GREEN SOLAR CITIES

PROJECTS THAT TRANSFORM

DANISH ASSOCIATION FOR SUSTAINABLE CITIES & BUILDINGS « AUGUST « 2013

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EU-CONCERTO

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FOREWORD

By **Peder Vejsig Pedersen,** technical coordinator of Green Solar Cities and director, Cenergia, Denmark

Now is the time for the last thematic magazine in three languages on the EU-CONCERTO project "Green Solar Cities" in Valby, Denmark and Salzburg, Austria.

A large number of new buildings and renovation projects have been realized - with 30 – 80 % energy savings compared to normal practice.

At the same time large-scale implementation of solar energy systems has taken place.

In Salzburg an innovative combination of 2.000-m² solar thermal collectors, together with a buffer storage and a heat pump, have been implemented in the old industrial area in Lehen. The solar thermal collector, combined with a low temperature micro grid, is connected with the existing district heating network. With this solar thermal collector and several other building and renovation projects a whole city district has undergone a transformation.

In Copenhagen the project has supported a continuous development of the Valby Photo Voltaic Implementation Plan from year 2000, aiming at realizing 15 % solar electricity in year 2025. By 2013 four MWp Photo Voltaics have been realized in Valby, including a 777 kWp Photo Voltaic system for a large waste water handling plant, Damhusåen, which is the largest Photo Voltaic installation in the Nordic countries.

Even though the Green Solar Cities, EU CONCERTO project officially ended after 6 years by June 2013, there will still be a lot of activities taking place until the summer of 2014, where final results for all project sites will be available through the project website: www.greensolarcities.com. In relation to monitoring and evaluating it is also the aim to use elements from the so-called "Active House" concept, including the "Active house Specifications" (www.activehouse.info).

It has been arranged to publish a best practice book with the title "Green Solar Cities" in cooperation with the Earthscan Publishers in the UK. Besides it will be possible to find the project on www.paneuropeannetworks.com and www.horizon2020projects.com.

CONTENT

VALBY WILL SHOW THE WAY

COPENHAGEN AS AN EXAMPLE

GABLE TOWARDS THE RAILWAY IN VALBY WITH SOLAR ART (BY ARTIST ANITA JØRGENSEN) BY NIGHT AND BY DAY. PV SUPPLIES ELECTRICITY FOR A NEON LIGHT, WHICH ILLUMINATES AT NIGHT AS A LANDMARK FOR THE VALBY PV-PLAN

By **Peder Vejsig Pedersen**, technical coordinator of Green Solar Cities and director, Cenergia, Denmark

Copenhagen has an ambition of becoming the first carbon neutral capital in the world by year 2025. Extensive retrofitting of buildings, reorganisation of the energy supply and change in transport habits are some of many initiatives the City of Copenhagen will implement in order to become carbon neutral. With the Copenhagen Climate Plan, the Danish capital combines growth, development and higher quality of life with a reduction in Carbon emissions of around 1.16 million tons.

In the EU-CONCERTOproject, Green Solar Cities (www.greensolarcity.dk) EU funding has been utilized as a strong support for the large scale PV implementation plan in Valby in Copenhagen. The plan was launched in year 2000, aiming at supplying 15% of all electricity use in Valby by 30 MWp PV electricity established by year 2025. By 2013 around 4 MWp PV have been established. And since year 2004, the aim to introduce large scale building integrated PV in Valby has been extended to cover all of Copenhagen by creating the Solar City Copenhagen association. The association has been very active since then (www.solarcity.dk).

At the same time a number of new buildings and housing renovation projects in the EU-CONCERTOarea in Valby have improved their energy frame values by 30 – 79% compared to normal practice.

PHOT VOLTAICS AT DAMHUSAAEN IN VALBY, THE LARGEST PHOTO VOLTAIC PLANT IN THE NORDIC COUNTRIES. 8% OF THE ELECTRICITY FOR THE CLEANING OF THE WASTE WATER IS COVERED BY PV. THE PLANT IS OWNED BY "LYNETTE COOPERATIVE" IN COPENHAGEN, AND - SUPPLEMENTED WITH BIOGAS FOR THE PRODUCTION OF ELECTRICITY, THE PLANT COVERS ALMOST 50% OF THE YEARLY CONSUMPTION OF ELECTRICITY

Concerning the PV installation at the "Damhusåen" waste water treatment plant in Valby, there are huge prospects of the approach, since waste water treatment plants use 8% of all electricity use in Denmark and even more of electricity use in Valby.

The 777 kWp PV system cover an area of approx. 14,000 m² of secured landfill with a built-in liner below the grass. This land cannot be used for anything else for many years due to pollution from resides of the waste water.

At the Hornemannsvænge housing estate low energy retrofit solutions are used together with a kind of solar energy combined heat and power, where both solar thermal and PV electricity is supplementing energy from the large combined heat and power plants in Copenhagen.

Demonstration of PV assisted ventilation has also taken place in Valby. There has been focus on documenting a low electricity use, which can be matched by PV electricity.

It is now also aimed at introducing elements from the so-called "Active House" concept (see: www.activehouse.info) in relation to monitoring and evaluating the Green Solar Cities project in Valby. The project will be finalized by the summer of 2014.

In the Active House Specifications a number of specifications are defined within areas like, energy, indoor climate and environment. And in the energy area there is a focus on the areas: yearly energy balance, energy design, energy supply, energy monitoring and verification, and follow up.

Concerning the energy balance it is based on a calculation of all energy uses in a building incl. electricity using appliances and effect of the used energy supply system.

In the Active House Specifications there is a demand for energy monitoring, verification and follow up. This is new compared to the situation in Denmark today, where there is a lot of focus on good calculation procedures, but, like in most other countries, no link to what the actual energy use will be in practice in realized building projects.

A good possibility could be to introduce the same demands for "verification" of all new building projects within a two-year period, which already have been introduced in Sweden.

The new "Industrial Standard for Energy in Buildings", SVEBY, consists of three main elements:

- **Calculation** (based on standardized energy data)
- **Agreement** (Power requirements and handling of deviations)
- **Verification** (Method for measuring and monitoring and analysis).

(see also www.fastighetsagerne.se and the article later in the magazine on the Swedish experience regarding calculated and measured energy consumption in newer low-energy buildings).

Active House Specifications can be found on the web page www.activehouse.info.

THE MANAGING DIRECTOR OF THE "LYNETTE COOPERATIVE" TORBEN KNUDSEN TO THE RIGHT WAS ONE OF THE MOST IMPORTANT INITIATORS OF THE PROJECT. HERE HE IS TOGETHER WITH THE OPERATING MANAGER

DETAILLE OF THE FUNDAMENT FOR THE PHOTO VOLTAIC

ENERGY RETROFITTING - THE URBAN CHALLENGE

HORNEMANNS VAENGE IN VALBY

By **Vilfred Hvid og Jakob Klint**, consultant and chief consultant, Kuben Management, Denmark

In addition to delivering a wide range of new low-energy buildings in Valby, Green Solar Cities project focused on the retrofitting of the existing building stock. That is the biggest challenge, our cities face, if we are to succeed in reducing CO_2 emissions.

One of the most extensive low-energy retrofittings that has been realized during the project is the renewal of the public housing "Hornemann's Vaenge". In Hornemann's Vaenge six concrete apartment buildings from the 1960s and 1970s have gone through extensive retrofitting. The degradation of concrete facades and general attrition has made it necessary to renovate the concrete, which has allowed the insolation of the entire building envelope with 200 mm mineral wool and replacement of all windows with energy efficient windows. EU concerto project has supported the retrofitting with better ventilation systems, solar thermal and photovoltaics, and the buildings now meet the energy requirements for new buildings. Hornemann's Vaengeis good example of a low energy refurbishment, where the need for a general building retrofitting has been combined with a far-reaching energy optimization.

HORNEMANN'S VAENGE

Now we have many examples of energy retrofitting of concrete buildings from the 1960s and 1970s, and Kuben Management's new office building in Valby has even shown that older office buildings in concrete can be renovated to a low energy class 2020 at market conditions.

KUBEN MANAGEMENTS HEADQUARTERS AT ELLEBJERGVEJ

During the project, a concept for energy retrofitting of brick buildings has also been developed. But these initiatives have generally not been as extensive as for the concrete constructions. The brick buildings from before 1950 are a much greater challenge, because the building envelope has a very long life, and the need for retrofitting is significantly less than for concrete facades. At the same time the brick facades are beautiful, and an outer insulation is excluded for that reason.

The economic most realistic measures to reduce the brick building's energy consumption are limited to:

- Better windows with low U-values,
- Internal insulation where possible, which is typically storey partition towards basement,
- Spandrels under the windows,
- Insulation of the roof, and
- Insulation in ports and of freestanding gables.

In addition, savings may be realized through better technical installations, such as ventilation with heat recovery rather than exhaust ventilation and renewal and optimization of heating and electrical systems as well as through behavioural changes due to visibility of the individual use of heat and hot water. Finally, in relation to exchange of the roofs, it is possible to consider integrated photovoltaic and solar heating.

10 KWP PV (70 M²) AND 60 M² SOLAR THERMAL ARE INSTALLED AT EACH OF SIX RENOVATED HOUSING BLOCKS

DIALOGUE WITH BUILDING OWNERS

Throughout the project we have been in dialogue with many housing associations, private landlords and owner associations, but often it has been difficult to demonstrate sufficient energy savings to make these investments attractive. The private landlords have not had the great interest in savings, as it is the residents who pay for energy, and in co-operative and owner-occupied housing, the financial crisis have limited the economic associations' financial flexibility, due to depreciation of the housing value. The best example is an exchange of a roof with insulation of the entire roof in combination solar cells.

URBAN RENEWAL IN VALBY

In the Green Solar Cities project, Copenhagen Municipality chose to prioritize Valby as an area for regeneration, which would make it possible to finance the building renewal. Simultaneously the Ministry of Housing, Urban and Rural Areas prioritized that urban renewal funds could be used for energy improvements, which have previously only been for improvements of the building envelope and the establishment of a bathroom. This created the basis for a more direct dialogue with the private landlord in Valby in terms of more stringent energy retrofit, and a smaller property came into play at Gl. Jernbanevej in Valby.

In the summer and autumn of 2012 a process started with a number of players about how extensive home improvements could play along with extensive energy improvements support from the Buildingowners' Investment Fund and the Ministry of Housing, Urban and Rural. The process began with a study trip to Basel and Zurich to look at some of the most extreme low-energy retrofittings of older buildings. Properties that are the same age as the typical Copenha-

gen properties, ie from the end of 1800 and early 1900.

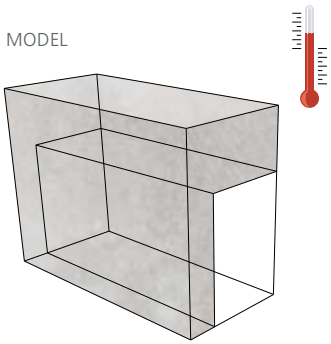
A series of workshops were conducted with the participation of experienced people in the field of urban development, construction, rental housing and building renewal, and the process resulted in a conceptual design for the renewal of the property, with its economy of transformation. The starting point for the implemented workshops were urban challenges and future demands for housing. Very briefly it can be summarized as follows.

The Danish cities are part of a global development and competition, and the cities are forced to fight to maintain and strengthen their local, national and international market position. Urbanization continues with renewed strength, and the cities are in constant motion to attract new inhabitants and not least: new jobs. Therefore, cities are also forced to become larger – or more intensive – to accommodate economic and population growth, as all cities today are expected to achieve.

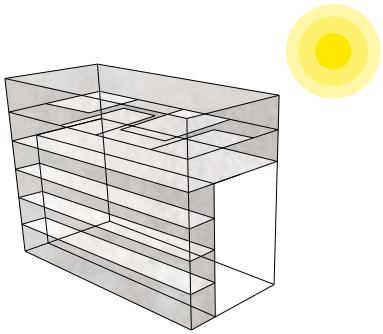
The need for dwellings will increase accordingly, because more and more people settle in the cities. At the same time, fewer and fewer people are living in the households and area requirements have generally been increasing the past several decades. Not only more but also larger homes are needed. And buildings from 1850-1930 are characterized by the fact that the homes are no longer adequate, since they are too small because they have small rooms, small kitchens and bathrooms (if they have bathrooms), and because they do not meet the future expectations for indoor climate, lighting and ventilation.

» The Retrofitting Concept is based on the following:

SOLUTION MODEL



OPTIMIZATION OF THE BUILDING ENVELOPE



OPTIMIZATION OF THE HOUSING QUALITY - LARGER FLATS AND BETTER DAY LIGHT CONDITIONS

» How can we continue the construction of new buildings in the central parts of the cities without losing architecture, materiality and quality?
» How can we create healthier and better housing for people?
» How can we reduce energy consumption in the buildings?
» How can we ensure the quality of urban spaces and urban environments, when the retrofitting wave rolls off in the cities in the coming decades?

Answers to these questions were found on the back of the building. It is very typical for multi-storey buildings from 1850-1930, which characterizes the Danish urban areas that they have great quality in architecture and materiality on the front, facing the street, but the back is often built with the cheap stones and may appear with husked plaster. It has always been the building façade towards the street that has been important in defining urban spaces.

Based on Active House principles a concept has been developed that adds significant changes in form of a comprehensive expansion in the back of the building and adds new homes on top of the building, while maintaining the facade facing the street.

THE HOUSING ESTATE AT GL. JERNBANEVEJ IN VALBY – BEFORE THE RETROFITTING

As it can be seen on the technical solution above, there is a relatively simple handle – an "embracement" of the building at the top and at the rear. It adds significantly more area to the building, it creates much better, bigger and healthier homes, it creates a closer city, because there will be more flats, it reduce building energy consumption to a contemporary level, and it maintains the materiality of architecture and quality that today is the hallmark the Danish urban spaces and urban environments.

LIVING IN LIGHT – VALBY

A serial of sketches and visualizations for the renewal of the properties in Valby has been prepared, and in autumn 2013 the renovation will start with an expected accomplishment during 2014.

THE HOUSING ESTATE AT GL. JERNBANEVEJ IN VALBY – THE RETROFITTING PROJECT "LIVING IN LIGHT

THE RETROFITTING PROJECT GL. JERNBANEVEJ – SEEN FROM THE YARD

GREEN SOLAR CITIES

EXPERIENCES FROM SALZBURG

By **Inge Straßl**, engineer, SIR – Salzburg Institute for Planning & Building, Austria

The Concerto Project 'Green Solar Cities' has started and supported the renewal process in Lehen in Salzburg. Generally, in the six years of the project, new homes and many other buildings were erected. Through the consistent low-energy design, 40% of energy per year could be saved. In addition, 2,700 m² solar thermal system and 50 kWp photovoltaic were built.

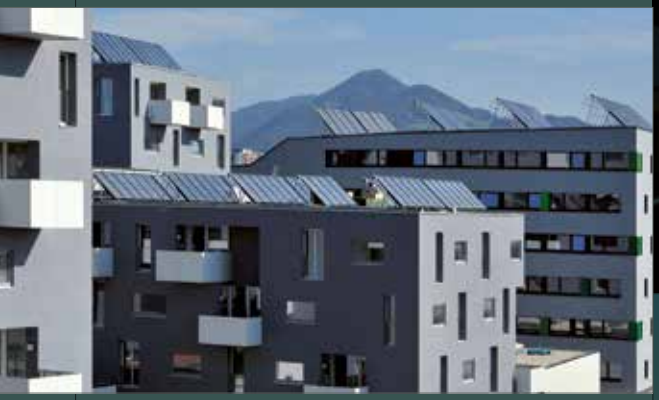
The district Lehen is very centrally located in Salzburg and has a good infrastructure. Most of the buildings were built between 1950 and 1970. In 2005, when the first plans for the "Solar Cities" project arose, there were many old houses in need of renovation, some brownfields and many shops, and social and public institutions that had moved away. Demographic trends and the many old residents of Lehen are also important.

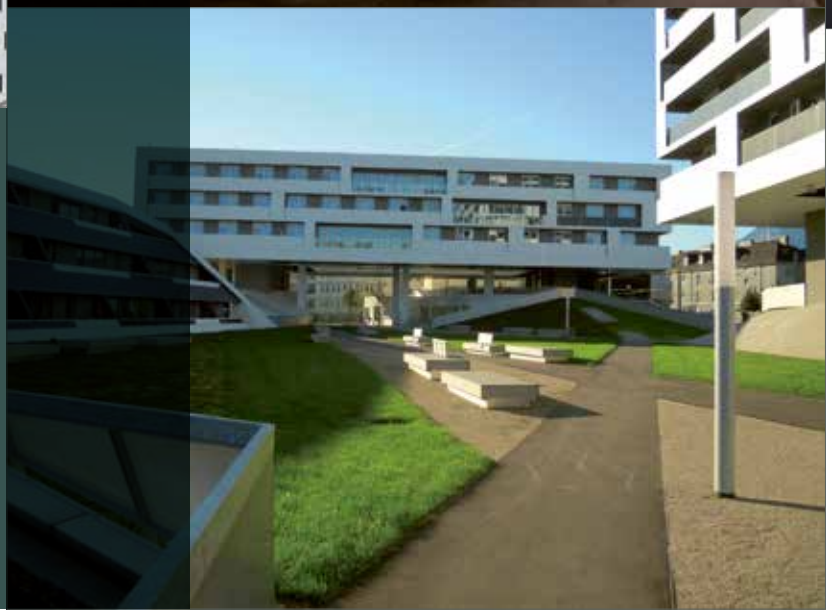
The adopted plan was then to launch a comprehensive renewal process.

The old stadium was demolished and the site, where the legendary Salzburg Champions League played, developed into a new center with the construction of the municipal library, shops, cafées and 48 subsidized apartments. A 144m² solar collector produces solar energy for hot water and heating.

THE NEW CENTRE IN LEHEN

In Esshaverstraße a low-energy house has been built at the area of a former mechanic workshop. Where earlier on a Mercedes store was located, the project "Parklife" has been developed as the result of a design competition for young architects. Now a nursing home with 90 rooms, 32 apartment for elderly people and 56 apartments for young families have been built. In the social center, there are many



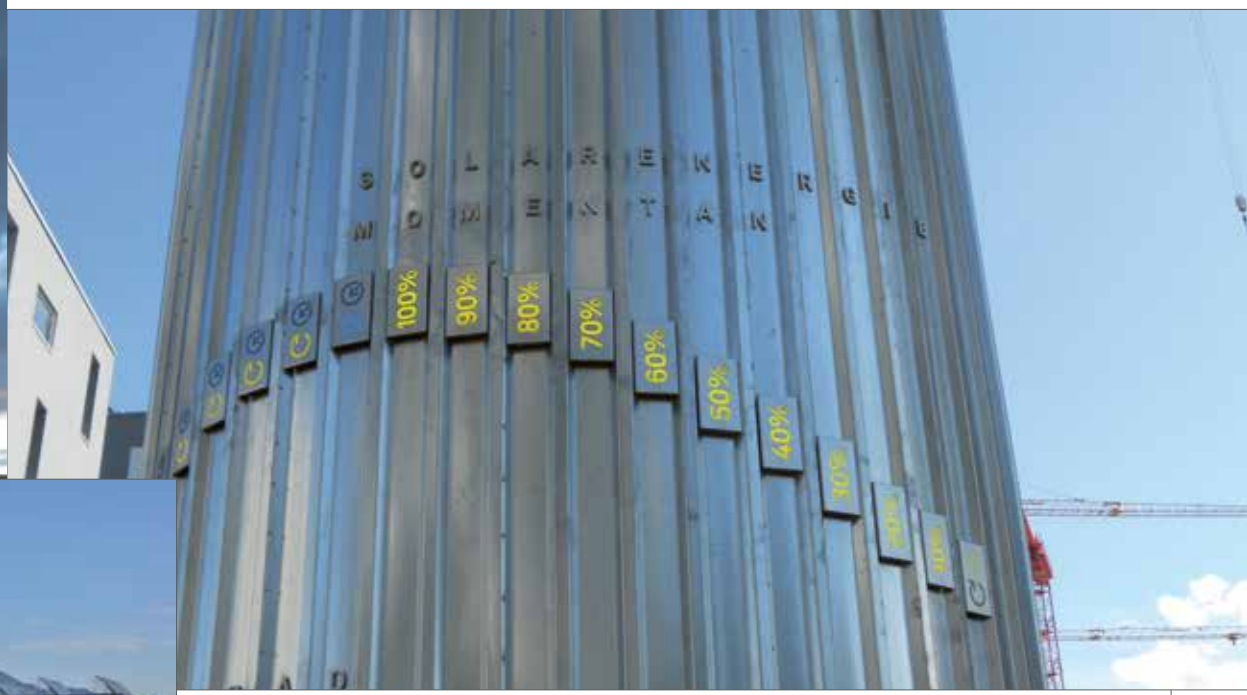


IMAGES ON THIS AND THE PREVIOUS PAGE SHOW THE NEW BUILDINGS IN THE DISTRICT OF LEHEN IN SALZBURG.

IN THE NEW CONSTRUCTIONS, THE EMPHASIS IS ON THE GENERATION CONSISTENT AND GOOD OUT DOOR AREAS WITH SPACE FOR ACTIVITIES FOR BOTH YOUNG AND OLD.

THERMAL SOLAR PANELS HAVE BEEN INSTALLED ON THE ROOFS OF ALL THE BLOCKS, PROVIDING SOLAR ENERGY DIRECTLY TO THE DISTRICT HEATING SYSTEM.

IT VISUALIZES THE LOW-ENERGY CONCEPT, WHICH HAS CAUSED THAT LEHEN SAVES 40% OF THE ENERGY USE EVERY YEAR.
READ MORE IN THE REPORT ON „GREEN SOLAR CITIES", WHICH CAN BE DOWNLOADED AT WWW.GREENSOLARCITIES.COM



BUFFERTANK IN SALZBURG, STADTWERK LEHEN, STANDS AS A SCULPTURE IN THE AREA. AT THE SIDE, THE PRODUCTION OF SUN ENERGY CAN BE READ

activities for the elderly and disabled, and it's not just for residents, but also people from the surrounding areas. Here you can get a cheap lunch, play games in the afternoon and other joint activities, and as a special feature: a gym for "70 plus", designed and equipped with special equipment. The buildings are all low-energy buildings with solar hot water and heating. On the ground floor there is a supermarket, shops and public green spaces.

PARKLIFE

For the old dwellings in Strubergasse a comprehensive redevelopment concept was created. The first phase of the thermal renovation was completed in winter 2012 - 2013 .

Next to Strubergasse is the site of the former Salzburger Stadtwerk. Here 287 apartments, the new city gallery, a dormitory and a kindergarten were built as part of the Concerto project. The apartments are in low-energy house standard with controlled ventilation with heat recovery. The existing office building was renovated, and in the southern area offices, laboratories and seminar rooms will be built.

As the urban district heating system of Salzburg contains a very high proportion of industrial waste heat and biomass, it was important to find a system for the power supply that optimally complement the urban district heating by solar energy. In the city of Lehen a solar thermal system was built with 2,000 m² collector, the heat is collected in a central buffer with 200,000 liters. A solar heat pump optimizes the system and gives an addition of 15 - 20%. The heat is distributed by means of a micro net to the appartments, offices and laboratories, as well as to the renovated houses in the area.

STRUBERGASSE

– RENOVATING AN OLD LIVING AREA

In the Strubergasse area in Salzburg, around 800 homes were built between 1950 and 1960. The houses are simple, with beautiful and generous green spaces, but the design of the apartments do in many cases not correspond to modern living requirements. The houses have no central heating. In about 50% of the apartments gas boilers have been installed. The other houses are still heated with individual stoves using wood, coal or electricity. Another problem is the lack of parking space.

By **Inge Straßl**, engineer, SIR – Salzburg Institute for Planning & Building, Austria

To create a meaningful renovation plan for the settlement, a working group was established. They created a study in which the buildings were analyzed, and the potential regarding redevelopment was described. An economic assessment was made, of which buildings should be renovated and of which possible energy standard.

Based on these studies, it was decided in a political process and with the involvement of the residents, which buildings should be renovated and which should be demolished and replaced by new buildings.

The houses along the Ignaz-Harrer-Strasse have a a very bad structural standard. All bedrooms are also located towards the road. The

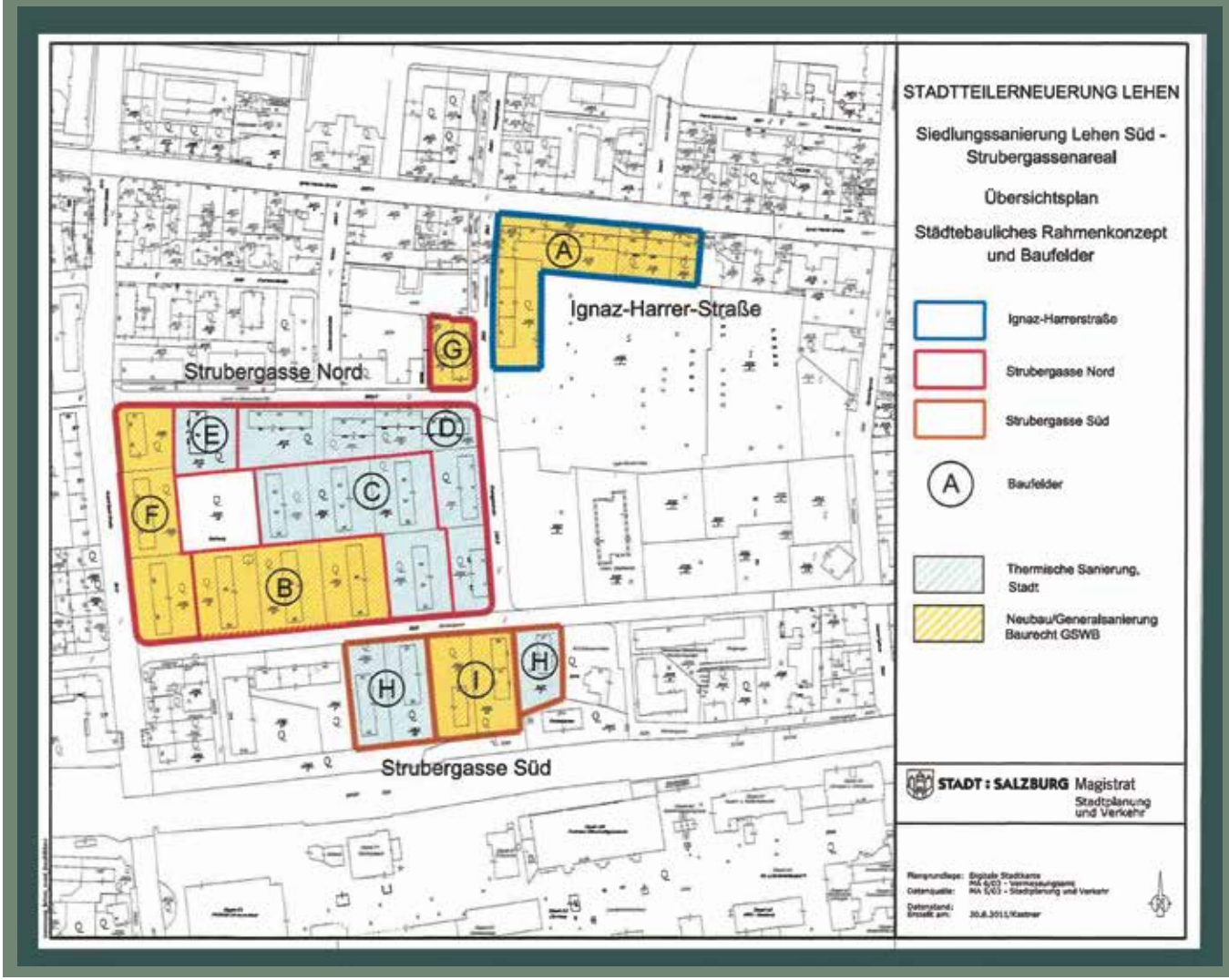
inhabitants of these houses could move to the newly built apartments in the city of Lehen.

In spring 2013, the demolition of the first homes began. Already in the autumn, the new construction of housing on low energy standard and with underground parking started. Other buildings along the Strubergasse are replaced by new buildings in a second stage, as the residents have the opportunity to move to the first new buildings.

The remaining buildings were renovated to low-energy standard and connected with the power supply of the public utility in Lehen. In this way it is also possible for these houses to use the solar energy from the largest solar thermal plant in Salzburg. Furthermore, all apartments were given a generous (insulated) balcony. The entire area is now an open space concept, and developed with the involvement of the residents. The residents' wishes are to be included as far as possible. A continuous cycle path, and differently designed outdoor area for children, young people and older people are planned. The situation of parking spaces can be improved by the new buildings with underground parking.

Here, a process was started, in which the entire settlement will be upgraded and modernized. By increasing the energy efficiency and the use of solar energy in the stock (through access to Stadtwerk Lehen), the new buildings can achieve a truly sustainable improvement.

STRUBERGASSE – PLAN



PHOTOS STRUBERGASSE

MONITORING IN GREEN SOLAR CITIES – EVALUATION OF THE MAIN MEASUREMENT RESULTS

EMPLOYEES FROM VIA UNIVERSITY COLLEGE IN HORSENS, DENMARK MEASURING ENERGY CONSUMPTION IN A FLAT

By **Jappe Goud**, energy Consultant, W/E Consultants, Eindhoven, The Netherlands

Green Solar Cities is a consortium of a number of partners, collaborating on two EU-CONCERTO sites, Valby in Copenhagen and Lehen in Salzburg. Both sites are large urban reconstruction areas. The reconstruction includes both retrofit and new buildings. The project goals include improving energy efficiency, increasing the use of renewable energy, enhancing competitiveness of the European industry and improving the quality of life in the project sites and cities.

The energy system in the projects in both cities includes solar thermal for domestic hot water and heating, combined with district heating. Other renewable energy systems include PV systems for renewable electricity, biomass and a heat pump. Many of the new buildings were built according to passive house standards, involving e.g. efficient heat recovery ventilation. In both cities the inhabitants and building users were involved in advance and they were asked about their experiences.

An important element of both CONCERTO and Green Solar Cities is monitoring of the effective energy savings and renewable energy production. Monitoring in this case consists of (1) comparing the (calculated) energy consumption of the buildings with the energy targets and (2) measuring the actual energy consumption of the completed buildings. Measuring is important because it is the way to see if the energy efficient and renewable energy technologies work well in practice and to be able to discover eventual problems in an early state.

In this article we discuss some monitoring results and a number of lessons learnt from the monitoring work. In addition we present two Dutch retrofit projects in the text boxes. More results and numbers are discussed in the report *Monitoring in Green Solar Cities — Evaluation of the main monitoring results* - view the site: www.greensolarcities.com

MONITORING RESULTS – HEATING

The project partners of Green Solar Cities have been monitoring the energy consumption and production of the completed new and retrofit buildings. We compare heating energy requirements, calculated – and measured values of five building projects in Figure 1.

OBSERVATIONS AND COMMENTS FROM THE GRAPH

– The calculated energy (heat) consumption of the buildings show that the buildings

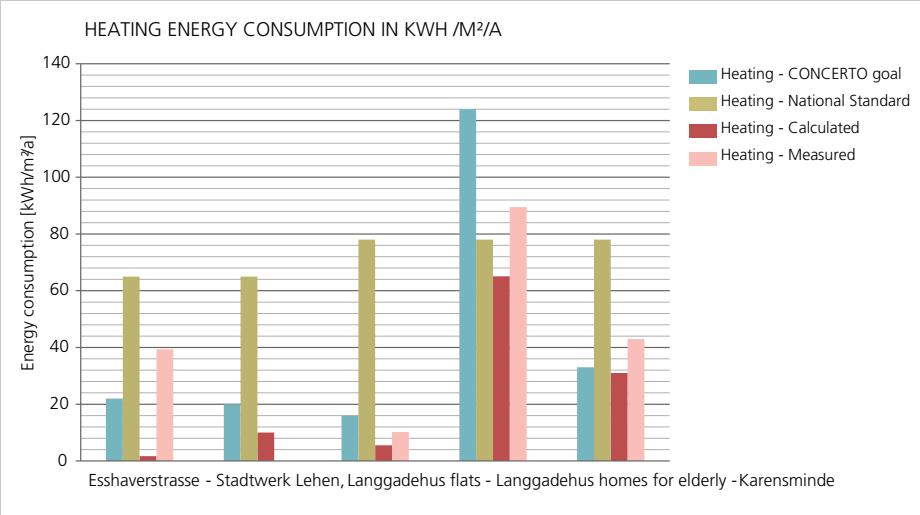


FIGURE1. HEATING ENERGY CONSUMPTION OF 5 NEW BUILDING PROJECTS. ESSHAVERSTRASSE AND STADTWERK LEHEN ARE IN SALZBURG, THE OTHERS IN COPENHAGEN. *THE GREEN BARS REPRESENT THE HEATING (SPACE HEATING) ENERGY ACCORDING TO THE NATIONAL STANDARD OF BOTH BUILDINGS IN AUSTRIA AND THE TOTAL ALLOWED ENERGY CONSUMPTION ACCORDING TO THE NATIONAL STANDARD IN DENMARK. THIS IS BECAUSE IT IS NOT CALCULATED SEPARATELY FOR SPACE HEATING. HOWEVER, AS ESTIMATION, THE MAXIMUM ENERGY FOR HEATING ACCORDING TO THE DANISH NATIONAL STANDARD IS ABOUT 25 KWH/M²/A LESS THAN THE TOTAL ENERGY. LANGGADEHUS IS A HOME FOR ELDERLY WITH SPECIAL REGULATIONS.

meet both the national standards and the CONCERTO goals. Most buildings however do in practice use more energy for heating than calculated and also slightly more than the CONCERTO goal. The Langgadehus family apartments in Copenhagen do also meet the CONCERTO goal in practice.
– No measurement data for a full year are yet available for Stadtwerk Lehen. The first monthly results indicate that actual consumption is higher than calculated.
The calculated energy consumption for space heating turned out to be very low for both Esshaverstrasse (Salzburg) and Langgadehus, family apartments (Copenhagen). The same may apply for Stadtwerk Lehen. A study performed in Salzburg shows that calculation of the heat energy consumption with the PHPP-method leads to better results. Practice in The Netherlands shows a comparable trend: the standard/regulated energy performance method (widely) underestimates the energy consumption of low energy buildings (including passive houses). See e.g. text box Case 2.

SUMMARY

The heating energy consumption for the building projects as calculated meets the CONCERTO goals. The CONCERTO goals are significantly more ambitious than the national energy standards for buildings. Based on the available monitoring (measured) data, the heating energy consumption is close to the CONCERTO goal and on average lower than that. Meaning that, based on the available measurement data, the CONCERTO energy goals were also realized in practice.

MONITORING RESULTS – SOLAR HEAT

The GSC partners measure the solar thermal energy production. For the projects in Austria, the solar yield of all solar thermal installations can be found on *www.energiebuchhaltung.at*.

The solar fraction as a percentage of total energy for heat and hot tap water (based on a number of projects in Salzburg) as measured is ca. 13%, which is less than the CONCERTO goal. This number increases if PV systems are included. For the solar thermal installations in Austria a certain yearly production is guaranteed. In all projects, the guaranteed values are met.

MONITORING RESULTS – SOLAR ELECTRICITY

The installed PV capacity in related projects in Salzburg and in Copenhagen amounts to 50 kWp in Salzburg and ca. 150 kWp on CONCERTO buildings and ca. 900 kWp on other locations Copenhagen. The expected yearly production (conservative estimate) is 52 MWh/a for Salzburg and 890 MWh/a for Copenhagen. The measurement results from Copenhagen suggest a higher electricity yield.

The combined solar electricity leads to 6,3 kWh/m² averaged across all related buildings in both cities (ca. 150.000 m²). The estimated contribution of PV to the project solar fraction is 5-10%. A more precise number can be derived as soon as the building dataset is complete.

LESSONS LEARNT

» **1.** The project partners did perform a large amount of monitoring work

CASE 1 – THE NETHERLANDS: 82 DWELLINGS IN THE CITY OF MONTFOORT

GOAL: Feasibility study of several levels of renovation, with emphasis on saving energy, lowering energy costs for the occupants and creating a healthy indoor environment.

ENERGY CONCEPT: Robust concept: proven techniques that need little maintenance and are not sensitive to the way the tenants interact with the house.

- less draught through insulation of the whole building façade, new window frames and HR++ glazing, minimizing infiltration losses and self-regulating vents;
- improving the indoor air quality by applying a CO_2-regulated ventilation system and a higher ventilation rate;
- low-temperature heating with radiators;
- solar water heating system to preheat domestic hot water.

RESULTS: The total investment of the renovation is € 60.000,- per dwelling, partly financed by increasing the rent by € 29,- a month. The approach leads to substantially lower energy costs for the tenants: the predicted energy saving is 48% in comparison with the former situation. An evaluation of the first year shows that the net yearly costs for the tenants did indeed decrease by the renovation.

collected an impressive data collection. The collection of data is not finished, however, for several reasons:

- A considerable number of projects started later than initially foreseen. So part of the monitoring work is still ongoing, and complete datasets are not available yet. Our conclusions are based on available data in June 2013.
- In addition, collection and analysis of the measurement data proved to be time consuming. Also initial problems with meters, loggers or (parts of) installations did delay the results.
- **2.** The regulated energy performance calculation methods do not provide an accurate estimation of the heating energy consumption of low energy buildings (ca. 15 kWh/m² and below). That is illustrated by e.g. projects Esshaverstrasse in Salzburg and Langgadehus in Copenhagen, as well as by our experience in The Netherlands. Also, for buildings like schools and swimming pools, with relatively high hot tap water consumption, the standard energy performance calculation methods might not accurately predict the energy consumption for hot water. This can lead to the situation that a building meets the national or CONCERTO energy requirements according to the official calculation methods and the building is built properly, but does not meet the requirements in practice.
- **3.** Monitoring is useful not only for validating energy performance in practice, but also to identify problems with buildings or installations in an early stage, and thus to enable better buildings in the future.
- **4.** Almost all buildings involved in GSC use district heating as a heat source. The heat sources of the district heating networks are (waste) heat from e.g. power plants. As a result, the net CO_2-emission for heating purposes is relatively low compared to natural gas fired boilers or

different electric heating technologies. District heating is relatively common in Salzburg and Copenhagen, but not in Europe as a whole. It proves to be an efficient method to lower the primary energy consumption and CO_2-emissions.

RECOMMENDATIONS

» **1.** Expand monitoring and evaluation period to at least one year for all GSC building projects. Recommendation (and trend) to do so for all energy efficient new and retrofit buildings. Important for owner and/or occupants to know whether investments return and environmental ambitions are met.

» **2.** Standard energy performance methods prove not sufficiently precise to predict the energy consumption of low energy houses. With the European Directives and national legislation towards (near) zero energy buildings this problem becomes more serious. Some form of prediction of the energy consumption of a new or retrofit building is very important for owners, buyers and tenants. The European and national (EPBD) energy performance calculation methods need to be improved to address this. One option is to use alternative calculation methods for low energy buildings, for example PHPP.

» **4.** In addition to the previous point, governments should realize that the calculated CO_2-emissions and energy consumptions of low energy buildings might not be in correspondence with the real values. This can have consequences for the manner in which energy and CO_2-reduction goals for the built environment are translated into energy performance requirements.

CASE 2 – THE NETHERLANDS: JUSTUS VAN EFFEN SOCIAL HOUSING COMPLEX

GOAL: Restore the world famous national monument to its former glory and make the dwellings fit for the 21st century.

ENERGY CONCEPT: Focus on a high-quality building shell with a high level of insulation and use of solar- and soil energy:communal heating system with a ground source heat pump that uses an ground water reservoir for thermal storage;

» improving the indoor air quality by applying a CO_2-regulated ventilation system with natural air supply;
» low temperature heating with floor heating / cooling;
» energy roof: use of solar energy for regeneration of the thermal storage system.

RESULTS: The energy use is predicted for calculation of the operating costs of the installations and to determine the energy deposit for the tenants. A first analysis of the measurement results shows that the actual energy use is higher than predicted. Studies of the quality of the building façade and measurements of the air tightness show no large deviations. The higher energy use is most likely to be assigned to a difference in the actual behaviour of the tenants and the assumptions the calculations were based on, or deviations caused by this being the first year after completion of the project.

HOW MUCH FOCUS ON USER INVOLVEMENT?

By **Evert Hasselaar**, dr.ir., Delft University of Technology, Department OTB – Research for the Built Environment, Delft, The Netherlands

In the Concerto project Green Solar Cities, the coordination between stakeholders, including community builders, has been a key to success in reaching ambitions. Finding social capital in a neighbourhood, facilitating bottom-up projects and creating a balance with top down actions represent a strategy for more user involvement. The answer to the question in the title is clear: much focus! The practice of participative planning needs much development.

SOCIAL CAPITAL

As Tonkens points out, there is a huge potential of people who want to become involved as active citizens, but lack the setting to co-produce their human capital (Tonkens & Newman, 2011). Participation in reconstruction or renovation plans is for that reason not obstructed by lack of interest from the side of consumers, rather lack of perspective from the planners and project developers.

'Participative planning' can be defined as a planning process in which the future occupants or people in the surrounding neighbourhoods are stimulated to become actively involved, are helped to form and express their ideas and eventually become co-producers of the neighbourhood and the city. (Hasselaar & Praag, 2012). Social sustainable quality refers to the power of (people in) a community to solve problems, either by good access to the city administrators, or by taking initiatives and develop projects bottom-up.

DESIGN COMPETITION IS A BARRIER FOR USER INVOLVEMENT

Many urban plans are selected on the basis of a design competition. The winner will present the best combination of a good design and a strong team that includes the investor, architect and some specialised consultants, the construction company is often included. The design follows a concept or a vision. Then the winner has to stick to this concept. This fixation makes architectural competitions a barrier for involvement of future users in the design process. This can be solved, however, by giving future users a role in setting the requirements of the plan and in the selection of the winning team plus conceptual plan. The competition can help the future users in finding their best team and concept as well, but practice does not show this involvement of users.

Participation in the planning process for new buildings and for renovation projects is like a one-way information channel from the owners to the tenants. There can be a discussion with a feedback group but more often the nearly finalized plans are presented during large meetings for a whole block or estate. On a ladder of citizen participation (Arnstein, 1969) this resembles tokenism and consultancy rather than participation or co-production. Lack of involvement may lead to reduced support for planning decisions and lack of identity and social integration in the communities. How much attention to give to user involvement in urban restructuring? How can neighbourhoods, along with physical measures, develop into strong communities and withstand future problems? The key in the Green Solar Cities project is "community organisation".

COMMUNITY ORGANISATION

The activities of Agenda 21 Centre and the Info Point Lehen are prominently visible in Valby (Copenhagen) and Salzburg. The centres organize many community activities in which people learn to know each other (including other cultures) and share their enthusiasm for an ecological sound way of life. This is a way to mobilize social capital in neighbourhoods. The re-possession of the public space by cyclists and pedestrians (including playing children) brings about a sense of greater ownership of the public spaces. The Concerto demonstration projects and public area reconstruction projects try to make an effective combination with community organisation.

QUALITY AGREEMENT

The Quality agreement that is part of the cooperation between local partners has been important to reach quality ambitions in urban restructuring in Salzburg. The quality agreement embraces the ambitions of the Concerto II-Green Solar Cities project and enjoys a high level of participation in the monthly Steering Group meetings with all relevant stakeholders. The tenants of housing areas are represented by a community organisation consultant from Info-Point. A good social environment is considered the basis for communication and cooperation on both physical and socio-economic improvements.

INFO-POINT LEHEN AND AGENDA 21 CENTRE IN VALBY

Ecological Sustainable quality is the main focus in Valby, while in Salzburg the focus is very much on social sustainable quality. Framework for actions is: meeting other people and learn to know and respect each other. Children and elderly have an important role. Health aspects and caretaking are included in the framework, because this relates strongly to the needs of people in the areas.

Methods applied in Lehen resemble activities by the Miljocentre in Valby:

- Questionnaires and/or interviews
- These methods are used to survey needs, to get to know the tenants better and in a post-occupancy study to investigate satisfaction.
- Open houses
- A show apartment where the tenants discuss the forthcoming changes and look at plans etc..
- Festivals, exhibitions, fairs and public meetings outdoors.
- A range of activities involve many partners and a large public. These festivals etc. are great for highlighting certain topics, such as transport, ecological living and energy savings.
- Information material
- Brochures or leaflets and well-illustrated books have been produced and distributed; posters were put on notice boards and reports or invitations for events distributed via Internet or e-mail. A facebook page for Stadtwerk Lehen is used as a "virtual meeting point", in support of the live-meetings. Newsletters during the renovation give a regular flow of information to the tenants.

Many other methods were applied, such as raising awareness events, training sessions,

social gatherings, symposia and workshops. A large variety is used, because each channel reaches a certain group of people.

UNPLANNED PROTEST: A SIGN OF SELF-RELIANCE?

Tearing down a few buildings and replacing them for new houses next to Stadtwerk Lehen created political turmoil during the latest elections for the city council. The mayor intervened and decided that the ambition for the project would be presented top down and without involvement of the neighbourhood. Doing so, he took the heat off the political controversy between urban planners and a populist movement that wanted to keep the area as it was. This move saved a plan but destroyed an opportunity to work on social sustainable processes.

Some citizens in the new Lehen area started a protest movement against the densely built area and suggest that at least one building in the commercial zone should not be constructed, to provide more open space. The activists collected signatures all over the city in support of their proposal and raised a broad discussion on the quality of the open spaces in the city. Despite a feeling of discomfort with the planners and other stakeholders, the protest turned into a positive discussion on quality issues in Salzburg. Where bottom-up actions meet the planners and administrators of the city, user involvement becomes part of a positive process towards co-production.

FACTORS FOR PRODUCTIVE USER INVOLVEMENT

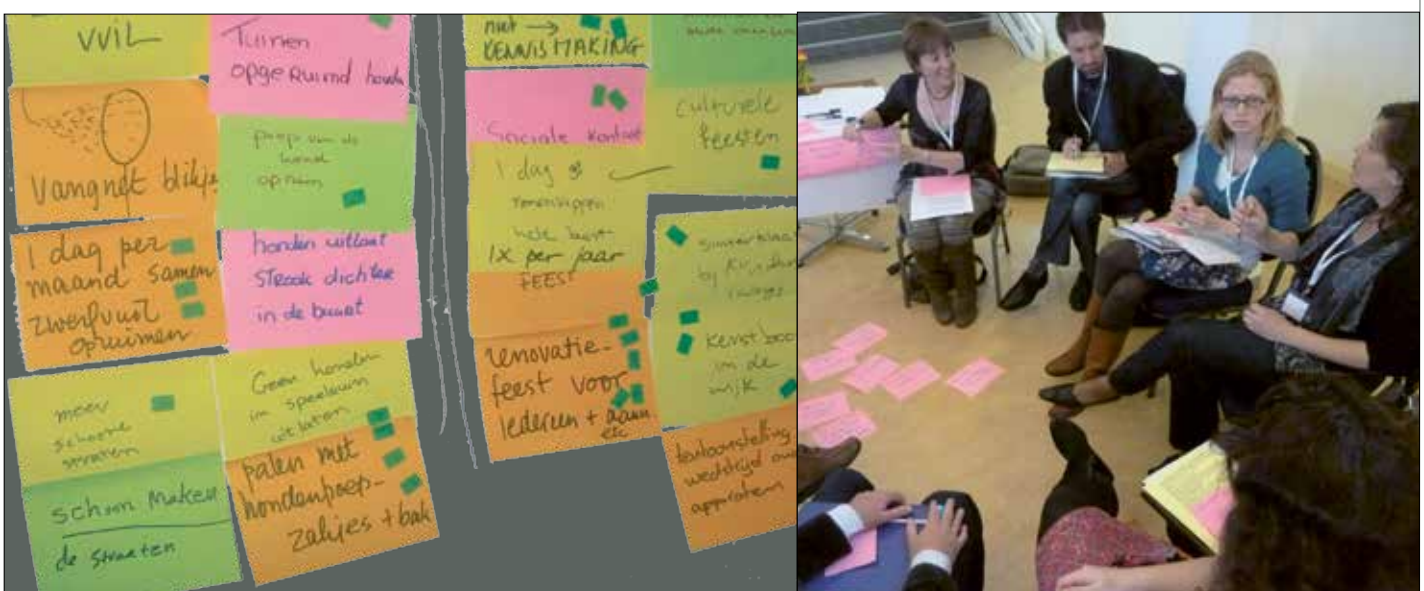
Previous experiences show conditions for a successful dialogue and coproduction (Hasselaar & Ravesloot, 2001, Bedir and Hasselaar 2010, Qu and Hasselaar, 2011 and Hasselaar and Praag 2012):

- Involvement early on in the process can be significant for how the tenants perceive the participation process as a whole.
- The housing owner is prepared to consider ideas and comments. This is very important for building trust between the housing owner and the tenants.
- The housing owner gives continuous feedback on incoming proposals and remarks: clarity is given on what can be followed and what is beyond reach or influence.
- To pursue traditional representation is not needed – enthusiastic people can make a difference.

To maintain social sustainable qualities after completion of a project, rather much attention is needed to keep "the dialogue alive". This could imply the provision of common spaces and meeting places for interaction, the constant generation of new ideas and activities – either social or building related, or both – the collection and handling of feedback from users – and to give a welcoming introduction to new occupants.

CONCLUSION

User involvement is a successful way of creating communities with stronger social cohesion, better identity and with active and creative people that know how to act when problems of many kinds occur. User involvement is a way of reaching social sustainable quality.



INDOOR CLIMATE AND USER SATISFACTION

– VENTILATION IN DWELLINGS

By **Evert Hasselaar**, dr.ir., Delft University of Technology, Department OTB – Research for the Built Environment, Delft, The Netherlands

The new built and renovated buildings in the Green Solar Cities project aim for low energy performance and a high contribution of sustainable energy. New technologies were applied and the buildings provide an indoor environment and control functions that are new for the tenants. Heat recovery ventilation, with ducted inlet of preheated fresh air into the rooms, has almost become the new standard. This article reviews experiences from users and experts.

A CHANGE FOR THE USERS

The user aspects received attention in the design process, but without direct influence of the new users, so it is important to check if the users perceive the buildings as user-friendly, comfortable and healthy. One of the major changes for users is the ventilation system: new mechanical ventilation with heat recovery, including non-adjustable air flow rates and ventilation combined with heating. The impact on the users is quite large. How well do the users adapt to these systems? How satisfied are the housing managers with energy efficient ventilation systems?

VENTILATION SYSTEMS AND ENERGY PERFORMANCE

The three system components of ventilation are: inlet of fresh air, circulation and exhaust of used air. A common system in passive houses is balanced flow ventilation with heat recovery (HRV): fresh air is ducted into all rooms and extracted from the kitchen, bathroom, restroom and storage room or attic. The heat from exhaust air is recovered though a heat exchanger with typical efficiencies of 75 to 85% (higher claims are often not realistic).

In Salzburg, the home owners opted for collective systems, meaning that fan units, filters and controls are outside the private apartment and within reach of professionals for maintenance and control. In social housing estates owned by GSWB and Die Salzburg, the collective ventilation systems cannot be adjusted by the users, the tenants of Heimat Österreich can select one extra ventilation capacity.

The most common solution in Denmark is the decentralised heat recovery ventilation system with one HRV unit per apartment, which is placed under the bathroom ceiling or in a closet or double wall partition. A survey (Simonsen and Hasselaar, 2008) indicates that the user satisfaction in Danish projects was good, although more instructions on use and maintenance are needed. Natural ventilation was necessary in the summer or after cooking or bathing. However, many suggestions for improving of the user friendliness of HRV was presented, targeting for instance on a by-pass for summer conditions, noise control, higher ventilation capacity in bedrooms, more robust control of the capacity, prevention of draught by inlet air flows, etc.

Many users of individual HRV systems apply the lowest set point, causing a range of indoor air problems and comfort problems when compensating "natural" ventilation services are missing. Also, when the system makes noise, the users most likely will choose a low capacity. The ventilation capacity often is too low in a regular-sized bedroom with two persons.

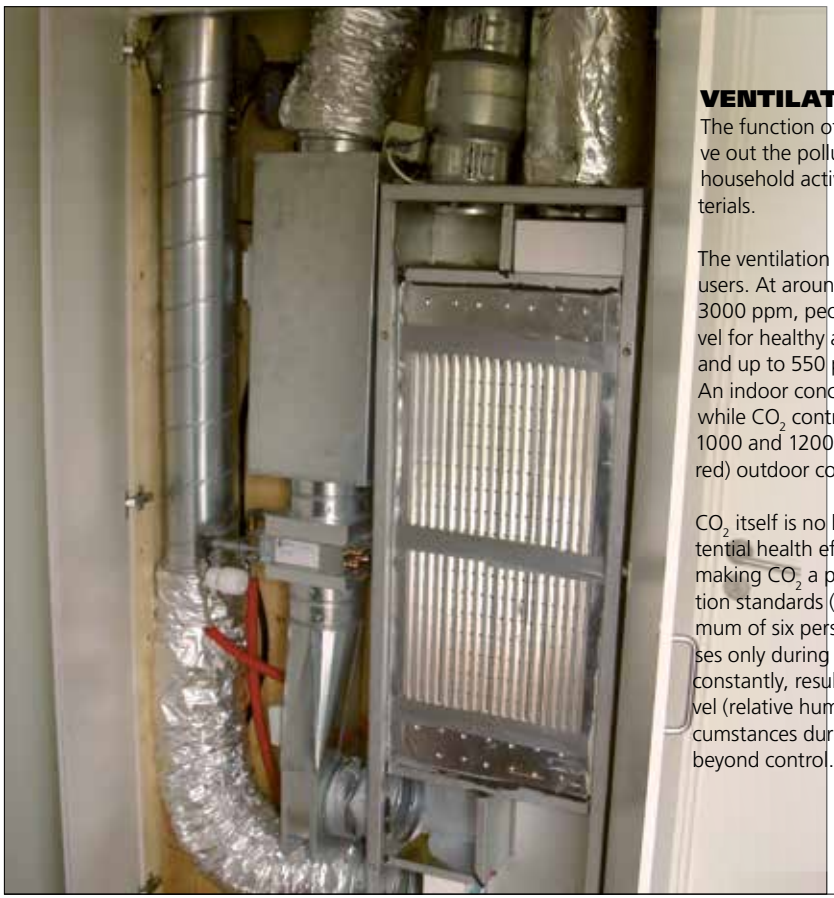
VENTILATION AND ENERGY EFFICIENCY

The ventilation system has lower influence on the energy demand than the heat transmission through the envelope or the use of hot water for washing and bathing. In low energy houses without heat recovery, the ventilation can however demand up to 50% of the energy demand for heating. With collective systems operating all the year round, also for apartments that are occupied only a few hours per day, the electricity use is a large portion of the energy consumption. Many users of individual HRV systems have

THE PASSIVE HOUSE IN ESSHAVERSTRASSE IN LEHEN, SALZBURG

PHOTO VOLTAIC VENTILATION. COMPACT HEAT RECOVERY VENTILATION UNIT FOR HOUSING RENOVATION, WHERE ELECTRICITY USE IS MATCHED BY PHOTO VOLTAIC. A TEST OF THE COMPACT HRV UNIT FROM ECOVENT / ØLAND SHOWS A DRY HEAT RECOVERY VENTILATION EFFICIENCY HIGHER THAN 85 %

COMBINED AIR INLET AND HEATING - ONLY 22 CM THICK. DEVELOPED BY ECOVENT TO FIT INTO A CUPBOARD OR A WALL



VENTILATION AND INDOOR ENVIRONMENT

The function of ventilation is to keep constructions dry and to drive out the pollutants from users, pets and the emissions from household activities, furniture, decorations and construction materials.

The ventilation standard is based on the CO_2 emissions of the users. At around 1500 ppm CO_2, the air will smell stuffy, above 3000 ppm, people may feel sleepy or get a headache. The limit level for healthy adults is 5500 ppm. Outdoor levels are 400 ppm and up to 550 ppm in congested urban areas with much traffic. An indoor concentration of 700-1000 ppm is considered healthy, while CO_2 controlled ventilation often reacts to two set-points: 1000 and 1200 ppm, or 600 and 800 ppm above the (not monitored) outdoor concentration.

CO_2 itself is no health hazard, but many other pollutants with potential health effects are correlated with the CO_2 concentration, making CO_2 a popular measure of indoor air quality. The ventilation standards (reference: the Netherlands) are based on a maximum of six persons in the household. The concentration increases only during occupation, while other pollution sources can emit constantly, resulting in potential health hazard. The moisture level (relative humidity) is a second best measure, but outdoor circumstances during wet periods may cause indoor humidity that is beyond control.

a wrong perception of the energy gains versus losses and choose the lowest set-point to avoid kWh-consumption. When windows are used instead, the effectiveness of heat recovery ventilation drops, for instance to 25%. The collective HRV-systems at constant set-point perform better, at least during cold periods of the year.

THE CASES IN VALBY AND SALZBURG

A survey of 181 inhabitants of new and renovated dwellings with mechanical ventilation in the Salzburg region indicated that improvements are still necessary. Two thirds of the respondents keep the ventilation operational for 24 hours per day, but the majority also relies on traditional ventilation methods by opening the windows. The probable reason is that the air quality is not satisfactory. The average rating is 2.25 on a 5 point scale (1=best, 5 =worst), meaning that many consider the air quality insufficient. Almost 50% of respondents consider overheating in the summer a large problem, 28% find the noise from the ventilation system disturbing while getting to sleep.

Noise is a serious comfort issue in many mechanical ly ventilated apartments. The recommended limit values range between 23-28 dB (A). However, these limits are often exceeded in practice. In a Valby project, all units had to be replaced because of noise problems. Higher limit values are allowed in e.g. the Netherlands (30 dB(A) during night time, Finland (28 dB (A)). The lowest required limit values are set in Germany, Austria and Switzerland (25 dB (A)).

In the housing project Solengen in Hillerød, based on prefabricated housing units, a good air-tightness of the buildings was obtained and only 22 cm thick ventilation unit was applied, placed in a partition wall. In Salzburg, a new system for pre-heating the fresh air was tested in Esshaverstrasse and applied in some other passive house projects: the fresh air is blown into the living rooms and heated up to the necessary temperature by a hot-water convector situated above the door. The temperature can be regulated by the users. In Stadtwerk Lehen both heat recovery ventilation and radiators for heating are applied.

CONCLUSIONS AND RECOMMENDATIONS

Permanent "standby" energy consumption of the advanced technologies and maintenance and monitoring of complex technical installations are costly. Many of the existing heat recovery ventilation solutions are not optimal, because of high electricity use, noise problems and too high costs. Further development and demonstration of better and more user friendly solutions are recommended.

SWEDISH EXPERIENCES

REGARDING CALCULATED AND MEASURED ENERGY CONSUMPTION IN NEWER LOW-ENERGY BUILDINGS

By **Peder Vejsig Pedersen**, technical coordinator of Green Solar Cities, director, Cenergia, Denmark

In Sweden it is decided to have a verification of the energy quality of new building projects. After two years there must be at least one year of measurements as a basis for a final certification of the construction from an energy expert. The two years correspond with the normal warranty period for new constructions. The developer is responsible for the verification and should also take the practical use into account e.g. with focus on the indoor temperatures and hot water consumption in practice.

The new requirements mean that both building owners and contractors adapt a new practice of measuring heat, hot water and electricity consumption in new buildings. It also means that interesting information about energy consumption in modern low-energy buildings is gathered.

KOMMANDÖREN AND FLAGGHUSET

The Engineering Consultant Company, WSP has carried out measurements in the settlements *Kommandören* and *Flagghuset* in the Western Harbour of Malmö, where the buildings were ready between 2007 and 2009 (see also www.ek-skane.se/files/publikationer). The expected use was of a maximum of 120 kWh/m² per year. But it was surpassed by 60-70% when measured, and the power requirement was 25-30 W/m², against the passive house requirement of 10 W/m².

WSP has found that it is important to develop good measurement systems. As an example it was difficult to get decentralized electricity consumption for ventilation measured. Conditions that caused problems were user behaviour, operational staff competence and commissioning of engineering. It was concluded that monitoring and measurement should be included in the design in the future.

MKB FASTIGHETER IN MALMØ

MKB Fastigheter in Malmø has 72,000 apartments. One of the lessons, MKB has learned is that all tenants, who have received ventilation with heat recovery are extremely pleased with this, and that one should not accept the proposal to make do with 2 layers of glass in the windows. (Lessons from MKB are collected in the book "MKB new function claims for production").

MKB is almost able to monitor indoor temperatures via Wi-Fi in all apartments. At the same time, MKB has introduced an energy monitoring system, which can monitor a wide range of energy information. In several cases it has tackled problems. As an example, there was a tenant in a passive house dwelling, who got a very high indoor temperature. Because of poor information, the heating system had been programmed to try to keep 33° C in the home. Or in another case, the apartment was very cold in the middle of March (17-18° C). It was only after six month of investigation that someone, who came to look at the supply temperature for district heating, could see that it was not put back on after repair. These examples show, how important it is to collect and use data of the properties.

Another experience is that also user training is important. For example, it has been found that a window that always stands ajar, can strain heating consumption with additional 25% (25 kWh/m² per year).

The experience is also that one can not rely on vendor information, as it is usually too optimistic. Here one should make a reliability control. This is particularly true for ventilation.

CONCLUSION

The new requirements for verification of energy quality with measurements, focus on key opportunities for improvements in the construction sector, because the measurements can reveal important functional problems. In this context, it would be advantageous to repeat the energy calculations in each phase of the project as a natural follow-up (pre-project, planning and realization). And when contractors are involved in verifying energy results, they will be keen to avoid the problems described in this article. One idea would be to let the turnkey contractor be responsible for the operation in the early years of the life of the building.

FACT BOX

Boverket (www.boverket.se) in Sweden, which manages the build environment, is working to develop a new "Industry standard for energy in buildings" SVEBY, which consist of three main elements:

- **1: Calculation (based on standardized energy data)**
- **2: Agreement (Power requirements and handling of deviations)**
- **3: Verification (Method for measuring and monitoring, and analysing).**

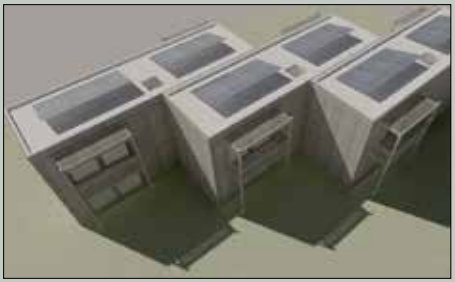
EXAMPLES OF BUILDING INTEGRATED PV (BIPV)

By **Peder Vejsig Pedersen**, technical coordinator of Green Solar Cities, director, Cenergia, Denmark

PV Boost has been ongoing since the summer of 2011. One of the most entrepreneurial activities in the project has been a conceptual design scheme for existing and new construction projects with building integrated photo voltaic (BIPV) under the direction of architect MAA Karin Kappel from Solar City Copenhagen (www.solarcity.dk) - an extension of the previous PV Cities 2012 project. PV Boost gives suggestions for the architectural integration of solar cells together with a technical assessment and calculation of the project.

In PV Boost project a series of demonstration projects using solar cells as part of the overall solutions has been conducted. Besides BIPV a lot of work is done with the measurement and monitoring of projects in collaboration with the Technological Institute and Energy Midt in Denmark.

At the same time a solar cell architecture competition with a focus on the use of solar cells has been supported. The competition was developed in collaboration with the housing association FSB and Kuben Management.



EXAMPLES OF CONCEPTUAL DESIGNS WITH INTEGRATION OF SOLAR PV TO EXISTING RESIDENTIAL BUILDINGS. THE DRAWINGS ARE FROM THE ARCHITECTS MAA MARTIN RUBOW AND CARL GALSTER AND ARE SHOWING AN OLDER HOUSE IN SORÖ AND THE SETTLEMENTS "THE COWBOY TOWN OF HERLEV" AND "LANGE ENGE" IN ALBERTSLUND

The EU-CONCERTO project 'Green Solar Cities' is expected to be a driving force for change into climate protection, use of renewable energy and sustainable energy efficient building for large reconstruction of urban areas in Copenhagen and Salzburg.

This magazine presents the results from the project.

Read more at www.greensolarcities.com

and **www.fbbb.dk**