 9 383 504	€ 5 681 652
NEXT-BUILDINGS	€ 8 462 118	€ 4 963 808
DEMONSTRATION OF OPTIMISED ENERGY SYSTEMS FOR HIGH PERFORMANCE-ENERGY DISTRICTS		
CITyFiED	€ 46 038 298	€ 25 828 319
City-zen	€ 41 163 736	€ 25 189 520
READY	€ 33 340 203	€ 19 213 448
SINFONIA	€ 43 845 296	€ 27 908 272
DEMONSTRATION OF NEARLY ZERO-ENERGY BUILDING RENOVATION FOR CITIES AND DISTRICTS		
BEEM-UP	€ 7 675 483	€ 4 858 848
E2REBUILD	€ 7 843 339	€ 4 716 490
EU-GUGLE	€ 26 389 085	€ 15 257 775
R2CITIES	€ 14 681 501	€ 9 011 331
SCHOOL OF THE FUTURE	€ 4 974 936	€ 3 473 360
ZENN	€ 12 946 255	€ 8 163 069
LARGE-SCALE ENERGY SYSTEMS FOR URBAN HEATING AND COOLING		
CELSIUS	€ 25 630 496	€ 14 074 931
PITAGORAS	€ 9 145 179	€ 5 871 455
SUSTAINABLE ENERGY SOLUTIONS: THE CONCERTO COMMUNITIES		
ECO-Life	€ 22 052 705	€ 12 255 646
GEOCOM	€ 14 276 124	€ 3 513 704
SOLUTION	€ 20 560 606	€ 11 235 627

Timeline

Co-funded by the Horizon 2020 Research and Innovation Programme of the European Union

PROJECT — 2009 · 2011 · 2013 · 2015 · 2017 · 2019 · 2021

PROJECT		
SMART CITIES & COMMUNITIES LIGHTHOUSE PROJECTS		
GrowSmarter	01/15	12/19
REMOURBAN	01/15	12/19
REPLICATE	02/16	01/21
Sharing Cities	01/16	12/20
SmartEnCity	02/16	07/21
SMARTER TOGETHER	02/16	01/21
TRIANGULUM	02/15	01/20

Co-funded by the 7th Framework Programme for Research of the European Union

PROJECT — 2009 · 2011 · 2013 · 2015 · 2017 · 2019 · 2021

PROJECT		
STRATEGIC SUSTAINABLE CITY PLANNING		
InSMART	12/13	03/17
PLEEC	04/13	03/16
STEEP	10/13	09/15
STEP-UP	11/12	07/15
TRANSFORM	01/13	06/15
DEMONSTRATION OF VERY LOW-ENERGY NEW BUILDINGS		
BUILDSMART	12/11	11/16
DIRECTION	01/12	03/16
EE-HIGHRISE	01/13	04/16
NEED4B	02/12	01/18
NEXT-BUILDINGS	01/12	12/17
DEMONSTRATION OF OPTIMISED ENERGY SYSTEMS FOR HIGH PERFORMANCE-ENERGY DISTRICTS		
CITyFiED	04/14	03/19
City-zen	03/14	02/19
READY	12/14	11/19
SINFONIA	06/14	05/19
DEMONSTRATION OF NEARLY ZERO-ENERGY BUILDING RENOVATION FOR CITIES AND DISTRICTS		
BEEM-UP	01/11	12/14
E2REBUILD	01/11	06/14
EU-GUGLE	04/13	03/19
R2CITIES	07/13	06/18
SCHOOL OF THE FUTURE	02/11	01/16
ZENN	03/13	10/17
LARGE-SCALE ENERGY SYSTEMS FOR URBAN HEATING AND COOLING		
CELSIUS	04/13	12/17
PITAGORAS	11/13	10/17
SUSTAINABLE ENERGY SOLUTIONS: THE CONCERTO COMMUNITIES		
ECO-Life	12/09	06/16
GEOCOM	01/10	12/15
SOLUTION	11/09	11/14

Conclusion

In this publication, the Smart Cities Information System has gathered together the best practices from over 80 cities from across 19 countries. From Norway to Slovakia, from Hungary to Turkey, these projects showcase how forward thinking on a grand scale can introduce technological advancements not only to buildings, but also entire communities. The cities presented here are using innovation to encourage wiser energy use and to pave the way forward to smarter and better cities for their citizens.

We highlight the success stories and the challenges that these cities encounter. Their story is told through the technological focus in energy, mobility and transport and ICT emphasised by the impact the projects have had on their communities. Importantly, we also present the economic barriers, legal challenges and social issues that these cities may have faced, at the same time offering solutions and lessons learned from their experiences.

Successful replication means meeting the challenges of finding suitable financing and coming up with innovative business models to create a project with strong impact and meaningful results. European countries differ in their climates, regulations and cultures, so the experience of one city will not necessarily custom-fit another, but by presenting projects from a wide range of countries and sectors, we believe we offer the widest possible collection of replication opportunities to assist future project managers, technical experts and urban planners in this task.

The transformation of energy use is as **Dominique Ristori, Director General of the European Commission for Energy** points out 'a collective movement built by big and small changes'. We hope that this publication inspires and supports you on this quest for change.

'Empowering smart solutions for better cities' is the motto of SCIS and lies at the heart of our ambition of creating a more secure and sustainable energy sector in Europe.

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