Linero district, Lund (Sweden)

Country: **Sweden**

Name of city/municipality: **Lund**

Title of case study: Linero district

Year and duration of the renovation: 2014-2021

Author name(s): Erik Johansson, Henrik Davidsson
Author email(s): erik.johansson@hdm.lth.se, henrik.davidsson@ebd.lth.se

Link(s) to further project related information / publications, etc.:

Schematic figure or aerial overview

Figure 1. Aerial overview of Linero district in Lund, Sweden (copyright: Creative Commons).

Table 1. Basic information (*CITyFiED* "Facts & Figures").

No. of buildings	16 (out of all 28)
No. of dwellings	379
No. of levels	3
Years of construction	1969-1972
Total heated floor area	40,400 m²
Population in the area	1,150 inhabitants
Owned by	Lunds Kommuns Fasighets AB (LKF) (public housing company)
Usage	residential

Figure 2. Linero demonstration site (opyright: CITyFiED).

Introduction and description of the situation before the renovation

The intervention is located in Vikingavägen in the district Linero of Lund, Sweden.

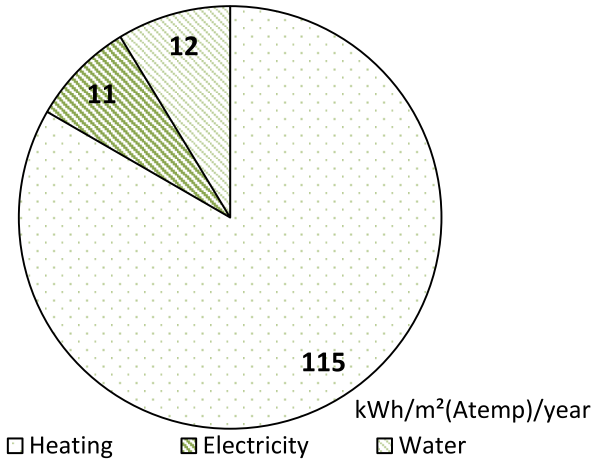

Figure 3. Energy demand before renovation based on statistical data from 5-year period (2009-2013) measured by LKF (Heating and Water together ± 13 kWh/m²/year).

The main characteristics of the building systems before the renovation were:

District heating:

- One central substation
- 800 m of culvert
- Large distribution losses
- Uneven heat
- 100 % renewable sources as of April 2018 (the shift was made by Kraftringen, independently of but concurrently with the retrofit project)

Heating system:

- Based on outdoor temperature curves
- No consideration for internal loads
- Uneven heat

There is neither on-site energy production nor cooling.

The envelope of the blocks presented a good state of preservation and did not call for a radical renovation.

Ventilation flow was insufficient. The ventilation was through exhaust air only with two shafts coming out of each dwelling from the kitchen (9.2 l/s) and the bathroom (7.4 l/s). The Swedish building code requires 10 l/s for both kitchen and bathroom, but overall the flow should not be less than 0.35 l/s per square meter of floor area, which depending on the size of an apartment equates to 20 l/s to 30 l/s.

The area was losing appeal as the buildings, built during 1970s as a part of the Swedish "Million Programme", were increasingly more expensive to operate, therefore unsustainable and unattractive.

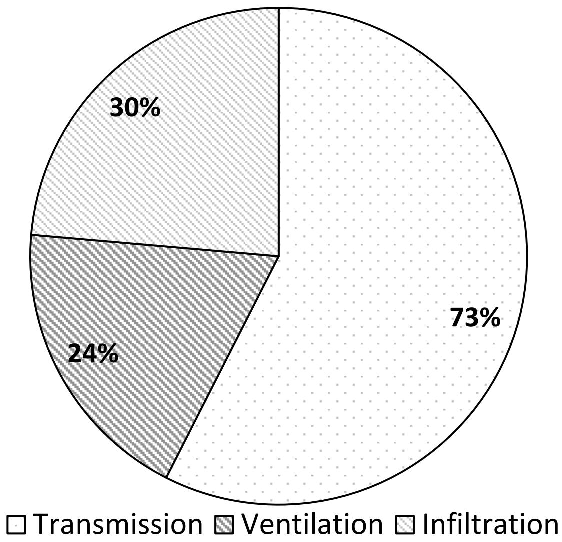

Figure 4. Heat losses distribution of the pilot dwellings.

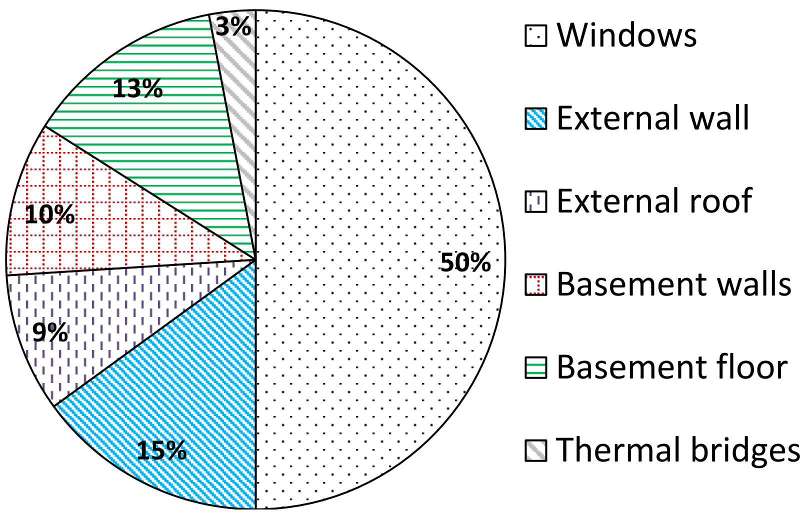

Figure 5. Heat losses from transmission for the pilot dwellings.

Description of the renovation goal

CITyFiED chose to pilot this renovation project (as one of three European urban sites) with the aim to develop a holistic and replicable collaboration model using innovative and cost-effective technology. The focus of the strategy was to reduce energy use and greenhouse gas emissions, and to increase the use of renewable energy sources.

By raising the energy standards, the project aimed to improve thermal comfort in the dwellings. One of the chief objectives was to maintain affordability without having to raise the monthly rent for the tenants, who rent the apartments from the public housing company. The area is widely regarded as a poor part of the city.

The project leaders decided to include the tenants into the process and encourage them to participate in the discussions throughout the project. Thus, a lot of weight was placed on communication and public acceptance.

Description of the renovation concept

The main features of the renovation works are:

Electricity:

- In the communal areas, the lighting was changed to LED (Estimated savings -> basement: 0; stairwells: 385; outside: 160; all values in kWh/yr).
- Presence lighting control installed in stairwells, cellars, entrances and gable ends.
- Washing machines in common laundry rooms with both cold and hot water intake installed (hot water from the grid and not electrically heated by the machine – 5 kWh/m²a reduction of electricity and 5 kwh/m²a increase in hot water use).
- Solar photovoltaic system installed with estimated electricity savings of 2 kWh/m²a (500 m² of solar panel area).

District heating:

- Six substations (before there was only one).
- 450 m of culvert (350 m less).
- Reduced distribution losses (200-350 MWh/year).
- About 3 years payback time.
- Local district heating company to reach 100 % renewable energy sourcing in 2018.

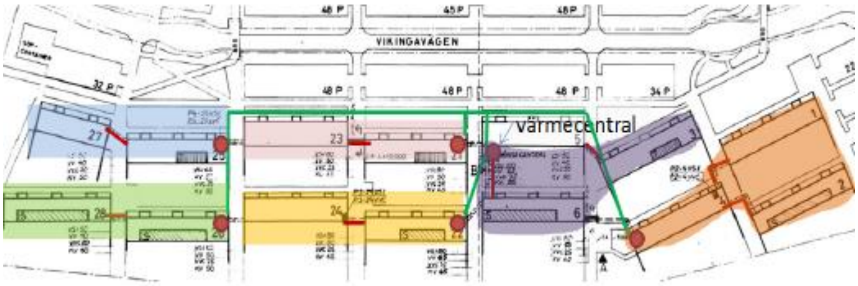

Figure 6. District heating network retrofit with 6 smaller substations.

Heating system:

- Temperature sensors in each apartment.
- Improved indoor comfort (by improvement of windows, insulation, radiators' temperature). It is continuously measured with the NODA system.
- Target air temperature: 21°C (lowered by 1-2°C).
- Heating savings on a level of 30%.
- Radiator thermostats, adjustment and shut-off valves were replaced.
- NODA system – automatic regulation of radiator hot water supply, which included indoor temperature sensors.

Hot water:

- Individual hot water metering (replaced split-share common metering).
- Possibility to replace bathtubs with showers (around 50 % of them were replaced partially owing to the individual water metering that was introduced).

Ventilation:

- Total ventilation flow for the pilot building augmented from 609 l/s to 850 l/s (basic flow).
- Heat pumps installed on exhaust air from ventilation only in buildings with district heating heat exchangers (6 substations). The heat recovered by heat pumps is added to domestic water and radiators (COP = 3.5 -> heating reduction of 26 kWh/m²a and electricity use of 7.5 kWh/m²a).
- Renovation of the ventilation system will yield an energy increase due to higher air flow thus higher heat losses.
- Expected savings from replacing of the fans to more efficient ones with lower pressure losses.

External envelope:

- Replacement of the openings such as windows with the least performing characteristics. Savings can reach up to 19 kWh/m²a (new windows U-value: 0.8 W/(m²·K)) but with the current prices the investment payback time would exceed the expected 10 years period, being almost double.
- Balcony doors on level 1 to be replaced in order to accommodate wheelchairs. U-values thereof reduced from estimated 2.7 W/(m²·K) to 0.9 W/(m²·K).
- Renovation of south oriented façade (levels 1-2) to improve the external wall U-value from 0.5 W/(m²·K) to 0.2 W/(m²·K) with savings of 3,000 kWh/year and payback time of minimum 30 years.
- Insulation of the roof aiming to improve the U-value from 0.3 W/(m²·K) to 0.1 W/(m²·K), with energy saving of 4 kWh/m²a, which was estimated as cost-efficient considering a 10 years period.
- An opportunity to glaze balconies (optional). Expected result is increased glazing of balconies from around 30 % (existing) to 50 % (after renovation) for a building, which by keeping a higher temperature in the balcony area would reduce the building’s transmission losses.

Other:

- Discount on renovation for residents. There was not much interest initially but now almost 2/3 are doing some extra renovation works. It provides an opportunity for those who have money to get a better standard.
- Electric cars fast-charging stations.

Project Fact Box (I)

General information

Parameter	**unit**	**before renovation**	**after renovation**
Urban scale of area:	m²	90,300	90,300
Population in the area:	-	1,150	1,150
Number of buildings in the area	-	28	28
Heated floor area of all buildings	m²	40,400	40,400
Building mix in the area:			
Single family homes (SFH)	% of heated floor area of all buildings	0	0
Multi-family homes (MFH) - up to three stories and / or 8 flats		0	0
Apartment blocks (AB) - more than 8 flats		100	100
Schools		0	0
Office buildings		0	0
Production hall, industrial building		0	0
other (please specify)		0	0
Consumer mix in the area:			
Small consumers: SFH + MFH – < 80 MWh/a	in % of annual heat demand	0	0
Medium consumers: AB, schools, etc. – 80-800 MWh/a		100	100
Large consumers: industrial consumers, hospitals, etc. > 800 MWh/a		0	0
Property situation of buildings:			
private	% of heated floor area	0	0
public		100	100
Property situation of energy supply system (district heating):			
private	% of heated floor area		
public		100	100

Project Fact Box (II)

Specific information on energy demand and supply:

Parameter	**unit**	**before renovation**	**after renovation**
heating demand (calculated)	kWh/m²a	98-182	66-107
domestic hot water demand (calculated)	kWh/m²a	12-30	21
cooling demand (calculated)	kWh/m²a	0	0
electricity demand (calculated)	kWh/m²a	11	9
heating consumption (measured)	kWh/m²a	115	not available yet[1]
domestic hot water consumption (calculated)	kWh/m²a	30	not available yet
cooling consumption (measured)	kWh/m²a	0	not available yet
electricity consumption (measured)	kWh/m²a	11	not available yet
(Thermal) energy supply technologies:			
decentralized oil or gas boilers	% of heated floor area	0	0
decentralized biomass boilers		0	0
decentralized heat pumps		0	0
centralized (district heating)		100	100
other *(please specify)*			
renewable energy generation on-site:			
solar thermal collector area	m²	0	0
photovoltaics	kWp	0	153
other (please specify)	kW	0	-

[1] Still under measurements. The results will be available after 2 years or more due to necessary calibrations and adjustments during the immediate years after completion of the project.

Financial issues:

Parameter	**unit**	**before renovation**	**after renovation**
total investment costs of the renovation	Euro/m^2	-	4,200
- building envelope renovation costs	Euro/m^2	-	860
- heating/cooling supply costs	Euro/m^2	-	195
- renewable energy production costs	Euro/m^2	-	50
LCC available	yes / no		yes

Description of the technical highlight(s) and innovative approach(es)

Good communication with the community prior to and during the retrofit process was a big success. The retrofit achieved a higher satisfaction rate since residents were included in the process from the early stages and appreciated being asked for their opinions and approval of the proposed changes. This approach has a potential to mitigate negative attitudes within the community and establishes communication between the parties. However, it should be noted that it can also be time-consuming and costly for the project, as well as cause delays. One should keep in mind to commence communication with tenants early, prior to the start of the project, and approach residents with complete transparency to create mutual trust.

Strategies included in the approach:

→ *Local events*

Engaging the tenants into the process and encouraging active involvement is a good strategy to foster social acceptance and increase overall satisfaction with the retrofit project. Tenants will then be more likely to endure temporary living inconveniences, like noise and limited accessibility, which are inevitable during the retrofit. Through various workshops and meetings in the early stages of the project, the project team has an opportunity to acknowledge community ideas and needs. It is crucial to reach out and prepare events in a way that would attract many residents of different demographics.

→ *Energikollen*

A smartphone app was provided with the aim of helping tenants to keep control over their energy use. It leads to increased awareness among the users. However, the risk is that people would not be willing to use the app or would have trouble with the technology depending on their background. Such app should therefore be adjusted to match the target users.

Decision and design process

General / organizational issues:
The project was initiated to maintain affordability of the apartments by reducing current and future energy costs.
The project was one of CITyFiED demo-site district retrofit projects, which were initiated and powered by the EU.

Stakeholders involved
Lund municipality, LKF, CITyFiED, Boverket (Swedish National Board of Housing, Building and Planning), Prime Project (energy-efficiency consultancy), Kraftringen (district heating company), IVL (Swedish Environmental Research Institute), Peire (Lund University).
The agents in charge of promoting this project were LKF, CITyFiED and Lund municipality.

Main steps
The process for its successful implementation included a pilot study (carried out on just 4 apartments; measuring energy use and indoor climate and proposing retrofit measures; savings calculations) -> Communication with the tenants -> Implementation (some retrofits were optional).

Resources available before the project
Surveys with the tenants about problems, needs, and experiences (e.g. ventilation and window openings) and the pilot study aforementioned.

Drivers and barriers (opponents)
Drivers: EU, CITyFiED, Lunds Kommun, Boverket, living affordability, sustainability, energy and comfort improvement.
Barrier: Funding (as project was limited to retrofits that were found most cost-efficient in the projected investment period).

Main challenges regarding decision finding
Firstly, to receive extra funding for the maintenance budget from board to refurbish old residential buildings from the “Million Program”.
Secondly, finding the optimum amount of renovation tasks in accordance with the budget, since there are a lot of target conflicts and one needs to find a good middle ground.
The crucial parameters for go / no-go decision were the cost-efficiency, energy savings, residents comfort and safety.

Stakeholders' role and motivation

Main stakeholder	Level of influence (1 min- 5 max)	Type of influence (decision maker, influencer, technical advisor, delivery)	Driver/motivation
Policy actors (municipality department, government body, innovation agency, etc.) *Lund Municipality, CITyFiED*	4	facilitator	Seeking new district retrofit approach models and trying innovative technologies.
Users/ investors (individual owner, housing association, building managers, asset manager, project developer) *LKF*	5	decision maker	Increasing the value of the area, maintaining financial sustainability.
District-related actors (Community/occupants organizations, etc.)	3	influencer	Minimising the negative impact of the retrofit measures, maintaining affordable rent.
Energy network solution suppliers (Distributor system operator, energy supply company, energy agency, ESCO, renewable energy companies) *Kraftingen*	2	delivery	Modernisation of the district heating network, maintaining customer trust and satisfaction.
Renovation solution suppliers (Planning and construction parties, urban planners, architects, design team general contractors, products suppliers, ESCO, contractor, energy monitoring, facility manager, installation provider, one-stop-shop, etc.)	1	delivery	Contracting for construction jobs.
Other intermediaries (public bodies, trade organizations, NGO's, consultancies, research institutes) *Prime Project, Peire*	3	technical advisor	Finding out the most energy- and cost-efficient solutions.

Design approach:

The design targets have been set based on the BBR – Swedish building code and regulations (buildings in Sweden have to comply) and the goals of the project CITyFiED – finding a strategy for developing the smart cities of the future, seeking innovative retrofit methods.

The decision steps to lead to the retained solution were as follows:
Estimate or measure the present performance -> Recognise highest energy reduction opportunities -> Estimate retrofit benefit -> Calculate savings -> Calculate maximum retrofit measure cost for a given investment period (LCC) -> Compare with market prices to check if investment cost-efficient -> Approve of the retrofit measure -> Present solutions to the community -> Account for residents' opinions

The tools used during the design phase consist primarily on simplified hand-calculations combined with on-site measurements and surveys. LCC calculations were used assuming a fixed energy cost and investment time. No available information about the interest rates, inflation, or price change that had been used.

Technical issues:

The major technical challenges / constraints regarding system design / implementation have been: the tenants staying in the buildings during renovation, faulty cables that were cut by mistake, replacement parts for the ventilation system that could not be replaced as were old and no longer manufactured.

Financing issues:

Building and energy systems renovation was financed by public money, specifically by the EU and LKF (public housing company).

Financial incentives that were decisive to implement the project were coming from the EU and Boverket (Swedish National Board of Housing, Building and Planning). EU funding drove the project with 25 M SEK funding from CITyFiED. Boverket contributed another 12 M SEK.

The main challenges / constraints regarding financing have been that firstly, the renovation scope had to be limited as to avoid monthly rent increase and, secondly, the determination of the renovation tasks putting all the design calculations together was a difficult process.

The actions performed in Linero were compared with a theoretical Business as Usual scenario, in which only basic investments considered as inevitable are made over 30 years and a Beyond Best Practice scenario where instead near-zero energy-performance was achieved. The purpose was to assess if a more ambitious way to manage and develop the buildings would be economically feasible. The study concluded that the investments made in CITyFiED scenario are the most financially viable option in the long term.

Policy framework conditions:

The key policy actors are Lund Municipality's politicians, as they have the opportunity to set the direction for LKF company and how the city should grow.

Main experts were the researchers from CITyFiED, EU project, Peire – researchers at Lund University, LKF employees, Prime Project employees.

There were links between the EU, Lund city, Lund University, professional profile (energy-efficient buildings).

There were some regulations that hindered the process. Starting a large-scale renovation project means that it will have to comply with the new building rules, especially when it comes to accessibility. It was required to install a lift in the area. Rules that stimulated were the ones that helped achieve various subsidies that eased the budget.

A preaching policy (communication actions, raising awareness) was performed.

Lessons learned

The major success factors have been:

- Pilot study.
- Community engagement.
- EU funding.

The major bottlenecks are related to the cost and affordability.
LCC was performed and the most cost-efficient viable solutions were recognised. The final scope of works was limited by the available budget.

The major lessons learned have been the following:

- Pilot study – In a retrofit project it is important to perform on-site measurements of the buildings to establish existing problems that would further determine the direction of renovation works. This study showed that it is sufficient to perform a thorough analysis only on a few exemplary dwellings.
- Community engagement – The decision to communicate with the residents from the early stages of the project led to a higher overall satisfaction rate. Raising awareness about the existing problems by taking the opportunity to explain why renovation works are necessary in the area shows respect to the community, builds mutual trust, and ultimately brings benefits for all involved parties.

From this intervention, it should be transferred that not all retrofit measures have been found cost-effective. Financial aspect was the driving factor of the renovation scope and can be a major limitation to progress towards urban sustainability. This project’s success depended on the EU funding, and without this incentive, it would have been much more difficult for the housing company to cover all the costs. It might have transpired that the tenants would have had to pay for the retrofit works with increased rent prices over the following years, which would defeat the chief purpose of the project that was to maintain the living affordability.