REPLICABLE RETROFITTING FOR CITYFIED LINERO DEMONSTRATOR IN LUND, SWEDEN

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ABSTRACT

The overall objective of EU funded CITyFiED (repliCable and InnovaTive Future Efficient Districts and cities) project is to develop a replicable, systemic and integrated strategy to adapt European cities and urban ecosystems into the smart city of the future, focusing on reducing the energy demand and GHG emissions and increasing the use of renewable energy sources by developing and implementing innovative technologies and methodologies for building renovation, smart grid and district heating networks and their interfaces with ICTs and Mobility. One of the most important goals of this project is the development of a deep retrofitting of the buildings and innovative district heating solutions in three large scale demonstrations at Laguna-Valladolid (Spain), Soma (Turkey) and Lund (Sweden) in order to achieve powerful models suitable for replication across Europe.

This paper presents the wide intervention that will be carried out in the Linero district (Lund), which aims to reduce drastically the energy consumption and CO^2 emissions by means of passive and active measures on building and district scale. Energy conservation measures on building level will be based mainly on the retrofitting of the façade, changing of windows and heat recovery from ventilation. The interventions on district scale involve the implementation of advanced control and distribution systems, such as a smart grid for electricity and smart distribution of district heating. Finally, the tenants' energy use and the environmental impact are analyzed by means of real time visualization of energy consumption. The overall impact will be further enhanced by the integration of renewable energy from multiple production units to the large scale district heating network that heats the buildings in Linero. This includes solar energy, wind energy, biomass, geothermal heat as well as residual heat from industries for example the new research facilities in Lund, European Spallation Source (ESS) and Max IV-laboratory)

The paper also presents a model that has been developed in the CITyFiED project in order to evaluate the replication potential of the CITyFiED measures that will be deployed in 11 European cities. The model consists of three parts, energy simulation, semi-strucutred interviews for the identification of non-technological barriers and suggestion of new business models. The purpose of the model is to provide innovative, affordable solutions that are effective to address the current technical, financial, social and organizational challenges that exist in respective city.

Key words: retrofitting, district heating, smart grid, renewables, visualisation, replication

INTRODUCTION

The overall objective of EU funded CITyFiED (repliCable and InnovaTive Future Efficient Districts and cities) project is to develop a replicable, systemic and integrated strategy to adapt European cities and urban ecosystems into the smart city of the future, focusing on reducing the energy demand and GHG emissions and increasing the use of renewable energy sources by developing and implementing innovative technologies and methodologies for building renovation, smart grid and district heating networks and their interfaces with ICTs and Mobility. One of the most important goals of this project is the development of a deep retrofitting of the buildings and innovative district heating solutions in three large scale demonstrations at Laguna-Valladolid (Spain), Soma (Turkey) and Lund (Sweden) in order to achieve powerful models suitable for replication across Europe.

LINERO, A SWEDISH HOUSING DISTRICT IN NEED OF RETROFITTING

Lund is a medium-sized university city (115.000 inhabitants) 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 stock of buildings from the 1960s and 1970s now needs retrofitting. Almost 90% of the heat demand is supplied by the district heating network which has a large share of renewables.

The district of Linero is found in the eastern part of Lund. Over the next few years the district is going to undergo major changes. Lunds kommunala fastighetsbolag, LKF, is currently constructing six new tower blocks with 24 flats in each. At the same time the square in the centre of Linero is being refurbished, with new shops and offices, a supermarket and two new tower blocks with 94 flats. The final phase of the district refurbishment of Linero is the renovation of the Eddan and Havamal properties. The area consists of 28 three storey building with an area 71 258 m^2 $A_{temp.}$. Today there are approximately 2,000 tenants in the area, with 681 flats owned and managed by LKF. The road Vikingavägen divides this residential area into two by a road, Havamal in the north and Eddan in the south. Of the 28 buildings in the area only 16, with an area of 40 400m^2 A_{temp}, are included in the CITyFiED project. This includes the urban block Eddan and two buildings in the urban block Havamal [1].

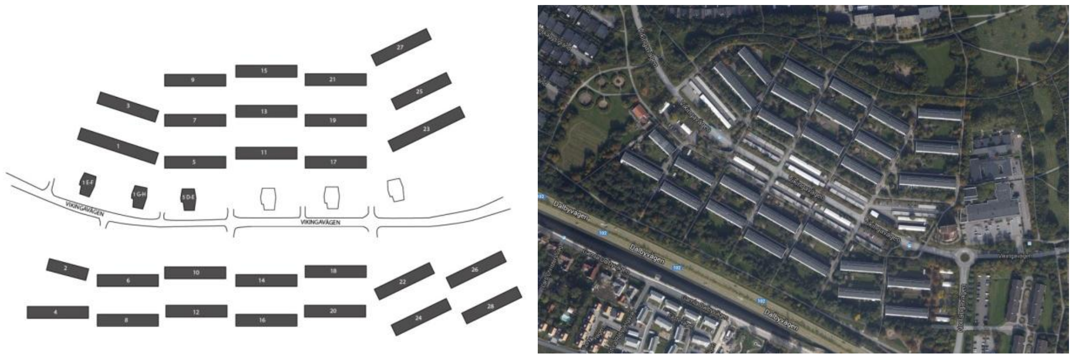

Figure 1. The road Vikingavägen divides Linero into two; Havamal and Eddan.

All buildings in the area are almost identical in appearance and design. They are all three-story buildings with a basement with a consistent orientation within the residential area. The buildings and the whole residential area is characterized by concrete façades combined with metal components.

In the Linero districts a connection from the main district heating grid is feeding two substations which in their turn are feeding the 28 buildings through a culvert network. This district heating pipe is owned by Kraftringen AB and its media is at a high temperature and pressure, approximately 95°C and 16 bar (Primary line). In each substation there is one heat exchanger for heating water and one heat exchanger for hot tap water. The district heating substation contains main pumps for heating water and hot tap water circulation. The pipe systems within the buildings are owned by LKF. The culvert network has pipes for supply and return heating water, hot tap water, hot tap water circulation and cold tap water. Inside the buildings the culvert pipes are suspended in the basement ceilings. Between the buildings they are buried underground. Auxiliary pumps for heating water and hot tap water circulation are installed at some locations due to the long pipe runs. The culvert network is from the 1970's when the area was built and is a relatively poorly insulated pipe system. The total length of the culvert network is approximately 800 m. The long culverts lead to external energy losses.

Energy simulation of heat losses in the district [1] shows that the culvert network corresponds to 13% of the total heat loss of the district. The simulations also indicates that major losses are ventilation and the building envelope; Figure 2. Airtightness tests have however indicated that the building envelope is however largely of such a high standard as to be comparable with the standards for new buildings. Consequently, the renovations will be targeted at the elements in the building envelope that can be given an improved U-value. Early investigation has also reviled that the ventilation flow in the buildings does not work as it should and does not comply with Swedish building regulations or LKF's ventilation policy.

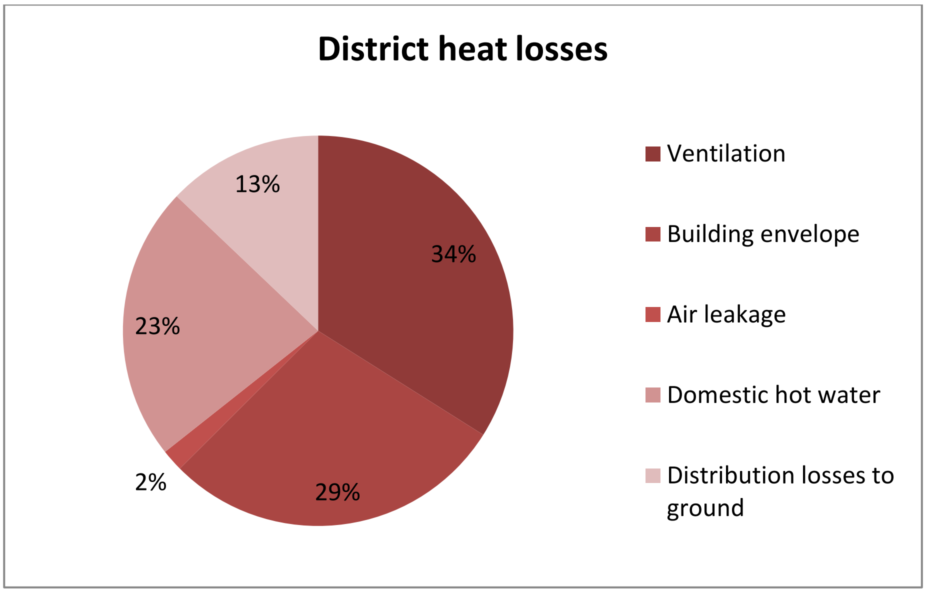

Figure 2. Distribution of heat losses in the district

GOING FOR LOWER CO2-EMISSIONS, INCREASED SHARE OF RENEWABLES AND SMART GRID INTERVENTIONS

The final retrofitting strategy [1] included in CITyFiED is in line with the Swedish Building Regulation incentives to reduce bought energy consumption exceeding the goal of 31% for energy efficiency measures (Table 1) and reaching a share of 87% for renewable energy sources for the district included in the CITyFiED project. It also meets the demand for ventilation according to Swedish regulation. It is in line with the affordability demands for the tenants and presents an overall decreased environmental impact in regard to CO_2 and Primary energy (Table 1).

		Energy consumption [kWh/(m² year)]	Primary energy consumption [kWh/(m² year)]	Greenhouse gas emissions [g/(m² year)]
Current situation	District heating	127	80	10,457
	Electricity[1]	31	65	4,960
After renovation	District heating	68	38	4,566
	Electricity	38	77	5,942
Total reduction		**52**	**31**	**4,909**
Savings		**38%**	**21%**	**32%**

Table 1 Results from the district energy simulation

The retrofitting strategy includes following measures:

- Replacement of the one existing district heating substations to 6 new custom and prefabricated efficient modulars.
- Replacing windows on the south side floor 1 and 2
- Replacing balcony doors on the south side floor 1 and 2
- Additional wall insulation on the southern long side of floor 1 and 2
- Additional roof insulation
- Reduction of the interior temperature
- Replacement of radiator thermostat
- Glazing of balconies
- Change stairwell lighting to LED and install presence control
- Change the lightning in the cellar to LED and install presence control
- Change the lighting at the entrance and gable ends to LED
- New culvert solution
- Upgrading of the ventilation system
- Exhaust air heat pump
- Individual metering and billing
- Replace bathtubs with shower

The overall impact will be further enhanced by the integration of renewable energy from multiple production units to the large scale district heating network that heats the buildings in Linero. This includes solar energy, wind energy; biomass, geothermal heat as well as residual heat from industries for example the new research facilities in Lund, European Spallation Source (ESS) and Max IV-laboratory increasing the share of renewables from 74, 8% to 94.1% of the district heating.

The smart grid interventions in the district include new electricity generation from photovoltaics and new electricity use by an EV charger. At least 70 kWp roof mounted photovoltaics will be installed in the project, divided on at least two of the buildings. The installation of photovoltaics will be connected to the electricity system of the building and the electricity production will primarily feed the building and reduce the need of bought electricity. In cases when the production exceeds the consumption of the building the excess electricity is fed to the grid and sold to the chosen electricity trading company. The display

[1] Includes the total electricity in the district, lighting and domestic electricity

showing the solar production data will be combined with the visualisation tools for showing the energy use in the buildings and in the district. Combining display of energy use and local energy production is intended to increase the awareness of the energy flow in the district for the people living in the area.

An EV charger will be installed in the demo area in order to give the tenants easy access to quick and well-functioning charging infrastructure that fits their needs, both now and in the future. The charger will be configured in order to host one car for car-sharing and one other private car at the same time. In order to facilitate well-functioning car-sharing-functionality, the charger will be configured to enable full charging within one hour. The EV charger will be connected to the 400 V grid and the location will be easily accessed by the tenants.

Visualization will be implemented on three level; district, building and home level. Home level will focus on household electricity use, since that is the parameter that the tenant has the ability and the incitement to influence on the Swedish demo site. A solution giving the tenant real-time visualization of the household electricity consumption will be implemented. In the application for energy visualisation of the apartment, possibilities for controlling loads are integrated. The solution will be made available to the tenant through mobile devices such as tablets and smart phones. Building level will include electricity, heating, and local solar PV production. The solution for visualization on building will instead be made available to the tenant through stationary screens in the buildings. On district level aggregated use of energy will be visualized in order to evaluate the energy use of the demo site as a whole. The energy use of the buildings in the demo site area will be intercomparable. On district level aggregated use of energy will be visualized in order to evaluate the energy use of the demo site as a whole. District level visualization will be made available to the tenants on the most suitable common areas synced with the renovation process.

Other interventions concerns monitoring of energy flow, power quality and fault analysis in the demo site. The purpose of the enhanced monitoring is to increase the energy awareness of the people living in the area in order to reduce the electricity consumption and for the distribution system operator to get a better control of the electricity quality in the grid in order to enable a high penetration of further local electrical generation in the area. Noise on the power lines, originated from for example electronic devices connected to the power grid, can sometimes interfere the communication. With an increase in photovoltaics and other local electricity production sources connected to the grid by power electronic converters these problems are assumed to increase. In order to handle this communication problem the new generation power line communication, G3-PLC, will be tested in CITyFiED.

REPLICATING THE RESULTS IN EUROPE

In order to investigate the potential for replication of the CITyFiED results demonstrated in the three demo sites of CITyFIED in other cities a framework for a feasibility model for building technology and retrofitting has been developed in the CITyFIED project [2]. The feasibility model is based on known concepts for modelling energy demand in buildings together with and energy system modelling approaches. As a complement to the quantitative model, a methodology for semi structured interviews has also been developed. The methodology will be used to find out what non-technological aspects such as financial, organizational, cultural, juridical and social can either boost the replication potential or hinder it. In addition to this Business model should be defined according with city council criteria and taking into account stakeholders at district level.

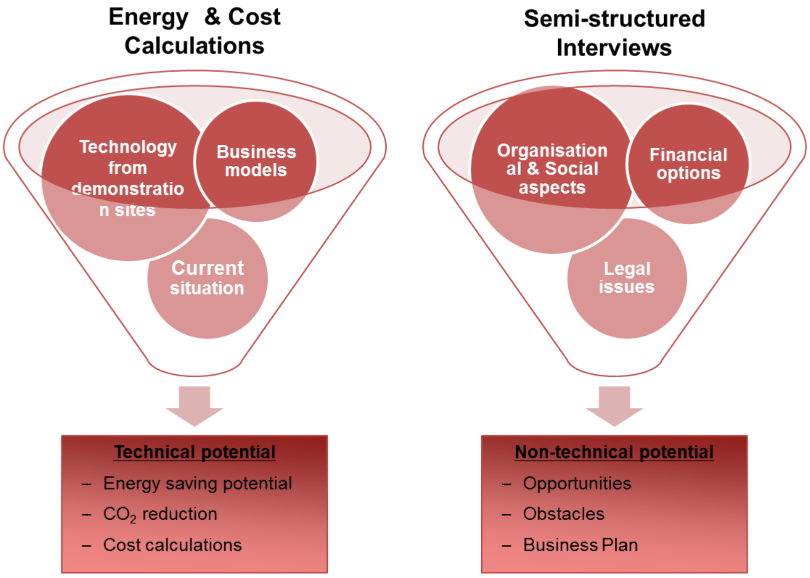

Figure 3. Replication model of CITyFIED

As a first step of deploying this process a refining process of several cities was performed including a selection of appropriate city districts for detailed analysis according to e.g. energy systems, building typology, climate, how well the city is represented by the area where it is located in the district, financial options, social aspects, etc. As a result of this a CITyFiED city cluster was established including 11 districts in 11 European cities. The next step in the CITyFiED project is to deploy the replication model in order to demonstrate the replication potential of the CITyFiED measures implemented in the three demo sites.

CONCLUSIONS

Despite many existing initiatives on buildings retrofitting, the systemic renovation strategies at district or city level are still not generalized enough in Europe or in Sweden. It is clear that some general barriers are holding the massive deployment of this kind of interventions back. Even if the technology is available there is a need for more affordable solutions and new business models. The Demo site in Lund, along with the demo sites in Soma and Valladolid, will evaluate several interventions for smart city retrofitting, this along with a strong effort to spread the benefits of the integrated refurbishment in other European cities will provide and promote innovative and affordable solutions that are effective to address the current technical, financial, social and organizational challenges in many European cities.

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