Green Solar Cities

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Results and Experiences

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EU Concerto project, contract no. TREN07/FP6EN/S07.70775/038573
6. Frame Work Programme – Concerto II Integrated Project

Green Solar Cities EU-Concerto project

Preface

Green Solar Cities is a policy for cities focussing on a holistic approach, which includes good, energy efficient constructions and installations in buildings leading to comfort and a good indoor climate, combined with use of optimised energy supply systems together with a local contribution from renewable energy sources. And in this way it lives up to the aims of the EU Concerto programme in a strong way, especially when good energy results is secured by help of an appropriate performance documentation as part of the strategy, something which is already known will be a future demand from the EU Building Directive.

The Danish part of the Green Solar Cities EU Concerto project was defined on basis of the agreed upon Valby PV implementation plan from year 2000 which aims at introducing at least 15% PV solar power by year 2025.

This PV implementation strategy was aimed spread from Valby, which is approx. 10% of Copenhagen to the whole of Copenhagen from year 2004 by the establishment of the Public, Private Partnership Solar City Copenhagen.

In practice, the Valby PV plan has besides involvement of local groups and organisations from Valby, mainly relied on a continuous engagement from two of the authors of this book, Peder Vejsig Pedersen from the energy specialist company, Cenergia and Jakob Klint from the Copenhagen Urban Renewal Company which is now part of the Kuben Management organisation.

In addition, from year 2004 when a PV implementation approach towards the whole Copenhagen was aimed at, there has been a close cooperation with the third author, Karin Kappel head of the Solar City Copenhagen secretariat.

To be able to understand the whole background of the Green Solar Cities project, it is actually relevant also to look back to the start of the tradition of working with a combined focus on use of solar energy and low energy building, which actually dates back to the establishment of the Cenergia energy specialist company in 1982 by 4 colleagues at the Thermal Insulation Laboratory which was part of the Danish Technical University, DTU. It was here the first zero energy house in the world was developed primarily based on work by professor Vagn Korsgård and civil engineer Torben Esbensen already in 1973. This was a really good timing since it was the same year that the first word wide oil crisis emerged.

The first zero energy house included a lot of innovations and many of the solutions did not work very well, but it lead at the same time to numerous of new RTD initiatives in the 1970'es and 1980'es. And it is actually the same philosophy that have been followed by Cenergia over the years, to realise innovative building and solar energy solutions in practical full scale demonstration projects and to try to learn from this. In fact this is not so simple to do for a private company, but a large number of practical implementation projects have any way been possible to realise together with a large number of engaged builders and cities, based on a combination of funding from the EU and national programmes in Denmark.

In the period up to year 2000 the main focus concerning solar energy solutions, was on solar thermal systems and use of passive solar designs also coupled with a few innovative PV initiatives since Peder Vejsig Pedersen and Cenergias first EU supported PV project from 1992.

And exactly as it has been the case with the development of wind mills in Denmark it has always been a button up approach with engaged local people and not strong governmental policies that has created the basis of the development.

Up to year 2000 the first convincing solar power projects with PV emerged in Europe, with the most inspiring examples from Switzerland and the Netherlands, and it was actually a delegation tour to the city of Amersfort in the Netherlands where 10 MWp of PV was installed in a new city area which lead to the idea to establish a PV plan for the Valby city part of Copenhagen. The was at least to reach 15% electricity supply from PV in year 2025, here aiming at developing building and infrastructure integrated solutions with PV which would be accepted as a positive contribution to the city development. At the same time avoiding a “not in my backyard” development like we have seen from the wind mills in Denmark leading to a main focus on more costly off shore wind mills parks.

With respect to the actually possibility to realise low energy building and solar energy projects in buildings in Denmark the main support has since year 2002 been the EU Building Directive which demanded a strong energy saving policy in the EU member states. And at the same time the fact that the Danish Building Research Institute and the Danish Energy Agency made a definition for low energy buildings where the calculated energy frame value you had to live up to include a possibility to include both solar thermal and PV systems as a possibility to live up to the demands when the EU Building Directive rules was introduced in the Danish building regulations by year 2006.

In combination with an early agreement of the future demands for year 2010 and 2015 in the building regulations and changes of the “Danish Planning Law” which allowed municipalities to introduce future energy frame value based building demands in their local planning, this meant a completely new situation for the building industry in Denmark, with a large number of low energy class 2015 projects being realised, and at the same time also an important influence on large renovation projects as well.

But in the PV area there was still a very limited implementation in Denmark until year 2010 where 4 MWp was realised in all and the existing net metering practice became a law. So from year 2000 to year 2010 the cooperation between Cenergia and Kuben Management with focus on building integration of PV and PV implementation activities by the EnergiMidt company from Jutland was responsible for the main part of the Danish PV implementation. In year 2011 the PV market in Denmark increased to 12 MWp and in year 2012 due to continuously decreased PV costs, the market rocketed with up to 500 MWp PV installed, leading to a situation where many people in one family houses became almost independent of paying for their electricity costs for the next 20-30 years, a development which lead to a new solar PV legislation by end of 2012 changing the net metering from yearly to hourly accounting, to limit the market again, also supporting a future oriented smart grid policy.

The situation in year 2014 is unfortunately that the use of solar energy is still only seldom prioritized, even though many people accept that evidently solar energy must have an important role as basis of a sustainable energy supply in the future.

Even in Denmark where an “Energy Agreement” from 2012 in the Danish Parliament aims at 50% wind energy contribution to the electricity use already in year 2020, and a 100% renewable energy electricity supply in year 2035, there is still a quite reluctant interest in using PV. And it is not acceptable that PV systems due to recent huge reductions of investment costs in many cases can be more economical than off shore wind mill parks even in the Danish climate with limited solar resources in the winter.

In the Green Solar Cities, EU Concerto project there has been a cooperation with the City of Salzburg in Austria and the local energy agency SIR. The most impressive demonstration project in Salzburg includes a so-called micro grid with district heating combined with 2000 m^2 solar thermal solar collectors and a buffer tank in combination with a heat pump, as part of large scale urban renewal of the old industrial area, Lehen. Here building in a Green Cities cooperation, which started back in 1996.

For the Green Solar Cities project partners the realisation of the EU Concerto project has been very valuable and there is no doubt about the commitment to continue to develop a completely new practice for both new building as well as refurbishment of existing buildings, since there exist a large green growth opportunity in Europe if a development of completely new types of active roofs and facades for the building industry and for European cities can be secured.

And to give the best input to this development it is the idea to showcase both positive and negative results from a large number of demonstration projects including the realised Concerto demonstration projects in both Copenhagen and Salzburg.

Peder Vejsig Pedersen

1. Towards Green Solar Cities in EU Concerto

CONCERTO is a **European Commission initiative** within the European Research Framework Programme (FP6 and FP7). Responding to the facts that buildings account for 40 % of total energy consumption in the Union, for 33% of CO_2 emissions and that 70% of the EU's energy consumption and a similar share of GHG emission take place in cities, with a huge untapped potential for cost-effective energy savings, it aims to demonstrate that the energy-optimisation of districts and communities as a whole is more cost-effective than optimising each building individually, if all relevant stakeholders work together and integrate different energy-technologies in a smart way. See also : www.concerto.eu .

The EU initiative under of the European Commission's Directorate General for Energy started in 2005 and has co-funded with more than 175 Million € 58 cities and communities in 22 projects in 23 countries.

CONCERTO demonstrates implemented examples of:

- innovative technologies that are ready to be applied
- the use of renewable energies sources for cities
- energy efficiency measures
- sustainable building and district development
- economic assessments
- affordable energy
- energy transparency for citizens

The **CONCERTO initiative** proves that if given the right planning, cities and communities can be transformed into pioneers in energy efficiency and sustainability.

The results so far have been very encouraging: CONCERTO cities and communities have shown that existing buildings can cut their CO_2emmissions, at acceptable costs, by up to 50%. CONCERTO does this by implementing renewable energy sources, innovative technologies and an integrated approach.

The **58 CONCERTO cities and communities** integrate innovative energy efficiency measures with a substantial contribution from local renewable energy sources (RES), smart grids, renewables-based cogeneration, district heating/cooling systems and energy management systems in larger building settlements. These sets of innovative technologies and measures are optimised locally in order to take into account the specific characteristics and possibilities of the local site, climate and cultural differences or local political aspects.

CONCERTO cities and communities demonstrate role-models towards zero energy communities. The experiences and technology performance data from the CONCERTO sites have been thoroughly gathered and analysed in the meta-projects CONCERTO Plus and CONCERTO Premium. The results are made available on this website; in reports and via the interactive technical monitoring database with intelligent inquiry facility. Recommendations for practitioners and policy makers based on the lessons learned in CONCERTO are particularly relevant for the Smart Cities and Communities European Innovation Partnership, which addresses the challenge of making entire cities energy-smart.

The **CONCERTO** shows cities and communities how to make their energy-systems fit for the future. It helps the EU reaching its objectives of saving 20% of its primary energy consumption and cutting its greenhouse gas emissions by 20% by 2020, and by 80-95% by 2050 (compared to 1990 levels).

Green Solar Cities CONCERTO project summary page

Project full title: **Global Renewable Energy and Environmental Neighbourhoods as Solar Cities**

Proposal acronym: **Green Solar Cities (www.greensolarcities.com)**

Strategic objectives addressed, presented in decreasing order of importance to the project, but almost of equal importance:

- Improving energy efficiency
- Increasing the use of renewable energy
- Reducing greenhouse gases and pollution emissions
- Enhancing competitiveness of the European industry
- Reducing the environmental impact of associated products and services
- Improving quality of life
- Implementing solar cities

CONCERTO project abstract

In the CONCERTO project in Valby 1198 kWp PV and 840 m² solar thermal collectors have been integrated to match 81% of the yearly energy use in the new-built and renovated Concerto buildings in Valby comprising 67.143 m² housing, public & commercial buildings. This gives a high renewable energy contribution to electricity use for ventilation, domestic hot water and heating etc.

As part of the renewable energy contribution in Valby a large 777 kWp PV solar plant for a waste water treatment plant has been realised as the largest PV system in the Nordic countries.

In Salzburg they are also like Copenhagen already a kind of solar city. Their plan was in the Concerto II project to demonstrate how you can expand the use of solar heating to a higher level of the total need for heating and DHW, e.g. from 15% normally and up to 45% in the best new apartment building schemes.

This has been done by combining solar collectors with an electric heat pump and buffer storage. At the same time they use district heating which is at least 50% based on biomass for the rest of the heating supply. For the Lehen area with 287 housing units, a 2.000 m² solar thermal system have been used, and also another 600 m² solar thermal collectors for several other building projects. And besides 50 kWp PV has also been demonstrated.

Concerning the Ecobuilding both the projects in Copenhagen and in Salzburg have a large part of the proposed realisation projects which deal with renovation of existing buildings.

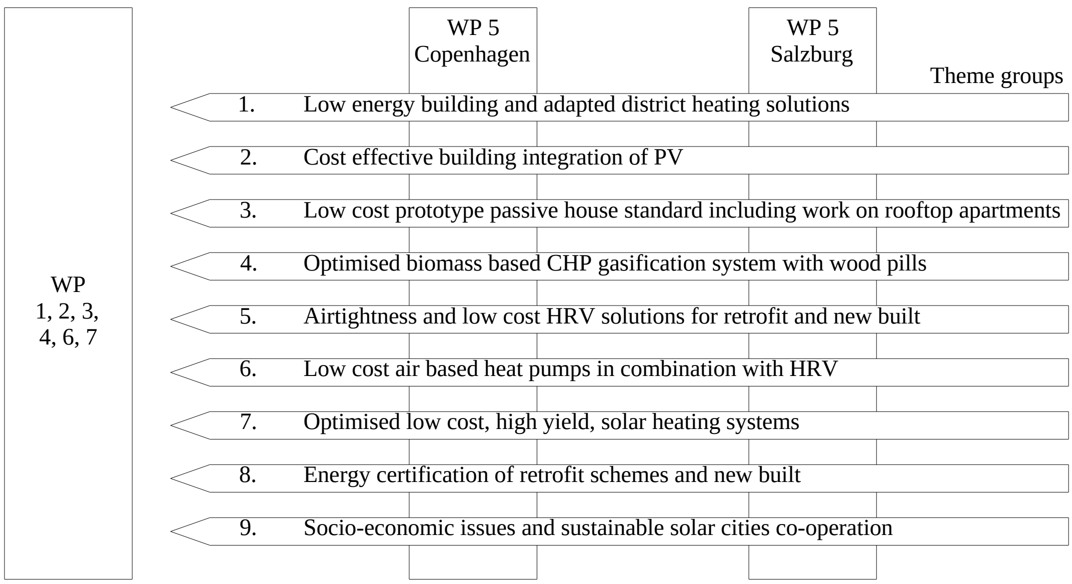
In Copenhagen it is 288 housing units and 13.500 m² public building which are retrofit based, and in Salzburg it is around 35% of a total ecobuilding area of 43.000 m². But in Salzburg they will expand this a lot in the Concerto area in the coming years, so the realised 235 renovation housing units will expand to about 1000 during a longer period. Both places it was the idea to try to develop an ecobuilding standard for retrofit aiming to achieveat least 25% better than normal new built.

Besides this there is around 500 new built housing units in Copenhagen (40.000 m²) and 480 new built housing units in Salzburg together with around 6.000 m² new build public building in Copenhagen.

Below in shown the work packages of the Green Solar Cities EU-Concerto project

WP1	Socio Economic Optimised Energy Community Action Plans	OTB	RTD
WP2	Innovative RUE and RES Technologies	Cenergia	RTD
WP3	Energy Quality Control Protocol	Cenergia	RTD/Demo
WP4	Local Design of Concerto II Communities	Kuben	Demo
WP5	Implementation of Demonstration Projects	GSWB	Demo
WP6	Monitoring of Performance Key Figures	Steinbeis	RTD
WP7	Community Training	SIR	Training
WP8	Dissemination Activities.	Green Cities	Dissemination
WP9	Management	Kuben	Management

During the realisation of the Green Solar Cities Concerto project special RTD theme groups was established as follows as basis of the strongest possible workplan for the overall Concerto II project:

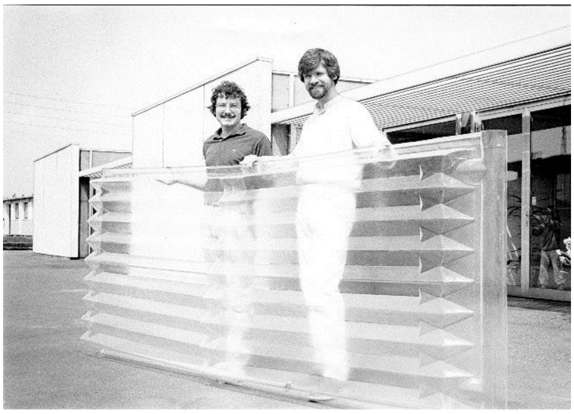


Green Solar Cities – Theme groups.

2. 30 Years of solar energy development in Denmark

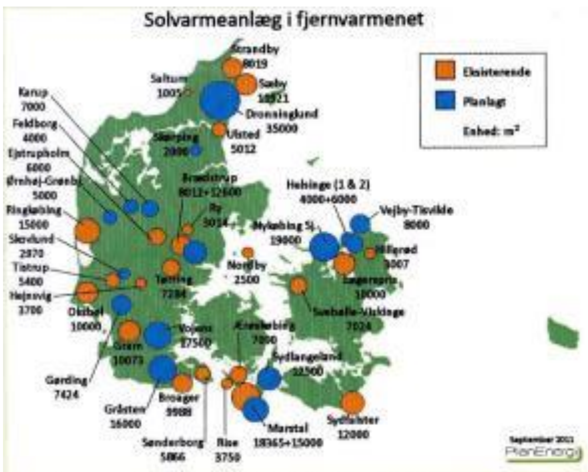
As it has been mentioned before, the Green Solar Cities project is actually based on RTD work concerning solar energy, which has taken place over a 30 years period, and the early part of this development work is mainly connected to Peder Vejsig Pedersen and the other partners of the Cenergia energy specialist company.

Back in the early 1980'es solar energy primarily had to do with solar heating, here both connected to solar thermal systems, but also comprising passive solar heating and different kinds of solar wall systems.



Two of the partners in Cenergia, Peder Vejsig Pedersen (to the right) and Ove Moerck, presenting an innovative solar collector glazing system in 1982.

Today, where the main focus is on PV or photovoltaic solar electricity, it is worthwhile to include a focus also on solar thermal systems, which in fact has led to very interesting results in the recent years. Here mainly in relation to large solar thermal systems connected to district heating, where in e.g. Denmark a wide spread use has been created all over the country with more than 500.000 m² thermal solar collectors installed.



Overview of large solar thermal installations for district heating in Denmark by 2012.

Recent very interesting examples are solar thermal systems in e.g. the smaller cities of Marstal and Dronninglund, which in combination with district heating and large seasonal storages in the ground, makes it possible to cover 50 % of the yearly district heating demand by solar heating, which is quite Impressive if you are familiar with the Danish climate, which is cold and with only limited sunshine in the winter season.

At the city of Marstal at the island of Ærø with 1.500 inhabitants, an existing solar heating plant with 18.300 m² solar collectors and a 10.000 m³ seasonal storage was in year 2012 expanded with extra 15.000 m² solar collectors and a 75.000 m³ seasonal pit storage and a 1,5 MW heat pump in the EU supported SUNSTORE4 project. This had led to 55 % solar supply and 45 % biomass supply for the district heating in Marstal.

And it was actually the same kind of solar thermal systems that created the background of making it possible for Cenergia to exist as a full time private company for the partners, when EU- and Danish national – funding was obtained for the Tubberupvænge housing area in Herlev near Copenhagen in Denmark. Here it was the aim to cover up to 70 % of the yearly heating demand for 100 low energy housing units by solar heating. This was done by help of a combination of 1.400 m² primarily high temperature, 12,5 m² large solar thermal collectors together with use of a 3.000 m³ seasonal storage in the ground, working together with a heat pump, so it was possible to create temperatures up to 95 °C during summer and cool the bottom of the storage down to 5 °C in the winter, so heat losses was limited to a reasonable size on a yearly basis.

Solar plant with seasonal storage and heat pump in Herlev near Copenhagen

3.000 m³ seasonal storage in Herlev placed under the solar collectors.

The Tubberupvænge project was finalised in 1990 as the first RTD project with seasonal storage in Denmark, and as an interesting aspect it can be mentioned that the large solar thermal system in the Salzburg part of the Green Solar Cities EU-Concerto project was actually made according to the same principles based on design work from the Steinbeis Institute in Stuttgart in Germany, here with a 2.000 m³ buffer storage and a heat pump together with 2.000 m² solar collectors. With around 257 housing units the aimed yearly solar contribution is around 35 %.

Compared to this can be mentioned, that recent projects in Marstal and Dronninglund in Denmark had seasonal storage sizes of 60 – 75.000 m³ and solar collector areas up to 50.000 m².

After the Tubberupvænge project, Cenergia was responsible for a new project in the nearby city of Ballerup also with funding from the EU. Here 700 m² solar collectors was used for 100 prefabricated low energy housing units, leading to very successful result for the operation together with low temperature district heating and a local gas fired CHP plant. This was the so-called, Skotteparken project, which was not so successful with respect to the constructions, where too high air leakages was observed, but where the holistic approach led to the world Habitat Award in 2004.

Optimised solar heating system for low energy housing project Skotteparken in Ballerup near Copenhagen.

Steel roofs and solar thermal collectors at "Skotteparken"

Initiator and Technical coordinator of the EU Ecobuilding target project, European Green Cities, Peder Vejsig Pedersen at the city hall in Copenhagen, signing the EU-contract with Jens Frendrup from Green Cities and the mayor for the environment overlooking

And especially based on this project it was then possible to form an European cooperation between housing association, The European Housing Ecology Network, EHEN and attract EU-funding for large scale Ecobuilding demonstration in 7 EU countries, and at the same time realise a number of demonstration projects in the UK, where housing renovation of 350 apartments in the Stanhope Street housing project in Newcastle in combination with Danish district heating solutions and use of a gas driven CHP system, was the most interesting.

And already in 1996 it was possible to create an European cities network, European Green Cities (www.europeangreencities.com) and get funding from EU for demonstration projects in 9 EU countries, where the first examples of building integrated PV systems was demonstrated in the Danish Urban Renewal demonstration project in the Hedebygade area in Copenhagen, and where the cooperation with Salzburg and SIR was established in connection to realisation of the Salzburg region demonstration project in the city of Radstadt.


Urban renewal in the Hedebygade area in Copenhagen, with an example of a combined solar wall/ integrated heat recovery ventilation system operated by PV modules.

Other important RTD and demonstration projects from this period includes a full scale solar energy oriented renovation of a research building at the EU Joint Research Center in Ispra in Italy, which incorporated demonstration of a very cost-effective Canadian Solar Walls solution and very successful operation in practice documented by a detailed monitoring programme.

In Denmark it was at the same time possible to realise a number of EU funded projects with use of building integrated PV solutions with the solutions at the Lundebjerggaard housing project in the city of Ballerup as the most interesting.

Here RTD work was made on both PV solutions and ventilation designs as basis of a large architectural competition, with an international jury led by NTNU from Norway. This led to very interesting results in the end, but off course still influenced by the fact, that PV systems were still expensive and not economic for the users without some kind of extra funding.

Solar research building at JRC Ispra before renovation


Solar research building renovated with Canadian Solar Wall preheating ventilation air

Also by the end of the 1990'es, interesting PV demonstration initiatives like the Solar Village project in the city of Brædstrup in Jutland, led by the EnergiMidt electricity company and the Sunyard project in Kolding with BIPV demonstration for a large housing block.

PV integration for an east / west oriented housing block in Skovlunde near Copenhagen based on architectural competition. PV here matched electricity use for ventilation.

The solar village project from year 2001 in Brædstrup by EnergiMidt.

And in 1998 the quite small community working with PV implementation in Denmark, also participated in a delegation tour to Holland to visit the so-called PV city initiative in the city of Amersfoort demonstrating integration of 1 MWp PV in a new city part in a convincing way. After which the initiative of creating a city oriented PV plan for the Valby city part of Copenhagen was created.
After year 2000, when the PV plan for Valby was launched, the interest for use of PV increased a lot in Denmark, there was a very useful BIPV development programme supported by the government, EnergiMidt here also started the SOL-1000 initiative primarily aiming at demonstration of PV in one family houses, also with a link to PV implementation work in Valby.
And Cenergia was lucky to obtain EU funding for a very large EU supported project "Resurgence", led by the Peabody Housing Trust from London and with other partners from Switzerland, Germany and Holland.

Example of PV implementation project in London by the Peabody Housing Trust and supplementing funding from the EU

And with a situation after 2001 with a new government in Denmark with absolutely no interest in supporting renewable energy implementation, the EU-Resurgence project together with supplementing funding from the city of Copenhagen, and the Sol-1000 project represented the only active implementation work with PV, also supported by a limited amount of RTD work which it was possible to secure.
Especially the funding opportunities from the city of Copenhagen was crucial here, securing important BIPV demonstration projects including the SOLTAG project from 2005, with the CO2 neutral roof top apartment, which was realised with the VELUX company as an important partner. Also by end of 2005, Peder Vejsig Pedersen and Cenergia realised the first passive house building project in Denmark, Rønnebækhave II in Næstved south of Copenhagen. Here with a zero energy heating design based on both solar thermal collectors and use of PV modules.
And by 2007 the EU Concerto project, Green Solar Cities started with focus on PV implementation in Valby in Copenhagen.

PV-art project in Valby supporting the Valby PV plan

The SOLTAG CO2 neutral rooftop apartment. Here exhibited at VELUX's premises.

In Rønnebækhave II in Næstved, a small housing block was realised, based on the passive house principles and with a zero energy heating design

Initiative by VELUX to make a south European zero energy SOLTAG building in Bilbao

Green Solar Cities housing renovation in Valby with both PV and solar heating supporting the idea of solar energy combined heat and power

3. Solar City Development in Copenhagen and Salzburg

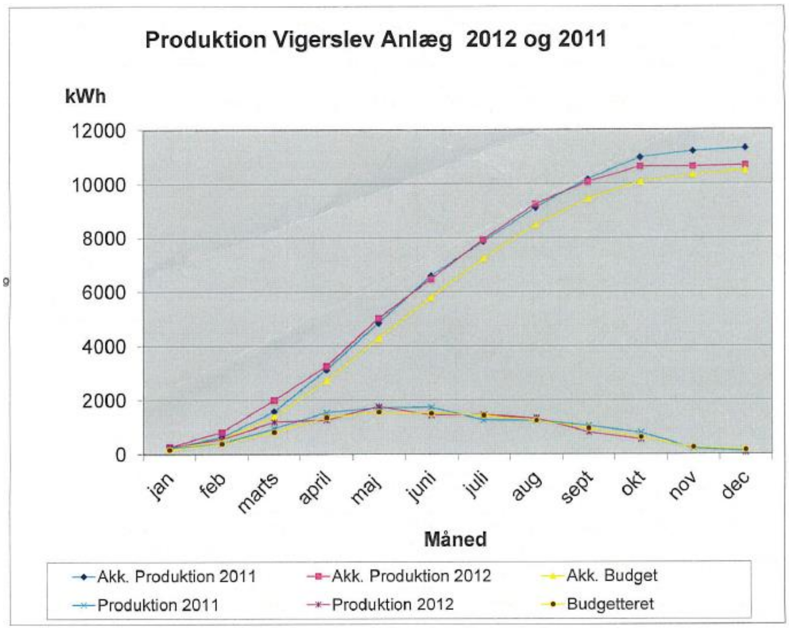
3.1 Green Solar Cities development in Copenhagen

Introduction

When the EU Concerto project, Green Solar Cities, was started in the summer of 2007, The Copenhagen PV

Coop had existed for 3 years with 65 different investors, who had invested in two PV installations of 40 kWp and 14 kWp, one on a municipal building and one on a building owned by the electricity company "Dong Energy". (www.solcellelauget.dk)

This initiative was inspired from the Solar Stock Exchange model from Switzerland, which had existed there with good results for many years as a way to expand local investments in PV. During the realisation of the Green Solar Cities project it has been possible to realise a PV project in Valby by Copenhagen PV Coop with 22 kWp based on the same model.



Copenhagen PV Coop (www.solcellelauget.dk) has existed since 2004, Here PV production figures from the Vigerslev PV system in Valby

However, the situation is now that this type of investments will be difficult in the future since the model of selling the PV electricity to people interested in supporting sustainable electricity production has been difficult to realise in practice in Copenhagen, mainly due to a very limited marketing of the concept.

However, the fact is at the same time, that the huge reduction in PV costs until 2013 has changed the whole focus on PV implementation and the market as a whole.

Below is shown how the expected development of PV costs were in 2008, where typical installed costs was 35 -38 DKK/Wp (around 5€/Wp)

Expected development in PV economy in Denmark (figures from 2008)

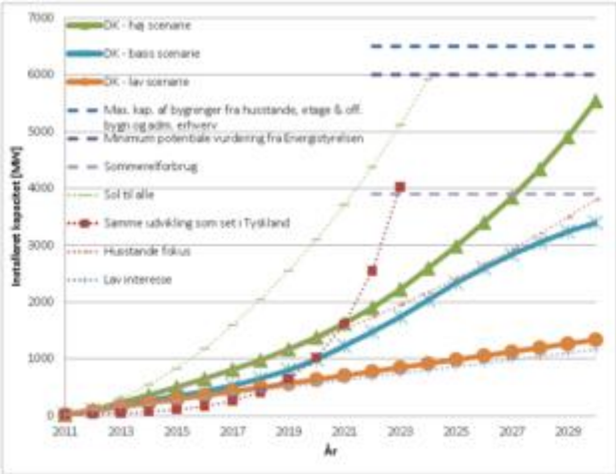
Year	PV costs DKK/kWp	Expected electricity costs with-out VAT DKK/kWh	Pay-back time (years)
2004 Establishment of Solar City Copenhagen	35-42	1,4	35
2009	30-36	1,7	23
2015	18-24	2,2	11
2025	10-12	3,0	4

The interesting thing is now that during 2013 the aimed PV costs for 2025 have already been reached in the best cases and for larger PV installations. And based on this a whole new situation emerged during 2012, when grid parity was reached in Denmark due to the relative high electricity costs, and 500 MWp was installed compared to 12 MWp in 2011.

US Department of Energy Secretary Steven Chu takes questions from the press after discussing the future of renewable energy in a plenary session of WREF. Photos (2): NREL

Solar is becoming cost-competitive

At the WREF 2012 (World Renewable Energy Forum) conference in Denver, Steven Chu told the audience that at present PV systems were already cost competitive in Germany France, Italy and Denmark. The same situation would be reached in the US before year 2020.



Possible development of PV in Denmark according to a basic and both more and less aggressive scenarios.
In the basic scenario a PV capacity of 1 GW is obtained in year 2020, and in 2030 the installed PV effect is 3,4 GW equal to 8 % of the electricity use in Denmark.

The big transformation towards use of solar energy

For Peder Vejsig Pedersen from Cenergia, it has ever since the first oil crisis in 1973, been very clear, that solar energy, wind energy and other renewables are the energy sources of the future, since the amount of fossil fuels are very limited and CO2 emission is a serious problem.

If you can agree to this, then it must at the same time be clear, that one of the most important research and technical development areas, which is needed, is the combined focus on how to save on the energy use, optimise the energy supply systems and combine with use of renewable energy sources with solar energy as the most promising option.

The situation was in the late 1970'es that there was only very few examples of solar energy utilisation.

To change this has been a main aim of Peder Vejsig Pedersen and Cenergia for more than 30 years. Cenergia was established in 1982 as an energy specialist company based on experiences from RTD work on low energy building and solar energy at the Technical University of Denmark.

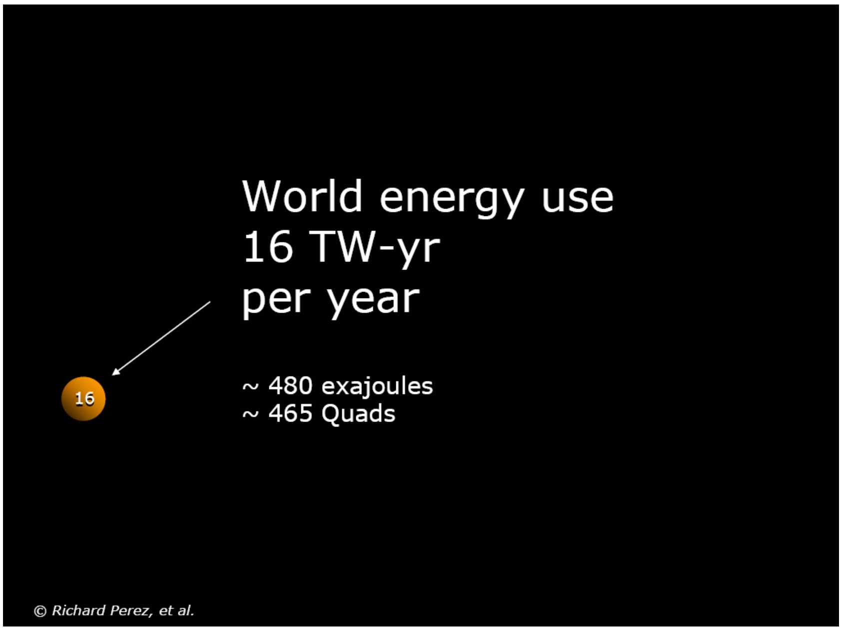
Since then a large number of solar low energy new build and retrofit schemes have been realized, in many cases as either EU or Danish funded demonstration projects.

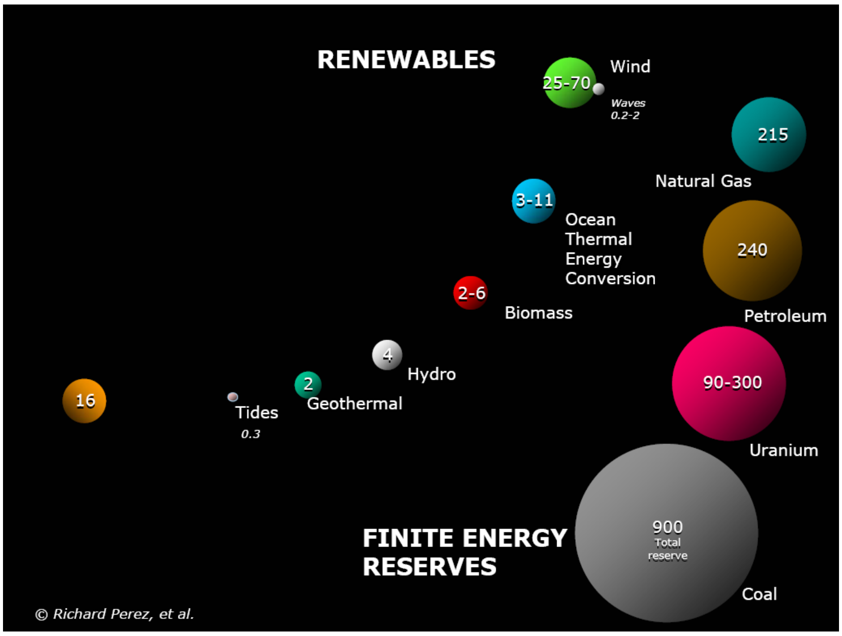
Since the new building rules was implemented in Denmark in 2006, based on demands from the EU, Cenergia has participated in a large number of building projects where new optimized constructions and installations have been introduced often in combination with use of solar energy.

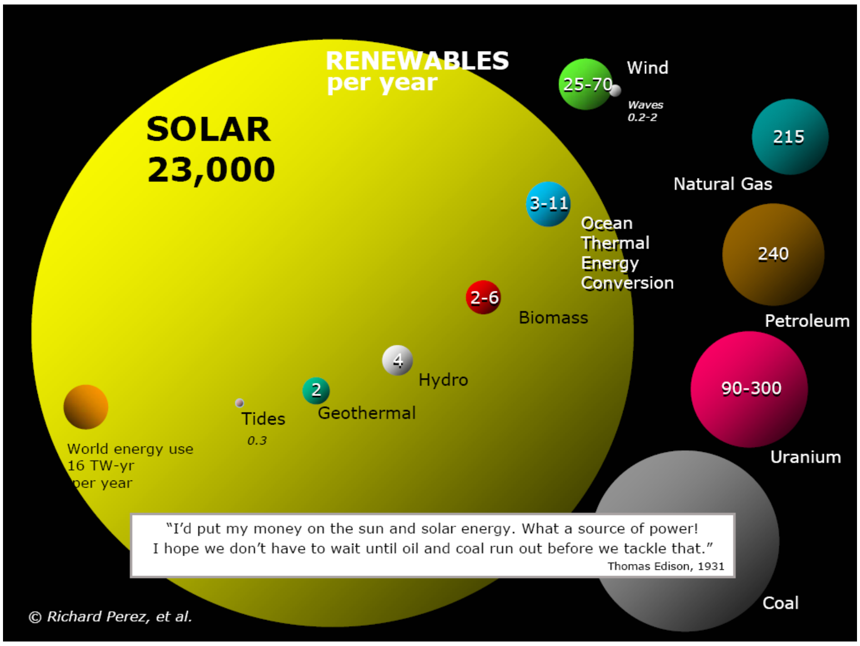
And with the improved demands in the EU building directive from 2010 aiming at a nearly zero energy standard for new build already from 2018 in public buildings and in 2020 for all buildings together with demands towards the EU member states to create a similar standard for existing buildings, it is now a challenge to create a whole new basis of energy efficient building design in Europe.

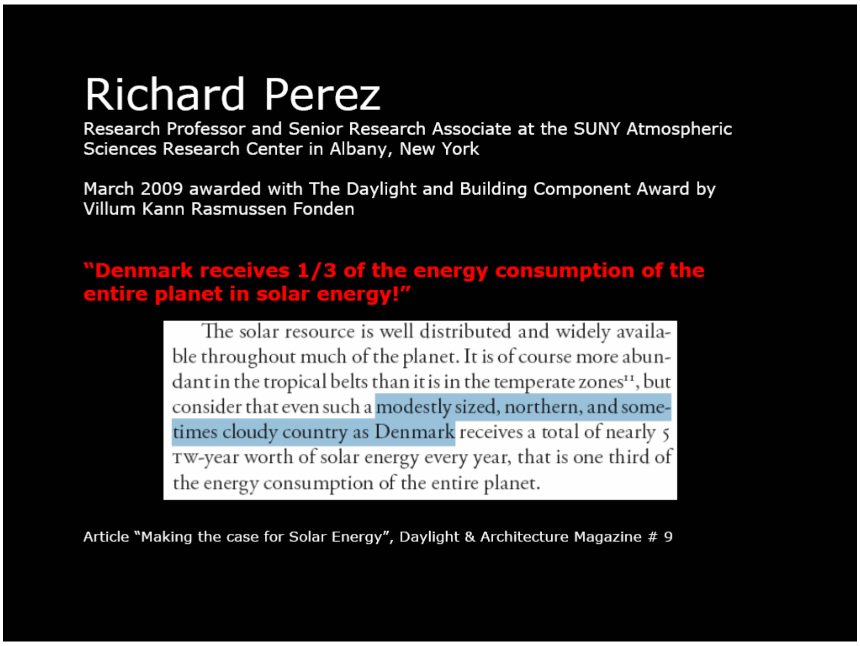
There has been both positive and negative experiences during this period based on which can be stated, that a main barrier of both energy saving and solar energy solutions is, that you can not always be certain, that building projects, realised in practice will perform in accordance with calculations, which means performance verification is a very important task to focus on. In the Green Solar Cities book, it is a main idea to be open about experienced problems and failures, also showing, that both older demonstration projects as well as quite recent projects, show a clear mix of both good and less good performance results, but all this experience is very relevant to learn from.

<u>The incredible amount of available solar energy in the world is shown below:</u>




RENEWABLES
25-70
Wind
Waves
0.2-2
215
Natural Gas
3-11
Ocean
Thermal
Energy
Conversion
240
2-6
Biomass
Petroleum
4
Hydro
90-300
16
2
Geothermal
Tides
0.3
Uranium
FINITE ENERGY
RESERVES
900
Total
reserve
Coal
© Richard Perez, et al.

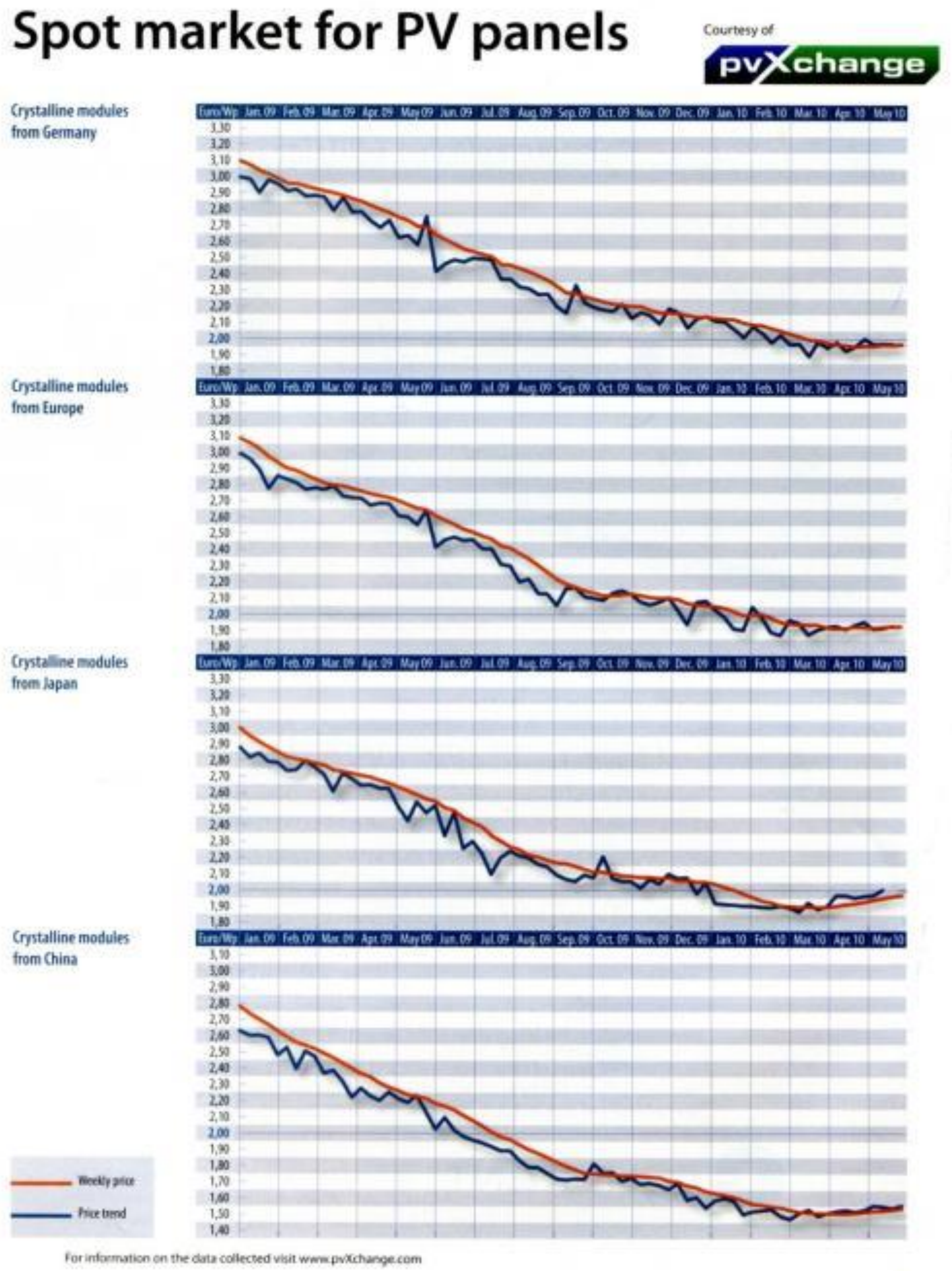

RENEWABLES
per year
25-70
Wind
Waves
0.2-2
SOLAR
23,000
215
Natural Gas
3-11
Ocean
Thermal
Energy
Conversion
240
2-6
Biomass
Petroleum
4
Hydro
2
Geothermal
90-300
Tides
0.3
World energy use
16 TW-yr
per year
Uranium
"I'd put my money on the sun and solar energy. What a source of power!
I hope we don't have to wait until oil and coal run out before we tackle that."
Thomas Edison, 1931
Coal
© Richard Perez, et al.



The roadmap for PV from 2009 according to the International Energy Agency and EPIA (www.iea-pvps.org)

PV is currently only 0, 1 % of global electricity generation, but PV is expanding rapidly due to dramatic cost reduction with 40 % reduction in system prices from 2008 to 2009.

Since 2000 with average annual growth rate of 40 %, new IEA Renewable Energy Division Roadmap envision that PV, will provide 5 % of global electricity consumption (900 GW PV) in 2030 with annual market growth rate of 17 %, increasing to 11 % in 2050 (4500 TWh per year) corresponding to 3000 GW installed capacity. European Solar Europe Industry (EPIA) projects alone in Europe 400 GW PV by 2020 and 700 GW by 2030.



<u>Example of huge PV costs reduction in 2009 and 2010.</u>

The “Green Solar Cities” vision is based on the universal relation between the necessary initiatives you need to work with for the future. That means that energy savings in both new build and renovation is the first thing you need to introduce and optimise. And when this is done you should look to first an optimised energy supply solution and secondly investigate how solar energy can be utilised with a high contribution in connection to this, e.g. making near zero energy or plus energy building possible.

And also when it comes to the market for low energy building, both in connection to new building projects and renovation projects there are unique opportunities in Denmark. This is mainly based on the EU based increased demands towards new building energy standards coming from the EU Building Directives from year 2002 and 2010, and the fact that an energy renovation strategy for existing building has been agreed in Denmark aiming at renovating all buildings before year 2050, when a completely CO2 neutral society is the goal. The result of this is that the renovation rate, which today is around 1 % of the building stock per year, has to be increased to 3 % per year.

There is however still an important barrier here since low energy building projects is still not realised based on holistic and high quality solutions.

This is in fact the main aim of the Green Solar Cities publication to provide people with a vision of how cities and buildings of the future can be implemented with a high energy quality and with an optimised energy supply which is to a high extend is based on renewable energy. But still with an equal focus on how to secure best practice in practice by introducing a clear policy for performance documentation. And this can be handled by looking at experiences up to now showing where the risks of obtaining bad performance results lies in practice.

If we want to realise Green Solar Cities in practice one important example is how the City of Copenhagen has changed its policy from not allowing solar energy solutions to be seen from public city and street areas to developing a real solar energy plan for Copenhagen, where best practice solutions are supported and documented and inspiration is transformed to stakeholders by a solar energy city atlas showing where the best opportunities to utilise solar energy on buildings exists.

The understanding of the opportunities to mix solar electricity with solar heating has not been implemented yet in Copenhagen on a large scale, but here the EU supported cooperation with the City of Salzburg in Austria during a seven year period from 2007 to 2014, has shown how city based solar energy implementation, mainly based on solar thermal energy, can work in practice and in this way give an important inspiration, so solar energy combined heat and power can be a realistic option for the future.

Due to having a situation with the highest energy costs in Europe since the early 1980'es (except for industrial organisations), Denmark has a unique opportunity to be a frontrunner in the necessary transformation to a renewable energy based society.

The result of this policy, where the politicians decided to keep the high costs of oil, gas and electricity by help of taxation as a result of the second oil crisis in the early 1980'es, has led to a situation where Denmark has a clear leadership in the use of district heating with 55 % of buildings utilising this often together with combined heat and power as well as use of wind energy, which is now coming around 30 % of the yearly electricity production.

Another not so much recognised result of the situation with the high energy prices is that solar energy solutions have started to penetrate the energy market on a large scale. During the last 10 years we have seen a large number of solar thermal plants being connected to the widespread district heating systems in Denmark, typically covering up to 20 % of the yearly district heating demand and without any kind of subsidies, and in some cases covering up to 50 % of the yearly district heating demand, when it is coupled together with large seasonal storage solutions.

And for the PV, solar electricity market, which has been kick-started by German feed in tariffs from around year 2000, there was not much happening in Denmark based on a yearly netmetering scheme (which also was used for the windmills in the beginning), but when huge reductions of PV costs emerged in the last few years, there was suddenly a situation where PV systems could be installed with good economy for the users, something which especially one-family house owners became aware of.

The result was, that where there was a nearly not existing market in year 2010, a small market was established in year 2011 with 12 MWp and this catapulted into approx. 500 MWp PV installations in year 2012. This is something that had to be quickly handled politically in an energy system like the Danish, because the energy taxes are now a quite big part of the state budget every year. And very quickly complaints were made about one-family house owners, who invested in the allowed up to 6 kWp PV installations, and in fact could avoid any electricity bills for the next 30 years even though they needed to utilise the common electricity network especially during winter where there is not so much sun in Denmark.

The politicians were unaware of this situation in early 2012 when they signed a long term energy strategy aiming at transforming the Danish society into a 100 % renewable energy supply society mainly based on off-shore wind energy, already in year 2035. Here they were only allowing 800 MWp solar PV installed by year 2020. The situation now is that the yearly netmetering scheme for solar PV has been changed into an hourly based netmetering scheme as part of a smart grid strategy and future PV installations is aimed to have a stronger focus towards housing associations and cities.

With the continuous reduction of installed PV costs the situation in Denmark today is that PV systems in some cases are becoming more cost effective than off-shore wind installations.

This situation is still not recognised by the politicians, but it creates in fact the opportunity to create a basis for large scale implementation of solar energy solutions in Denmark.

Here it is relevant to look at the situation we have in Denmark, where it is being discussed what to do with the combined heat and power based district heating, when the main part of electricity will come from windmills.

In relation to this barrier, large scale use of solar energy provides an opportunity for a win-win situation, if it is installed in the form of so-called solar energy combined heat and power, which provides solar heating and solar electricity in a relation 1:1, in the same way as the existing large scale combined heat and power (CHP) systems does. This means that operation of the large CHP system can be reduced in sunny periods with saving of fuels as a result.

For the city part of Valby, which is approx. equal to 10 % of Copenhagen, a PV plan was launched in year 2000 aiming at covering 15 % of the total electricity use by PV solar electricity in year 2025. This should be possible with 30 MWp PV installed. In 2013 we have reached 4 MWp PV in Valby but only 600 m² solar thermal installations. If this would be increased to 54.000 m² solar thermal capacity a true 1:1, solar energy combined heat and power solution will be able to document an optimised combination with the large scale combined heat and power system in Copenhagen which actually will utilise biomass in the future.

In areas outside the district heating areas the combination of continuously reduced PV costs and use of todays improved heat pump solutions also provides an interesting business case.

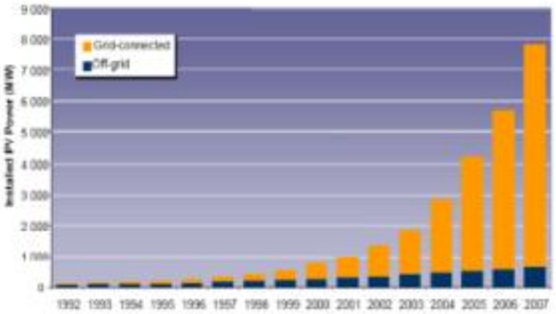
Here a main obstacle is the lack of integrated performance documentation, even though continuously increased demands concerning energy efficiency like the low energy classes 2015 and 2020 in Denmark are already utilised by many cities. The result of this is that builders cannot be certain to obtain the high energy performance which has been paid for, since the only documentation is relying on calculations. Until today we have only experienced one area where a much increased energy quality has been introduced in practice in Denmark, and that is the demand for airtightness of buildings, since it is easy to control and there is still responsibilities for contractors up to 5 years after a building is completed.

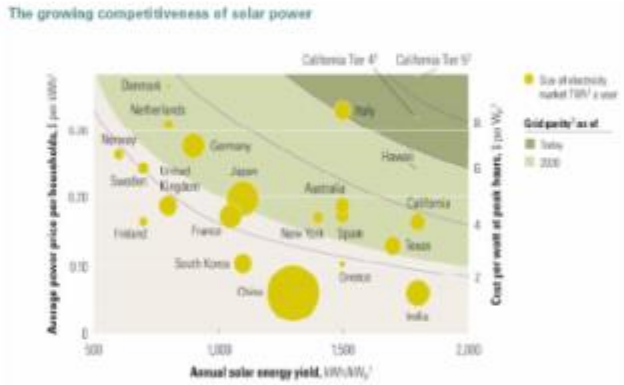
Here it is a clear challenge to introduce much more useful monitoring and survey systems so it is possible in a short time to establish what the performance of a new building is in practice, so this quality can be included in the way buildings are realised. And this should also be the approach for building renovation.

In connection to this it is very important not only to focus on how to make new building projects, but to try to utilise experiences from already realised solar low energy building projects, and here especially not only focus on the good results but at the same time try to learn from the not so good results, so the same failures are not implemented again and again.

Example of housing area with courtyard houses renovated with solar energy combined heat and power (PV + Solar thermal in relation 1 : 1)

The European PV producers association EPiA has in 2008 documented that 6-12% of the EU electricity use can be covered by PV in year 2020





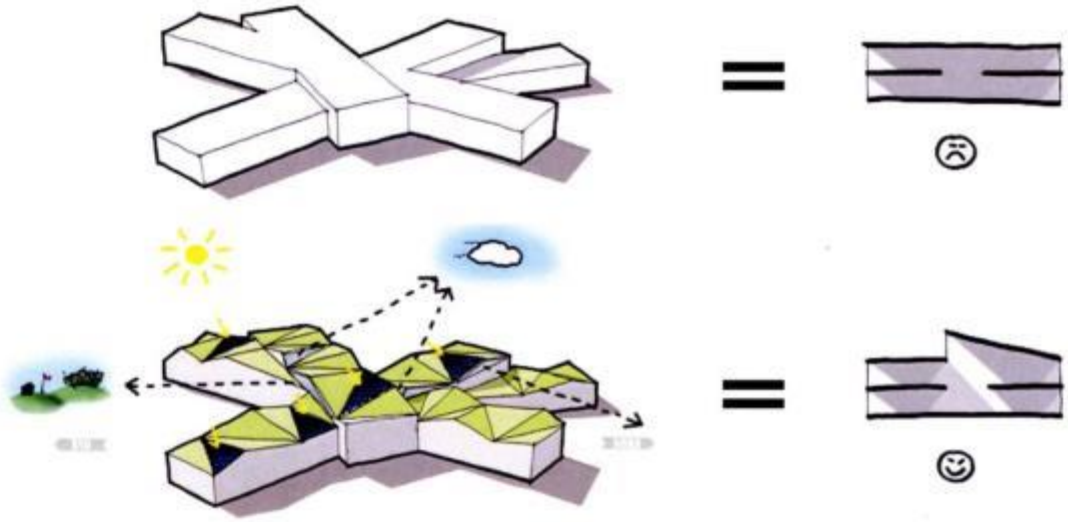
PV economy compared to off shore wind mill economy

The production cost for electricity from PV was by October 2013 somewhere between the cost for land based wind mills and for off shore wind mills. This is based on a PV installation cost of 14.000 DKK pr. kWp for larger systems leading to PV electricity production costs of 90 €/MWH

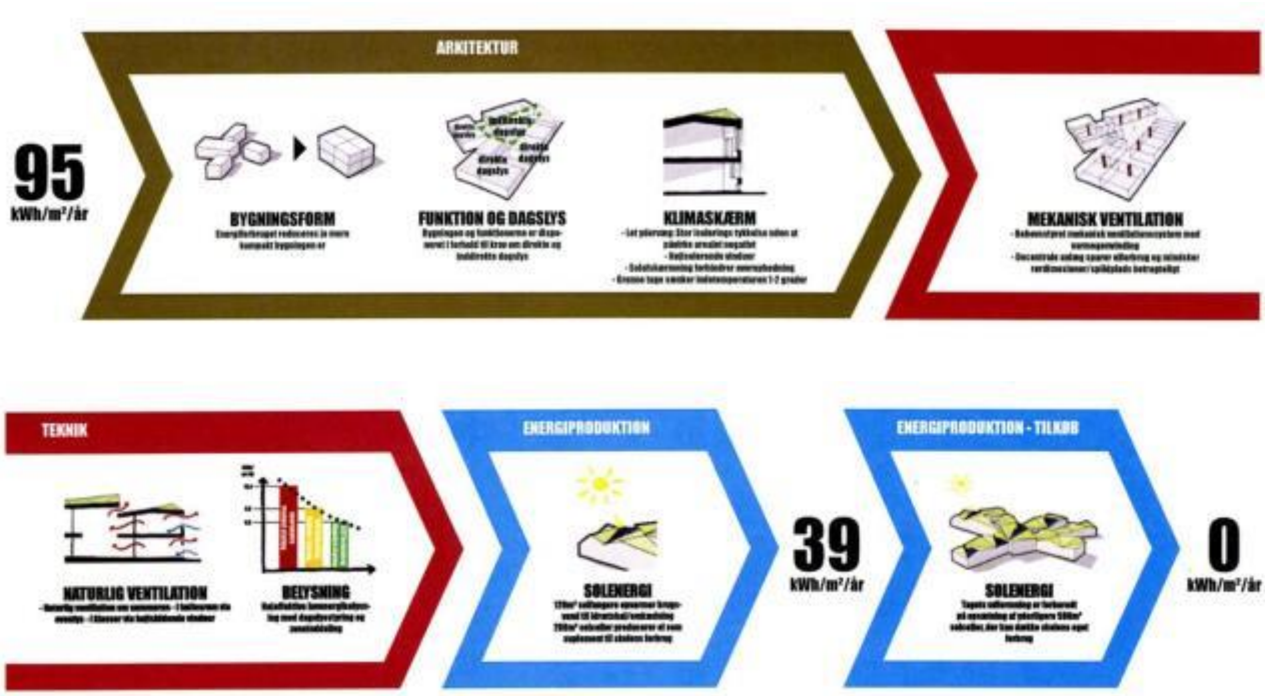
At the same time it is a fact that the Danish energy company, Dong Energy informs that electricity from off shore wind mills have a production cost of 160 €/MWH and with an aim to reach 100 €/MWH in year 2020. Compared to this can be mentioned that large solar thermal installations like the Strandby heating plant in

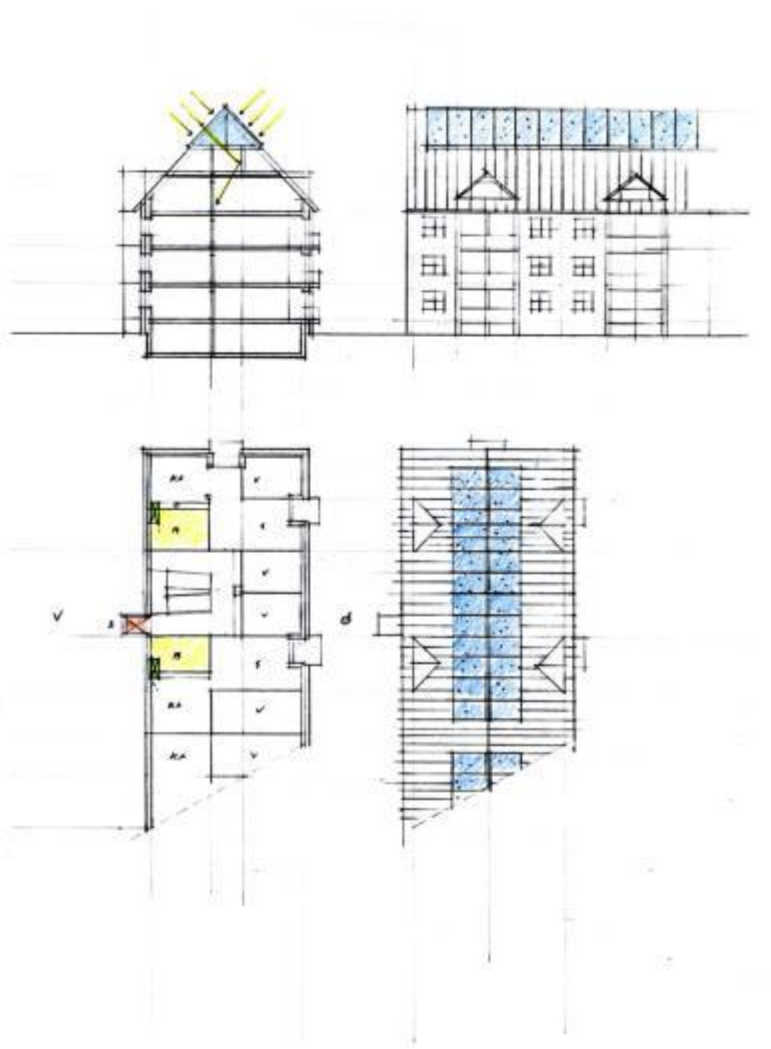
Denmark with 8000 m² solar collectors produces solar heat for district heating at a cost around 30 €/MWH.

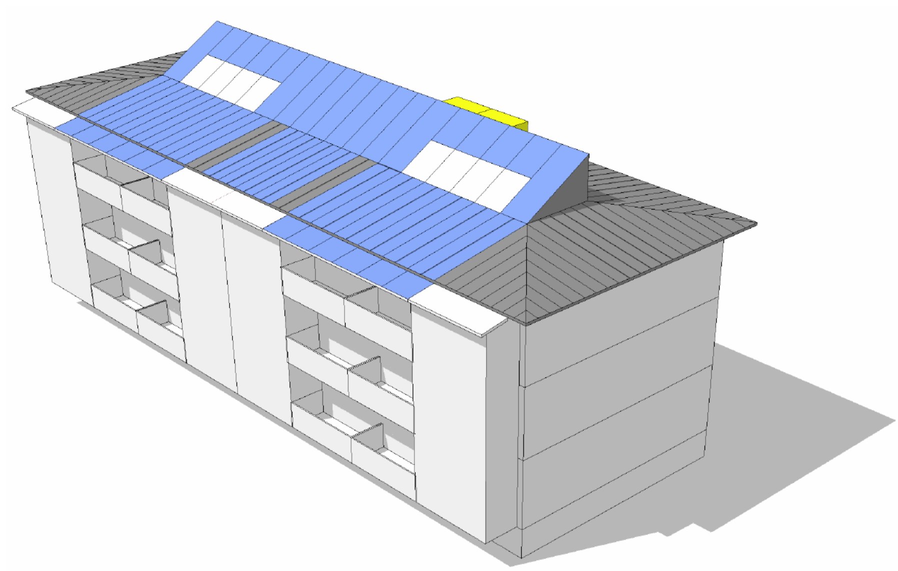
Example of large scale solar heating supply for a whole city, Marstal in Denmark, where 55 % solar supply for district heating was secured in 2012, based on 35.000 m² solar collectors, 75.000 m³ seasonal storage and a heat pump, supplementing 45 % biomass based heat.



KRAV TIL DAGSLYS OG ENERGI FORMER BYGNINGENS TAGFLADE







Example of housing renovation possibilities, based on solar energy combined heat and power, which both utilises BIPV and solar thermal collectors.

GREEN SOLAR CITIES EU Concerto project in Copenhagen

A basis for a completely new way to build in Europe has been created by the recast of the EU Energy Performance for Buildings Directive from 2010, which demands that new buildings should achieve a nearly-zero energy standard based on local renewable energy sources already from 2018 for new public buildings and from 2020 for all new buildings, at the same time as the EU members states shall create incentives to ensure a similar development for existing buildings.

In Denmark we are well on the way towards meeting these goals due to recent improved energy saving demands in building regulations including new protected low energy classes 2015 and 2020.

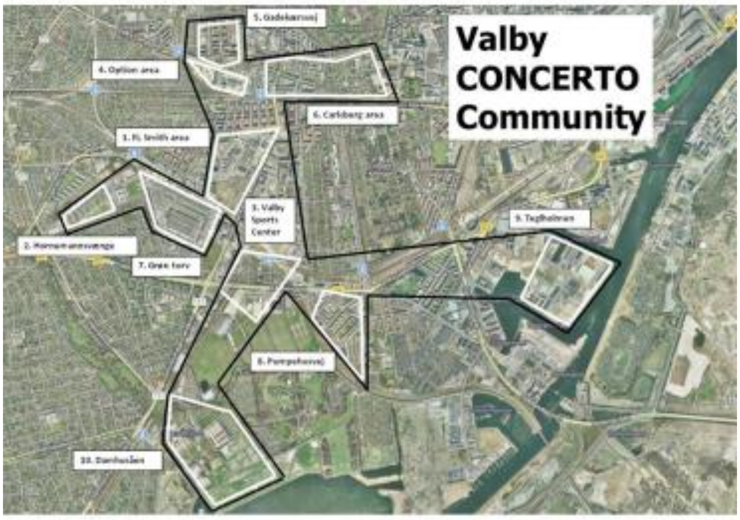
This means that there is, besides a high standard for new build, also a focus on extensive retrofitting of buildings, something which has also been included in the aims of the EU-Concerto project, Green Solar Cities (2007 – 2013), where EU funding has been utilised as a strong support for the large scale photovoltaic (PV) implementation plan in Valby in Copenhagen. This was launched in year2000 with the aim of supplying 15 % of all electricity use in Valby by PV technology in year 2025.

Valby will show the way – Copenhagen as an example

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-Concerto project, Green Solar Cities (www.greensolarcities.com) EU funding has been utilized as a strong support for the large scale Photo Voltaic 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 Photo Voltaic electricity established by year 2025. By 2013 around 4 MWp Photo Voltaic have been established.

And since year 2004, the aim to introduce large scale building integrated Photo Voltaic 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-CONCERTO area in Valby have improved their energy frame values by 30 – 79% compared to normal practice.

The largest PV installation, which was realised in relation to the Green Solar Cities project, was the "Damhusåen" waste water treatment plant in Valby. In relation to this project it can be concluded that 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 Photo Voltaic system cover an area of approx. 14,000 m^2 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. The PV system is here supplementing biogas based electricity production to cover almost 50% of yearly electricity use by renewables.

Another very interesting example is the Hornemannsvænge housing estate, where low energy retrofit solutions are used together with a kind of solar energy combined heat and power. Here both solar thermal and Photo Voltaic (PV) solar electricity is supplementing energy from the large combined heat and power plants in Copenhagen.

Photo of the Damhusåen PV plant in Valby which is the largest PV plant in the Nordic Countries. It covers 8% of the electricity at the Damhusåen waste water threatment plant, which is owned by the "Lynette Cooperative" in Copenhagen. And is supplementing biogas based electricity production to cover almost 50% of yearly electricity use by renewables.

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.

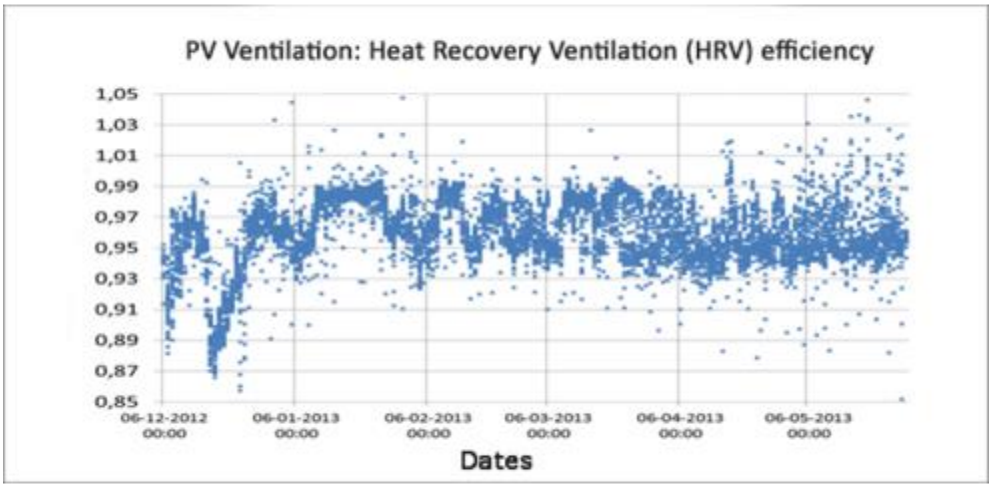
Photo from realisation of large housing retrofit project in Valby at Hornemannsvænge housing estate. 14 kWp PV (100 m²) and 100 m² solar thermal is used for each of 6 renovated housing blocks.

Close up photo of the PV inst allation on a new sloping roof at the Hornemannsvænge housing estate.

	
	Prebricated rooftop dwellings in Langgadehus in Valby, which is build according to the Danish low energy class 2015 standard, utilising both solar heating for hot water, and innovative and energy efficient heat recovery ventilation units from the Danish company Ecovent.

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

PV-ventilation. Compact Heat Recovery Ventilation for housing renovation where electricity use is matched by PV. Test of compact HRV unit from EcoVent / Øland is showing a dry heat recovery ventilation efficiency higher than 85 %.



Monitoring results showing very high heat recovery ventilation efficiency of 90-98 % for one apartment during winter / spring 2013. Electricity use for the fans at 115 m³/h is as low as 18 W.

More information on the results on RTD work on heat recovery ventilation can be found in the deliverable report D2.14 Actual design work and implementation status for Copenhagen.

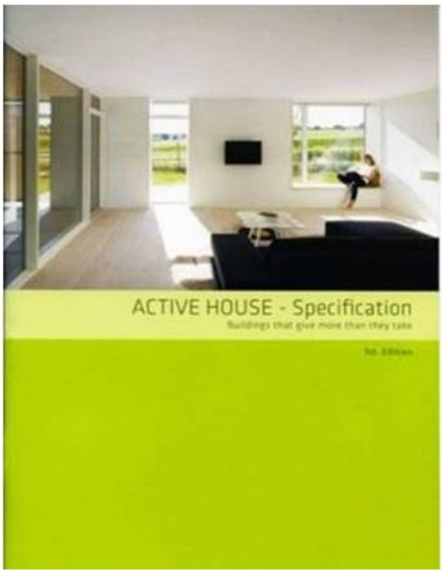
Gable towards the rail way in Valby with solar art (by artist Anita Jørgensen). Here PV is supplying electricity for neonlight which illuminates at night as a landmark for the Valby PV-Plan.

It is also aimed until the summer of 2014 to introduce elements from the so-called "Active House" concept (see: www.activehouse.info), in relation to the Green Solar Cities project monitoring and evaluation in Valby. In the Active House Specifications there is defined a number of specifications 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 and Energy Monitoring and Verification, Follow up.

In the area of Energy Balance this is as mentioned based on a calculation of all energy uses in a building incl. electricity using appliances and effect of the used energy supply system.

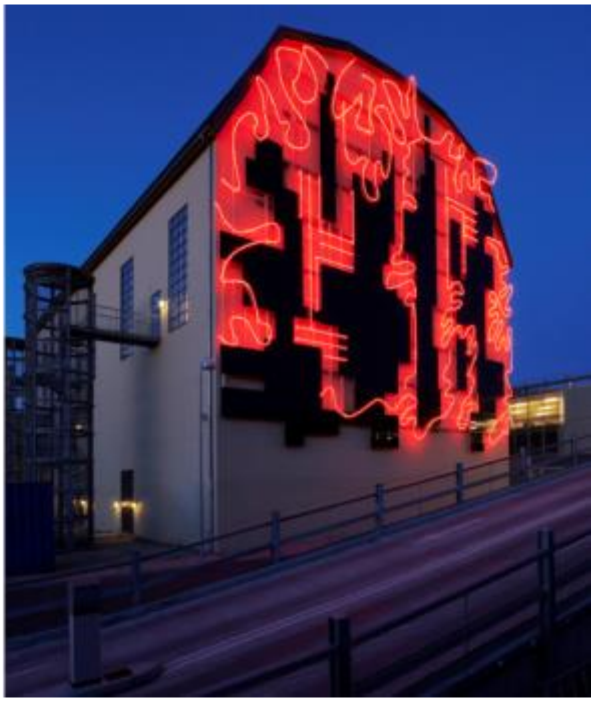
In the Active House Specifications there is a demand for energy monitoring, verification and follow up. This is new compared to the situation in Denmark today where there is a lot of focus on good calculation

procedures, but, like in most other countries, no link to what the actual energy use will be in practice in realised building projects.
A good possibility here 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 Active house specifications can be found at (www.activehouse.info).

In year 2000 the Valby PV plan was launched introducing 30 MWp PV (300.000 m²) aiming at 15% BIPV for electricity use in year 2025 in Valby in Copenhagen.

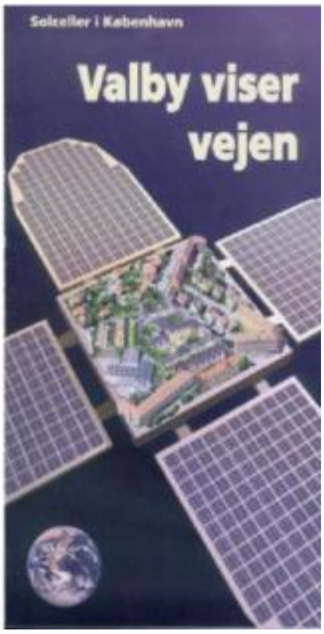


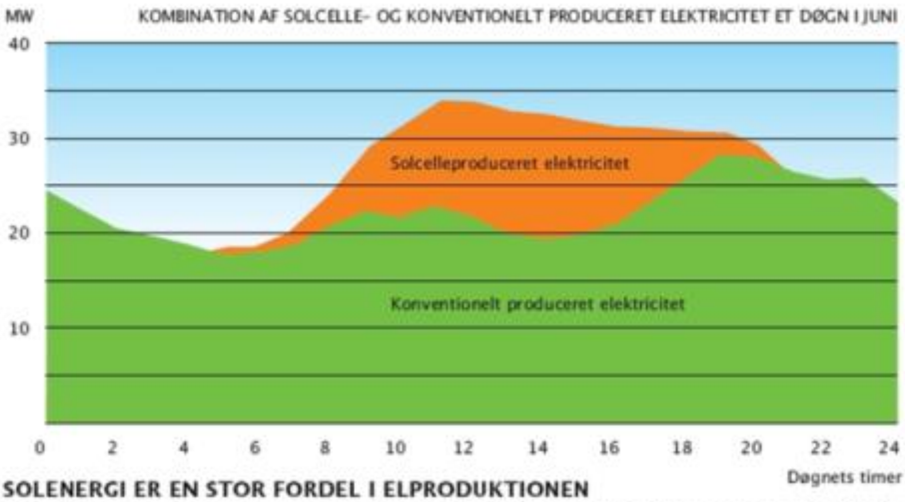
An important background of the PV implementation plan in Valby was to ensure that PV would be a positive element in the city development

www.solivalby.dk

Here a brochure on solar energy in Valby funded by the EU Concerto project Green Solar Cities

Valby PV plan aiming at 15 % solar electricity by 2025





SOLENERGI ER EN STOR FORDEL I ELPRODUKTIONEN

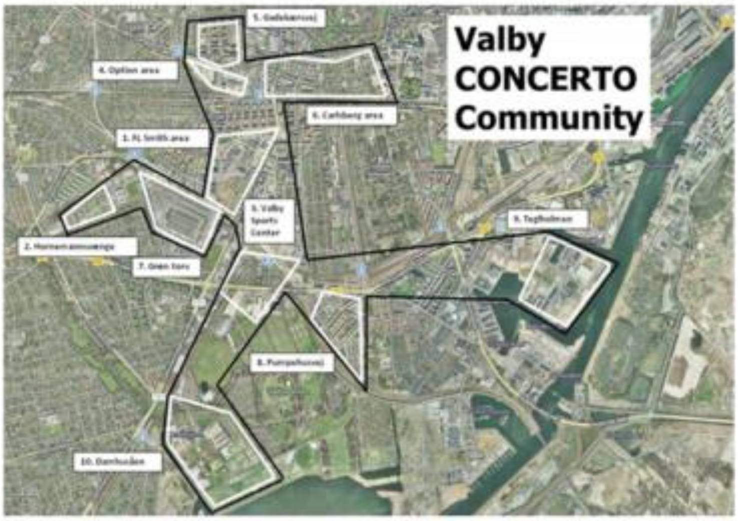
Udfordringen for elforsyningen har altid været at distribuere elektricitet svarende til det aktuelle behov. Et behov som veksler meget i løbet af et døgn. Her bliver solestrøm en fordelagtig medspiller. Som man kan læse af grafen giver den solcelleproducerede elektricitet lige netop det boost midt på dagen, som gør at elselskabernes konventionelle produktion kan undgå de store udsving.
Grafen er en visualisering af det man med et engelsk udtryk kalder peakshaving.

A positive peak sharing effect of the Valby PV plan.

Development of zero energy test house in Denmark in 2003, which was exhibited in Valby.

Valby School in Copenhagen with BIPV (Building Integrated Photo Voltaic)

The EU-Concerto project, Green Solar Cities (www.greensolarcities.com) have since 2007 included a cooperation between Valby in Copenhagen and Salzburg in Austria. EU funding is here utilised as a strong support for the large scale PV implementation plan in Valby.

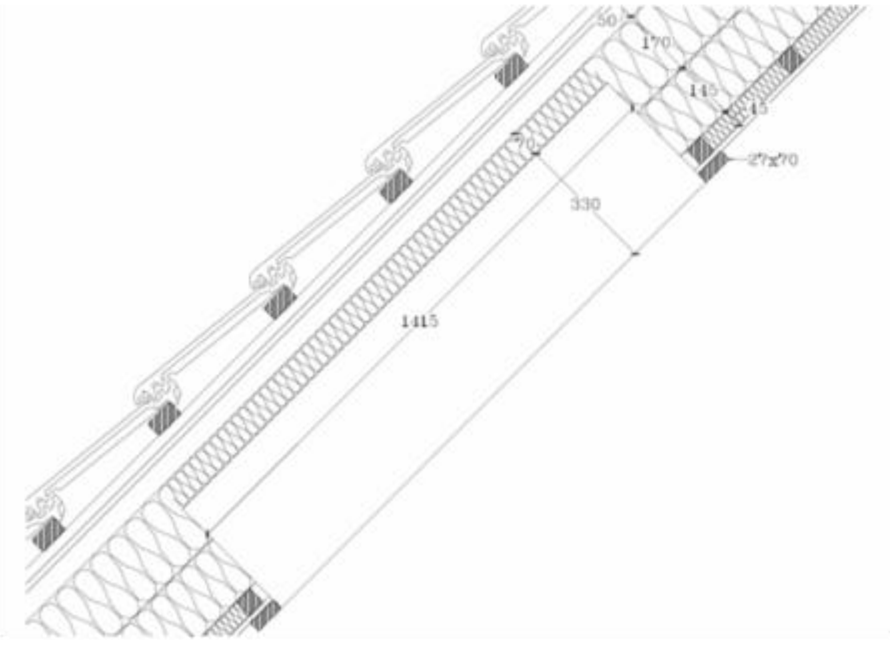


Sjælør S-train station in Valby

PV balconies in Folehaven in Valby

30 smaller PV projects were also supported by Concerto in Valby

PV-ventilation systems has been introduced in Valby and Copenhagen. This is compact Heat Recovery Ventilation for housing renovation where electricity use is matched by PV. Test of compact HRV unit from EcoVent / Øland is showing a dry heat recovery ventilation efficiency higher than 85 %.



Example of wall or roof integrated heat recovery ventilation (HRV) with low electricity use implemented in Valby, Copenhagen

Compact HRV unit which can be roof or wall integrated

<u>Example of demonstration projects with BIPV.</u>

Cenergia has been actively involved in BIPV (Building Integrated PV) demonstration projects since 1992 where there was obtained EU support for the “PV in Valby” project.

In year 2000 a PV plan for an entire city part of Valby in Copenhagen was launched in co-operation with the Urban Renewal Copenhagen company (now; Kuben Management), the local electricity company, Copenhagen Energy and the municipality of Copenhagen.

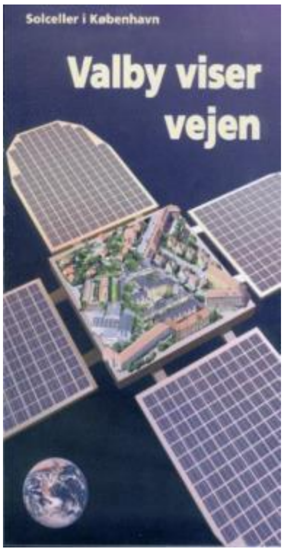


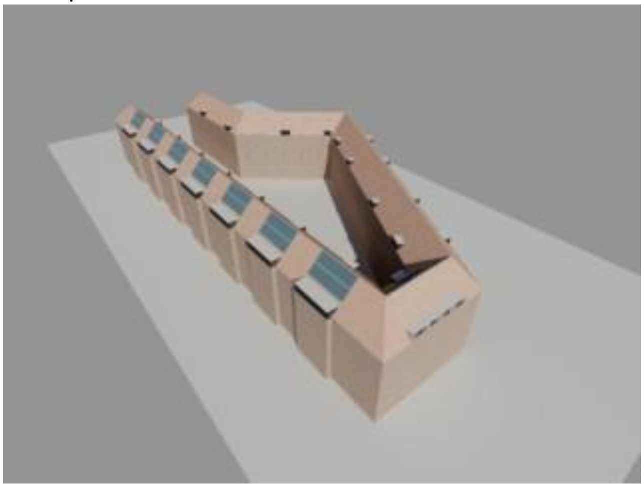
Illustration of the PV-plan for Valby, with the aim to cover 15% of all electricity use in year 2025 by 30 MWp PV (approx. 300.000 m^2 PV)

Since then work on practical PV implementation in Valby and in the rest of Copenhagen has been realised with support from EU projects like, Resurgence and Concerto-Green Solar Cities in Valby (www.resurgence.info) (www.greensolarcities.com) but also from the municipality of Copenhagen, which has given a total support of approx. 12 million DKK, and from the Danish Energy Agency as well as the PSO system in connection with the "PV-Optitag project". And in year 2004 the Solar City Copenhagen Association was established with support from the municipality of Copenhagen (www.solarcitycopenhagen.dk). And in a brochure from 2008 on "PV in Cities" it was advocated that it wais now there was a need to kick-start use of BIPV due to the expected development in the economy of such systems.

The PV activities in Copenhagen has also been promoted in relation to the member magazine of the Association of Sustainable Cities and Buildings in Denmark (www.fbbb.dk)

PV and Architecture.
Book from 2005 showing best practice BIPV examples.


Sketch design project for Hedeparken housing association in Ballerup with 1.000 apartments


Example of proposed PV integration in connection to red tile roofs in Copenhagen


Street area view of BIPV solution in red tile roof

Combined Solar Roof and PV at Frederiksberg

0-energy renovation from 2009 in Albertslund in Denmark with Solar Prism with PV mounted on the flat roof.

Example of a PV project from early 2013 in Valby Copenhagen in connection to a roof exchange project. Here the normal tile roof is exchanged first and later PV panels are mounted on top of this.

A more holistic solution would be to use an under roof with asphalt layer cover where the PV modules are supposed to be. Here a m² saving would be possible since red tile roofs are very expensive.

Zero energy housing area with 60 dwellings from 2012 in Tranbjerg Aarhus uses prefabricated Solar Prism systems from Danfoss / VELUX with built in heat pump, HRV system, PV panels and VELUX roof windows.

An innovative PV installation at the shared ownership housing cooperation "Søpassagen" in Copenhagen.

By the end of 2011 a very interesting PV project with 45 kWp PV (approx. 360 m²) for 90 apartments at Østerbro has been realised.

This is the first BIPV installation in Copenhagen which has been allowed even though it can be seen from the street area, and the background for this new policy is the climate plan of Copenhagen from 2009 which aims at CO2 neutrality by year 2025.

Due to the location towards the "City lakes" in Copenhagen and the very trafficked "Fredensgade" the project was based on an intense and detailed dialogue with the chief architects office in Copenhagen.

The PV system consists of 28 kWp PV on sloping roof areas and 17 kWp PV on the flat roof.

The BIPV integration has been a success although the cost for the sloping roof with a cost of DKK 32.000,-/kWp was more expensive (approx. 50 % more) than the flat roof installation of DKK 21.000,-/kWp.

The design was developed by the company Solarvent in cooperation with Solar City Copenhagen, who supported an initial sketch design project. Energy and construction engineering were handled by Cenergia and Moe & Brødsgaard.

Another interesting aspect of the project is the way the situation with a PV capacity beyond the common electricity use was handled.

The solution here was to agree on a common purchase of all electricity by the tenants instead of the normal individual purchase. In this way yearly individual meter costs for each apartment was avoided and a better electricity price for a "large" consumer could be negotiated. The result has been that even with high costs for scaffolding and installation of a new meter system a payback time of 13 years was obtained, with a positive balance for the tenants already from the first year. At the same time it has been shown that for more simple installations on flat roofs a payback time as low as 6 – 8 years can be obtained based on this model.

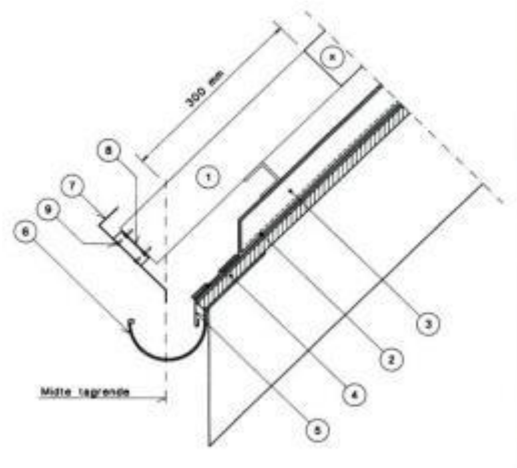
Illustrations from the realised BIPV project at ”Søpassagen” in Copenhagen.

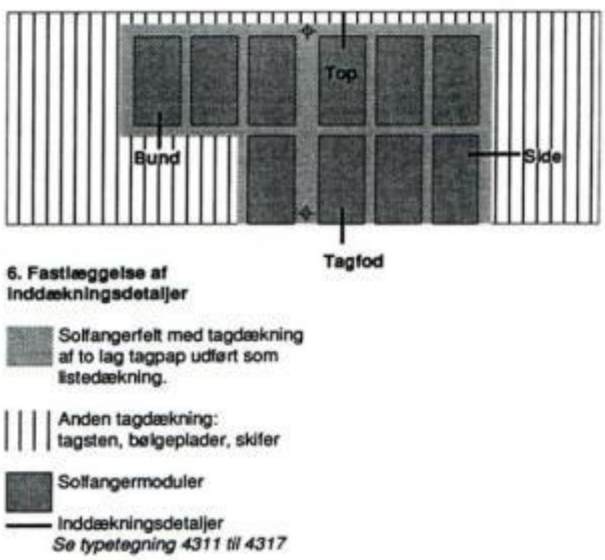
New build housing association project in Aarhus from 2012 with Solarprism technology with PV for 60 zero energy dwellings

At the “Søpassagen” shared housing project existing shale roofs were changed to PV in a very nice way. Actually very few people notice that this is a PV roof.

BIPV solution for “Søpassagen” housing project in Copenhagen

At “Søpassagen” there is a nicely integrated BIPV solution for the visible part of the roof, while the flat roof has an installation you cannot see from the street area.





It is actually possible to use previously developed BPS guideline for thermal solar collectors, also for PV integration in tile roofs.

Example of PV integration. This was the winning project from the first PV architectural competition in Denmark. The project was realised in 1999.

3.2 Green Solar Cities development in Salzburg

Incentive System for Energy Efficient and Ecological Housing in Salzburg

Since 1993 the government of the federal state Salzburg applies an incentive scheme for energy-saving measures and the use of renewable energy in housing. Energy bonuses are part of the housing subsidy system, for the construction of social apartments and provide sponsorship for the buyer of a newly constructed apartment that was built by a property developer. By this means, the reward system reaches a very high percentage of newly constructed houses and flats.

The number of points gained depends on the energy and ecological quality of a building. Every point increases the subvention level granted by the federal state Salzburg. The buildings are divided into 10 classes, ranging from standard to passive buildings. The ten classes (see chart 1) are presented on a simple and transparent chart, which is also a positive marketing instrument, giving buyers easy access to the energy quality of a building ("class nine must be better than class five"). This point system was the forerunner of the "Energy Certificate", even before it was part of building regulations in Salzburg. Additional points exist, for example, for the use of biomass, solar energy and controlled ventilation in dwellings.

Using this simple system, the quality of sponsored housing increased significantly and renewable energies were successfully introduced into the housing sector.

The system

The point system supports an energy-saving construction method, and the performance level is expressed by specific heating load and the "LEK"-value ("Line of European Critiera", ÖNORM B8110 und H 5055- developed by Prof. Panzhauser of the Technical University, Vienna), This "LEK"-value designates the thermal insulation of the building envelope in relation to the geometry of the building.

The specific heating load and the energy quality of the building envelope determine the class of the building (class 1 – 10), resulting in 1 -10 points. The following aspects entail additional points: use of biomass, the use of industrial- or commercial waste heat, the connection to a district heat or a central heat plant, the installation of a solar plant, the use of a heat pump, a heater possessing a return temperature below 40 degree centigrade, the installation of a controlled living space ventilation with heat recovery, and the installation of innovative technologies (photovoltaic, natural insulation, recycling material…). Every point increases the sponsorship credit with 15% per m² living space (see chart 1).

Chart 1: Energy points

Awards for energy ecological measures									
Sponsor-ship class	Building envelope Energy index LEK – value [-]	**Award points for particular measures**							
		Building envelope Evalutation according to LEK-value	Biomass use Waste heat use	Conncection District heat	Heat Pump	Active Solar-Plant	Living space ventilation with heat recovery	Passive Solar Energy	*Sum Energy - Points*
	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
1	<28 - 26	1	3	1	-	2	3	2	
2	<26 - 25	2	3	1	-	2	3	2	
3	<25 - 24	3	3	1	-	3	3	2	
4	<24 - 23	4	3	1	-	3	4	2	
5	<23 - 22	5	3	1	1	3	4	2	
6	<22 - 21	6	3	1	2	3	4	2	
7	<21 - 20	7	3	1	2	3	5	2	
8	<20 - 19	8	3	1	2	3	5	2	
9	<19 - 18	9	3	1	2	3	5	2	
10	<18	20	3	1	2	3	5	2	

In 2002 a second chart was introduced, and since then additional points for ecological measures were given. The ecology of the building materials is evaluated according to the OI3-factor: In this value the primary energy input, the CO^2-potential and the acidification of the soil is measured for each building material (database from the IBO – österreichisches Institut für Baubiologie). Furthermore less sealing and more open surface, water saving appliances, the use of rainwater or energy accounting are awarded with points.

Chart 2: Ecological Points

Awards for miscellaneous ecological measures									
Sponsor-ship class	Building-ecology Kennzahl OI3 Lc -Value	**Award points for specific measures**							
		Building Eval. Acc. to OI3 lc-Value	Rain- or Grey Water Use	Surface Sealing	Water-Saving Sensor Armature	Roof-Greening	Energy Accounting Efficiency Surveillance	Controlled Ventilation Including Exhaust-air plant	Sum Ecological Points
	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
1	<28 - 26	2	2	1	1	2	2	3	
2	<26 - 25	4	2	1	1	2	2	3	
3	<25 - 24	6	2	1	1	2	2	3	
4	<24 - 23	8	2	1	1	2	2	3	
5	<23 - 22	10	2	1	1	2	2	3	
6	<22 - 21	12	2	1	1	2	2	3	
7	<21 - 20	14	2	1	1	2	2	3	
8	<20 - 19	16	2	1	1	2	2	3	
9	<19 - 18	18	2	1	1	2	2	3	
10	<18	20	2	1	1	2	5	3	

Handling and accompanying measures

Using a special software tool called "GEQ", which stands for “Gebäude Energie Qualität” (energy performance of buildings-software), it is possible to calculate energy- and ecological points by the input of the building geometry as well as windows, wall- and ceiling superstructure. Additional to this the planner can create the Energy Certificate. The software tool contributes greatly to the overall success of the point system, because of its user friendliness for every planner. It is easy possible for the planner or construction firm to perform energy optimizations. The GEQ requires little bureaucratic effort. The checking of the "energy points" for the whole federal state Salzburg is carried out by one single official of the State government,. To ensure the effectiveness of the selected measures, precise quality specifications were generated for the particular points. Performance checks are required from the executing companies as guarantee, for example concerning the output of a solar plant.

Since 2006, the input of the Energy Certificate and the checking for the sponsorship go through the internet platform ZEUS (www.geq.at)., without any paperwork: the Energy Certificate including point calculation are being posted on the Internet. Planners, house builders and authorities can have access at any time and query the state of progress. After the checking and possibly optimisation, the documents are clear for the sponsorship via digital signature. Also in the ZEUS is a statistic evaluation of the accounted building projects.

https://www.energieausweise.net/homepage

In the past years the system was also adapted for the general sanitations and the municipal buildings.

To ensure the effectiveness of the used measures, precise quality presents were generated for the particular points and declarations are required by the executing companies as guaranty (for example concerning the output of a solar plant). In the energy-monitoring database of the federal country Salzburg 186 thermal solar plants in Salzburg are online connected, so that everybody can look at the gains and the way of working of the plants. A green line shows the proposed gain and it is possible to see, if the solar plant is working efficient. This transparent system helps a lot to increase the real solar gains because problems or defects are obviously and the error can be corrected very quickly.

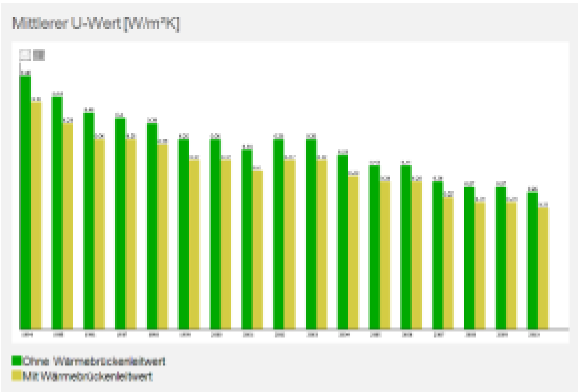
Results

About 70% of the whole construction sector in Salzburg is covered by the energy point model. Almost 95% large-volume residential building and 80% of the single-family houses are realised according to the point system.

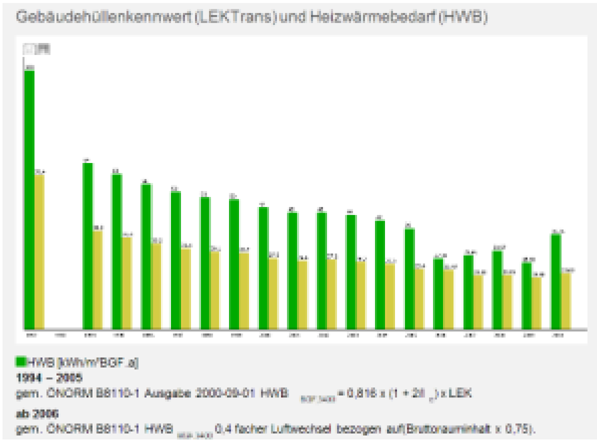
The incentive system in Salzburg has led to a real success story and improvement of building standards towards better sustainable performance. The energy points have led to a new way of thinking and awareness in the building business. Technologies for the use of renewable energies became standard solutions of the sponsored residential building:

- The specific heating load (W/m²) for residential buildings has decreased from 63 W/m² in the year 1992 to 25 W/m², which signifies a minus of 60%.

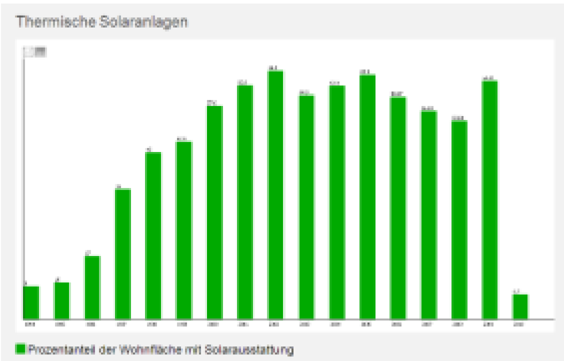
- The LEK-Value of the buildings averaged in 1993 was 59% and could be decreased to 20% (minus 65%).
- The medial U-Value could be reduced from 0,43 to 0,23 W/m².
- The use of the solar energy for hot water generation and heating backup in the sponsored residential building increased from 9% to 64%. (667%).
- The usable living space, which is heated via biomass, even increased from 10% to 83%.



Development of the middle U-value



Development of the specific heat load HWB and the LEK-value.



Development of solar collector systems (in % of total m² living area)
status January 2010- datas for 2010 not significant!

Apartments using biomass-heating systems in % (of total m²)

The first cooperation between Cenergia, Green Cities and SIR was in a low energy housing demonstration project in 1996 in relation to EU-Target, European Green Cities. Meeting at building site between Cenergia and Austrian partners.

Inge Straβl from SIR was the main responsible for the EU-Supported demonstration project in Radstadt in the ski area of the Salzburg region

The finished low energy housing project in Radstadt. This was the first larger solar low energy demonstration project in Salzburg.

European Green Cities partner meeting in Radstadt. Here Jens Frendrup and the mayor of Radstadt

The sun shading solution was reliable to avoid over temperatures

European Green Cities partners at site visit (more information at www.europeangreencities.com)

The European Green Cities partners also visited a new solar low energy project in Salzburg Gneis Moos, which made the first experiments with large communal solar thermal collectors together with a buffer storage tank connected to the district heating.

In the following years the Salzburg region became a model of how to secure implementation of solar low energy building as a support to Kyoto targets. This was also supported by help of the energy point system, which secured an improved economy for the builders if they used the right solutions like a low energy standard or used solar heating or biomass, as mentioned before.

Some examples of projects with high energy performance level

Gneis Moos in Salzburg: The whole roof of this house is covered with about 400m² thermal solar collectors. Solar energy covers here about 1/3 of necessary energy for heating and domestic hot water for 60 dwellings.
Builder: gswb
Planer: Architect Georg Reinberg

Stieglgründe in Salzburg: In this buffer tank the heat of the solar system is stored and heated up via a pellet heater for 128 social dwellings.
Builder: "Die Salzburg"
Planer: Architect Wolfgang Schwarzenbacher

Samer Mösl: 3 wooden passive houses in Salzburg with 60 social dwellings. The additional necessary heat comes from thermal solar and wood pellets.
Builder: Heimat Österreich
Planer: Architect Simon Speigner

4. Demonstration projects and monitoring results in Valby, Copenhagen

Peder Vejsig Pedersen, Director, Civ. Ing., Cenergia

In the following there is a presentation of the individual demonstration project in the Concerto area in Valby and Copenhagen.

Dr. Ingridshjem	
Status	Finished
Dwellings	110
Gross floorage area/ Gross space, m^2	11,671
External wall	0.2 W/m2K
Roof	0.09 W/m2K
Ceiling in cellar	0.15 W/m2K
Floor in cellar	0.15 W/m2K
Ground deck	0.15 W/m2K
Windows	0.9 W/m2K (3 layer of glass) Protec
Glazing	-
The Final energy consumption, $kWh/m^2/yr$	*Heat: 30.4* *Electricity: 13.04* *Total: 43.44*

Implementation

Dronning Ingrids Plejehjem, AAB, Carl Jakobsens Vej – new elderly institution

Dronning Ingrids Plejehjem is 132 elderly dwellings with connected service facilities in total 11.671 sq. m. The detailed architect project was prepared and the building process started in autumn 2009 and was finished autumn 2010 for the first phase, while the second phase was finished June 2012. It is possible to have a good monitoring here for at least one year. Triple glazing and better insulation is the added EU

Concerto qualities. Due to the relatively large hot water consumption 60 sq. m thermal solar collectors is integrated on the roof.

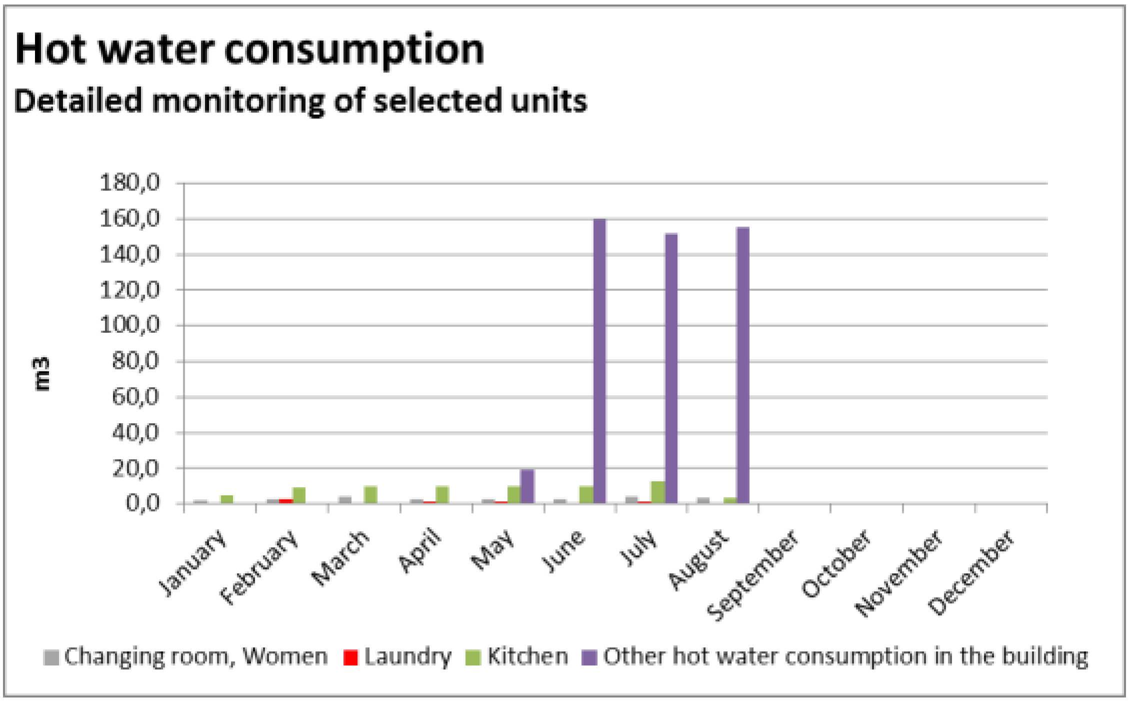
Dronning Ingrids Plejehjem – Phase 1 and 2
Energy supply
Domestic hot water
District heating
Ventilation with heat recovery
Solar heating system (60 m²)

<u>Thermo photoes:</u>

Here is general shown good results without problems with coldbridges, except a few places.

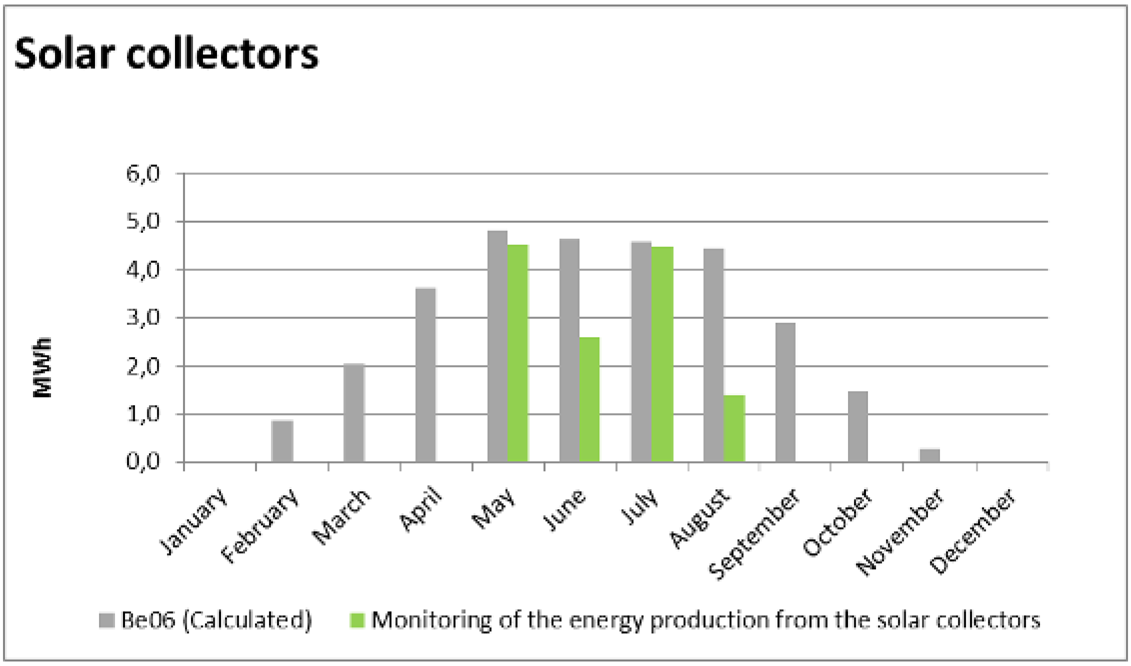
Picture parameters:
Emissivity: 0.95
Refl. temp. [°C]: 20.0

Remarks:
Here it's visible that there is a small heat loss at the foundation of the building. At the normal picture you can also see that the snow has melted

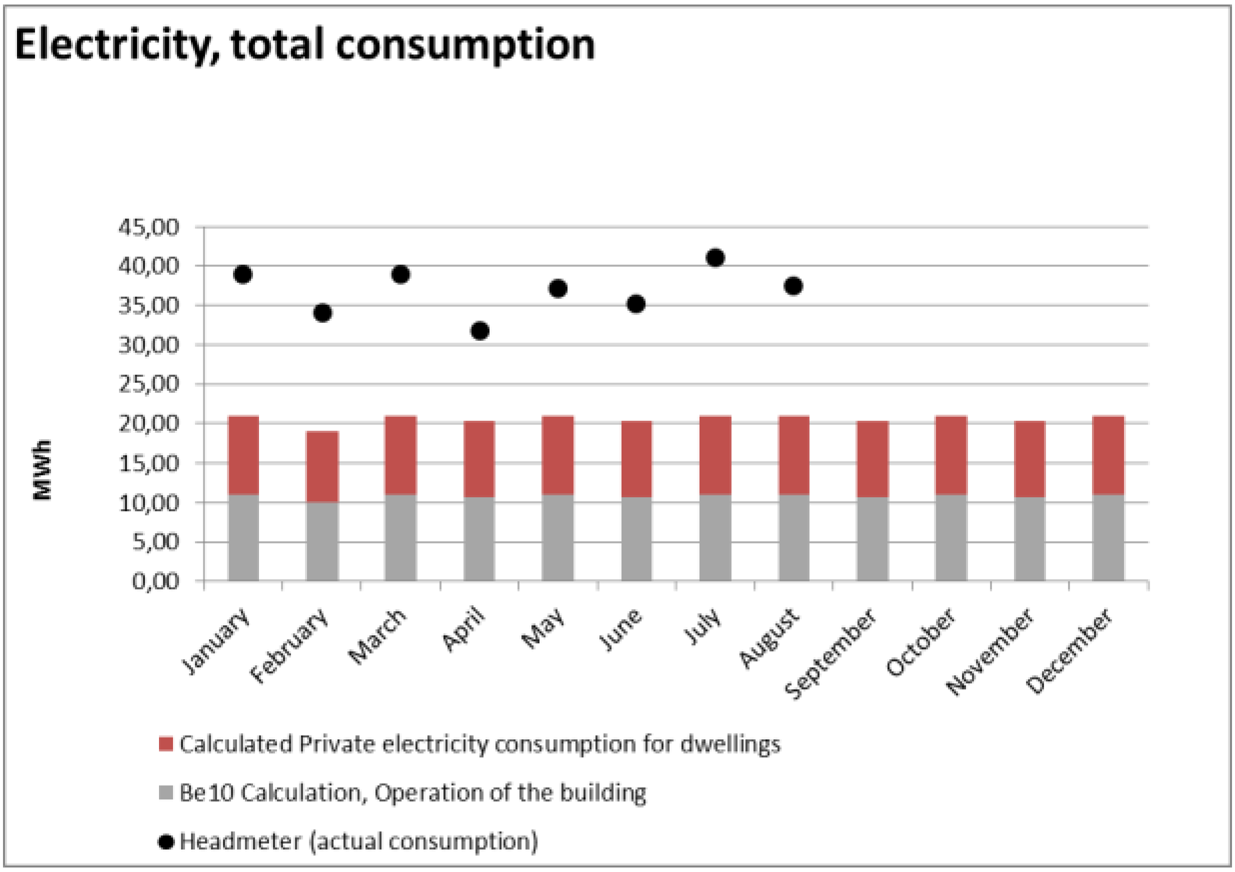


Monitored hot water consumption for selected units

In the graph there is not shown the hot water consumption for the category "Other hot water consumption in the building" before May 2013 because this has not been registered.



The energy production from the solar collectors



Calculated electricity consumption fore operation of the building and estimation on the private electricity consumption compared with the actual electricity consumption of the building.

In the private electricity it estimate that there is a consumption on 10 kWh/m2/year and fore the operation of the building 11,2 kWh/m2/year. As can be seen in the graph the electricity use is higher than could be expected. It is difficult to conclude if the problem is to be found in the operation of the building or in the private electricity consumption. This will be analysed further.

Henkel II (Building A)	
Status	Finished
Gross floorage area/ Gross space, m²	6,840 m2 (total area 13,149) Office
The Final energy consumption, kWh/m², yr	*Heat: 0* *Electricity: 26.7* *Total: 26.7*
External wall	0.18-1.77 W/m2K (not all the envelope is getting insulated)
Roof	0.1 W/m2K
Ground deck	0.2 W/m2K
Windows	1.5-1.7 W/m2K
Glazing	-

Implementation

Henkel site II

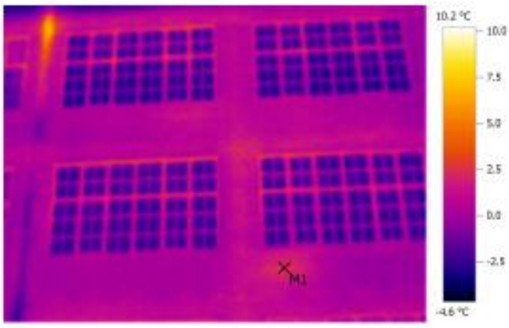
This is two large 13.149 sq. m old industrial buildings being renovated at present concerning all constructions. Besides this, it is a very interesting project with a high overall saving goal. 6,840 sq. m in Concerto project to match total available Concerto volume – but rest of building sq. m renovation follows same Concerto principles. One building was finished in Sept 2011 and the other in December 2011. Extensive use of Green Roofs. Use of ground coupled heat pump connected to air con.

According to calculations the energy frame value is around 69 kWh/m², year equal to a new build 2010 standard, which must be considered as good for an old renovated industrial building.

Henkel site II April 2012

Henkel site II Oct. 2013
Energy supply
Domestic hot water (hot water tank)
Heating system (radiators)
Heating Pump System connected to ventilation air and ambient air

Thermo photoes



Picture parameters:

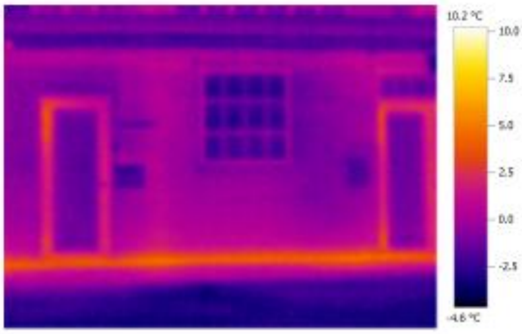
Emissivity: 0.95

Refl. temp. [°C]: 20.0

Picture markings:

Measurement Objects	Temp. [°C]	Emiss.	Refl. temp. [°C]	Remarks
Measure point 1	2.3	0.95	20.0	-

Remarks:
Here it's possible to see a small heat loss underneath the window (spot M1). Also between the windows and underneath the other windows it's possible to see a small heat loss.



Picture parameters:

Emissivity: 0.95

Refl. temp. [°C]: 20.0

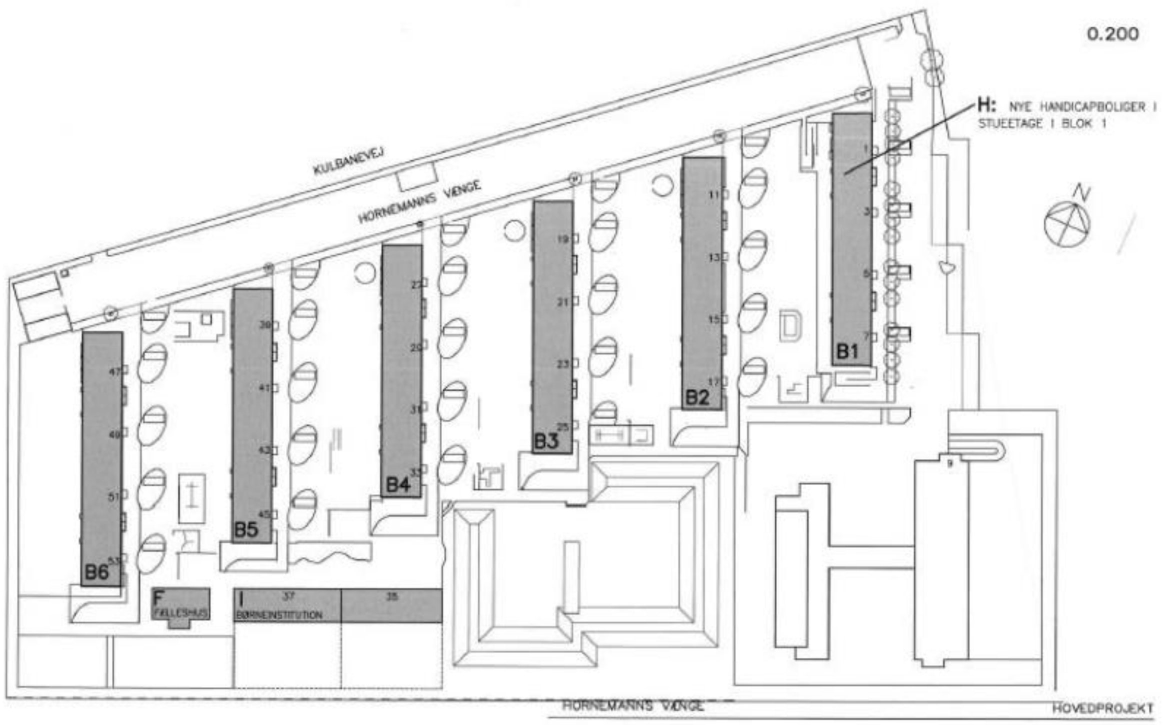
Remarks:
Here it's really visible that there is a heat loss in the foundation.

Overall energy monitoring

By the "Building Council" which rents the building.

The total electricity use is 47 kWh/m² including both normal electricity use and heat pump electricity use, which is lower than the previous place the "Bygningsstyrelsen" was situated. The total heating energy use is 62 kWh/m².

Hornemannsvænge	
Status	Finalised
Dwellings	288 dwellings with 6 housing blocks
Gross floorage area/ Gross space, m²	16,580 (Total area 22,230 m2)
External wall	0.14-0.18 W/m2K
Roof	0.15 W/m2K
Ground deck	0.4 W/m2K
Windows	1.8 W/m2K
Glazing	-
The Final energy consumption, kWh/m²/yr	Heat: 52



Situationsplan of the blocks.

Implementation

Hornemanns Vaenge

Renovation of 288 dwellings in 6 blocks of social housing has been delayed because of needed revised local planning documents to extend area, so that 66 planned extra rooftop apartments could be approved. Delay was caused by needed including consideration for a new railway track neighboring the area. So to avoid waiting for that the board of the social housing decided to leave out rooftop apartments. After having approved extension with one more year for Concerto project it became possible to renovate all 6 blocks before June 2013 – and to have enough time for representative monitoring after implementation. A pilot project on ventilations systems with heat recovery was demonstrated in one apartment and the tenants approved the installation. An extended monitoring program with before and after monitoring has as well been approved. The results will be disseminated by AlmenNet which is a network for sharing experiences on refurbishment of social housing departments. Construction work started in August 2011 and new roofs with PV panels and solar thermal collectors have been established for all housing blocks together with overall renovation works. Inspection of PV systems by Technological Institute was successful. The monitoring system is connected to an overall energy management system (EMS), which has been complicated to commission, so we only have useful monitoring from autumn 2013. The installed innovative solar energy combined heat and power system with both PV modules and solar thermal collectors (600 m^2 solar thermal and 85,5 kWp PV) will be detailed monitored.

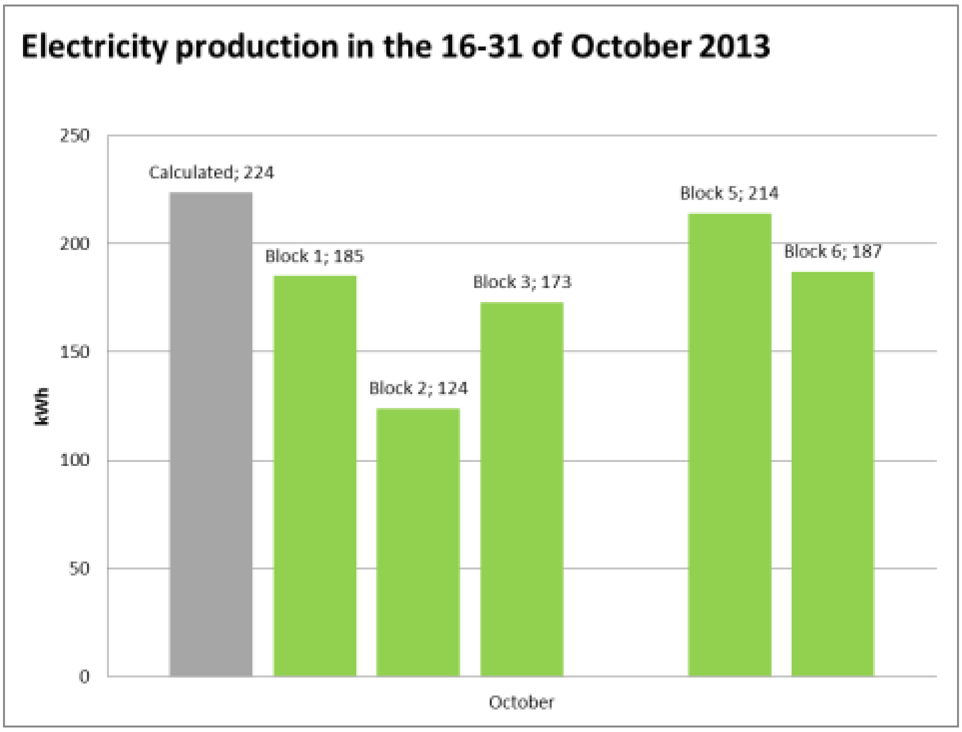
South Facade Hornemanns
Vænge Oct. 2012

Pictures from Hornemanns Vænge

Block 1	14,25	kWp
Block 2	14,25	kWp
Block 3	14,25	kWp
Block 4	14,25	kWp
Block 5	14,25	kWp
Block 6	14,25	kWp
All blocks	85,50	kWp

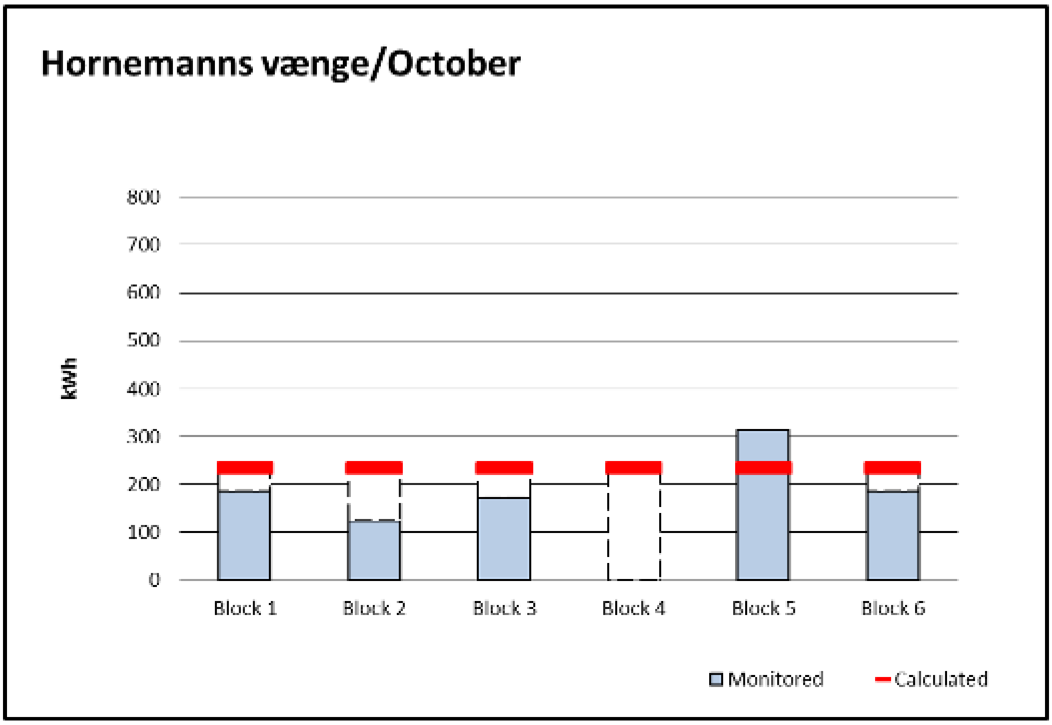
Installed photovoltaic

The photovoltaics that are used is mono crystalline. They are all oriented Southwest with a slope of 30^o.



PV production incl. Block 4 until 16. Oct. 2013 showed overall good results for nearly a year, with 7,558 hours of operation. The result was 14,012 kWh per year equal to 983 kWh/kWp, which is good. A PV quality inspection by Technological Institute showed overall good result of the PV installation.

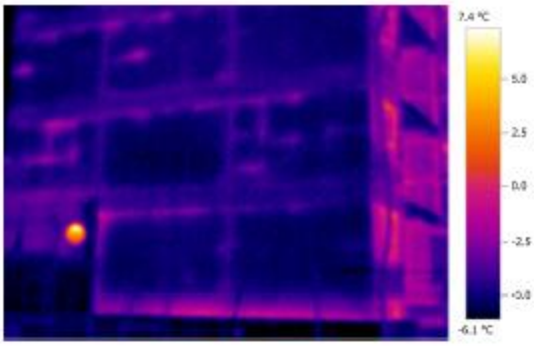
PV-Production for October 2013 (16-31th)



For block 4 there is some problems with the online monitoring.

The variation will be analysed further.

Thermo photos



Picture parameters:

Emissivity:	0.95
Refl. temp. [°C]:	20.0

Remarks:
This picture is before the renovation, here it's possible to see that there is a heat loss, between the construction elements in the wall. Also it's possible to see the heat loss, just above the foundation.

Picture parameters:

Emissivity:	0.95
Refl. temp. [°C]:	20.0

Remarks:
This picture is after the renovation, here you can see that there aren't the same spots of heat loss on the wall as before the renovation.

Energy supply
District heating
Ventilation with heat recovery
Solar heating system (600 m²)
PV (85 kWp) (600 m²)

Karensminde			
Status	Building finished may 2010.		
Dwellings	38 + 1 common house		
Gross floorage area/ Gross space, m^2	4,300 m^2		
External wall	0.21 W/m2K		
Roof	0.12 W/m2K		
Ceiling against unheated attic	-		
Ceiling in cellar	-		
Floor in cellar	-		
Ground deck	0.12 W/m2K		
Windows	1.4 W/m2K		
Glazing	-		
The Final energy consumption, kWh/m^2, yr	Type 00: Heat: 52.2 Electricity: 5.9 (Overheat: 4.4) Total: 58.1	Type 01: Heat: 49.7 Electricity: 4.6 (Overheat: 3.6) Total: 54.3	Type 02: Heat: 47.5 Electricity: 4.8 (Overheating: 3.6) Total: 52.3

Implementation

36 new-built low energy prefab dwellings were finished in May 2008 according to Danish low energy class 2 (25% better than actual energy requirements) + improvement to reach Concerto standard (30% better). The total area of the dwellings is 4.300 sq. m. A PV-installation of 30,6 kWp has been included in spring 2010. The dwellings of Karensminde were the first dwellings of the affordable housing program of Ms. Ritt Bjerregaard, the former Mayor of Copenhagen. The concept has now been taken over by a major social

housing association KAB under the name Almen Bolig+ and spread out to the entire Denmark in cooperation with other social housing organisations.

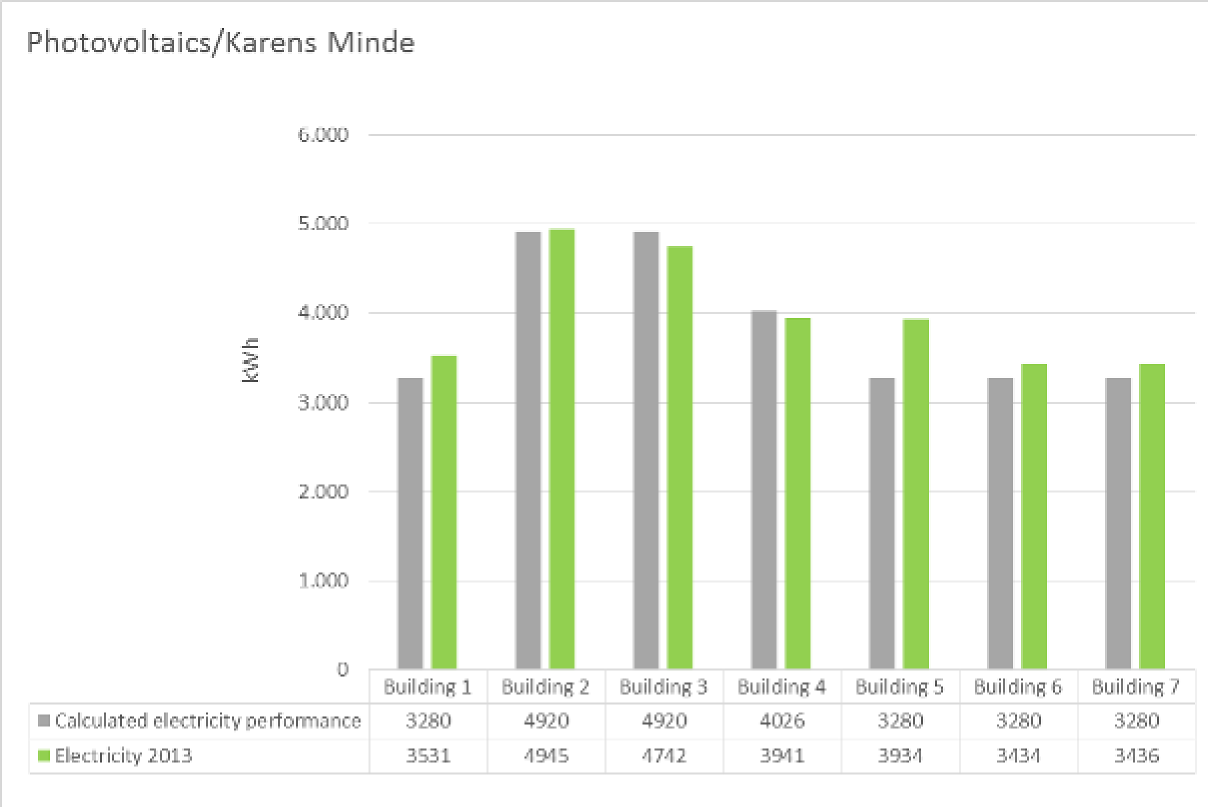
Energy supply
District heating
Heating system radiators
Ventilation with heat recovery
PV (30.6 kWp)

Picture of the placement of the photovoltaic.

Karens Minde. The picture shows the installed photovoltaics in detail. One panel is placed on the skylight (the boxes) and the other photovoltaics panels are placed directly on the roof in a montage system with a slope of 30°.

Karens Minde

Monitored electricity production for the whole photovoltaic plant



		Building 1	Building 2	Building 3	Building 4	Building 5	Building 6	Building 7	Total
Calculated electricity performance	[kWh]	3.280	4.920	4.920	4.026	3.280	3.280	3.280	26.988
Electricity 2013	[kWh]	3.531	4.945	4.742	3.941	3.934	3.434	3.436	27.964
Difference	[%]	7,7	0,5	-3,6	-2,1	19,9	4,7	4,7	3,6

One of the inverters in building 5 (Inverter 22 D) where first read in the 5th of February which to some extend can explain the good electricity production but in building 7 one of the inverters (Inverter 24 B) where first read the 9th of February and here the overproduction is more realistic regarding the calculations.

Conclusion from monitoring

The water consumption for all apartment (3 person) is 316,3 litres per day. That means 105,4 litres per person per day. The water consumption according to building regulations standard is expected to be 120 litres per person per day.

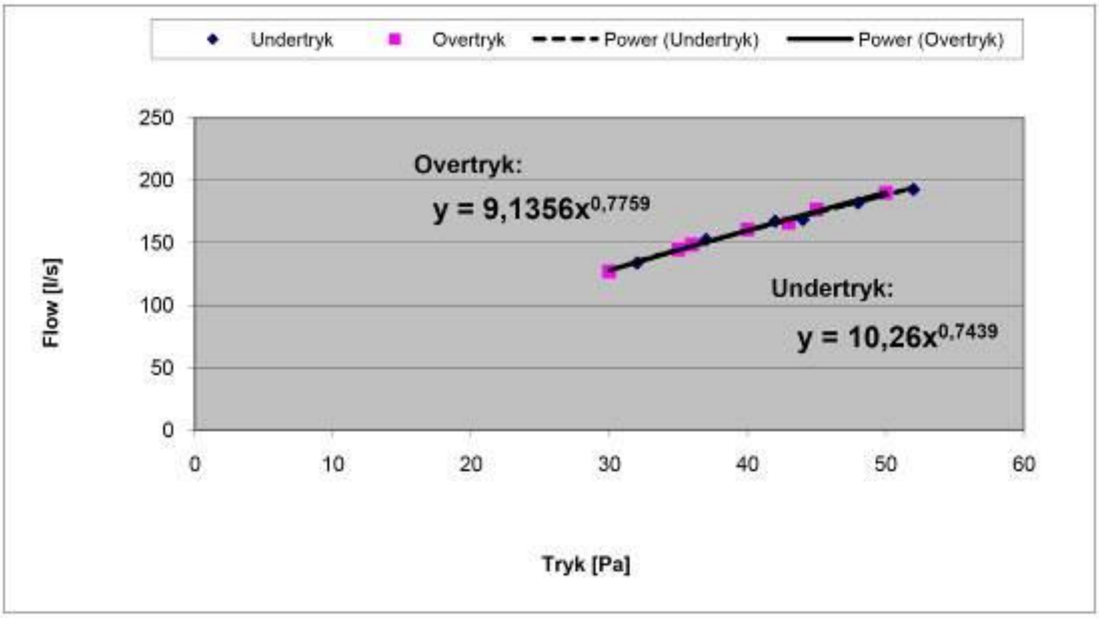
The district heating consumption is 65,2 kWh/m^2 per year (during the period: 15.09.08 – 18.09.09). The calculated demand from Be06 is 51,1 kWh/m^2 per year. So the consumption is 27,6% higher than the calculated.

Electricity consumption in the apartment is 4299,8 kWh per year, that means 1433,3 kWh per person per year. The average electricity consumption in Denmark is 1423 kWh per person per year.

Final conclusion

Some parts of the prefabricated house construction weren't made in the required quality. When the windows and doors were placed some mistakes were made. But the air tightness for the dwelling is fulfilled.

There are still some possibilities how to save energy. As the indoor climate test showed, the temperature in the apartment is too height and due to the heating consumption can be reduced.



Langgadehus		
Status	Finished	
Dwellings	Family Housing: 59 Elderly Housing: 68	
Gross floorage area/ Gross space, m²	Family Housing: 5,824 m² Elderly Housing: 8,642 m² (including service centre)	
External wall	0.14 W/m2K Family Housing 0.19 W/m2K Elderly Housing	
Roof	0.10 W/m2K Family Housing 0.14 W/m2K Elderly Housing	
Floor in cellar	0.28 W/m2K Family Housing 0.28 W/m2K Elderly Housing	
Ground deck	- Family Housing 0.3 W/m2K Elderly Housing	
Windows	Family Housing 0.5 W/m2K (windows which cannot be opened) and 1.1 W/m2K (windows which can be opened) Elderly Housing 1.5 W/m2K	
The Final energy consumption, kWh/m², yr	Family Housing: *Heat: 25.4 (incl. solar collectors 15.7)* *Electricity: 7.1* Total: 32.5	Elderly Housing: *Heat: 86.7* *Electricity: 6.2* Total: 92.9

Implementation

Langgadehus

New-built 8.723 m^2 elderly centre including service areas and 68 apartments in ground floor and 1st floor. In addition to the elderly centre will be social housing on 2^{nd} and 3^{rd} floor comprising 59 family dwellings of each 100 sq. m, 5.900 sq. m – in all 14.466 sq. m. The building is supplied with 200 sq. m solar heating. The work on the site started in autumn 2008 and the building was finished and ready for occupancy and monitoring in March 2011, a little delayed due to problems with a very heavy rainfall which gave damages to some of the apartments. The 59 prefabricated rooftop dwellings at Langgadehus have been made according to the same balanced building principles as for the Energibo concept (Carbon neutral rooftop concept).

Pictures of Langgadehus

Energy supply

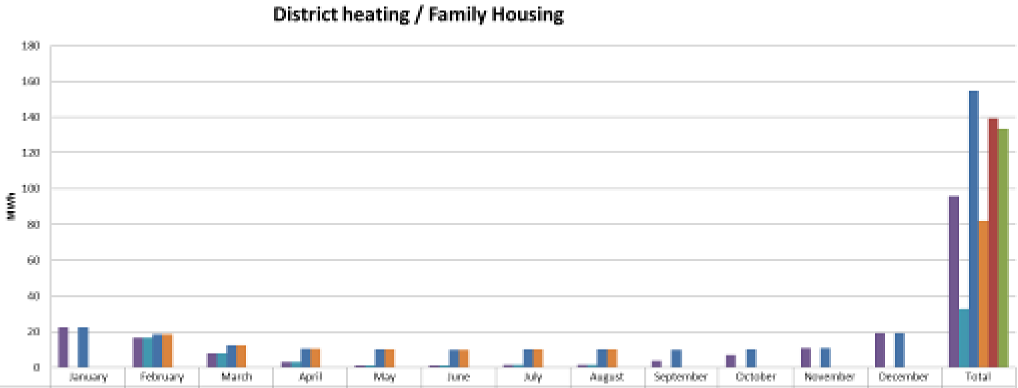
District heating

Solar heating system (200 m²) with priority for Family dwellings but export option to elderly housing

Heat recovery ventilation (very innovative concept for Family dwellings incl. detailed monitoring)

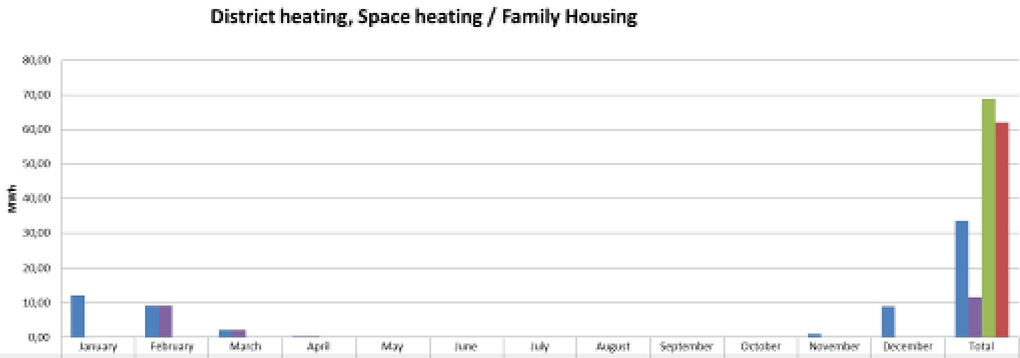
Energy monitoring

Family Housing



	January	February	March	April	May	June	July	August	September	October	November	December	Total
Be06 (Calculated)	22,47	16,64	7,80	3,16	1,19	1,07	1,30	1,49	3,78	7,04	10,77	19,18	95,89
Be06 (Calculated)		16,64	7,80	3,16	1,19	1,07	1,30	1,49					32,65
Be06 without solarcollectors (Calculated)	22,47	18,46	12,42	10,38	10,27	9,94	10,27	10,27	9,94	10,27	10,91	19,18	154,78
Be06 without solarcollectors (Calculated)	0,00	18,46	12,42	10,38	10,27	9,94	10,27	10,27					82,01
Monitoring Period 31-01-2011 to 31-08-2011		-	-	-	-	-	-	-					139,46
Monitoring Period 01-09-2011 to 31-08-2012	-	-	-	-	-	-	-	-	-	-	-	-	133,44

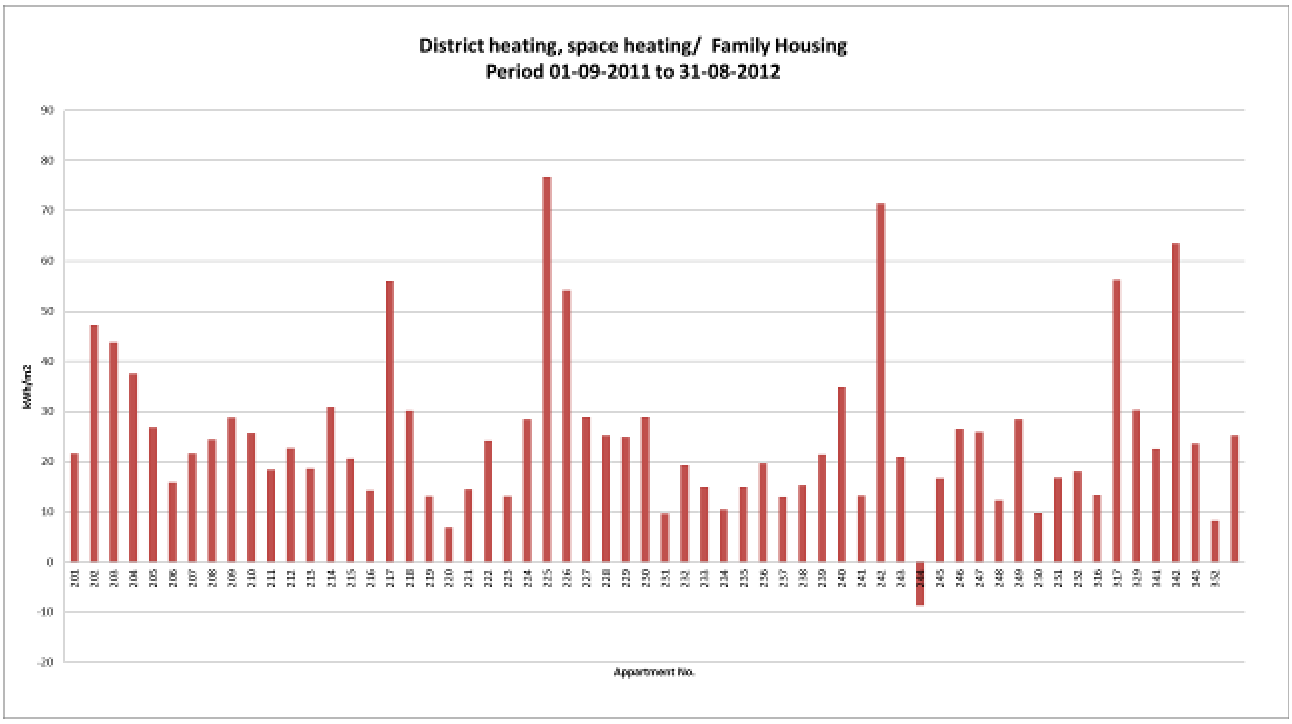
District heating for the Family Housing area. The basement is not included.
Here is seen a 70 % higher consumption than calculated. This is also influenced by operation issues after the housing units were taken into use February 2011. But with a total monitored district heating use of 23 kWh/m2/yr for the 7 month period it is likely to be better than the Concerto aim of 46 kWh/m2/yr.
For the period 01-09-2011 to 31-08-2012 the energy use is lower than the period before even though that this time the heating season is included. The reason for this can be the fact that the solar collectors now are contributing with solar energy even though that there still is problems with getting the system to work properly.
But the district heating consumption is still higher than calculated around 39 %.



	January	February	March	April	May	June	July	August	September	October	November	December	Total
Be06 (Calculated)	12,19	9,18	2,14	0,31	0,00	0,00	0,00	0,00	0,00	0,00	0,91	8,90	33,63
Be06 (Calculated)		9,18	2,14	0,31	0,00	0,00	0,00	0,00					11,63
Monitoring Period 31-01-2011 to 31-08-2011		-	-	-	-	-	-	-					68,92
Monitoring Period 01-09-2011 to 31-08-2012	-	-	-	-	-	-	-	-	-	-	-	-	62,06

District heating, Space heating for the Family Housing area.
For the period 31-01-2011 to 31-08-2011 the figures show that the dwellings are using more energy comparing to what was calculated in the Be06 tool. But from the beginning we knew that with a calculated

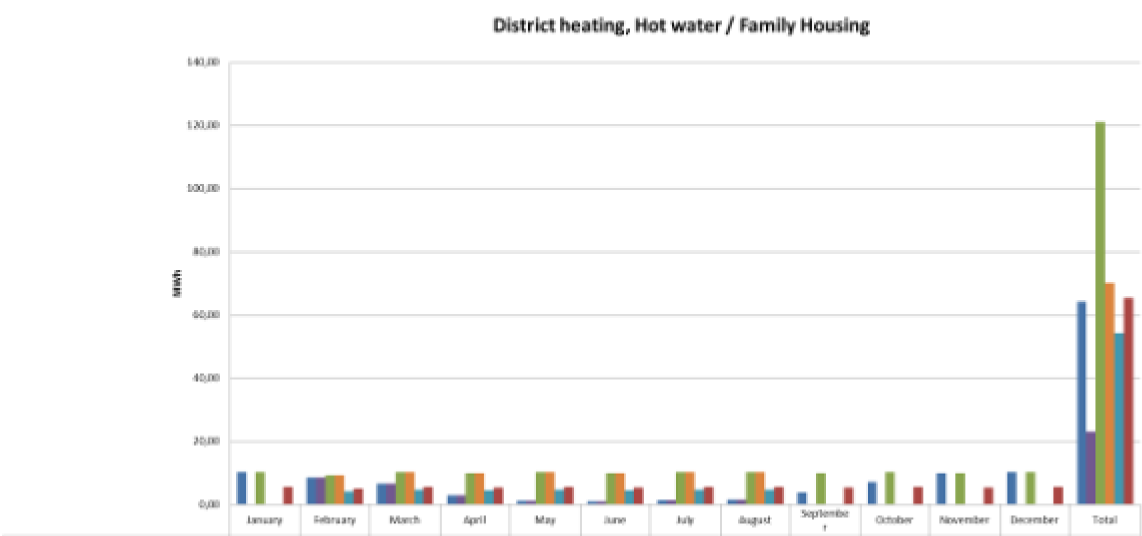
room heating demand of 5,5 kWh/m2/yr this seemed very low compared to a realistic energy consumption in practice.
Some explanation can be found in the Be06 calculation where the energy for heating relates to the presumption that the indoor temperature of the dwellings is 20 ^{o}C where people in general prefer to have a higher indoor temperature. If the temperature is raised to 22 ^{o}C in the Be06 the energy consumption for the monitored period the energy use will go up to 20,6 MWh which still is lower than the monitored consumption. But again based in the 6.088 m2 housing area the monitored heating use in the 7 month period is still only 11,3 kWh/m2/yr., which is actually a very low consmption.
In the next period 01-09-2011 to 31-08-2012 the energy for heating up the apartments are reduced but still higher than the calculation.
This is the same conclusions as in many other building projects that you cannot rely on the BE06 calculations to give a good prediction of the actual heating consumption.
The actual energy use for space heating is actually only 10.2 kWh/m2/yr. for this monitoring year, which must be considered good and much better than the Concerto expectations, but is still higher than the too ideal BE06 calculation of 5.5 kWh/m2/yr.



District heating consumption for the space heating for each apartment in the Family Housing part for the period 01-09-2011 to 31-08-2012

Here is seen a quiet high variation in district heating use where some dwellings use 5 times more district heating than others.

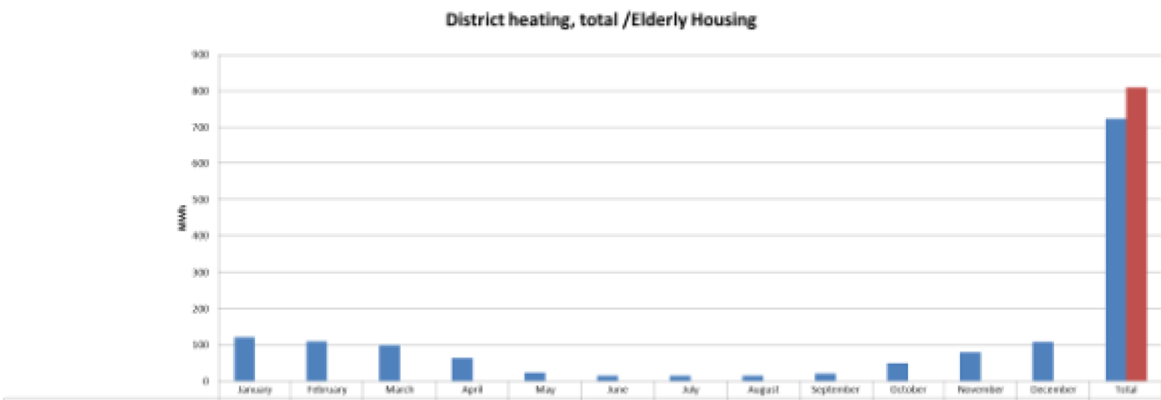
The meter in apartment 244 is broken and that is why the energy consumption is monitored negative.



	January	February	March	April	May	June	July	August	September	October	November	December	Total
Be06 (Calculated)	10,27	8,49	6,50	2,95	1,19	1,07	1,30	1,49	3,78	7,04	9,83	10,27	64,18
Be06 (Calculated)		8,49	6,50	2,95	1,19	1,07	1,30	1,49					22,99
Be06 without solarcollectors (Calculated)	10,27	9,28	10,27	9,94	10,27	9,94	10,27	10,27	9,94	10,27	9,94	10,27	120,93
Be06 without solarcollectors (Calculated)		9,28	10,27	9,94	10,27	9,94	10,27	10,27					70,24
Monitoring Period 31-01-2011 to 31-08-2011		4,15	4,59	4,44	4,59	4,44	4,59	4,59					54,04
Monitoring Period 01-09-2011 to 31-08-2012	5,55	5,01	5,55	5,37	5,55	5,37	5,55	5,55	5,37	5,55	5,37	5,55	65,37

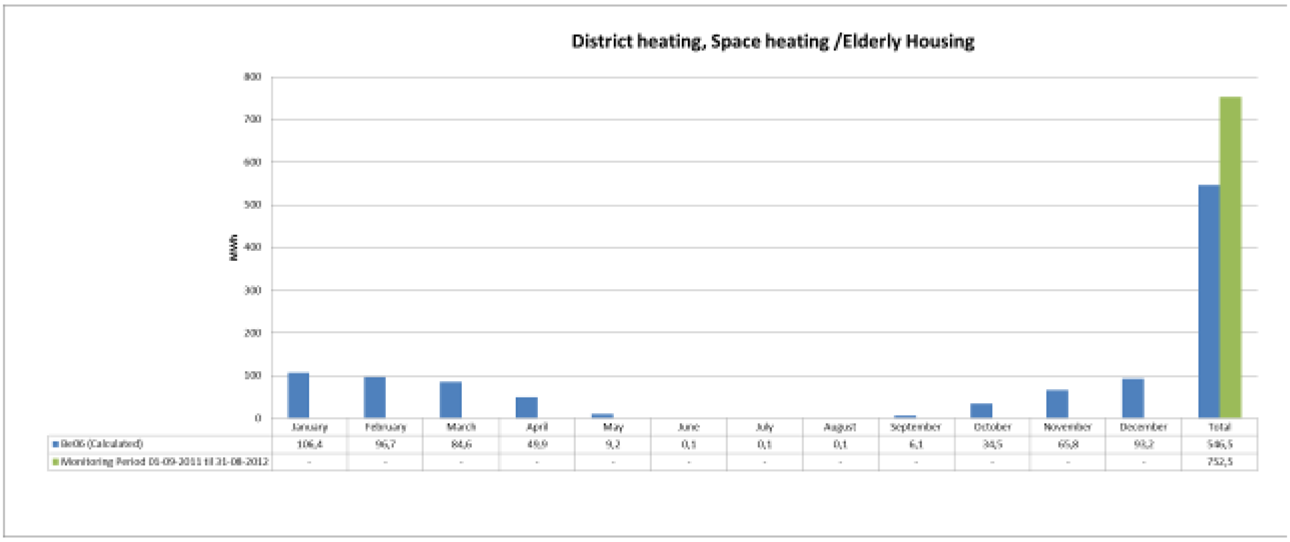
For the period 31-01-2011 to 31-08-2011 the hot water consumption which is calculated in Be06 and monitored is almost the same (Be06 884,2 m3 and monitored 882,0 m3). The monitoring shows that the building which covers the Family Housing is using 54 MWh for heating up the hot water. The Be06 calculation show that the building should use between 23MWh (with solar collectors) and 70 MWh (without solar collectors) which means that there is a good connection between the actually district heat consumption and the calculated district heating consumption.
For the next period 01-09-2011 to 31-08-2012 the energy consumption for the hot water is almost the same as the Be06 calculation with solar collectors. Considering that the hot water consumption have been monitored to be 27 % higher than calculated in the Be06 in the same period it is notable that the energy use is so low.

Elderly Housing



	January	February	March	April	May	June	July	August	September	October	November	December	Total
Be06 (Calculated)	121,4	110,2	99,6	64,4	24,2	14,7	15,2	15,2	20,6	49,5	80,3	108,2	723,6
Monitoring Period 01-09-2011 til 31-08-2012	-	-	-	-	-	-	-	-	-	-	-	-	809,3

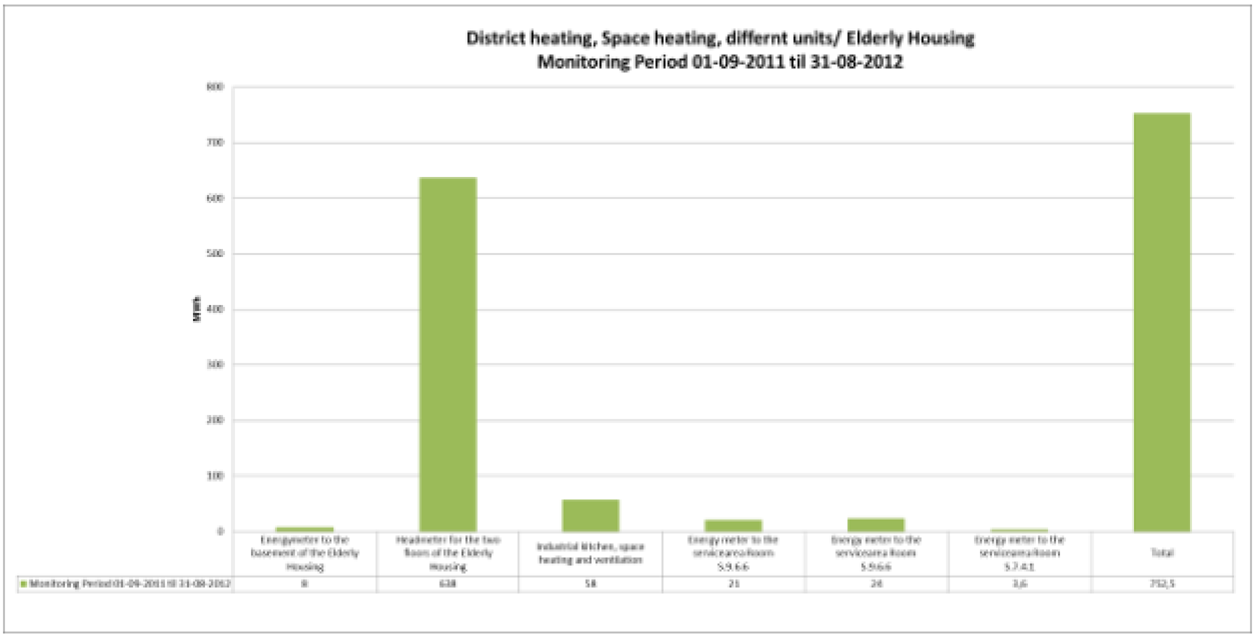
District heating, total/ Elderly Housing
The district heating demand is 11,8 % over the Be06 calculation.



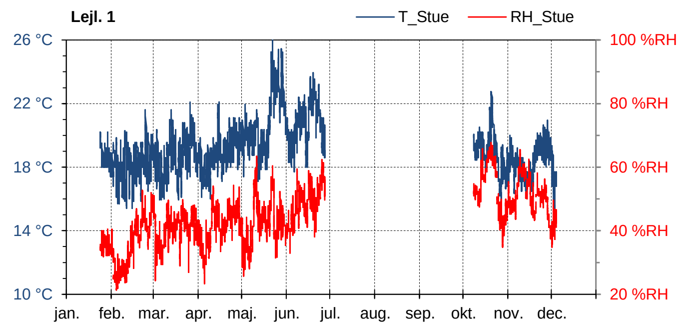
the heat recovery is 85 % and the air change is 0.37 l/m s. District heating, Space heating / Elderly Housing.

The district heating consumption is 37.7 % higher than calculated in the Be06 calculation.

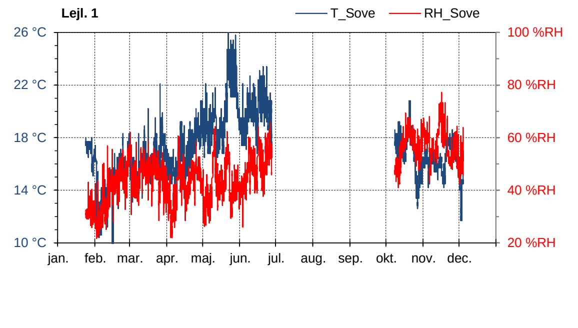
In the Be06 calculation it is calculated that the heating for space heating is 65.1 kWh/m2. The reason that the heat demand is so high is to be found in the extra high ventilation demand that “institutions” have. The average air change in the building is 0.75 l/m s, where it is 0.35 l/m s for private dwellings according to the National Building regulations. There is also used a central ventilation solution that has a low heat recovery around 65 %. In the Family Housing



District heating, Space heating, different units / Elderly Housing.
Indoor climate values has been monitored by the Danish Building Research Institute, SBi, for 2 apartments. The results are documenting the indoor temperatures, relative humidity and the absolute ventilation rate, also to see effects from demand controlled ventilation. Overall the indoor climate figures are acceptable for the users.



Mean values of temperatures and relative humidity monitored 2 places in the living room of apartment 1



Temperature and relative humidity in sleeping room in apartment 1

Lykkebo skole (School)	
Status	Renovation completed January 2010
Heated area	896 m2
External wall	0.18 W/m2K
Roof	0.08 W/m2K
Ground deck	0.09 W/m2K
Windows	1.5 W/m2K
Glazing	-
The Final energy consumption, kWh/m², yr	Heat: 65.4 Electricity: 26.34 Total: 91.74

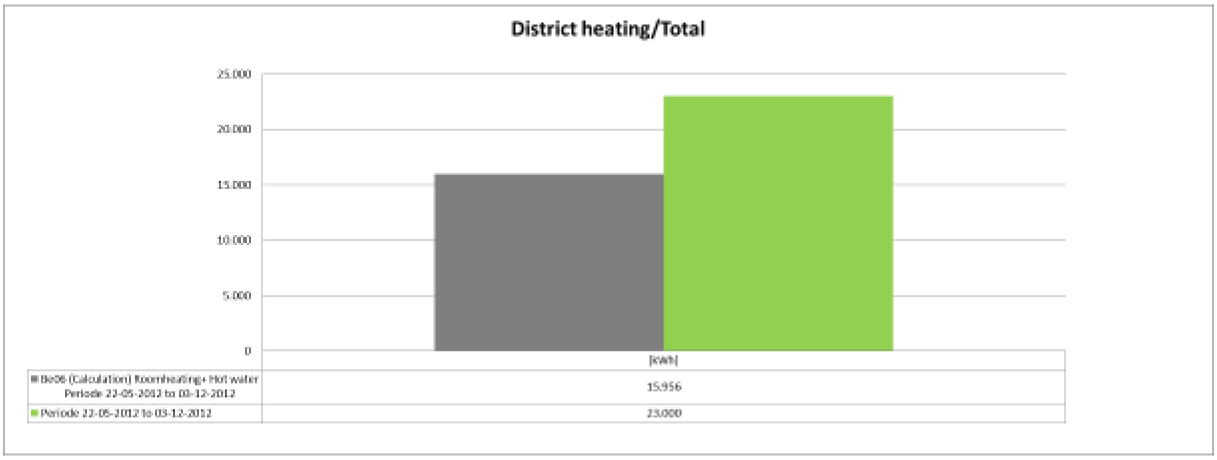
Implementation

Lykkeboskolen – new sports hall

Lykkeboskole is an extension on an existing school with 896 sq. m for a new sports facility. Building is low energy class 2 and Concerto standard with a 3,8 kWp PV installation integrated in the roof. Construction started May 2010 and was finished January 2011

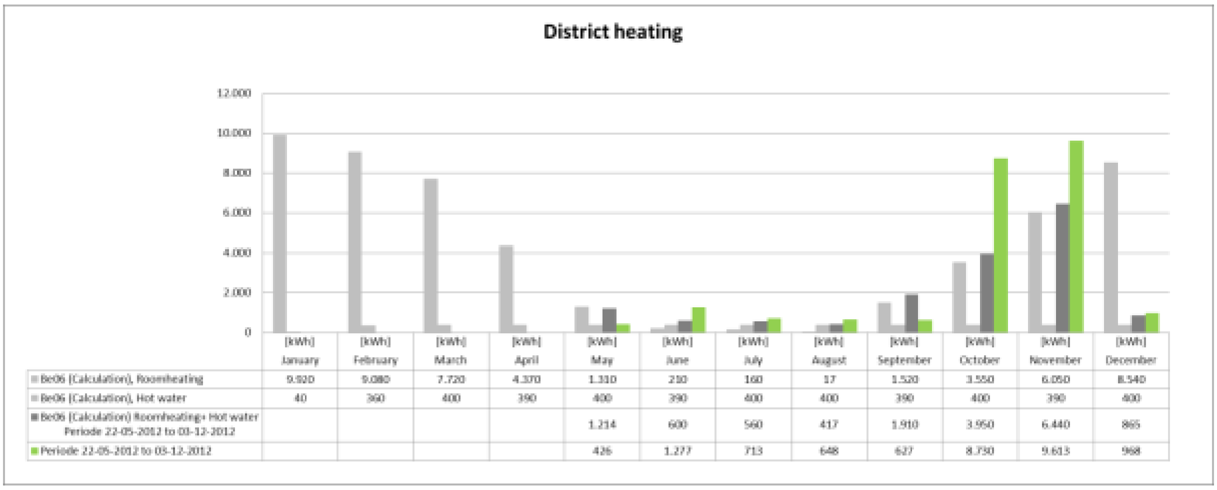
Lykkeboskolen

Energy supply
District heating
Domestic hot water
Ventilation with heat recovery
PV (3.78 kWp)
District heating
Periode 22/5 2012 to 3/12 2012



	[kWh]
Be06 (Calculation) Roomheating+ Hot water Periode 22-05-2012 to 03-12-2012	15.956
Periode 22-05-2012 to 03-12-2012	23.000

Total district heating consumption for both hot water and room heating for the period 22-05-2012 to 02-11-2012
The district heating consumption is 44 % higher than calculated in the Be06. Part of the reason is due to the water consumption that also is 53 % higher than calculated.



	[kWh] January	[kWh] February	[kWh] March	[kWh] April	[kWh] May	[kWh] June	[kWh] July	[kWh] August	[kWh] September	[kWh] October	[kWh] November	[kWh] December
Be06 (Calculation), Roomheating	9.920	9.080	7.720	4.370	1.310	210	160	17	1.520	3.550	6.050	8.540
Be06 (Calculation), Hot water	40	360	400	390	400	390	400	400	390	400	390	400
Be06 (Calculation) Roomheating+ Hot water Periode 22-05-2012 to 03-12-2012					1.214	600	560	417	1.910	3.950	6.440	865
Periode 22-05-2012 to 03-12-2012					426	1.277	713	648	627	8.730	9.613	968

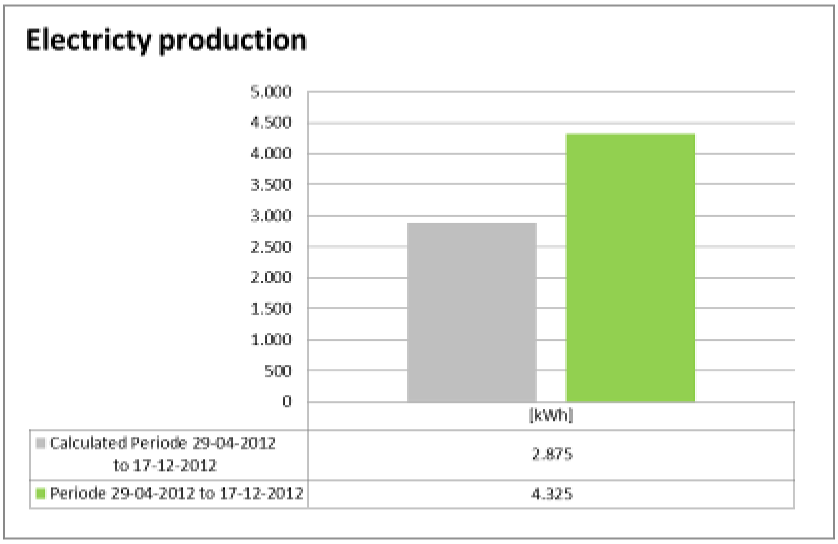
Calculated district heating consumption for both hot water and room heating for the period 22-05-2012 to 02-11-2012 for each month
Photovoltaic/Electricity production

The building is 896 m2 and contain a sports centre with

PV installation at Lykkebo School

depot room and two changing rooms, one for girls and one for boys. The building was finished in 2010. The building is replacing an old sports centre that burned down in 2007.

There is installed 3.78 kWp photovoltaic. The photovoltaic is oriented south and has a 30^0 slope

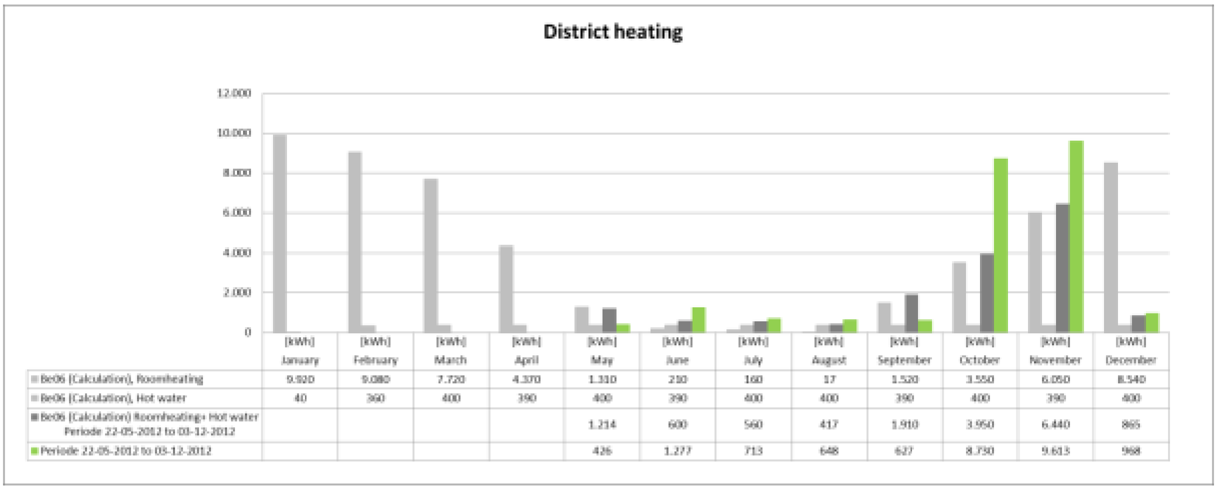


Electricity production from 29/4 2012 to 17/12 2012.

According to the monitoring data the photovoltaic has been running for 5,610 hours and produced 4,325 kWh.

The measured PV production is higher than expected. The reason is probably that the meter efficiency for the used small inverter is not precise.

The district heating consumption is 44 % higher than calculated in the Be06. Part of the reason is due to the water consumption that also is 53 % higher than calculated.



	[kWh] January	[kWh] February	[kWh] March	[kWh] April	[kWh] May	[kWh] June	[kWh] July	[kWh] August	[kWh] September	[kWh] October	[kWh] November	[kWh] December
Be06 (Calculation), Roomheating	9.920	9.080	7.720	4.370	1.310	210	160	17	1.520	3.550	6.050	8.540
Be06 (Calculation), Hot water	40	360	400	390	400	390	400	400	390	400	390	400
Be06 (Calculation) Roomheating+ Hot water Periode 22-05-2012 to 03-12-2012					1.214	600	560	417	1.910	3.950	6.440	865
Periode 22-05-2012 to 03-12-2012					426	1.277	713	648	627	8.730	9.613	968

Calculated district heating consumption for both hot water and room heating for the period 22-05-2012 to 02-11-2012 for each month

Ny Ellebjerg	
Status	On going
Dwellings	Family Housing: 52 Shared living for mentally and physically handicapped: Kindergarden: 5 groups
Gross floorage area/ Gross space, m^2	Family Housing (52): = 6,800 m2 Shared living for mentally and physically handicapped: Kindergarden: 1,100 m2
The Final energy consumption, kWh/m^2, year	Heat: 33.6 Electricity: 5.3 Total: 38.9
Roof	0.1-0.15 W/m2K
Ceiling against unheated attic	-
Ceiling in cellar	-
Floor in cellar	-
Ground deck	0.08 W/m2K
Windows	1.1 W/m2K
Glazing	-

Implementation

Ny Ellebjerg (KAB housing area) Carl Jacobsens Vej in Valby.

A housing area in low energy Class1 has been established with Vandkunsten Architects, comprising 52 social housing units, 30 elderly housing units and a kindergarten. KAB housing association will try to utilize the developed balanced building concept for the roof top dwellings, an optimized connection to the district heating network incl. use of solar heating and focus on low electricity use both for ventilation and other purposes with integrated survey.

KAB low energy Class1 housing project at Carl Jacobsens Vej in Valby.

Pictures of the building

Energy supply
District heating
Domestic hot water
Ventilation with heat recovery
PV (20 kWp)

Teglholmens skole/ Sydhavn skolen (School)	
Status	On going
Gross floorage area/ Gross space, m^2	(Total area 10,500 m2), only kindergarten and sports facility (1,260 m^2) is included in Concerto project due to a fire in Nov.2012.
External wall	0.12-0.24 W/m2K
Basement wall	0.11-0.21 W/m2K
Roof	0.11-0.15 W/m2K
Ground deck	0.09 W/m2K
Ground deck basement	0.14 W/m2K
Windows	0.8 W/m2K
Glazing	-
The Final energy consumption, kWh/m^2, yr	Heat: 22.6 Electricity: 4.52 Total: 27.12 Energy frame value: 46,6 kWh/m^2,year.

Implementation

Teglholmskolen/Sydhavnsskolen – new primary school

In the south part of Copenhagen Harbour nearly all traditional merchant and industrial harbour activities has been closed down or moved to the northern part of the harbour. It has given space for new office buildings and residential areas. One of the ambitious areas is Teglholmen. Teglholm School will be the new primary school for the area servicing the new and coming dwellings in the area as well as the existing urban areas of Valby. The school will be 10.500 sq. m and the development of the site has started January 2010 along with the detailed architect project for the school by JJW Architects. Building start was in April 2011 with finalisation aimed at October 2012, leaving enough time for monitoring within the Concerto project period. The energy performance for the building is Low Energy Class 2015 which is the standard for all new build in 2015. Due to a fire in the almost finished school in November 2012 only the kindergarten with some sports facilities is still included in the Concerto project. The school is now aimed for use by summer 2014.

Kindergarten with sports facility avoided the fire.
"Children's House" with sports facility was finalised by end of 2012 and not destroyed by the fire.
Energy supply
District heating
Domestic hot water
Heating system radiators
Ventilation with heat recovery
PV (20 kWp)

The Water Culture House in Valby sports park	
Status	Finished
Gross floorage area/ Gross space, m²	3,230
External wall	0.15 W/m2K
Roof	0.08 W/m2K
Ceiling against unheated attic	-
Ceiling in cellar	-
Floor in cellar	0.11 W/m2K
Ground deck	0.12 W/m2K
Windows	1-1.5 W/m2K
Glazing	-
The Final energy consumption, kWh/m², year	Heat: 22.95 Electricity: 10.9 Total: 33.85

Implementation

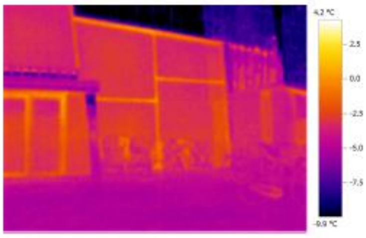
3.230 sq. m new-built public swimming pool with service areas built to low energy class 2. Part of the electricity consumption is supplied by a 19,1 kWp PVsystem and heat is supplied by the district heating network. The building start was in March 2010 and official opening of the centre was on the 15th of March 2012.

It was highly praised in newspaper articles during following days for quality in building and swimming/wellness facilities for the Valby families which are main customer target group.

The Water Cultural Centre is the state-of-the-art in low energy performance for indoor swimming facilities on both building design and water treatment technology. The air and water temperature are at least 28 degree Celsius to achieve the best comfort for the visitors. The building is in full use now and the monitoring program started 1st of May 2012.

The official opening of the Water Cultural Centre the 15th March 2012
Energy supply
District heating
Ventilation with heat recovery
PV (kWp)

Thermal photoes



Picture data:	**Date:**	2/22/2013	**Emissivity:**	0.95
	Measuring Time:	12:55:48 PM	**Refl. temp. [°C]:**	20.0
	File:	IV_00543.BMT		

Review: The pictures in this rapport, doesn't show anything importance. The reason that the zinc is black, isn't because it's cold from not being isolated, but because of the infrared reflection from the thermal camera.

It's visible that the framework on the windows has a small heat loss, but this is normal.

Resultat

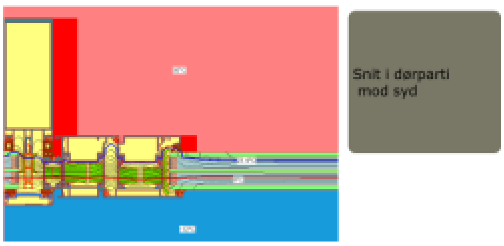
På grundlag af besigtigelsen vurderer energikonsulenten, at konstruktioner og installationer, som har betydning for bygningens energieffektivitet, afviger fra byggetilladelsen.

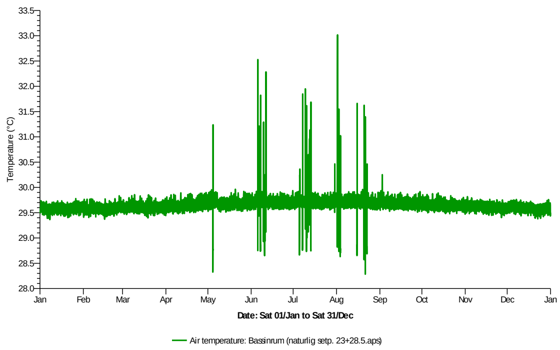
Det vurderes, at bygningens energiforbrug opfylder Bygningsreglementets krav til lavenergiklasse 2, som det er forudsat i byggetilladelsen. Men det beregnede energiforbrug er 55,97 kWh/m² år, hvilket er bedre end de 70,50 kWh/m² år, som er angivet i byggetilladelsen.

Beregnet årligt varmeforbrug:
91,11 MWh fjernvarme

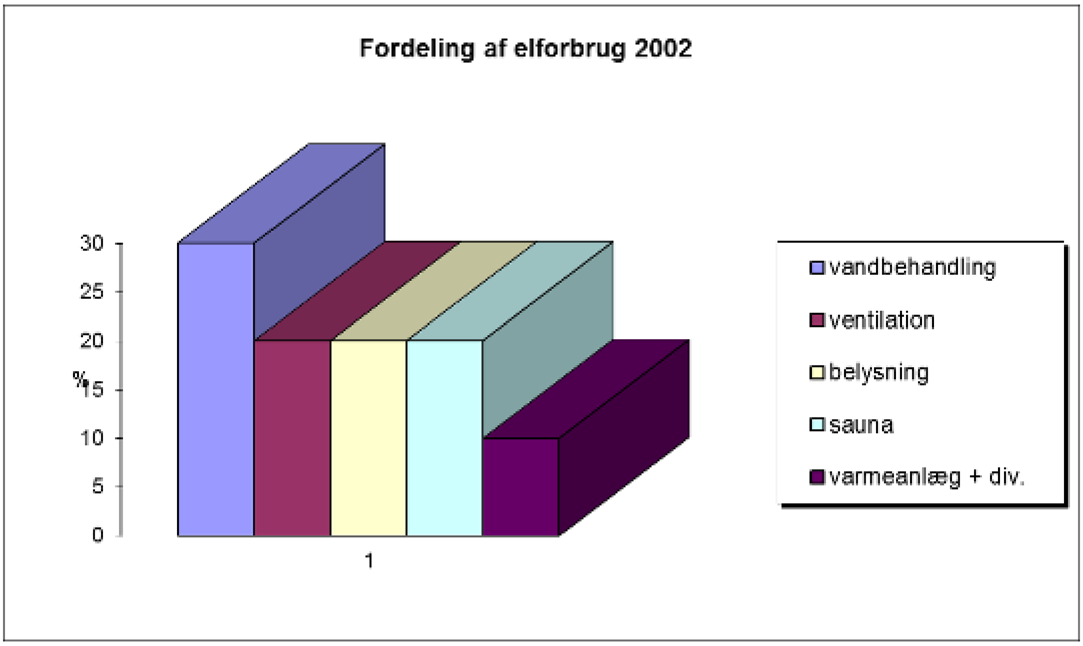
Calculated heat use matches A2

BEDSTE FACADELØSNINGER.... U 0,8-1,4

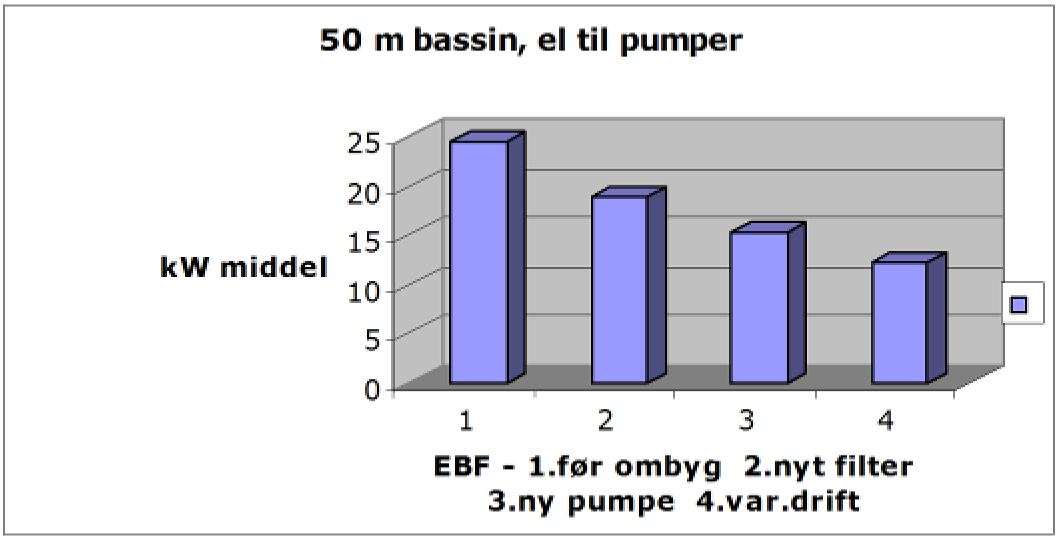




Airtemperature in swimming hall



Distribution of electricity use (water treatment, ventilation, lighting, sauna, heating systems etc.)



Experience of improvement of pump systems in renovated swimming halls in Copenhagen has been transferred to the project. Here is illustrated the improvement due to improved filter, new pump system and variable operation.

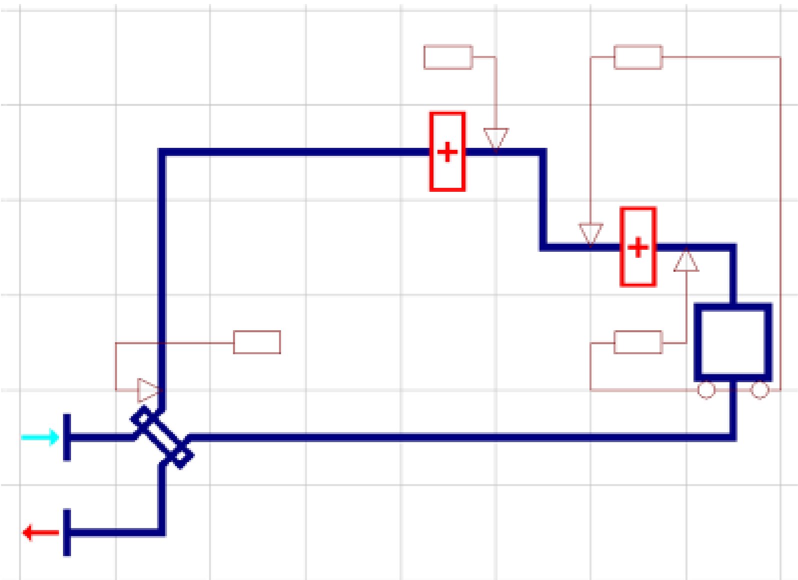
Effektive pumper – og motorer

Lave tryktab i filtre mm

Rørsystemers udformning

Regulering af vandhastighed

Efficient pumps, filters with low losses, optimised piping system, regulation of water velocity.



Ventilation med:

80-85% varmegenvinding

Recirkulering i svømmehal

1,8 kJ/m3 SEL

Behovsstyring

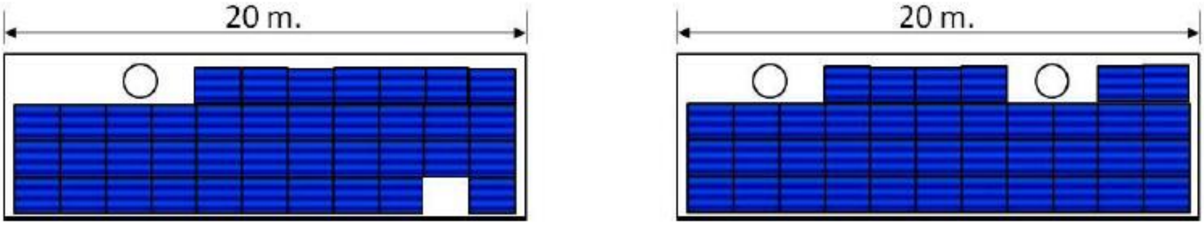
Mere effektivt indblæsningsmøns-ter

Ventilation system with heat recovery and recirculation in swimming hall.
SFP factor/electricity use for fans 1,8 kJ/m³.
Demand control.

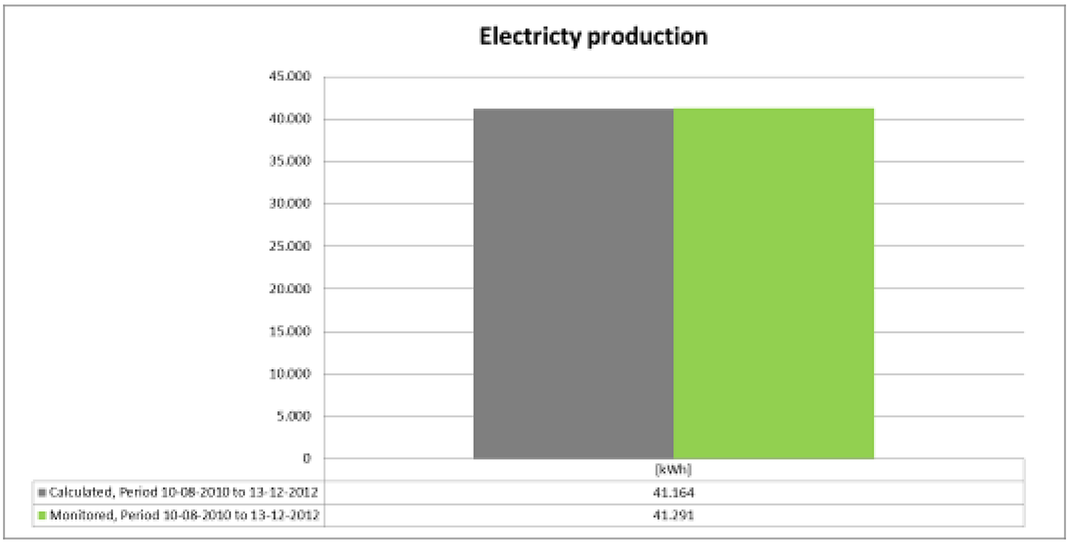
PV installation
There is installed 19.11 kWp photovoltaic modules (128.4 m2), which is placed on the roof of an existing neighbour building on the same land register. The photovoltaic has been installed since the 29th of June 2012. This rapport is only about the photovoltaic. There is another rapport analysing the energy consumption for the whole building.

Picture of the placement of the photovoltaic plant in the planning phase.

Picture of one of the neighbour buildings with photovoltaic.



Illustrations of the placement of the photovoltaic panels on both buildings



The calculated and monitored PV output is almost equal.

District heating and electricity use

Reporting

The new swimming bath – in Danish "Valby Vandkulturhus" (VK) – opened up for the customers March 15, 2012. As it is a part of the "Green Solar Cities" project under the EU FP6 Concerto program some of the energy measures are granted subsidies from the program.

This involves documentation of functions, performance and costs as well as making the features of the building visible to the public.

Valby Water Cultural Centre

2013.03.01/NHR

Total energy consumption

kWh/day

	2012 June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Heat	2667	1970	2167	2548	3000	2967	3529
Power	1904	1305	2036	2060	1972	2016	1659
Primary Energy adding *1	2856	1958	3054	3090	2958	3024	2489
TOTAL PRIMARY ENERGY *2	**7427**	**5233**	**7257**	**7698**	**7930**	**8007**	**7677**

Damhusåen PV plant	
Implementation	Finished January 2013
Plant size, kWp	777
Electricity production, kWh/year	700,000

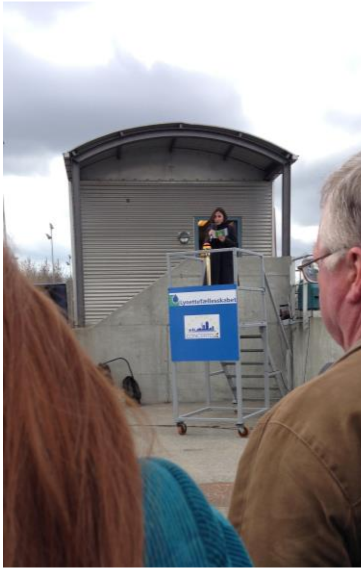




Intro

The photovoltaic plant is placed in Valby in connection to the waste water treatment plant. The photovoltaic plant is 777 kWp big and will be able to cover 8-10% of the electricity consumption of the waste water treatment plant.

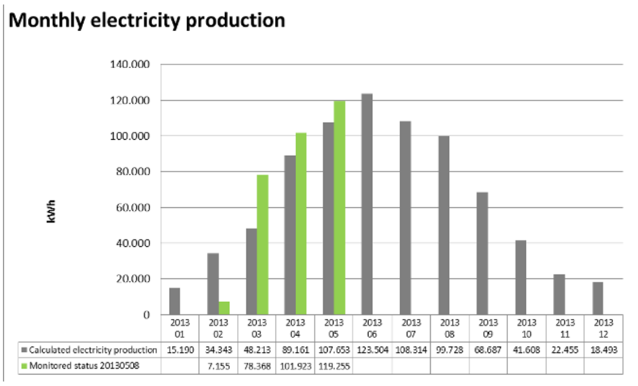
View over 777 kWp big photovoltaic plant



Opening of the photovoltaic plant the 30th January 2013 with the Technical- and environmentmayor in Copenhagen Ayfer Baykal

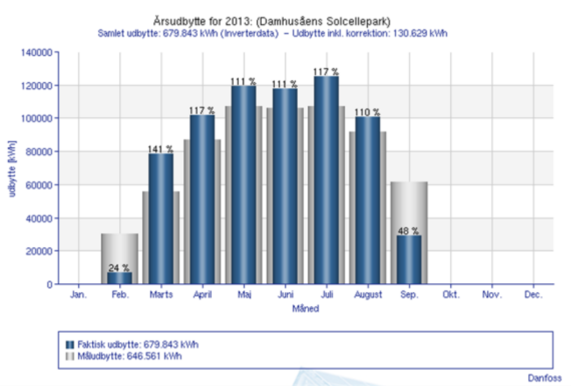
As part of dissemination work with video filming, a done has been used to make a movie of the installation, which has been presented on the internet.

Status 20130625



	2013 01	2013 02	2013 03	2013 04	2013 05	2013 06	2013 07	2013 08	2013 09	2013 10	2013 11	2013 12
Calculated electricity production	15.190	34.343	48.213	89.161	107.653	123.504	108.314	99.728	68.687	41.608	22.455	18.493
Monitored status 20130508		7.155	78.368	101.923	119.255							

It is seen that a somewhat higher PV production than calculated has been obtained



Stakhaven	
Status	Finished early 2013
Plant size, kWp	69.1 distributed as 8 housing blocks owned by the FSB housing association
Electricity production, kWh/year	63,000 kWh

PV is used in combination with asphalt layer roofs to cover common electricity use.
Review of the blocks

Block 5, 7.20 kWp

Block 6, 7.92 kWp

Block 5, realisation in snowing period

Block 6

Block 7

Staging

‘

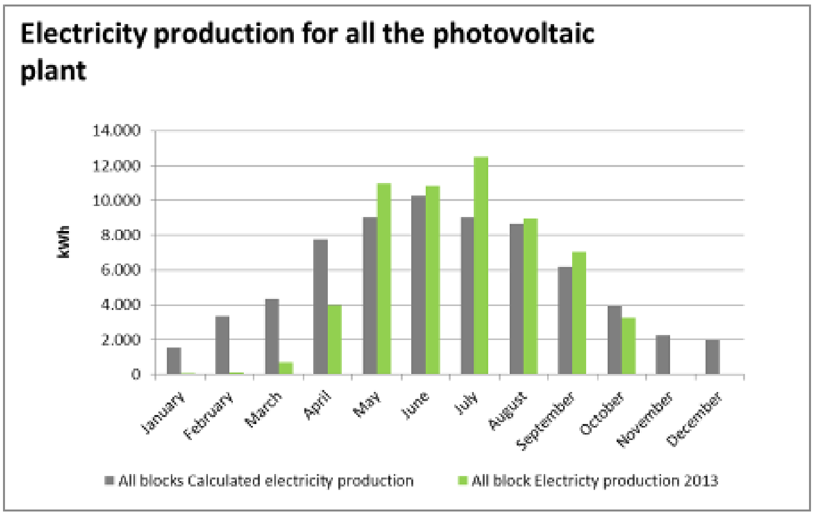
There is installed a total of 69.1 kWp photovoltaic where 8.8 kWp on block 4 already was installed according to the old regulations “Nettoafregningsordningen“ from before December 2012 which means that the electricity production is settled once a year with the energy supplier. The rest was installed according to the new hourly rules.

All the photovoltaics are oriented South-Southwest and has a slope on 15º.

	Moduls	kWp	kWh
1	33	7,9	6.756
2	39	9,4	8.109
3	123	29,5	25.714
4		8,8	7.656
5	30	7,2	6.326
6	33	7,9	7.000
7	30	7,2	6.326
Total	**288**	**69,1**	**60.231**

List over installed photovoltaic

Placement of the blocks

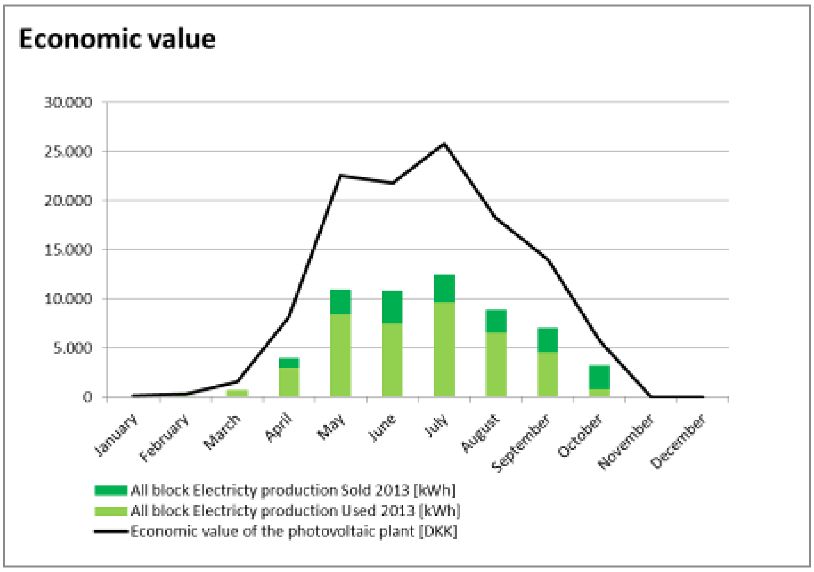


All the photovoltaic plants were not installed before 1. of May, which is the reason why the columns in February and March 2013 are low.

Economic value

The photovoltaic plants were installed in the Spring of 2013 which means that the photovoltaic plants came under the new scheme given from the state where all electricity that is not used in the produced hour will be sold to 1.6 DKK per kWh.

The black line in the table is showing the economic value of the photovoltaic plants for each month. The light green shows how much electricity that there were used and the dark green shows how much electricity that were sold to 1.6 DKK/kWh.



<u>Example on how the economic value for June was calculated</u>

Sold produced electricity:	7,451 kWh x 1.6 DKK =	11,922 DKK
Used produced electricity:	3,384 kWh x 2.2 DKK =	7,445 DKK
Economic value		19,367 DKK

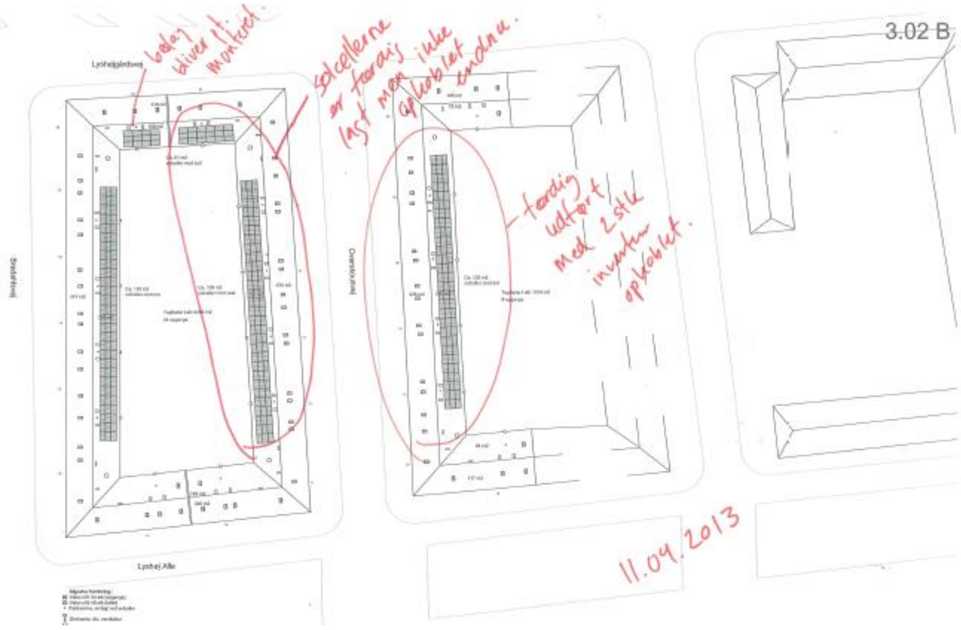
Lyshøjgård	
Status	Finished early 2013
Plant size, kWp	73, 500 m²
Electricity production, kWh/year	62,000

A/B Lyshøjgård was realized in spring 2013 with plan1 as architects combining PV with new red tile roofs and extra roof insulation (200 mm).

Photovoltaic on roof

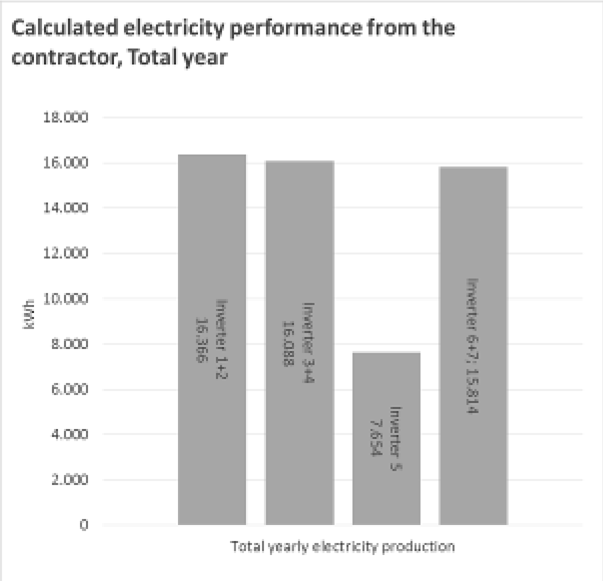
Energy monitoring
Monthly and yearly results
Monitoring period
January 2013 to July 2014.
Description of the photovoltaic plant
The photovoltaic plant is placed in Valby which a size of total 71,01 kWp.

Building [no.]	Inverter [no.]	Inclination [°]	Orientation [-]	Installered photovoltaics [kWp]	Installered photovoltaics [m2]
1	1 2	35	West	21,06	137,9
1	3 4	35	East	21,06	137,8
1	5	35	South	7,8	51
2	6 7	35	East	21,09	137,9

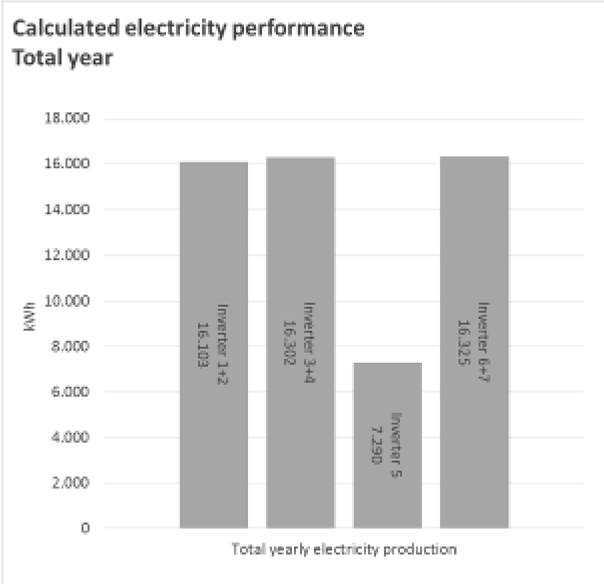


Picture of the placement of the photovoltaic.

Calculation of the performance for the photovoltaic plant



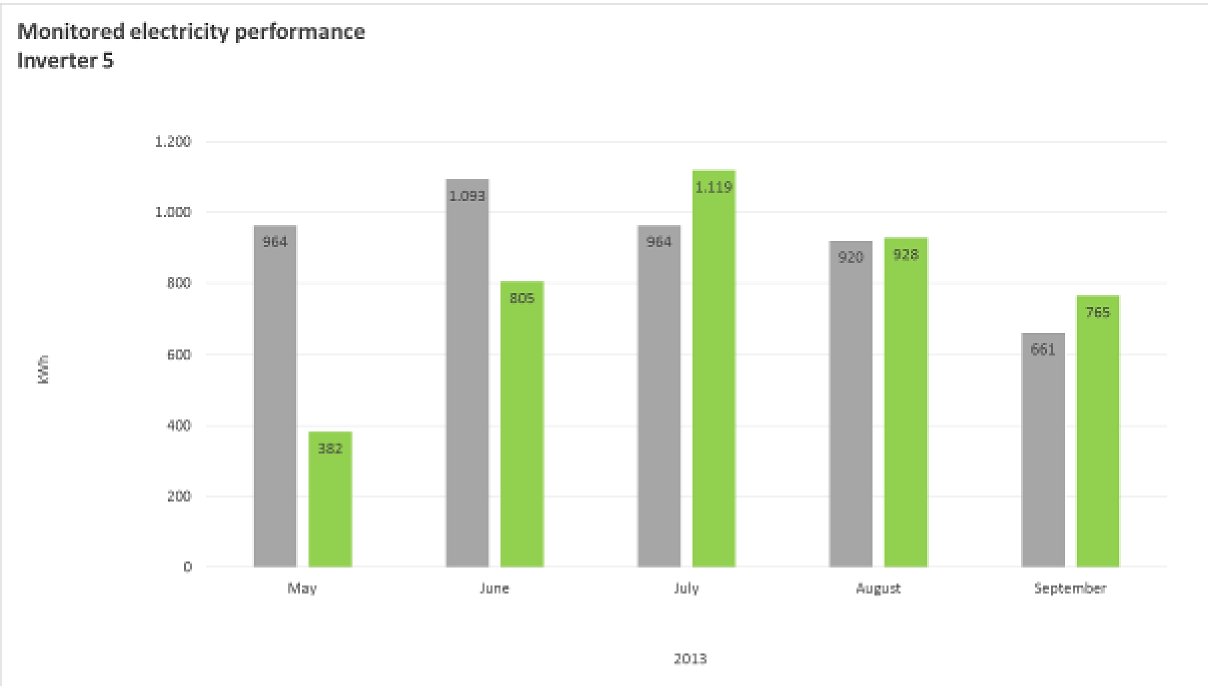
Calculated electricity performance from the contractor, Total year.

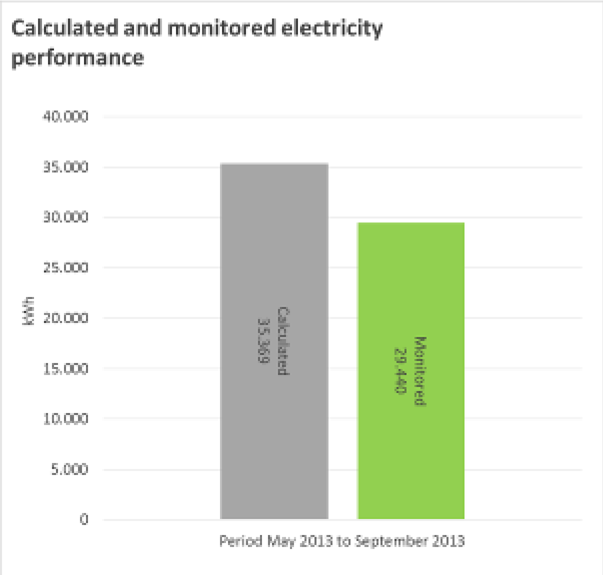


Calculated electricity performance, Total year

The first figure shows the performance figures informed from the contractor. And the second figure shows our calculations of what could be expected for the photovoltaic plant. The figures are more or less the same. There appear only small changes. The total sum from the contractor is 55.922 kWh and our calculation is estimating 56.020 kWh.

Monitored electricity production for inverter 5





Calculated and monitored electricity performance from the period May to September 2013.
The calculated figures is from our calculation while the contractor only has provided the exact kWh for a year and given rough graph of the monthly production, which do not show the exact kWh.
As the graph shows the photovoltaic plant has produced 83% of what could be expected but it is clear from the monitoring, that the performance has improved since start of operation and is satisfactory by August / September 2013.

Valby Sports Hall area

On the roof of the old Valby Sports Hall the Copenhagen PV Coop has established 22 kWp PV modules. The PV electricity is sold to Copenhagen Energy / DONG Energy in a special solar stock exchange feed-in tariff scheme and is recorded every month.

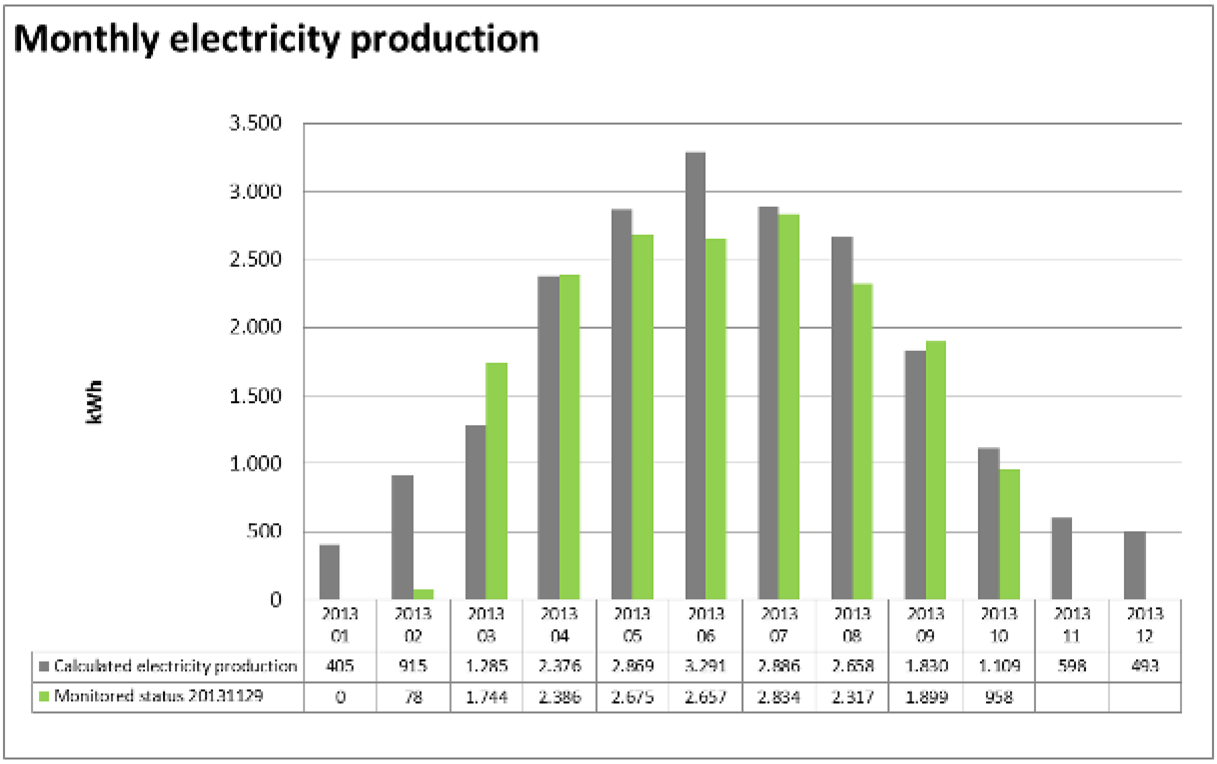
All the photovoltaics are oriented South with a slope on 30^o.







Pictures of the photovoltaic plant.



	2013 01	2013 02	2013 03	2013 04	2013 05	2013 06	2013 07	2013 08	2013 09	2013 10	2013 11	2013 12
Calculated electricity production	405	915	1.285	2.376	2.869	3.291	2.886	2.658	1.830	1.109	598	493
Monitored status 20131129	0	78	1.744	2.386	2.675	2.657	2.834	2.317	1.899	958		

Calculated and monitored electricity performance from February 2013 to October 2013.

Valby Citizen Center

In Valby Citizen Center 12 kWp was mounted on the south facing gable.

Demo Project Overview – June 2013

Building project						
Project	New/ retrofit	Use	Status	M²	Solar m²	PV kWp
Dr. Ingridshjem	N	Elderly Housing	Finished	11,671	60	
Henkel II (Building A)	R	Office, Public	Finished	6,840		
Hrnemanns Vænge	R	Housing	Finished	16,580	(600) 300	69,8 2
Karens Minde	N	Housing	Finished	4,300		30,6
Langgadehus	N	Family and Elderly Housing	Finished	5,824 8,642	200	
Lykkebo skole (school)	R	School	Finished	896		3,78
Ny Ellebjerg	N	Housing	Finished	7,900	-	10
Teglholmens skole / Sydhavn skolen (Kindergarten)	N	Kindergarten	Finished	1,260		8
Valby Hallen Area	R	Public sports center	Finished			20
Water Culture House	N	Public	Finished	3,230		19,1 1
Damhusåen waste water treatment plant		Public	Finished			229, 5 (777)
FSB Stakhaven	R	Housing	Finished			20
A/B Lyshøjgård	R	Housing	Finished			24
Valby Citizen Center	R	Public	Finished			(12) 6
Total				67.143	560	440, 81

*) Projects is in accordance with the last CDS revision, but under "Public Buildings" heading transfer part of building area from school to Henkel II due to fire at the school.

Revised calculation of total energy savings and total economy for Valby Project

Yearly energy balance for EU-Concerto area in Valby community:

In the analysis we both look at the buildings, which will receive EU-support (67.143 m²) like in contract and the actual realised low energy building area (80.553 m²). This includes extra building areas of 13.410 m2 m², which will not receive EU-support, but is included in the Concerto demonstration programme.

Below is shown figures on:

		MWh
Common electricity use Concerto area :	19.986 m² public/commercial building x 10 22.230 m² retrofit housing x 6 18.023 m² new built housing x 6 20.314 m² elderly people housing(new) x 15	200 134 108 305
	Total	747
District heating use Concerto area:	19.986 m² public/commercial building x 23 kWh/m² = 22.230 m² retrofit housing x 41 kWh/m² = 18.023 m² new built housing x 28 kWh/m² = 20.314 m² elderly people housing(new)x 43 kWh/m² =	459 911 505 874
	Total	2.749
	Aimed at maximum heat losses in district heating, 10% =	275
District heating	Total	3.024

Comment:

New energy balance for EU-Concerto area in Valby based on official energy frame value calculations from the Danish energy rules.

			m² Building area (A)	Energy frame value kWh/²,year (B)	Energy use Calculated as energy frame value MWh/year
1.	Water Cultural House		3.230	50	161
2.	Dr. Ingrids Plejehjem		11.671	63	735
3.	Langgadehus	- family	5.823	33,3	193
		- Elderly people home	8.643	101,9	881
4.	Karens Minde housing		4.300	66	283
5.	Hornemanns Vænge housing renovation		22.230	55	1222
7.	Teglholm School		1.260	50	63
8.	Ny Ellebjerg housing		7.900	36	284
9.	Lykkebo School		896	45	40
10.	Henkel II		13.500	45	608
11.	Ny Ellebjerg kindergarten		1.100	45	50
	Total excl. district heating losses		80.553		4.520 MWh

And compared to this we have a PV output of 1.078 MWh from 1.198 kWp PV as the new total PV implementation size in the Concerto project in Valby.
Multiplied with 2,5 we then have an Energy Frame value of : 2.695 MWh

And besides Solar thermal implementation of: 387 MWh

Total: 2.695 + 387 = 3.082 MWh = 68,2 % of the total building related energy frame value of 4.520 MWh
If you only relate to the 67.143 m² building area, which is the official Concerto building area, the renewable energy contribution grows to 81 %

Overview of energy frame values for different types of buildings:

		Energy frame value MWH	Building area m²	Energy frame value in kWh/ m^2,year	Of which electricity use : energy frame value and (consumption) kWh/m²,year	District heating consumption kWh/m²,year
1.	Public / commercial buildings	882	19.986	44	25/(10)	19
2.	Retrofit housing	1.222	22.230	55	15/(6)	40
3.	New build housing	776	18.023	43	15/(6)	28
4.	Elderly people housing new-built	1.616	20.314	80	37/(15)	43

Reference project

		MWh
Common electricity use :	19.986 m² public/commercial building x 20 kWh/ m^2/y 22.230 m² retrofit housing x 12 kWh/ m^2/year 18.023 m² new built housing x 12 kWh/ m^2/year 20.314 m² elderly people housing(new) x 25 kWh/ m^2/	400 267 216 508
	Total	1.391
District heating use :	19.986 m² public/commercial building x 45 kWh/ m^2/y 22.230 m² retrofit housing x 160 kWh/ m^2/year 18.023 m² new built housing x 56 kWh/ m^2/year 20.314 m² elderly people housing(new) x 80 kWh/ m^2/	899 3.557 1.009 1.625
	Total	7.090
District heating	Including 25% net heat losses :	8.863

Calculation as energy frame value we have: 1.391 x 2,5 + 8.863 = 12.341 MWh

Savings in all in Valby community based on new 2006/2010 energy rules in Denmark

Electricity in MWh :	(1.391 – 747) MWh=	644 MWh (54 %)
Electricity in EURO :	644 MWh x 227 EURO/MWh	146.188 EURO
District heating incl. network losses in MWh	(8.863 – 3.024) MWh :	5.839 MWh (66 %)
District heating in EURO :	5.839 x 48 EURO/MWh	280.272 EURO

The Concerto demonstration calculation as energy frame value: 747 x 2,5 + 3.024 = 4.891 MWh

This is only 39 % of the reference value, so 61 % have been saved only based on the building improvement.

Total Energy Supply from Renewables

	MWh
1.198 kWp PV x 900 kWh/kWp =	1.078
860 m² solar collectors x 450 kW/m² =	387

Total renewables :

Electricity :	1078 MWh (100% of 747 MWh) and (1078 – 747) = 331 x 2,5 = 828 MWh as support for district heating
District heating/solar heating :	387 + 828 = 1.215 MWh (40% of 3.024 MWh)

Total investment for Valby community including design: 5.128.000 EURO

RES savings in EURO

		EURO
Savings from solar energy	PV-electricity: 1.078 MWh x 227 EURO/MWh	244.706
	Solar heating: 387 MWh x 60 EURO/MWh	23.220
	Renewables in total	267.926

Total economy in EURO:

Total energy saving value :	267.926 + 280.272 + 146.188 =	694.386
Maintenance costs :	½ % of investment =	3.472
Real saving :	694.386 – 3.472 =	690.914
Payback time :	5.128/691 = 7,4 years excl. EU-funding	

Taking the risk into account when using new technologies this will lead to an acceptable overall economy for the project. Here it should be noted that part of the investment does not get funding from the EU. If this is taken into account the payback time is around 10 years.

The overall results from the EU Concerto project in Valby, Copenhagen is that compared to the aim of realising a Concerto ecobuilding standard for 67.143 m² building area, then it has been possible to realise this for 80.553 m² building area and with a 61 % saving compared to normal reference standard in Denmark. Concerning solar thermal collector area, which was aimed to reach 500 m², then 860 m² solar thermal collectors have been realised, and concerning PV systems, it was aimed to reach 441 kWp with the available EU funding. And here 1.198 kWp have been realised due to the much reduced PV costs in the project period.

If the energy frame value for the higher realised ecobuilding projects are compared to the solar energy input, then 68 % of the energy use is covered by solar energy. If you only use the original aimed at ecobuilding area as reference, then the solar energy contribution is 81 %.

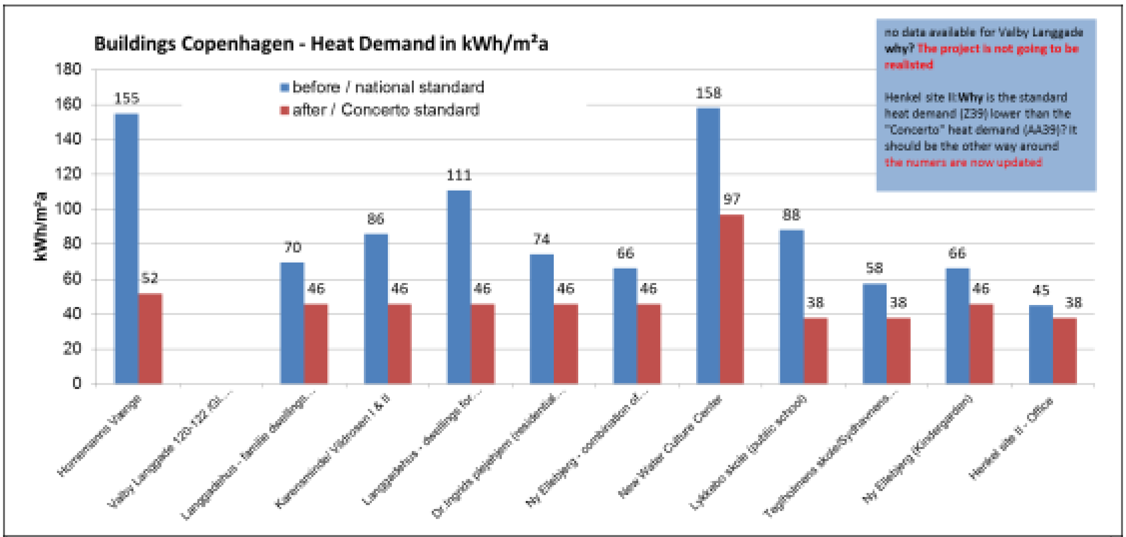
And looking at the payback time excl. EU funding for the original ecobuilding area, then this becomes 10 years, equal to 7 years including EU funding, which is reasonable, taking the involved risks into account.

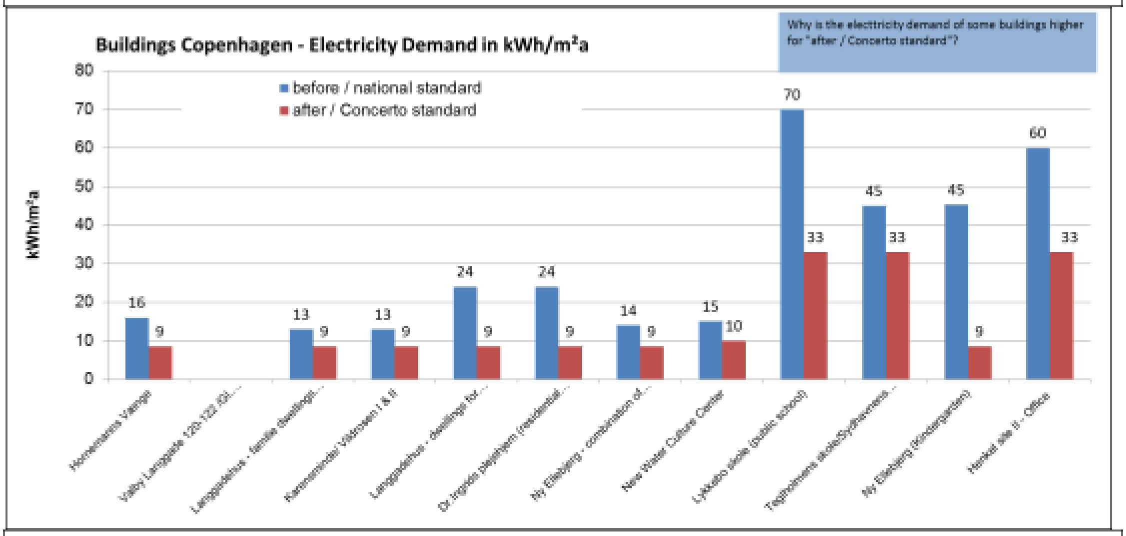
EU-Concerto, Green Solar Cities in Valby, Copenhagen Energy use in kWh/m², year			Existing	Heat + electricity Best sheet information			Danish national energy frame value					
				General national standard	EU-Concerto 2008 annex	Demon-stration project actual standard	Actual national standard	Improvement (%)	Actual building regulations	Demon-stration Project Actual standard	Concerto specifications	Improve-ment (%)
1.	New build housing	a) Karensminde (BR06)		78	55	58/54/51(54)	78	31	101	56/50/48	77.5	49
		b) Ny Ellebjerg (BR10)		78	55	38.9	58	33	66	35.6	77.5	46
2.	New build elderly housing	a) Dr. Ingrids Hjem (BR08)		78	55	43	92.5	46	112	63	77.5	44
		b) Langgadehus (BR06)		78	55	92.9	139.2	33	148.5	101.9	77.5	31
3.	Roof top dwellings	Langgadehus family housing (BR06)		78	38.5	32.5	83.5	61	101	33.5	58	67
4.	Retrofit housing	a) Hornemanns Vænge	178		54.5	46	155 (existing)	70	212 (existing)	52	67	75
5.	Public building	a) Teglholm/Sydhavn school (BR10)		112	71	38.9	84	46	95.2	35.6	120.5	63
		b) Lykkebo school / sports building (BR08)		112	71	91.7	133	31	188	131	120.5	31
		c) Henkel II (BR08)		112	71	26.7	112	76	95.3	66.6	120.5	30
6.	Water cultural house Valby	(BR08)		188	107	33.8	188	82	218	45.2	122	79

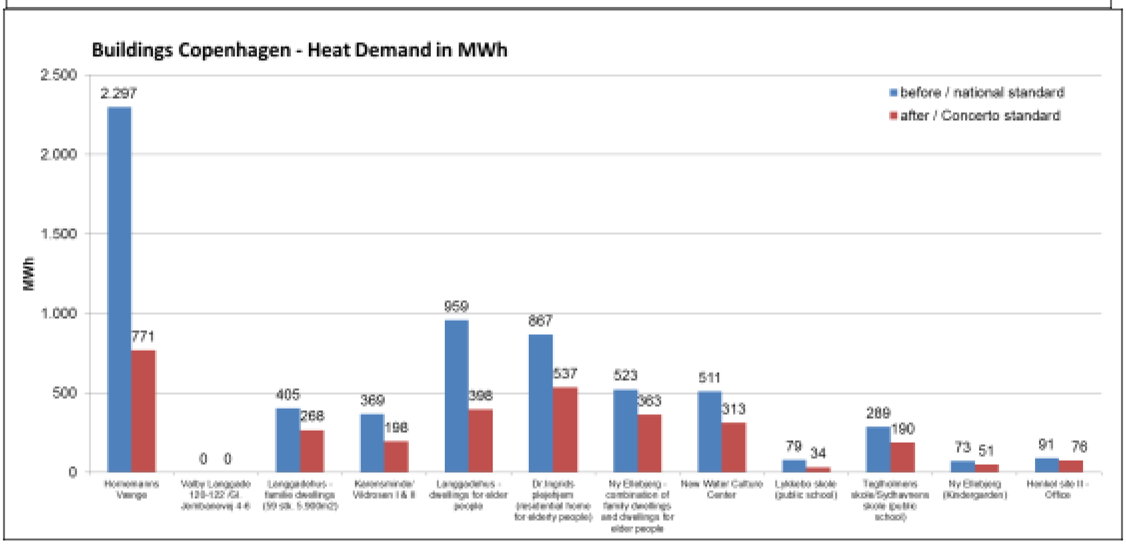
Table 1Overview of EU Concerto – Green Solar Cities individual demonstration projects in Valby in relation to overall energy savings and energy frame values shown as they are realised and compared to original expectations.

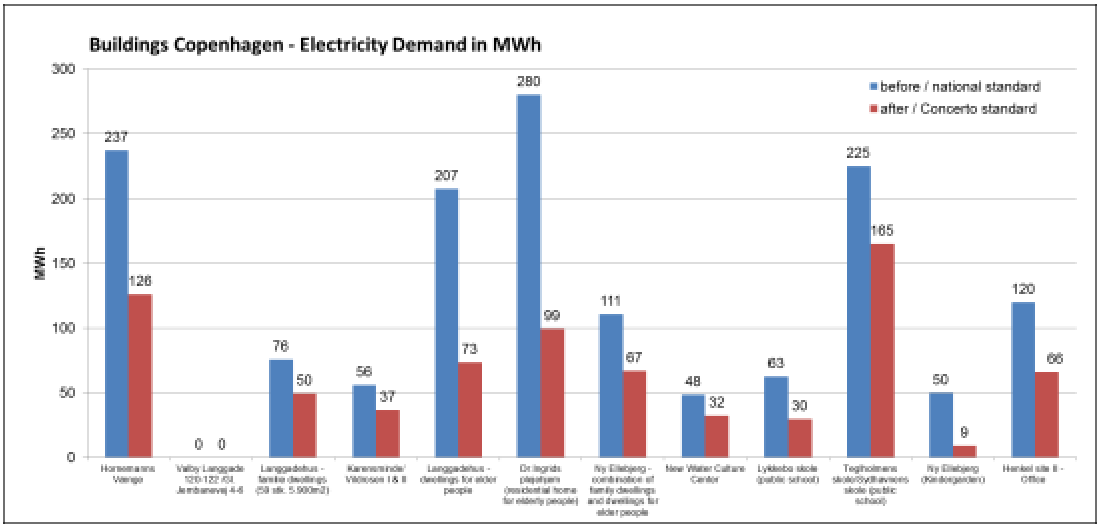
The conclusion is that it has been possible to obtain clearly improved energy saving results as a general rule.

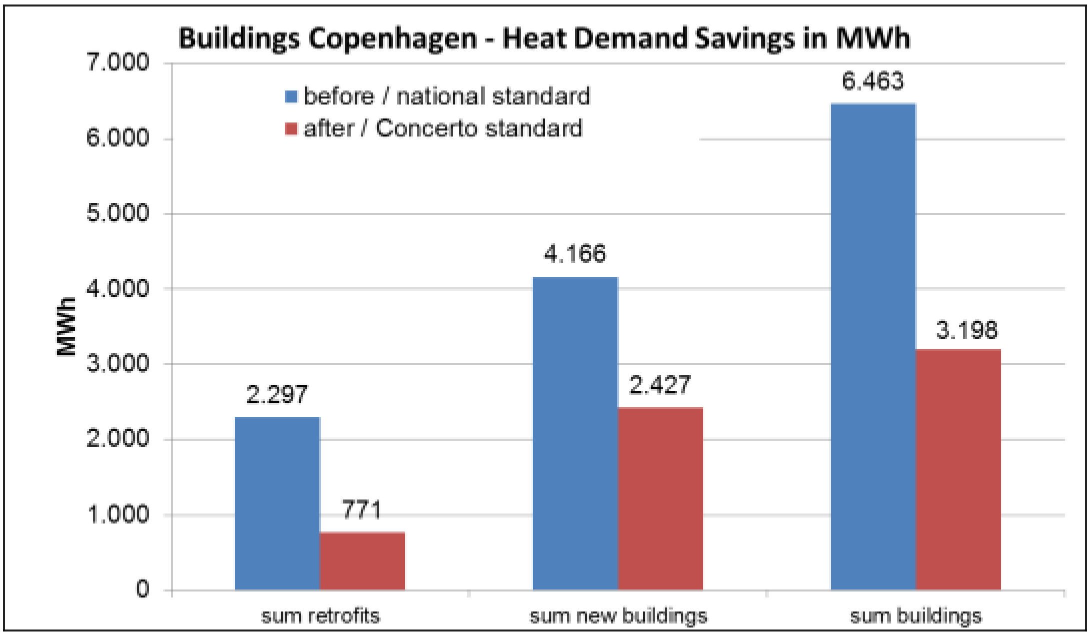
Below is shown overall energy analysis made by the Steinbeiss Institute in Stuttgart for the realised EU- Concerto project in Valby and Copenhagen.

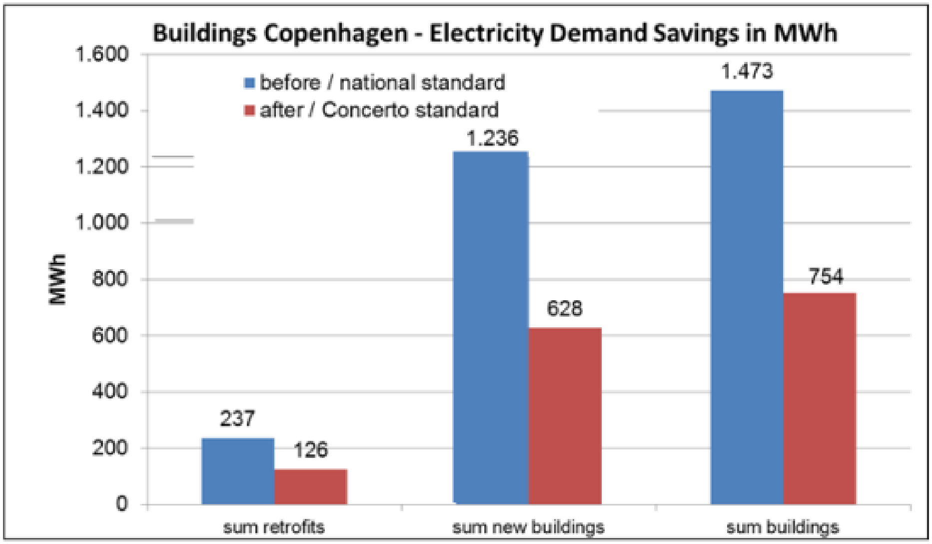


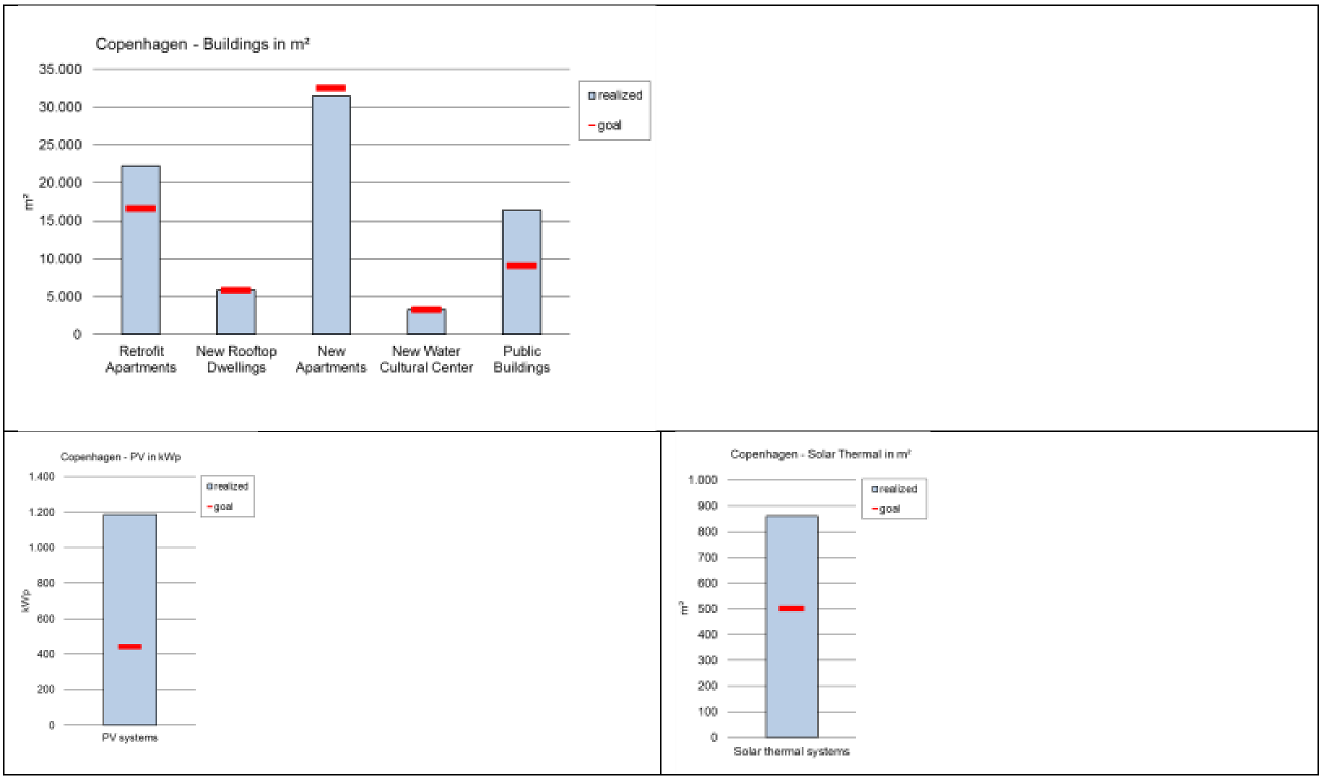





Buildings Copenhagen - Electricity Demand in MWh
MWh
300
250
200
150
100
50
0
before / national standard
after / Concerto standard
237
126
0
0
76
50
56
37
207
73
280
99
111
67
48
32
63
30
225
165
50
9
120
66
New Water Culture Center
Lykkebo skole (public school)
Ny Ellebjerg (Kindergarden)
Henkel site II - Office


Buildings Copenhagen - Heat Demand Savings in MWh
MWh
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0
before / national standard
after / Concerto standard
2.297
771
4.166
2.427
6.463
3.198
sum retrofits
sum new buildings
sum buildings





Compared to the aim to cover 69 % of energy use by solar energy in 2012, it can be concluded, that 60 % is covered instead, but this for around 80.000 m² compared to 67.400 m² in the contract. If you only compare to this the coverage is 71 %.

5. Demonstration projects and monitoring results in Salzburg

Inge Straßl, Engineer, SIR Salzburger 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, cafes and 48 subsidized apartments. A 144m ² solar collector produces solar energy for hot water and heating.

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 centre, there are many 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.

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 Stadtwerke. 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 litres. A solar heat pump optimizes the system and gives an addition of

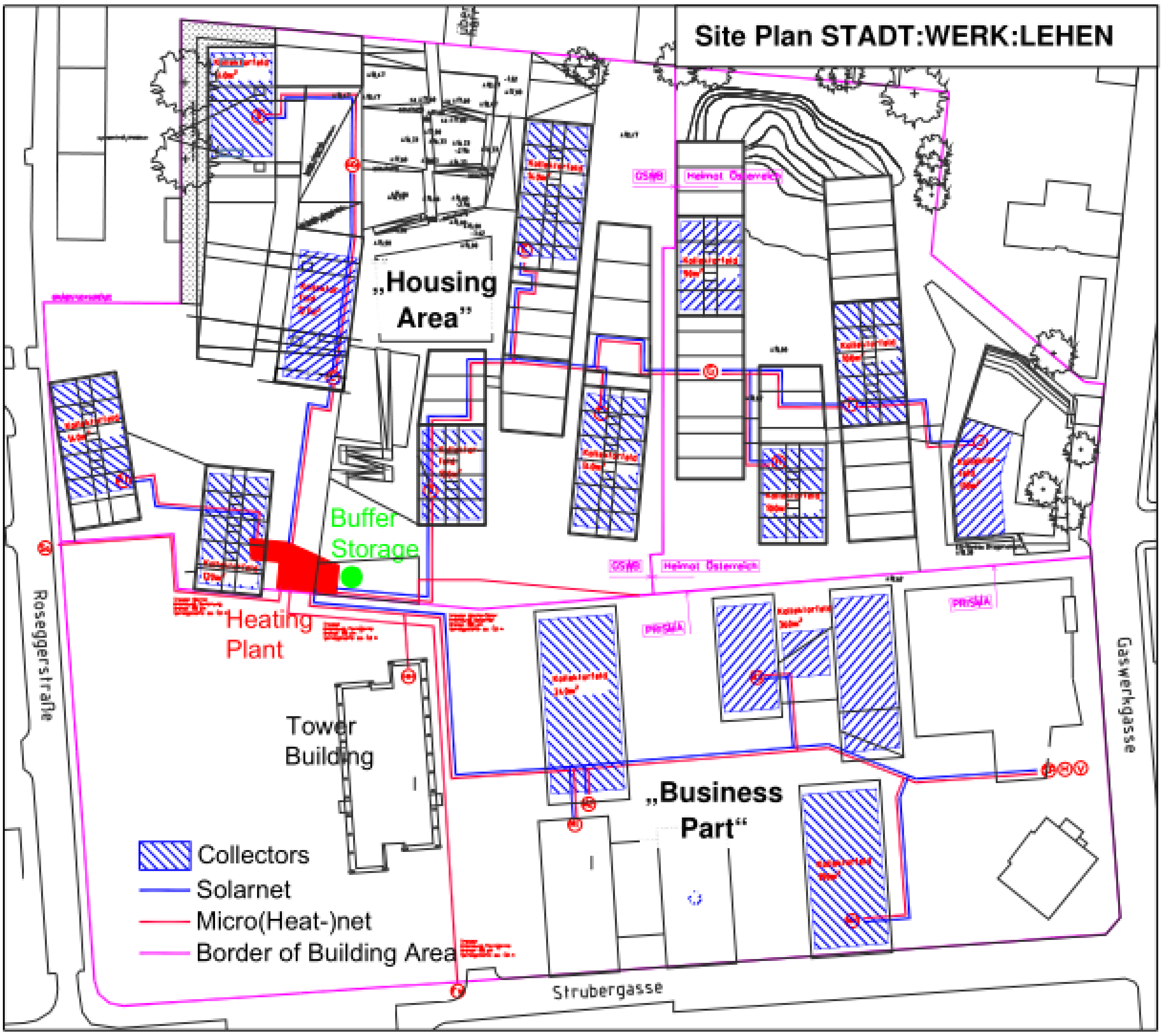
15 - 20%. The heat is distributed by means of a micro net to the apartments, offices and laboratories, as well as to the renovated houses in the area.

Demo Project Overview in Salzburg

Project	New/ retrofit	Use	status	GFA m²	Solar m²	PV kWp
1) Stadtwerk Lehen residential part	N	housing	Finished 11|2012 Monitoring	36117	1551	20
2) Stadtwerk commercial part solar	N	office	Finished 05|2013		496	
3) Stadtwerk Lehen high raised building	R	office	Finished 02|2013	7975		
4) Esshaver strasse	N	housing	Finished 06|2008 Monitoring	1072	38	
5) Neue Mitte Lehen solar plant	N	housing	Finished 11|2008 Monitoring		144	
6) Parklife senior residence	N	old-age home	Finished 02|2012 Monitoring	7145	238	
6a) Parklife Apartments	N	housing	Finished 11|2011 Monitoring	5975	204	
7) Kuenburgstraße	R	housing	Finished 03|2010 Monitoring	4568		
8) Strubergasse	R	housing	Finished 02|2013 Monitoring	16660		
9) PV hospital	N	hospital	Finished 04I2013			

DESIGN BACKGROUND FOR SOLAR PLANT AND MICRO NET SALZBURG

The following description is based on a design report from Steinbeis – Transferzentrum Energie-, Gebäude und Solartechnik from Stuttgart made in 2011.



The shells of the buildings in the housing area are finishedby summer 2011. At the moment the completion of the interior of the buildings is installed. The dormitory for the students building J is nearly finished. The move-in is planned for August. The move-in in the rest of the buildings will start in October 2011.

The construction of the buildings in the business part has not yet started. Detailed plans are available for two of the four office / laboratory buildings, as well as for the existing building the tower and the basement garage between these buildings. According to the actual planning the construction of the first two buildings and the tower will start at the end of 2011.

The main installation of the district heating plant in the basement garage of the housing area has started in March of 2011. Actually at the end of June 2011 the heating plant is about 85 % finished. At the moment the insulation of the piping is mounted.

View of the district heating plant in the basement of the housing area

Solar station for 2000 m² collector area (left), District heating transfer station 1,5 MW (right)

Electrical Heat Pump,
nominal heat output 170 kW

The micronet for the heat distribution to the buildings and the solarnet for the connection of the collector fields to the district heating plant respectively in the housing area was installed during winter 2010 / 2011 and has been finished in April 2011.

View of the connection point for micronet und solarnet in a building with shut-off valves and place for the heat meters (not yet installed)

The buffer storage of the solar system the steel tank with the capacity of 200.000 litres was installed in May 2011. The tank was connected to the heating plant and filled up with conditioned water which was taken from the pipes of the district heating of the Salzburg AG.

Installation of the buffer storage with 200.000 litre capacity

Installed Collectors and sub construction on the roof of building J

View of buffer storage in front of the tower building (left). Connection pipes and installation of the heat insulation and of the moisture barrier ("Klima Me mbran") at the buffer storage (right).

The collectors on the roof of the first six buildings A1, A2, D, F, H and J were set up in June 2011. Actually the piping of the collector fields is installe d on these roofs. The collectors on the remaining buildings will be set up at the latest in Au gust 2011. To reach the necessary collector area of about 1.400 m² large collector modules are used to build up the collector fields. Mainly collectors with 3 m height are installed. For the collector fields on the building D and H 2 m high collectors are used

View of the buildings H and F with installed collect ors and the ventilation unit on the north

View of the buildings H and J with installed c ollectors

side of the roof

The district heating plant was put into operation in June 2011. At the moment only the building J is supplied with heat, which is delivered by the district heating transfer station. The solar system in the housing area with in total 1.416 m² collector area (transparent area) has to be finished at end of August 2011. The heating plant with solar system and heating pump will start operating in September 2011.

Projekt-Nr.:	27311
Projekt-Name:	Concerto II, Stadt:Werk:Lehen

Cost of the Project:

Collectors (Fa. TISUN)	634 T€
Buffer Storage (Fa. BTD)	140 T€
Solarnet	166 t€
Micronet	169 T€
Solarstation in the Heating Plant	100 T€
Heat Pump with integration	75 T€
Measuring, Controlling and Electric	86 T€
District Heating Plant with Transfer Station	148 T€
Miscellaneous	35 T€
System Cost	**1.543 T€**
Design and Monitoring	133 T€
Total Project Cost	**1.666 T€**

Problems encountered:

Intensive communication had to be done for realising maximum solar area on the roofs. It was difficult to find solutions that were accepted by the hvac designer (space for ventilation systems on the roof), architects (location and nice view) and building owners (clear distinction between solar part and roof)

Due to the height of the buildings there is significant wind load to be calculated. This caused some trouble concerning the boundary condition of the supporting structure

During installation of the micronet some difficulties came up concerning crossing points of solar pipes and sewage pipes.

Several minor changes of the buffer storage had to be done during the final design phase.

Further comments on monitored results in Salzburg at Stadtwerk Lehen.

The total investment costs of 1.543.000 € can here be divided into 900.000 € for the complete solar thermal collector system and 215.000 € for the heat pump and buffer storage, which mean a total cost for this of 1.105.000 €. Besides ia used 86.000 € for energy Management system and monitoring equipment, while district heating and microgrid system costs are 352.000 €. And extra design costs were 8,6 % of the complete package. With 2.047 m² solar collectors the solar system investment including storage is: 1.105.000/2.047 = 540 € / m². The operation results shows that a low district heating return temperature from the buildings is obtained with 35°C, that the 50°C stratification between top and bottom in the buffer storage is good, while there have been some problems when the heat pump was fed with higher entry temperatures (normally up to20°C is best). The overall heat use for the 45.164 m² building area was 38 % higher than calculated, primarily due to indoor temperatures around 23°C instead of 20°C.
Overall it is aimed to save 1.680 MWh in district heating, while 80 MWh is used of electricity for the heat pump. The economic benefit from this is around 112.000 €, which compared to the before mentioned extra costs leads to an overall payback time of 10 years without EU funding.
The aimed heat use was 60,8 kWh/m².year of which 21,3 kWh/m² should be covered by solar thermal energy leading to a total heat consumption of 39,5 kWh/m²,year.
Since only 1.551 m² solar collectors have been available in 2013, it will only be possible to judge the final energy balance by summer 2014.

Stadtwerk Lehen residential part

Status	Dwellings
Handed over 11|2012, monitoring	• 287 + Kindergarten and student dormitory • 36.117 m² gross floor area
Thermal benchmarks	**Detailed u-values [W/(m²K)]**
• THD 4-18 [kWh/(m² GFA)] • LEK 16,4-17,9	• Walls 0,13 • Roof 0,10-0,11 • Ceiling above ceiling 0,19-0,25 • Windows 0,69-0,89
Housing technology	
Heating	Micro net + district heat + thermal solar
Ventilation system	Controlled air ventilation with heat recovery in a central system
Solar	1551m² + 200000 l buffer tank
Part of the concerto project	
Building operations, solar plant 1551m²	

General information

On the former premises of Salzburgs municipal utility, two non-profit housing developers (gswb and Heimat Österreich) built a total of 287 subsidized apartments from 2009 to 2011. They were handed over in November 2011. Furthermore the area of 43 000 m² contains a student hall with 97 units and a kindergarten.

Energy supply

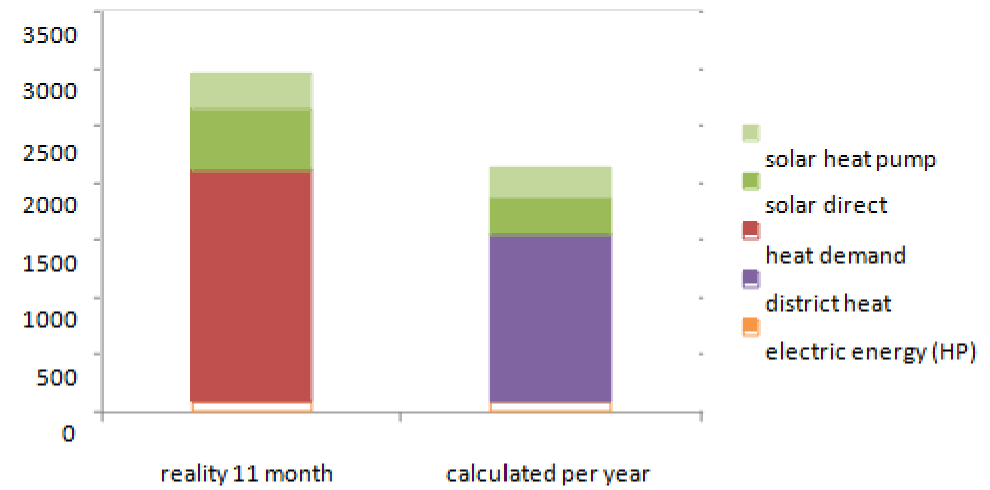
In the course of extensive construction measures, new innovative ideas on energy supply in the region have to be implemented in the district of Lehen; for example the largest thermal solar power plant in Salzburg with 2.000 m² of solar collectors and a 200 000 litre buffer tank with an integrated solar-heat pump. A grid of micro-networks distributes the generated solar energy to the new and some of the old buildings of the area .This system shall cover about 30 % of the areas energy demand through solar energy.

Monitoring of Solar system and micro net

The Steinbeis Transferzentrum in Stuttgart is partner in the Concerto project and responsible for the planning, simulation and monitoring of the solar system in Stadtwerk Lehen.
A total of 310 different control points have been installed on the area, which deliver a range of information. Sensors control the temperature of the solar panels, feed and waste line of the heat pump and the district heating system as well as temperatures of the thermal distribution grid. Heat meters measure quantities of flow rates and capacity of solar plant, heat pump, and amounts at heat transmission stations of the district heating network.

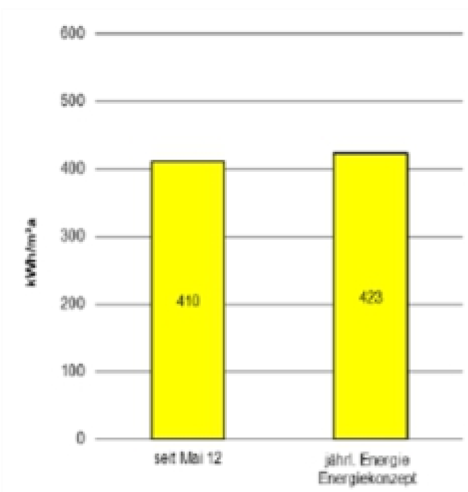
The test phase from January to April 2012 has been finished and the data was analysed. The experience shows, that the first months in a new housing area does not bring representative data (non-characteristic user behaviour in the phase of relocation), but are very important to optimise the technical systems.

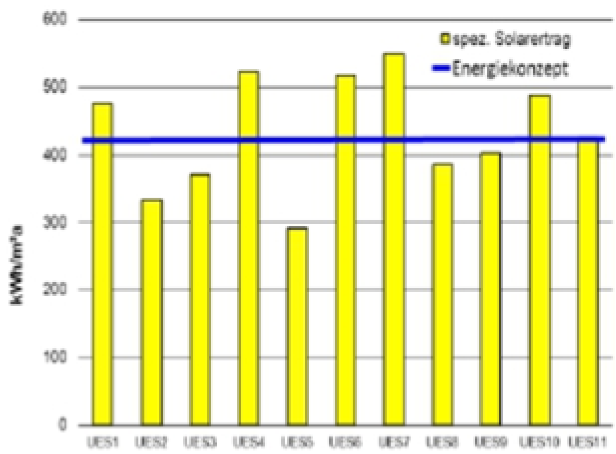
<u>Heating energy demand calculated compared to real consumption:</u>



The heat demand is actually about 38% higher as calculated. This is for several reasons:

- Room temperature for calculation was 20 °C. Reality in average is around 22 °C
- Solar panels for calculation were 2000 m². During the monitoring period 1551 m²

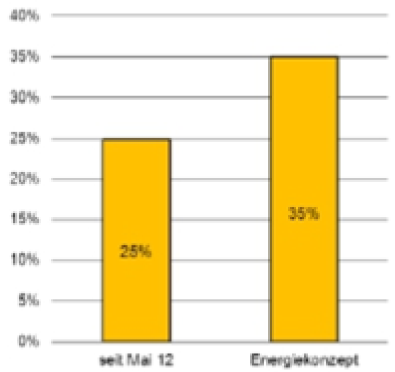




Specific solar gains

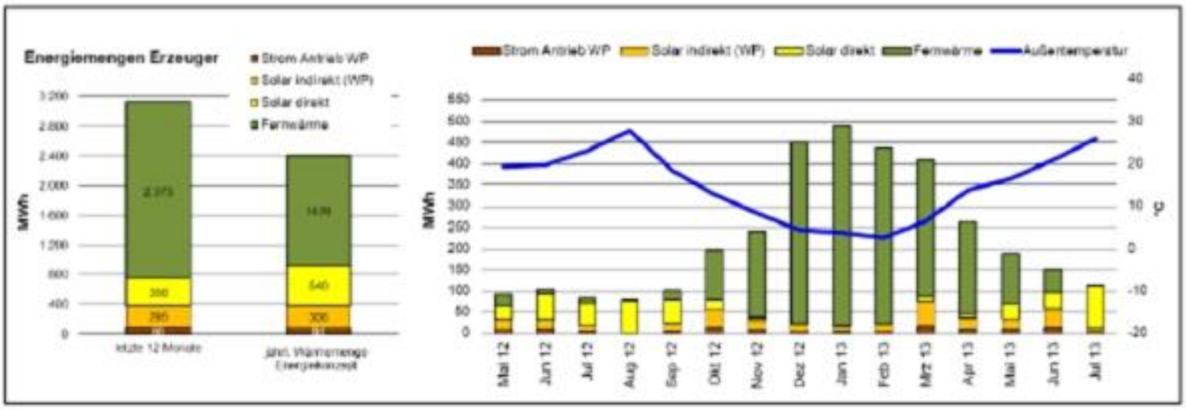
The solar gains in total are better as planned.

Solar amount of coverage



The amount of solar coverage is about 10% lower as presumed (shown in the left diagram after 11 months monitoring). Reasons are the not completed collector area and the extention of the micro net to the total renovation area in the west. The global radiation during the monitoring period is displayed with the red line and compared to the solar coverage per month.

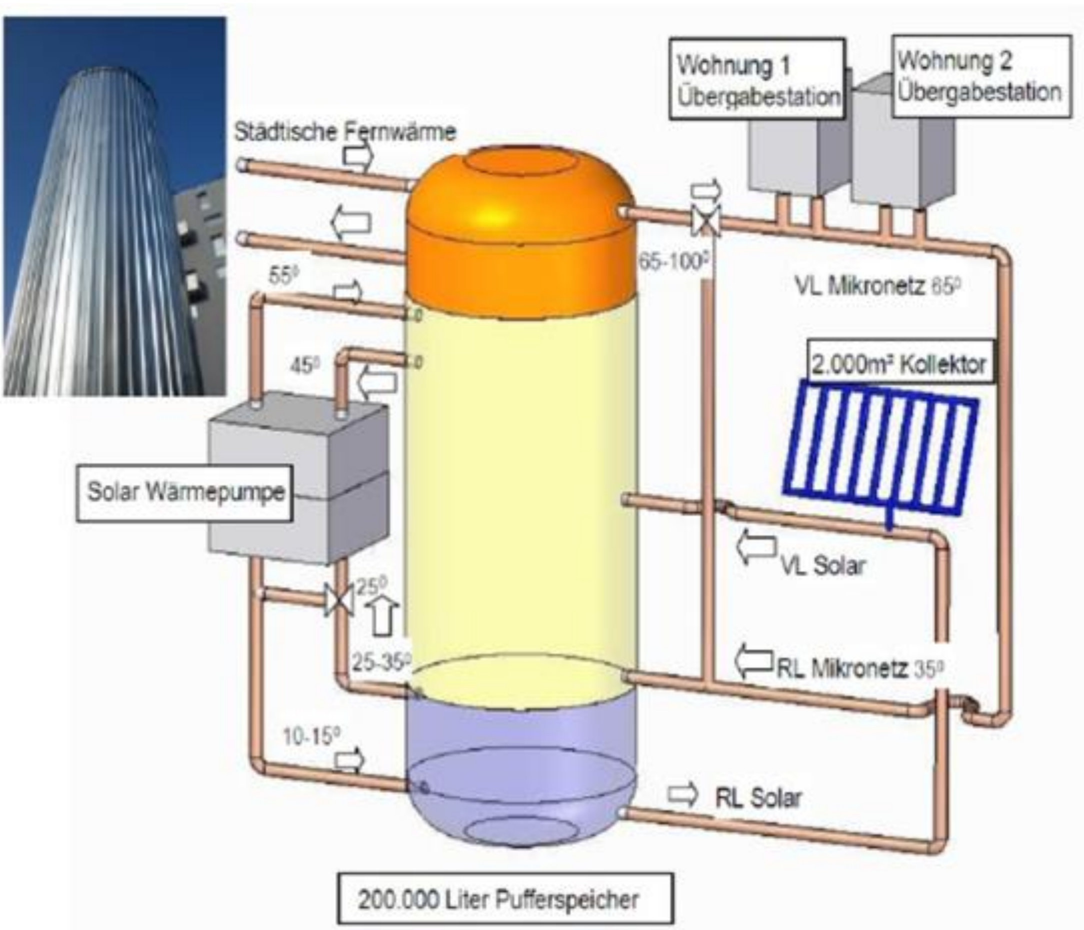
Energy produced by the heating system



The energy need in totally is higher than calculated. Reasons for this are a change in the use of the ground floor area in one house and the user behavior – the average temperature in the apartments were calculated with 20 degree and measured now with nearly 23 degree.

More detaills in the report of Steinbeis Transferzentrum from August 2013.

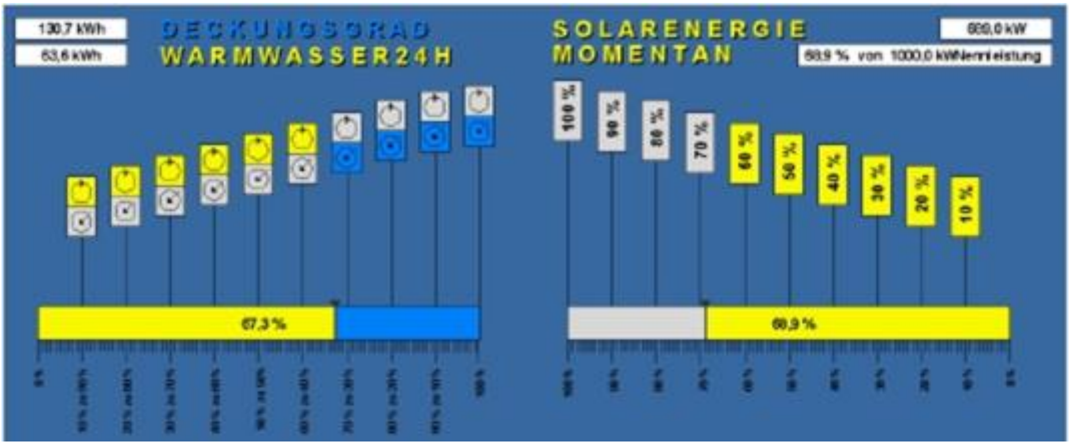
The Steinbeis Transferzentrum will continue the monitoring of the solar plant till summer 2014.



Scheme of the solar system in combination with buffer tank and heat pump

Visualization:

To inform and motivate the people living there or passing by a LED-visualization was placed at the buffer tank. Here the actual input on thermal solar energy and PV is shown (changing rather quick) and the share of solar in the last 24h.



Conclusion

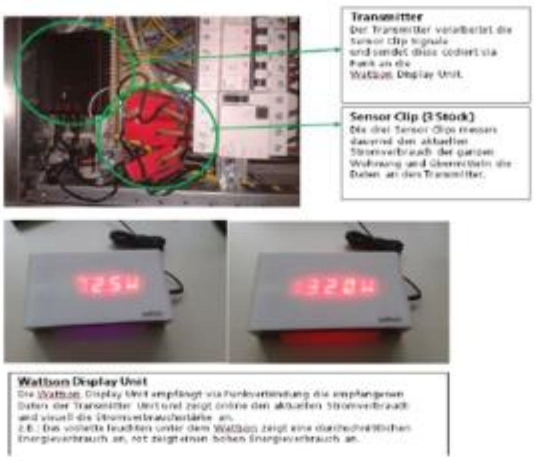
- Overall System (hydraulic) works very well
- Specific solar gains are higher as expected
- Return temperature of about 35°C -> very good
- Principle of temperature spreading in the buffer tank via heat pump works
- The big buffer tank offers a very good temperature stratification (50K)
- Heat pump has troubles with high entry temperatures (despite promises from the producer), complex troubleshooting
- Energy demand of the building is much higher as planned
- Monitoring supports the optimisation of operations

Energy monitoring

To monitor the energy consumption of the apartments and to test if (and what kind of) information can help to motivate people to save energy a special research project has been lauched in the course of a second research program of the federal Ministry of Transport, Innovation and Technology, "Haus der Zukunft" called “intelligentes E-Monitoring”.

The project partners implemented smart meters in 76 apartments. For research reasons the municipal utility Salzburg AG, gswb and SIR divided these into four groups, receiving different amounts and kinds of information on the energy consumption data. (a: reference group with no extra information, b: access to internet monitoring tool and receives monthly information on energy demands by mail, c: has access to an internet portal monitoring tool + additional monthly information on personal demands per mail, d: additional real time data tool calles “Watson” in the apartment).

Tenants are offered a personal training on the use of their high quality housing equipment, as well as a free energy consulting. SAG installed a 24 h hotline in case of any technical or usage concerns.



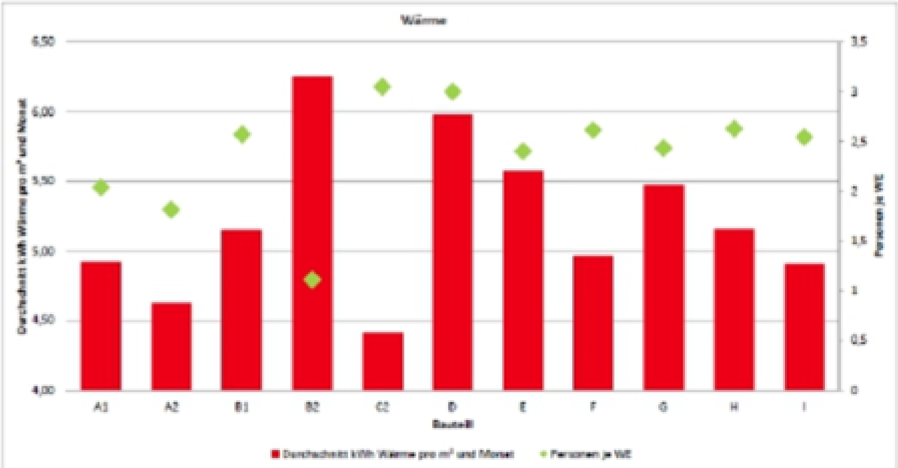
The watson unit receives the dates of actual electricty use vi a radio and shows it with different colours (green – low, violet – average, red – high).

For this “intelligent monitoring” no EU funding was us ed, but the results can help in the total overview of the project.

The monitoring shows that there is a real wide difference within the normal users and there is no big difference between der test apartments and the “normal” users.

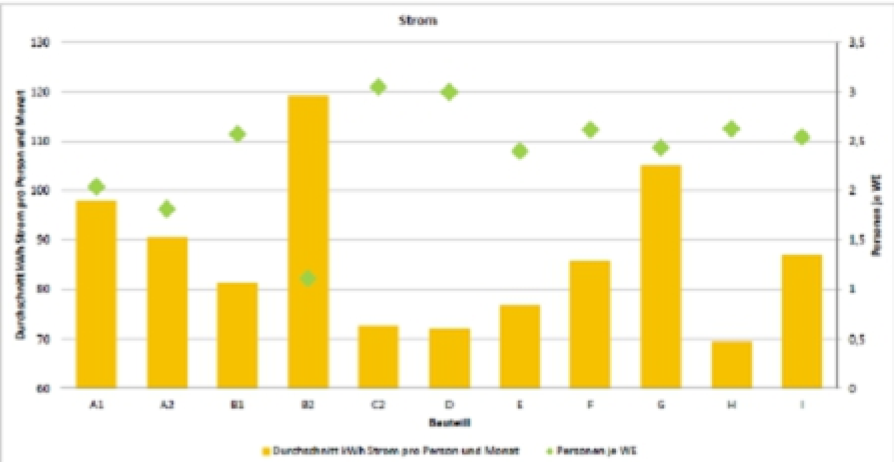
There is a 90m² apartment needing 6800kWh for heating (=75,5 kWh/m²) and there is a 77m² apartments that used 1.730kWh in the same time (=18,0 kWh/m²).

The test apartments are in the Blocks A1, A2 and B1:

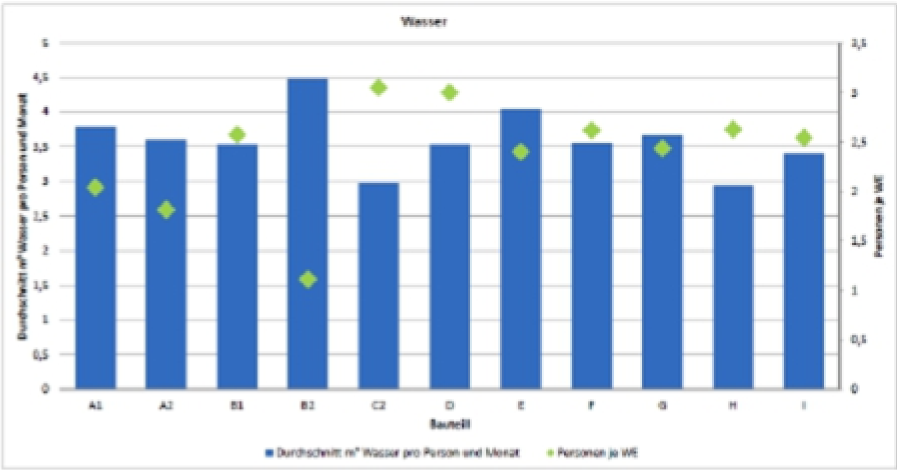


Red blocks: avarage kWh heat per m² and month   green dot: Persons per apartment

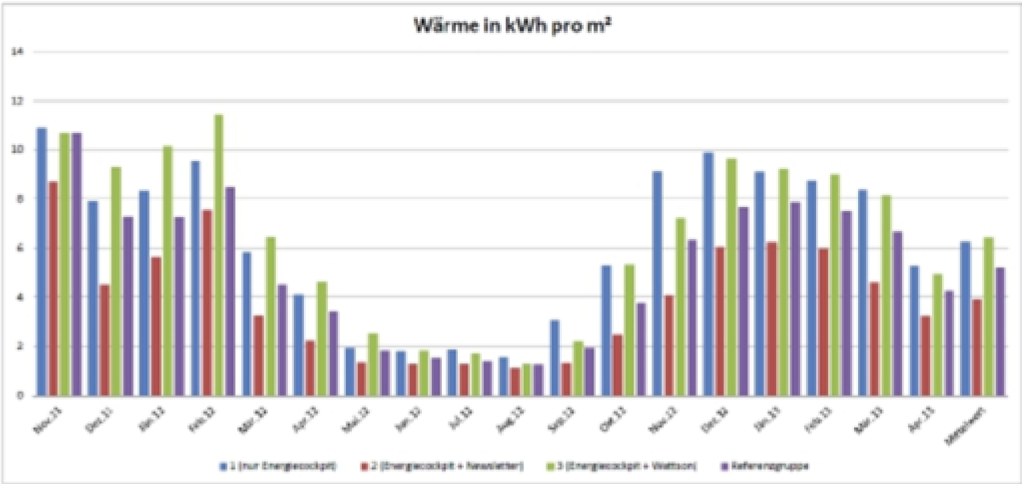
This shows the wide difference in energy need for heating in the different houses. A2 in one Block with “testapartments”, so here the energy use is a little lower, than in the most others. Block B2 is special, because here are only 1 person apartments.



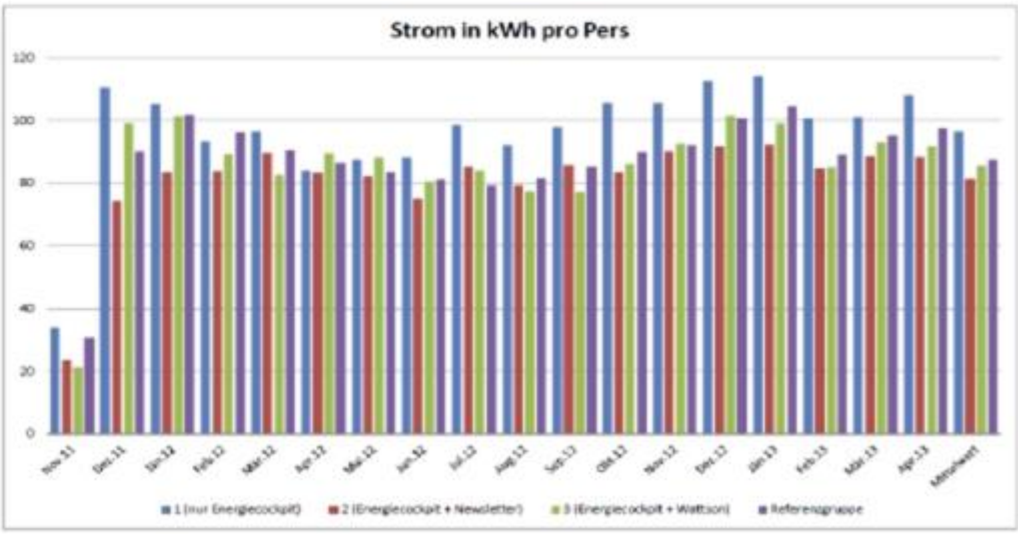
In the electricty use there is no difference between test apartments and the others



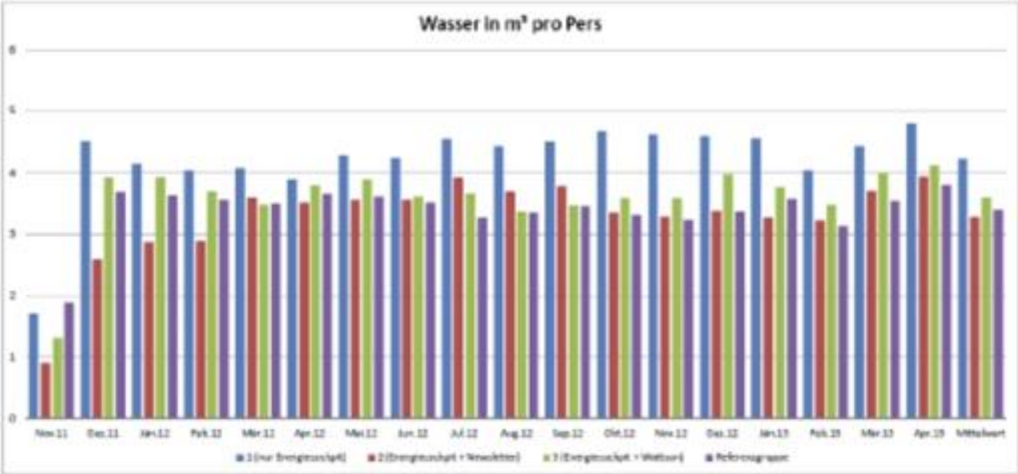
Water consumption



Heat consumption over 1 year



Electricity consumption over 1 year



Water consumption in 1 year

	The system with the „Wohnungsstationen“ has proved to work as a perfect system for large housing areas with very different users. Here the heat is supplied to each apartment and here the domestic hot water is produced decentralised. The system has a perfect hydraulic regulation in all radiators and so the user behaviour has no influence any more to the efficiency of the total system.

Esshaverstrasse

Status	Dwellings
Finished 06|2008 · 1.072 m² gross floor area	· 12 apartments
Thermal benchmarks	**Detailed u-values [W/(m²K)]**
· THD calculated with GEQ = 1 [kWh/(m² GFA)] · THD calculated with PHPP = 34 [kWh/(m² GFA)] · Measured THD = 39 [kWh/(m² GFA)] · LEK 18 (building law 38)	· Walls 0,10-0,15 · Roof 0,10 · Ceiling above ceiling 0,10 · Windows 0,71
Housing technology	
heating	District heat + buffer tank 4000l
Ventilation system with heat recovery	Level of effinciency 87%
Solar	38,55 m² (2,57 x 15)
Part of the concerto project	
Building work, thermal solar plant 38m², Detailed monitoring	

General information

The four-storey building project Esshaverstraße 3 has been commissioned by the non-profit building association "Die Salzburg" and is located in the city of Salzburgs' central district Lehen. It contains 12 funded rented and owner-occupied flats, which were accomplished in June 2008. The project was planned by Mayer und Seidl Architektur as a passive house.

Energy Supply

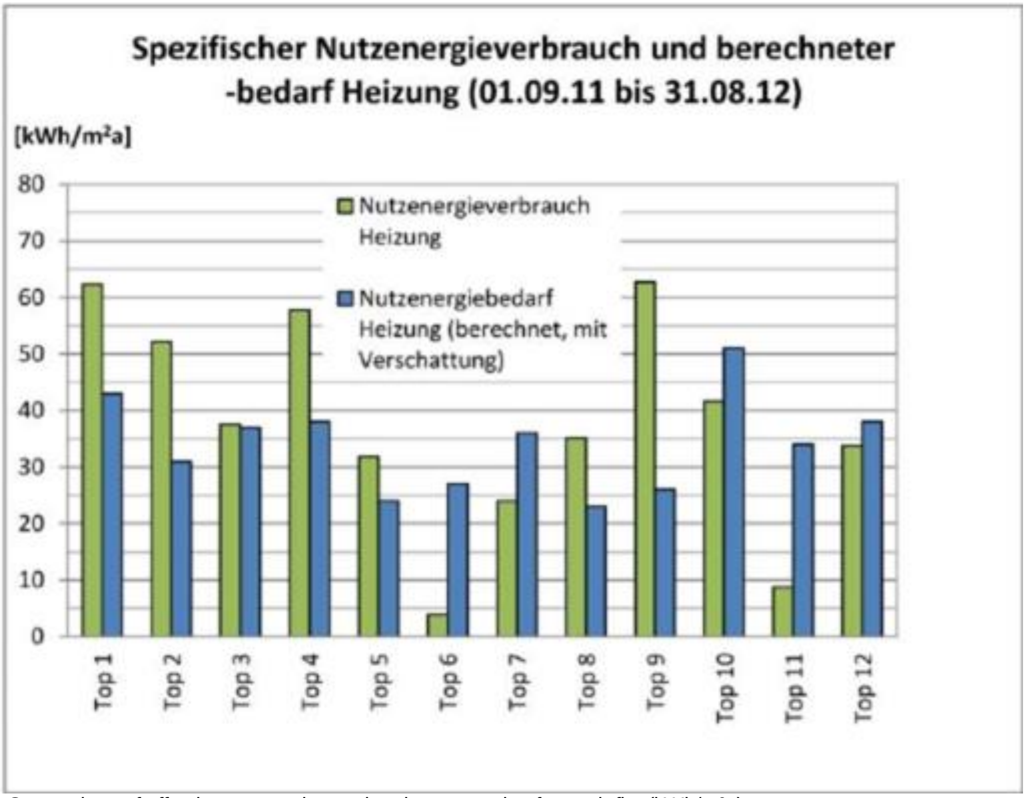
Heat supply is mainly covered by district heating grid of city Salzburg. Additionally, 36 m^2 of thermal solar heating was erected on the roof of the building, which support the generation of domestic hot water as well as low-temperature heating through a storage tank. The use of solar energy annually gains about 11.900 kWh of heat energy.

Conclusion Monitoring

The apartment building Esshaverstraße 3 has been concepted in passive house standard and calculated with software GEQ 2006. A further calculation with PHPP software as well as an analysis of monitoring data show, that limiting value for heat demand of a passive house is exceeded definitely.
This particularly occurs on account of shading of window surfaces, orientation and shaded building-elements and levels. A former calculation done with GEQ insufficiently represented the influence of inner and solar gains. This discrepancy has been mended in actual versions of the software. However passive houses should always been calculated with an appropriate software, PHPP. This topic was specially analysed within a diploma work 2010.

Thermal heat consumption

Measured thermal heat consumptions average at 38,2 kWh/m²a for the whole building – about 11% beyond 34,4 kWh/m²a calculated by PHPP 2007. This overstepping can be explained by several reasons:
For example during heating period the average measured room temperatures were between 21 and 23°C, whereas the typical value of 20°C has been used for calculation. Further reason could be the fact, that it is possible to heat the building the whole year over, which is partly used by tenants.
For energy saving reasons it is recommended to implement zone valves in future project, which enable the locking of heat supply durin summer and transit times.
Furthermore the temperature efficiency of ventilations' heat recovery plant under matches required and by the manufacturer guaranteed values, which have been used as the calculation basis. Measured values have to be verified and if necessary, the system has to be rectified.



Comparison of effective energy demand and consumption for each flat (kWh/m²a)

Green: effective energy consumption heating

Blue: calculated effective energy demand (shaded)

<u>Hot water consumption</u>

The average building hot water heating consumption is just over 15 kWh/m2a and therefore slightly higher than assumed in the PHPP calculation. However it was found that the surface-related heat requirement can further be used for the determination of the average hot water heat demand and also reflects the usual occupancy in sufficient accuracy.

<u>Comfort parameters in the apartments</u>

The temperature is comfortable in all apartments in winter and evaluated very high. In summer, inside temperatures of top floor flats are a little high temporarily.
In winter the room humidities are at a minimum of 25 to 30% relative humidity over short times and therefore comply with the inside air humidity in exvlusively window ventilated buildings. So no reduction in comfort or additional drying of the air can be determined due to the ventilation system.

When it comes to residents' ventilation behaviour, measurement data show the combination of air conditioning system and window ventilation both in summer and in winter. There is no proof for a correlation between window ventilation and an increasing thermal heat demand. The possibility to operate the ventilation plant as needed with different intensities is perceived by the tenants, the 3 step multi-level scheme has proved to be a success.

<u>System engineering</u>

By checking measured data and tracking of faults, weak points of the control system and insulation of the service plant can be discovered and rectified. It is recommended

to use fortified insulated ducts in future projects.
The solar plant covers about 22% of the total end energy consumption and provides a specific solar entry of 422 kWh/m²a, which is significantly beyond requested 350 kWh/m²a of housing fund Salzburg. The plant operates reliably and delivers a precious share of the overall energy demand of the building Esshaverstraße 3.

Find detailed information attached: Final Monitoring Report Esshaverstraße

Siebenstätterstrasse Parklife social apartments

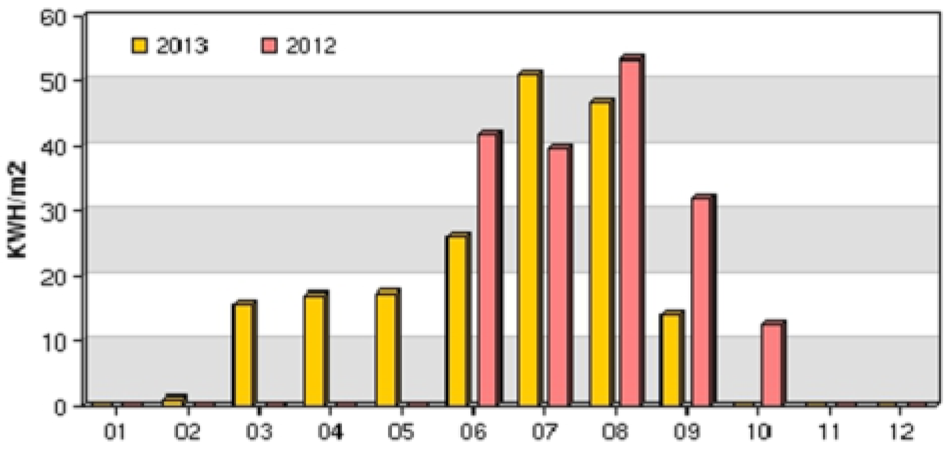
Status	**Dwellings**
Finalised 11|2011	· 56 apartments for rent · 5975 m² gross floor area
Thermal benchmarks	**Detailed u-values [W/(m²K)]**
· THD 23,96 [kWh/(m² GFA)] · LEK 17,81	· Walls 0,19-0,21 · Roof 0,17 · Ceiling above ceiling 0,14 · Windows 0,75
Housing technology	
Heating	District heat + thermal solar support
Ventilation system	Humidity steered air ventilation
Solar	Solar 204m² + buffertank 23000
Part of the concerto project	
Building work and thermal solar plant 204m²	

Energy Supply

A 204 m² solar plant is used for warm water (via central fresh water module) and space heating. In addition the building is connected to the district heat system of Salzburg. In the basement are three buffer tanks with a capacity of 7700 litre each. There is a demand-actuated ventilation system with exhaust air unit in use.

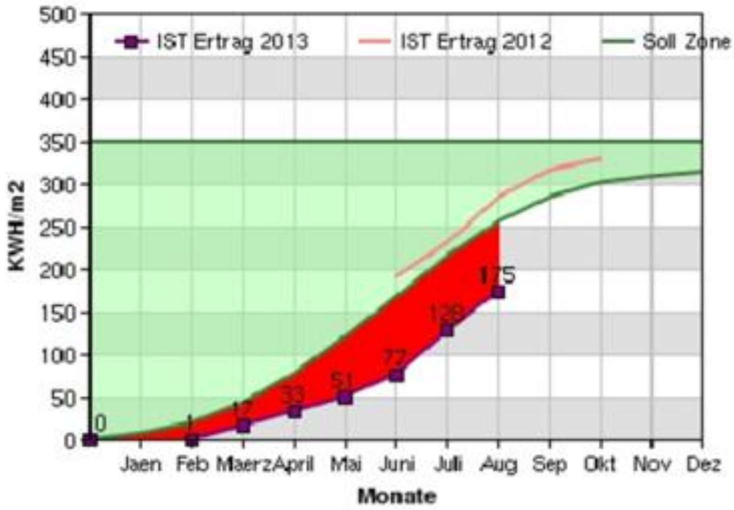
Monitoring:

Solar gains per month (energiebuchhaltung.at):



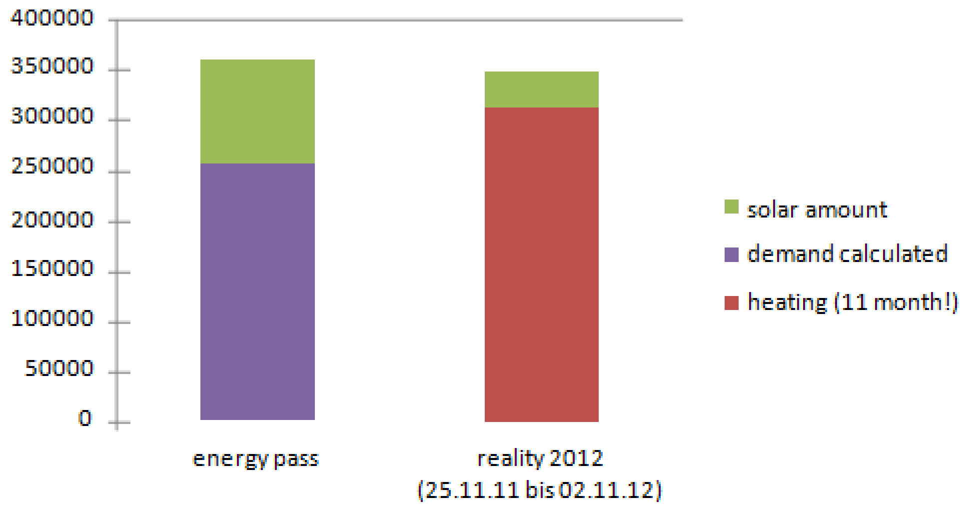
The solar plant was put into operation in June 2012 and worked quite well from the beginning. The earning 2013 are very low. One reason is the rainy springtime but compared to other plants there must be other reasons which are recently analysed

Diagram solar progression (energiebuchhaltung.at):



The diagram shows the accumulated monthly solar gains. The actual status should be in the green area to reach a minimum yearly solar gain of 350 kWh/m². The red line represents the accumulated solar earnings of the year 2012. As already mentioned the earnings should be much higher and the system has to be checked.

Heating energy demand calculated compared to real consumption;



The real consumption in the year 2012 is roughly as it was calculated beforehand. But there were only 11 month within the account period and therefore the overall amount should be a higher. All in all the results are satisfying. The solar coverage was expected to be much higher. But as already shown on the page before, the solar plant was taken to operation in the middle of the year 2012 and so the green part of the right graph displays only 6 month.

Conclusion:

- building is very close to the calculated values
- solar coverage should be higher
- reasons for the low solar gains have to be analysed

Refurbishment Kuenburggasse

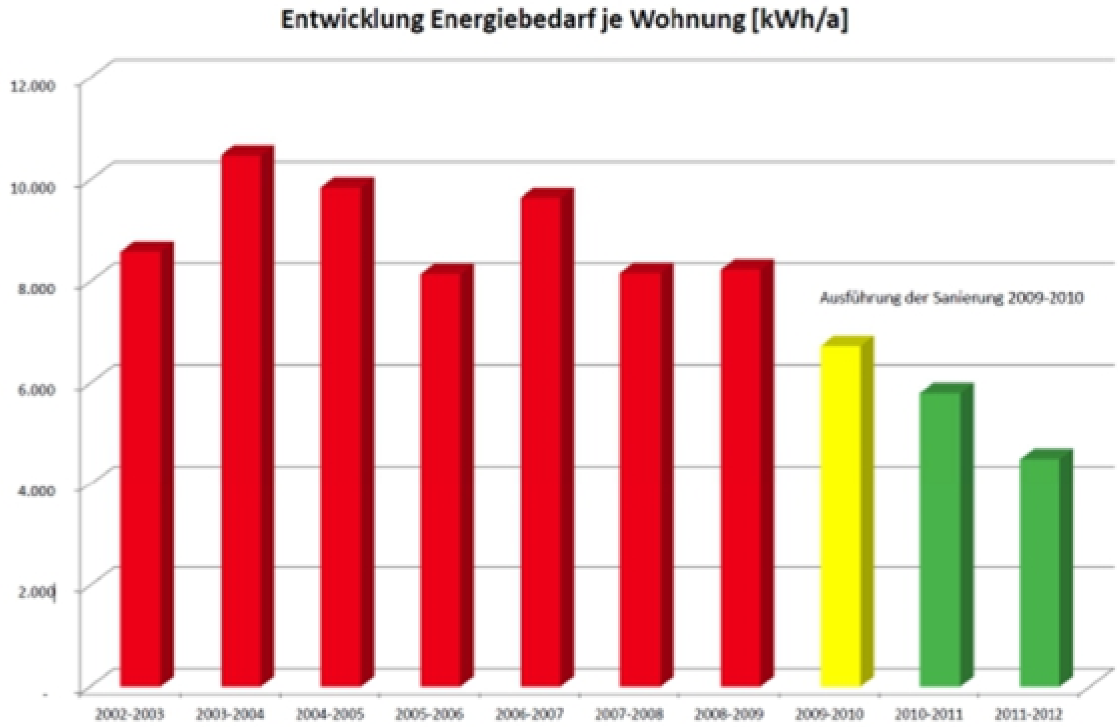
Status	Dwellings
Finalised 03|2010	• 45 apartments • 4.568 m² gross floor area
Thermal benchmarks	**Detailed u-values [W/(m²K)]**
• THD 22 [kWh/(m² GFA)] • LEK 44	• Walls 0,23 • Roof 0,15-0,19 • Ceiling above ceiling 0,26 • Windows 1,39 (partly landmar-ked)
Housing technology	
Heating	District heat
Ventilation system	Ventilation with exhaust air unit
Part of the concerto project	
Retrofit, air ventilation	

General Information

Within the Concerto II project the mentioned property was thermally retrofitted and an air ventilation system was installed.

Monitoring:

For comparison only those dwellings were taken which have continuously used the same energy source. Therefore just the flats with gas supply were contemplable because consumption data of single stoves etcetera are not available.



The building was finished in 2010 (yellow graph). Since then the energy demand gets regulated and decreases continuously. A few dwellings are already connected to the district heat but none of them used gas before. For that reason a comparison is not possible. The real estate developer offers a special financing model which allows payment within the rent. Therefore the rest of the single stoves should be changed to a district heat connection within 2013.

<u>Indoor climate measurement after retrofitting</u>

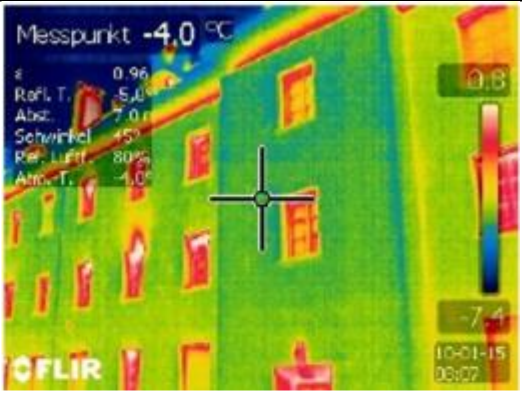
Example Flat 1:

	relative humidity % r.F.	room temperature °C	absolute humidity g/m³
minimum	27,10	17,90	4,34
maximum	51,10	21,60	9,22
average	41,75	20,44	7,20

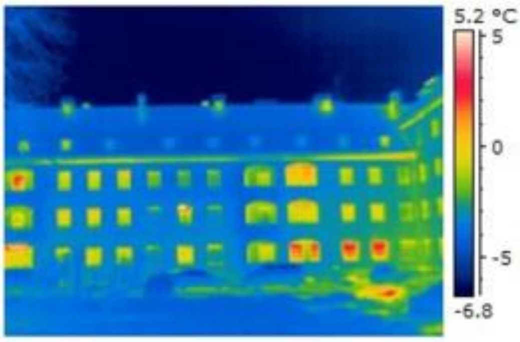
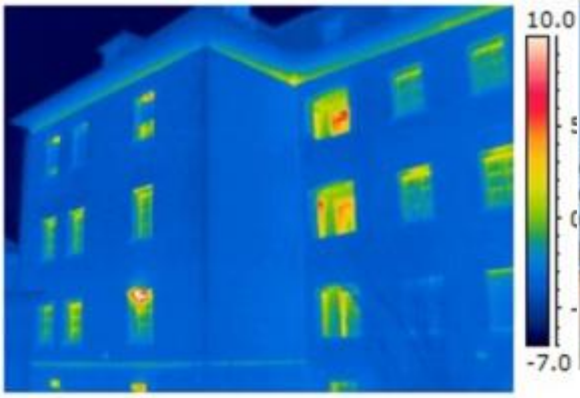
The measured data approves the proper operation of the air ventilation system. The boundary value of 9 g/m³ was not reached. The apartments were ventilated manually one to two times each day. But the additional manual ventilation was too short to transport the humidity or air pollutants out of the apartments.

<u>Thermographic exposures</u>

Pictures before:



In the pictures one can see very high tempera tures along all surfaces, especially at the eave area and the window transition.

Pictures after:  	 In the western wing the insulation of the façade shows n o weaknesses. Buffer areas in the open loggias are registered again.
 	

The uniform color on the facade points out the continuous insulating quality. In the internal loggias buffer areas are formed by the accumulated air - bright spots. This does not mean a poorer quality of insulation. The windows with closed shutters have less heat radiation than the others. The tilted windows are clearly visible. In the base area the brighter colors show a slight non recoverable thermal bridge.

<u>Refurbishment Strubergassensiedlung</u>

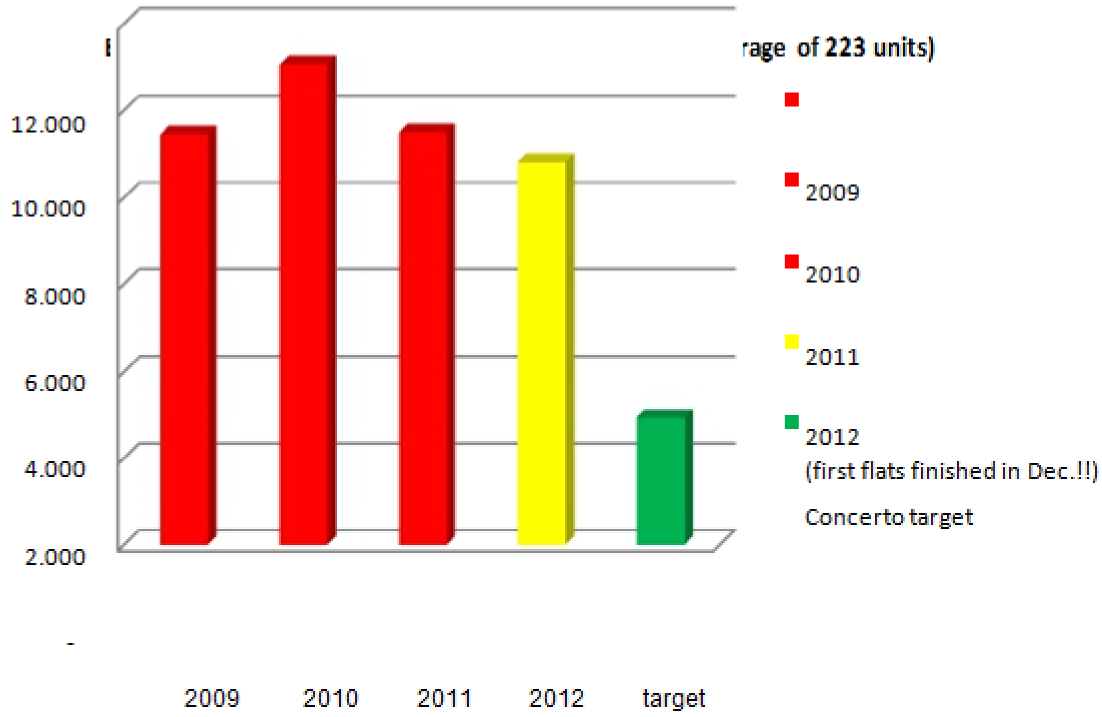
Status	**Dwellings**
Finished	• 189 apartments • 16.660 m² gross floor area
Thermal benchmarks	**Detailed u-values [W/(m²K)]**
• THD 24 [kWh/(m² GFA)] • LEK 30	• Walls 0,23 • Roof 0,15 • Ceiling above ceiling 0,35 • Windows 0,9
Part of the concerto project	
Retrofit and connection to micro grid	

Status Implementation

Renovation process started in May 2012. The thermal renovation of the first buildings was finished in November 2012, second building phase in March 2013.

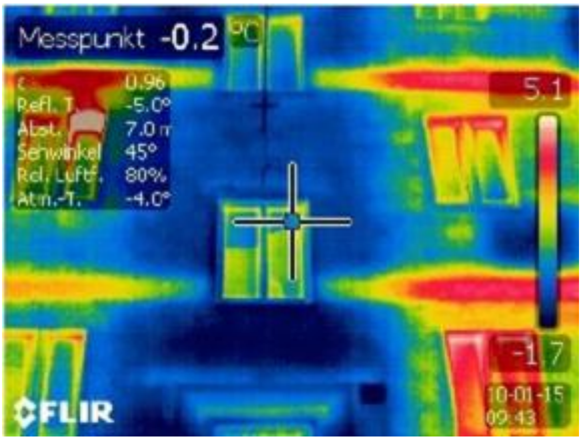
Monitoring:

The energy monitoring of the area Strubergasse turned out as petty challenging because there are just annual consumption data available until the year 2012. The first buildings were finished in the end of 2012 and by now there are no data for 2013.

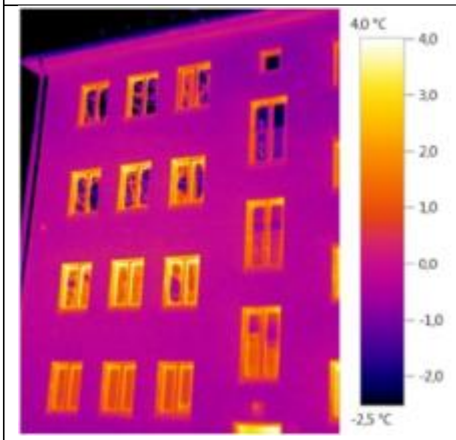
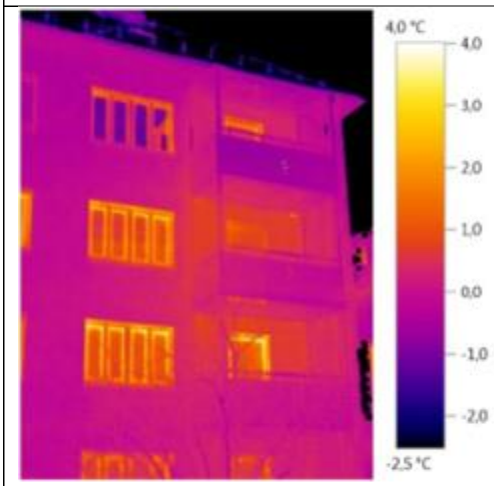


In the years 2009 until 2011 the average annual energy consumption per square meter was about 130 kWh/m²a. The concerto target is at 39 kWh/m²a. The retrofitting of the first flats was finished in December 2012. Since then the consumption is already slightly lower than in the years before. The account periods of the energy supplier only offers annual values and therefore the real savings cannot be calculated until start of 2014.

Thermographic exposures



Very high surface temperatures at all connections of floors, walls, etc

Pictures after	
 The dwellings are partial different tempered. All fittings w ere proper conducted. No thermal bridges are visible	
 Because of the new balconies the fittings in the base areas of the windows are not clearly visible. But there are no signs for bad processions.	

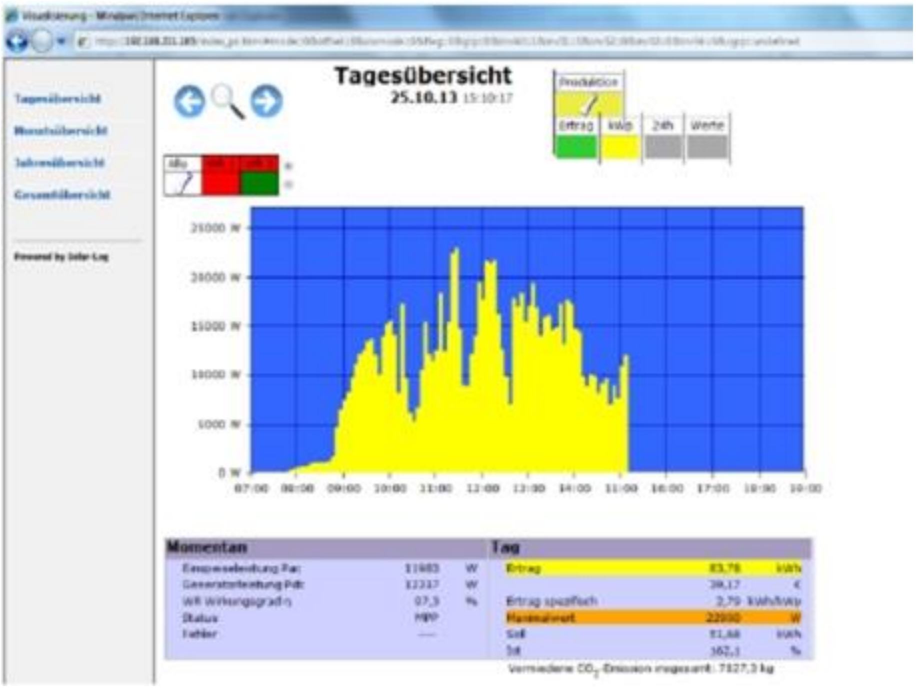
Conclusion:

- The thermal rehabilitation was realized very satisfying
- Factual savings cannot be shown until the end of 2013 or better 2014
- The connection to the micro grid of the Stadtwerk Lehen was successfull

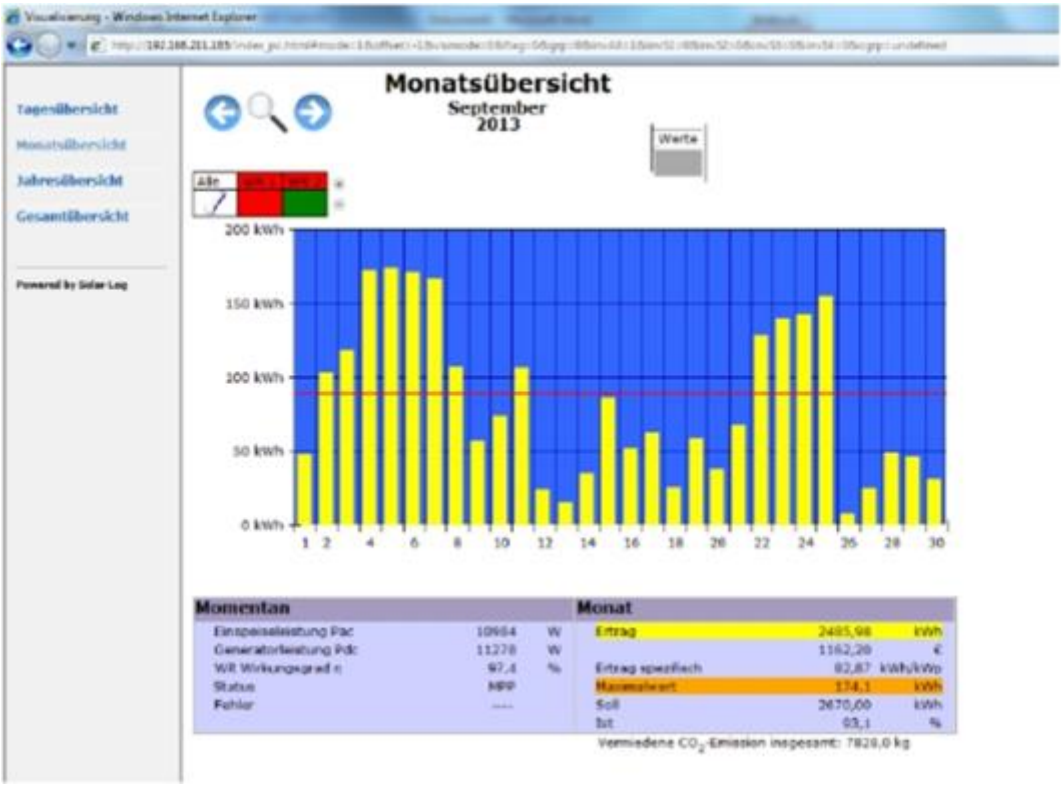
PV Hospital

On the roof of the Hospital in the south of the Concerto Area 30kWp PV was erected. The plant was planned to be built on the roof of the high raised office building, but this was not possible because of a part public roof terrace and a lot of house technique (air ventilation units and antennas).

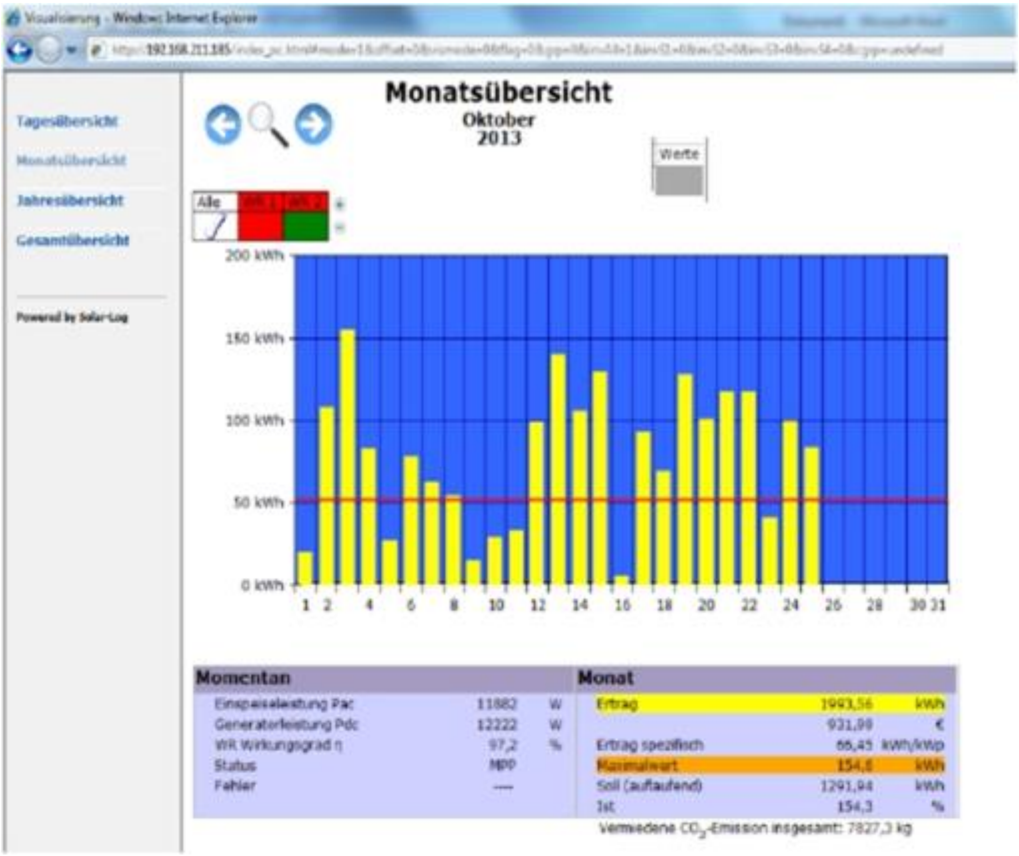
The plant with 30kWp is situated on the roof of the “Chirurgie West”, a new building within the area of the federal hospital. It was finalised in May 2013 and feeds into the local network of the hospital. It is assumes, that there will be a production of 29.000 kWh. The monitoring was started in July with not full transmitted dates in the first month. The first data monitored in August, September and October showed that the plant is working well and this goal will be reached.



Solar gains for one day: 25 of October – the value is 162% of the expected for that season

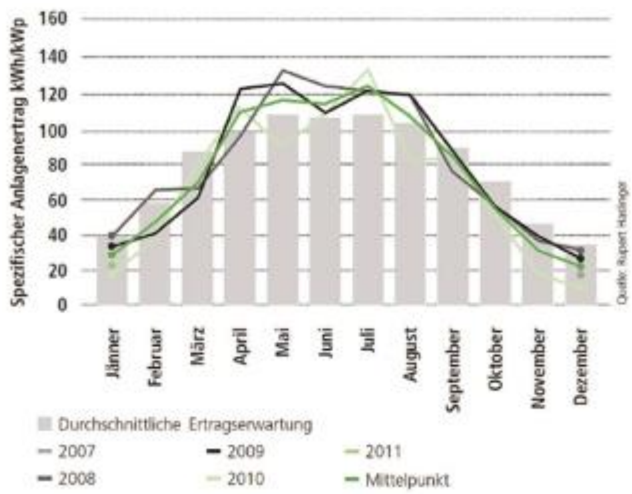


Overview solar gains for the month September 2013: The output was 93,1 % of the expected in average September.



Overview solar gains for the month October 2013: The output was 154,3 % of the expected in average October

Compare with the scenario for an average PV plant and the lines for the last years depending on weather conditions the PV plant in Concerto area Salzburg brings good results.



6. Executive Summary from Valby and Salzburg

EU-Concerto Green Solar Cities Executive Summary from Valby and Salzburg

Introduction to Concerto areas in Valby and Salzburg

A basis for a completely new way to build in Europe has been created by the recast of the EU Energy Performance for Buildings Directive from 2010, which demands that new buildings should achieve a nearly-zero energy standard based on local renewable energy sources already from 2018 for new public buildings and from 2020 for all new buildings, at the same time as the EU members states shall create incentives to ensure a similar development for existing buildings.

Denmark are already well on the way towards meeting these goals due to recent improved energy saving demands in building regulations including new protected low energy classes 2015 and 2020.

This means that there is, besides a high standard for new build, also a focus on extensive retrofitting of buildings, something which has also been included in the aims of the EU-Concerto project, Green Solar Cities (2007 – 2013).

At the same time the capital of 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-Concerto project, Green Solar Cities (www.greensolarcities.com) EU funding has been utilized as a strong support for the large scale Photo Voltaic 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 Photo Voltaic electricity established by year 2025. By 2013 around 4 MWp Photo Voltaic capacity have been established.

And since year 2004, the aim to introduce large scale building integrated Photo Voltaic 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-CONCERTO area in Valby have improved their energy frame values by 30 – 79% compared to normal practice.

The largest PV installation, which was realised in relation to the Green Solar Cities project, was the “Damhusåen” waste water treatment plant in Valby. In relation to this project it can be concluded that 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 Photo Voltaic 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. The PV system is here supplementing biogas based electricity production to cover almost 50% of yearly electricity use by renewables.

Another very interesting example is the Hornemannsvænge housing estate, where low energy retrofit solutions have been introduced together with a kind of solar energy combined heat and power. Here both solar thermal and Photo Voltaic (PV) solar electricity is supplementing energy from the large combined heat and power plants in Copenhagen.

The Concerto Project "Green Solar Cities" has built on a long term cooperation between Copenhagen and Salzburg in Austria. And in Salzburg it has started and supported the renewal process in the old city part, Lehen. Generally, in the six years of the project, new homes and many other buildings has been erected. Through the consistent low-energy design, 40% of energy use per year has been 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 were also an important background.

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, cafes and 48 subsidized apartments. Here a 144m ² solar collector produces solar energy for hot water and heating.

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.

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 Stadtwerke. Here 287 apartments, the new city gallery, a dormitory and a kindergarten were built as part of the Concerto project. The apartments are in a 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 solar thermal collector, the heat is collected in a central buffer tank with 200,000 litres. A solar heat pump optimizes the system and gives an added solar contribution of 15 - 20%. The heat is distributed by means of a micro net to the apartments, offices and laboratories, as well as to the renovated houses in the area.

CONCERTO project figures and results

In the CONCERTO project in Valby 1198 kWp PV and 840 m² solar thermal collectors have been integrated to match 81% of the yearly energy use in the new-built and renovated Concerto buildings in Valby comprising 67.143 m² housing, public & commercial buildings. This gives a high renewable energy contribution to electricity use for ventilation, domestic hot water and heating etc.

As part of the renewable energy contribution in Valby a large 777 kWp PV solar plant for a waste water treatment plant has been realised as the largest PV system in the Nordic countries.

In Salzburg they are also like Copenhagen already a kind of solar city. Their plan was in the Concerto II project to demonstrate how you can expand the use of solar heating to a higher level of the total need for heating and DHW, e.g. from 15% normally and up to 45% in the best new apartment building schemes.

This has been done by combining with an electric heat pump and buffer storage. At the same time they use district heating which is at least 50% based on biomass for the rest of the heating supply. For the Lehen area with 287 housing units a 2.000 m² solar thermal system have been used and also another 600 m² solar thermal collectors for several other building projects. And besides 50 kWp PV has also been demonstrated.

Concerning the Ecobuilding both the projects in Copenhagen and in Salzburg have a large part of the proposed realisation projects which deal with renovation of existing buildings.

In Copenhagen it is 288 housing units and 13.500 m² public building which are retrofit based, and in Salzburg it is around 35% of a total ecobuilding area of 43.000 m². But in Salzburg they will expand this a lot in the Concerto area in the coming years, so the realised 235 renovation housing units will expand to about 1000 during a longer period. Both places it was the idea to try to develop an ecobuilding standard for retrofit aiming to achieve at least 25% better than normal new built.

Besides this there is around 500 new built housing units in Copenhagen (40.000 m²) and 480 new built housing units in Salzburg together with around 6.000 m² new build public building in Copenhagen.

In the Green Solar Cities project in Valby/Copenhagen and Salzburg, there have been a programme for knowledge transfer and training between the two cities, including involvement of observer cities in Hungary and in the Netherlands and also with a link to the neighbour city of Copenhagen in Sweden, Malmø.

Besides yearly Green Solar Cities conferences dissemination work has also included presentation of the project at international conferences and towards the Active House cooperation (www.activehouse.info) , and many examples of replication activities can be identified.

It should be mentioned, that the Green Solar Cities results will also be published in a book by the Earthscan publishers from the UK.

Finally we can conclude that Green Solar Cities is a policy for cities focussing on a holistic approach, which includes good, energy efficient constructions and installations in buildings leading to comfort and a good indoor climate, combined with use of optimised energy supply systems together with a local contribution from renewable energy sources. And in this way it lives up to the aims of the EU Concerto programme in a strong way, especially when good energy results is secured by help of an appropriate performance documentation as part of the strategy, something which is already known will be a future demand from the EU Building Directive.

Paticipants in the Green Solar Cities EU-Concerto project:

No.	**Participant organisation name**	**Participant short name**
1	Coordinator Kuben Management (DK) Project Manager Jakob Klint jk@kubenman.dk Tel.: +45 6029 6035 Fax : +45 3542 3522	Kuben
2	Cenergia (DK)	Cenergia
3	City of Salzburg (AU)	Salzburg City
4	Gswb (non profit housing association) (AU)	Gswb
5	Heimat Österreich (non profit housing association) (AU)	Hö
6	Salzburg Institut für Raumordnung & Wohnen (AU)	SIR
7	Salzburg AG - biggest energy supply company in Salzburg (AU)	Salzburg AG
8	Steinbeis Institut - energy research institute in Stuttgart (DE)	Steinbeis
9	Die Salzburg (non profit housing association) (AU)	DS
10	Green Cities	Green Cities
11	DONG ENERGY (DK)	DONG
12	Grøn Valby (Municipal Environmental Organisation) (DK)	Green Valby
13	Valby City Council (DK)	Valby City Council
15	University of Lund (SE)	University of Lund
16	TU Delft (OTB Research Instutute) (NL)	OTB
17	WE of Delft (sustainable building) (NL)	WE
18	EMI (Hungarian Building Research Institute) (HU)	EMI
19	Prisma	Prisma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7. Solar Energy Combined Heat and Power

Green Solar Cities with Solar Energy Combined Heat and Power.

The “Green Solar Cities” vision is based on the universal relation between the necessary initiatives you need to work with for the future. That means that energy savings in both new build and renovation is the first thing you need to introduce and optimise. And when this is done you should look to first an optimised energy supply solution and secondly investigate how solar energy can be utilised with a high contribution in connection to this, e.g. making near zero energy or plus energy building possible.
And also when it comes to the market for low energy building, both in connection to new building projects and renovation projects there are unique opportunities in Denmark. This is mainly based on the EU based increased demands towards new building energy standards coming from the EU Building Directives from year 2002 and 2010, and the fact that an energy renovation strategy for existing building has been agreed in Denmark aiming at renovating all buildings before year 2050, when a completely CO_2 neutral society is the goal. The result of this is that the renovation rate, which today is around 1 % of the building stock per year, has to be increased to 3 % per year.
There is however still an important barrier here since low energy building projects is still not realised based on holistic and high quality solutions.
This is in fact the main aim of the Green Solar Cities publication to provide people with a vision of how cities and buildings of the future can be implemented with a high energy quality and with an optimised energy supply which is to a high extend is based on renewable energy. But still with an equal focus on how to secure best practice in practice by introducing a clear policy for performance documentation. And this can be handled by looking at experiences up to now showing where the risks of obtaining bad performance results lies in practice.
If we want to realise Green Solar Cities in practice one important example is how the City of Copenhagen has changed its policy from not allowing solar energy solutions to be seen from public city and street areas to developing a real solar energy plan for Copenhagen, where best practice solutions are supported and documented and inspiration is transformed to stakeholders by a solar energy city atlas showing where the best opportunities to utilise solar energy on buildings exists.
The understanding of the opportunities to mix solar electricity with solar heating has not been implemented yet in Copenhagen on a large scale, but here the EU supported cooperation with the City of Salzburg in Austria during a seven year period from 2007 to 2014, has shown how city based solar energy implementation, mainly based on solar thermal energy, can work in practice and in this way give an important inspiration, so solar energy combined heat and power can be a realistic option for the future.

Due to having a situation with the highest energy costs in Europe since the early 1980'es (except for industrial organisations), Denmark has a unique opportunity to be a frontrunner in the necessary transformation to a renewable energy based society.
The result of this policy, where the politicians decided to keep the high costs of oil, gas and electricity by help of taxation as a result of the second oil crisis in the early 1980'es, has led to a situation where Denmark has a clear leadership in the use of district heating with 55 % of buildings utilising this often together with combined heat and power as well as use of wind energy, which is now coming around 30 % of the yearly electricity production.
Another not so much recognised result of the situation with the high energy prices is that solar energy solutions have started to penetrate the energy market on a large scale. During the last 10 years we have seen a large number of solar thermal plants being connected to the widespread district heating systems in Denmark, typically covering up to 20 % of the yearly district heating demand and without any kind of subsidies, and in some cases covering up to 50 % of the yearly district heating demand, when it is coupled together with large seasonal storage solutions.
And for the PV, solar electricity market, which has been kick-started by German feed in tariffs from around year 2000, there was not much happening in Denmark based on a yearly netmetering scheme (which also was used for the windmills in the beginning), but when huge reductions of PV costs emerged in the last few years, there was suddenly a situation where PV systems could be installed with good economy for the users, something which especially one-family house owners became aware of.
The result was, that where there was a nearly not existing market in year 2010, a small market was established in year 2011 with 12 MWp and this catapulted into approx. 500 MWp PV installations in year 2012. This is something that had to be quickly handled politically in an energy system like the Danish, because the energy taxes are now a quite big part of the state budget every year. And very quickly complaints were made about one-family house owners, who invested in the allowed up to 6 kWp PV installations, and in fact could avoid any electricity bills for the next 30 years even though they needed to utilise the common electricity network especially during winter where there is not so much sun in Denmark. The politicians were unaware of this situation in early 2012 when they signed a long term energy strategy aiming at transforming the Danish society into a 100 % renewable energy supply society mainly based on off-shore wind energy, already in year 2035. Here they were only allowing 800 MWp solar PV installed by year 2020. The situation now is that the yearly netmetering scheme for solar PV has been changed into an hourly based netmetering scheme as part of a smart grid strategy and future PV installations is aimed to have a stronger focus towards housing associations and cities.

With the continuous reduction of installed PV costs the situation in Denmark today is that PV systems in some cases are becoming more cost effective than off-shore wind installations.
This situation is still not recognised by the politicians, but it creates in fact the opportunity to create a basis for large scale implementation of solar energy solutions in Denmark.
Here it is relevant to look at the situation we have in Denmark, where it is being discussed what to do with the combined heat and power based district heating, when the main part of electricity will come from windmills.
In relation to this barrier, large scale use of solar energy provides an opportunity for a win-win situation, if it is installed in the form of so-called solar energy combined heat and power, which provides solar heating and solar electricity in a relation 1:1, in the same way as the existing large scale combined heat and power (CHP) systems does. This means that operation of the large CHP system can be reduced in sunny periods with saving of fuels as a result.
For the city part of Valby, which is approx. equal to 10 % of Copenhagen, a PV plan was launched in year 2000 aiming at covering 15 % of the total electricity use by PV solar electricity in year 2025. This should be possible with 30 MWp PV installed. In 2013 we have reached 4 MWp PV in Valby but only 600 m² solar thermal installations. If this would be increased to 54.000 m² solar thermal capacity a true 1:1, solar energy

combined heat and power solution will be able to document an optimised combination with the large scale combined heat and power system in Copenhagen which actually will utilise biomass in the future.
In areas outside the district heating areas the combination of continuously reduced PV costs and use of todays improved heat pump solutions also provides an interesting business case.
Here a main obstacle is the lack of integrated performance documentation, even though continuously increased demands concerning energy efficiency like the low energy classes 2015 and 2020 in Denmark are already utilised by many cities. The result of this is that builders cannot be certain to obtain the high energy performance which has been paid for, since the only documentation is relying on calculations. Until today we have only experienced one area where a much increased energy quality has been introduced in practice in Denmark, and that is the demand for airtightness of buildings, since it is easy to control and there is still responsibilities for contractors up to 5 years after a building is completed.
Here it is a clear challenge to introduce much more useful monitoring and survey systems so it is possible in a short time to establish what the performance of a new building is in practice, so this quality can be included in the way buildings are realised. And this should also be the approach for building renovation.
In connection to this it is very important not only to focus on how to make new building projects, but to try to utilise experiences from already realised solar low energy building projects, and here especially not only focus on the good results but at the same time try to learn from the not so good results, so the same failures are not implemented again and again.

8. Low energy and passive house design

Development of zero energy buildings and use of an Active House standard
The EU Building Directive"nearly zero energy" standard for new buildings in year 2020 and implications for energy supply systems and energy quality

A basis for a completely new way to build has been created by the recast of the EU Energy Performance for Buildings Directive from 2010, which demands that new buildings should achieve a nearly zero energy standard based on local renewable energy sources already from year 2018 for new public buildings and from year 2020 for all new buildings, at the same time as the EU members states shall develop incentives to ensure a similar development for existing buildings.

In Denmark we are well ahead towards meeting these goals due to recent improved energy saving demands in the building regulations including a new protected low energy class 2015 standard which will soon be coupled also with a low energy class 2020 standard.

But when it comes to which energy supply solutions you should utilise there is a lot of discussions.

In Denmark we have at present the highest utilisation in the world of district heating, often in combination with combined heat and power and waste incineration, covering more than 50% of all heating demand, and due to this it seems like an obvious choise to rely on these technologies also for the low energy buildings of the future.

At the same time we see electricity based heatpumps being quite frequently used for new low energy building projects, but unfortunately still with not so convincing results with respect to actual yearly coefficient of performance (COP value) in practice, (this is the relation between heat supply and electricity use), since the aim is to reach a COP value of at least 3.0. A demand to document the COP value in practice could perhaps help here.

This could be part of a general performance verification procedure, which will be necessary to implement so there can be created a realiable link between the realised energy quality in building projects and the demanded certification of building energy quality.

It is also possible to introduce new interesting combinations of district heating and heatpumps, f.ex by letting very small heatpumps boost domestic hot water which has been preheated by very low temperature district heating at only 30-40 °C. In this way substaintial heat distribution losses can be saved in practice.

In general it is important to challenge the district heating business to be able to deliver adapted energy optimised solutions for low energy buildings of the future, so it is possible for municipalities to utilise this in new urban development. This should also include a policy for use of solar heating as a renewable energy source, which will have the best economy when you use large centralised solar heating systems.

And in connection to this it is also very important to work on ideas of how the zero energy building of the future look like, including a view to how far you need to reduce the energy use before you f.ex try to introduce photovoltaics or solar cells to ensure that the zero energy standard can be met by help of local renewable energy sources.

Here there is an interesting contribution from the socalled “Active House” concept (see: www.activehouse.info).
Here there is defined a number of specifications within areas like, Energy, Indoor Climate and Environment. And in the Energy area there is a focus on the areas: Energy Balance, Energy Design, Energy Supply, Energy Monitoring and Verification, Follow up.
In the area of Energy Balance this is based on a calculation of all energy uses in a building incl. electricity using appliances and the used energy supply system. Here an “Active House” can be classified in 4 classes based on the yearly energy balance:

Class A $\leq$ 0 kWh/m² for the building incl. all electricity use
Class B $\leq$ 0 kWh/m² for the building but only including electricity use for operation
Class C $\leq$ 15 kWh/m² for the building but only including electricity use for operation (at renovation)
Class D $\leq$ 30 kWh/m² for the building but only including electricity use for operation (at renovation)

It is important to note that 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 no link to what the actual energy use will be in practice in realised building projects.

A good possibility here 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.
In Denmark there is in fact no actual responsibility concerning the realised energy quality in building projects, and this is having a severe influence on how much focus consultants and contractors have on the realised energy quality in practice.
One area where there is an actual focus on energy quality in practice in Denmark is however in the area of air-tightness of constructions.
This can be controlled quite easily and due to this and a 5 year quality period for building failures, there is now consensus on the importance of living up to this demand in the building regulations.

The following is taken from a presentation at the Carbon Reduction 2013 conference in London in Nov. 2013.

PV-implementation in Valby and Copenhagen

At Hyldespjældet in Albertslund near Copenhagen in Denmark, the first zero energy housing renovation project in Denmark was realised in year 2009.
Due to large scale renovation plans for 3000 – 5000 concrete housing units in Albertslund during the next 5 years, this was a very important project, which also received the Energy Globe price for Denmark.

CENERGIA GREEN SOLAR CITIES – Carbon Reduction, London 21. November 2013

PV-implementation in Valby and Copenhagen

In Hyldespjældet a prefabricated so-called Solar Prism was placed on the flat roof and includes all installation elements.

CENERGIA GREEN SOLAR CITIES – Carbon Reduction, London 21. November 2013

PV-implementation in Valby and Copenhagen

The Solar Prism is placed on the flat roof and includes all installation elements.
Can be purchased from VELUX and Danfoss.

CENERGIA GREEN SOLAR CITIES – Carbon Reduction, London 21. November 2013

PV-implementation in Valby and Copenhagen

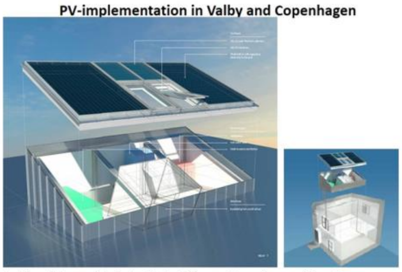


Illustration of the prefabricated Solar Prism and how it was utilised in Albertslund with a heat pump together with a solar domestic hot water tank and a heat recovery ventilation system. And towards the sun VELUX roof windows and solar thermal collectors together with PV modules.

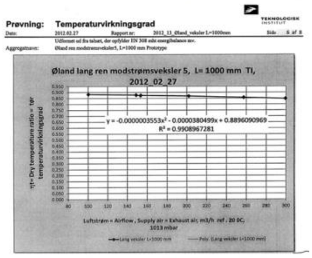
CENERGIA GREEN SOLAR CITIES – Carbon Reduction, London 21. November 2013

PV-implementation in Valby and Copenhagen

Example of decentralised heat recovery ventilation system (HRV) which can be installed in each apartment with building integrated components, low electricity use and very satisfied users as a result.
The same technology was used in the Solar Prism in Albertslund.

CENERGIA GREEN SOLAR CITIES – Carbon Reduction, London 21. November 2013

PV-implementation in Valby and Copenhagen



Test of compact HRV unit from EcoVent / Øland showing dry heat recovery ventilation efficiency higher than 85 %. This technology is used in the Solar Prism in Albertslund.

CENERGIA GREEN SOLAR CITIES – Carbon Reduction, London 21. November 2013

PV-implementation in Valby and Copenhagen

Front page of "Solar Solution" brochure

The Solar Prism development has now led to the promotion of the "Solar Solution" concept by VELUX and Danfoss.
You can see a small video concerning the Albertslund concept and "Solar Solution" at

www.velux.dk/solarsolution

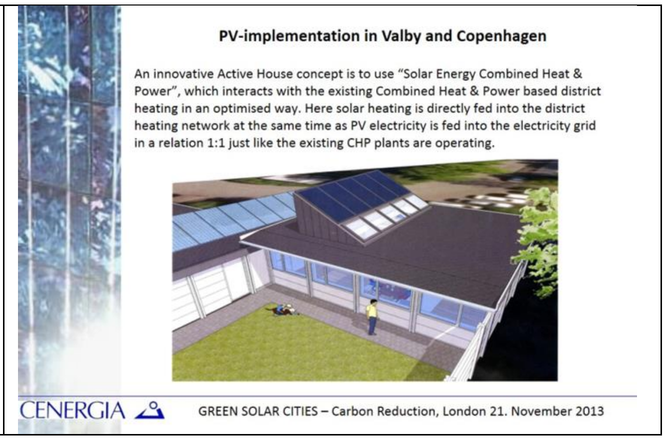
CENERGIA GREEN SOLAR CITIES – Carbon Reduction, London 21. November 2013

PV-implementation in Valby and Copenhagen

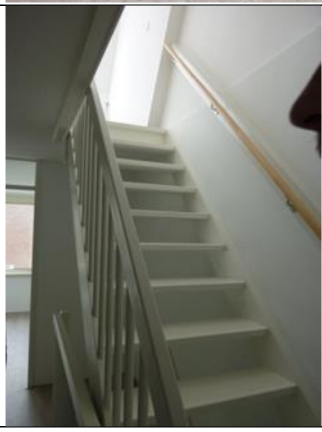
Installation of Solar Prism in Tranbjerg near Aarhus in Denmark

New example of new prefabricated Solar Prism projects. Here for a new building project with 60 dwellings in Tranbjerg near Aarhus in Denmark

CENERGIA GREEN SOLAR CITIES – Carbon Reduction, London 21. November 2013



Realisation of Active House renovation of row houses in Monnikendam in the Netherlands



Proposal for a configurable solar roof	

<u>Examples of well integrated PV solutions (BIPV) in roofs.</u>

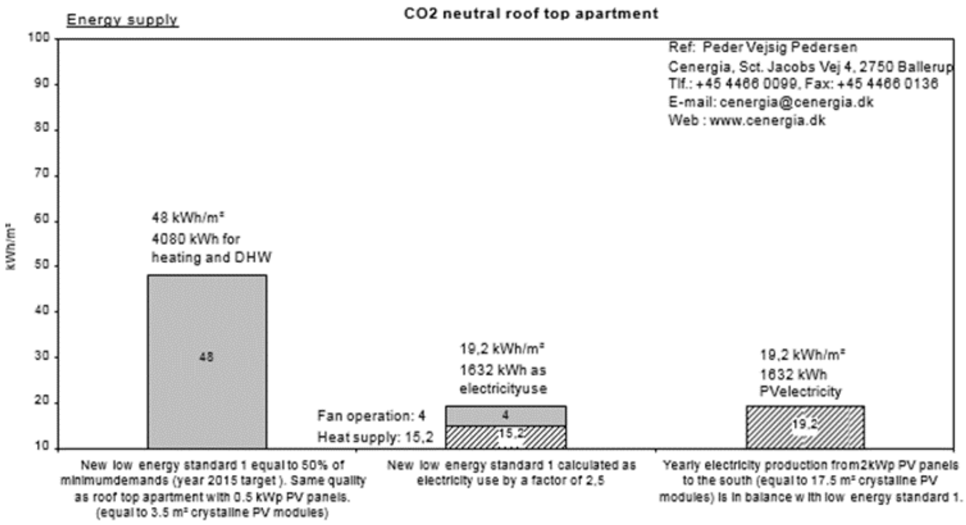
The SOLTAG prefabricated CO_2 neutral rooftop dwelling started a whole movement towards zero energy building and active houses.
A prototype of a SOLTAG CO_2 neutral rooftop dwelling, was build according to the Danish low energy class 1 or 2015 standard. And it was was exhibited at Ørestaden in Copenhagen from August 2005 until the spring 2006.

The prototype development was supported by the EU-Demohouse project, The Copenhagen Urban Ecology Fund, The Danish Energy Agency and Elkraft-PSO together with a group of sponsors lead by the Velux company from Denmark. Co-ordination of the project has been facilitated by Cenergia and Kuben Urban Renewal Denmark, who together with Velux and Rubow Architects developed the prototype housing unit.

The innovative solar roof with air solar collector and PV-panels was made by Roofing.dk/Ruukki and Danish Solar Energy, while the innovative heating and ventilation system was been made by Gilleleje Cooling&Energy together with EcoVent. The prefabricated rooftop dwelling was manufactured by the Danish company Jytas. (See also www.soltag.net).

Prefabricated SOLTAG CO_2 neutral rooftop dwelling exhibited in Ørestad,
Copenhagen, from August 2005 till the spring 2006. It is now situated at Velux headquarters in

Hørsholm.



Energy balance of SOLTAG CO2 neutral rooftop apartment.

The CO2 neutral rooftop dwelling was designed according to an “Energy Quality Design” philosophy: 6 steps to reduce energy consumption

1.	Prefabricated constructions without cold bridges and with a good airtightness. (Better than 0.6 l/s,m² as natural ventilation rate)
2.	Use of heat recovery ventilation (HRV) with low electricity use based on use of a thin EcoVent HRV unit which is easy to integrate. This is considered the cheapest way of obtaining the new Danish 2006 low energy demands with a 25 – 30% reduction in energy use. Experience from realised Danish housing projects has shown that item 1 + 2 alone can lead to a 50% reduction of the yearly heating bill and an improved indoor air climate without moisture problems.
3.	Use of low energy windows with a good daylighting transparency and at the same time avoidance of overheating problems by built in sun shading.
4.	Use of solar domestic hot water (DHW) system to obtain a 50-65% reduction of the energy use for DHW.
5	Use of Photovoltaic (PV) modules to reach a desired or even a climate-neutral low-energy level. With 0.5 kWp PV panels, equal to 3.5 m² crystalline PV modules, a low energy class 1 quality can be obtained for the rooftop dwelling (50 % better than 2008 building regulations demand). With an extra 2.0 kWp PV panels, equal to 14 m² crystalline PV modules, a zero energy and climate neutral energy design can be obtained on a yearly basis. The use of PV energy is considered a very interesting energy option, because we know that we need to depend on renewables in the future and also because there has been a trend of price reductions
6.	Use of an adapted energy supply for heating and DHW. For a low-energy class 1 housing unit you only need a very small energy supply level on a yearly basis. All existing energy supply options can in principle be used (gas furnace, district heating, a small heat pump or electric heating). When a small air and solar roof based heat pump is used you obtain a good energy “quality” and at the same time avoid a separate energy supply (besides electricity). In any case it is very important to avoid heat losses from the energy supply system because a normal-size heat loss will mean a much higher relative percentage in low-energy dwellings.

Passive house development in Austria, Sweden and Denmark

The following information is taken from the deliverable report 2.4 of the EU-Concerto, Green Solar Cities project: "Passive house standard in Sweden, Denmark and Austria" made by professor Maria Wall from Lund University, Division of Energy and Building design.

Here there is an interesting introduction on how the idea of passive house was first developed by the Swedish professor Bo Adamson from Lund University in the 1980'es, and later was developed further into practice by Wolfgang Feist from Germany, who also developed the Passive House Institute.

Alone in Germany more than 10.000 passive houses have been established.

Passive house development in Sweden

Sweden has a long tradition of development of low-energy buildings but during the 1990s the development almost stopped due to a period with poor economy and very limited production of new buildings. When countries like Germany, Austria and Switzerland developed passive houses and low-energy buildings, Sweden was therefore getting behind. However, one important step was taken with the development of the first passive houses in Sweden which as well were first in the Nordic Countries.

The Swedish passive house concept

A passive house has a highly insulated and airtight building envelope combined with a mechanical ventilation system with efficient heat recovery. This means that the space heating peak load can be so small that the supply air is enough to distribute the heat into the building, using comfort air flow rates. The energy source to preheat the air could be electricity (e.g. wind power) but preferably renewable energy, e.g. biomass, solar or district heating.

In Sweden, the space heating peak load fro residential buildings should be between 10 and 16 W/m² depending on climate zone and building type. In Germany the peak load is maximum 10 W/m². However, in Sweden our building code states that we need a higher minimum air flow rate than in e.g. Germany. Even if this implies higher ventilation losses, this also makes it possible to heat more by using the supply air system which we do need in our colder climate. The limit is that the supply air never should be heated to more than 52°C, which is based on the German criteria. The Swedish definitions for passive houses (residential) can be found at www.energieffektivabyggnader.se.

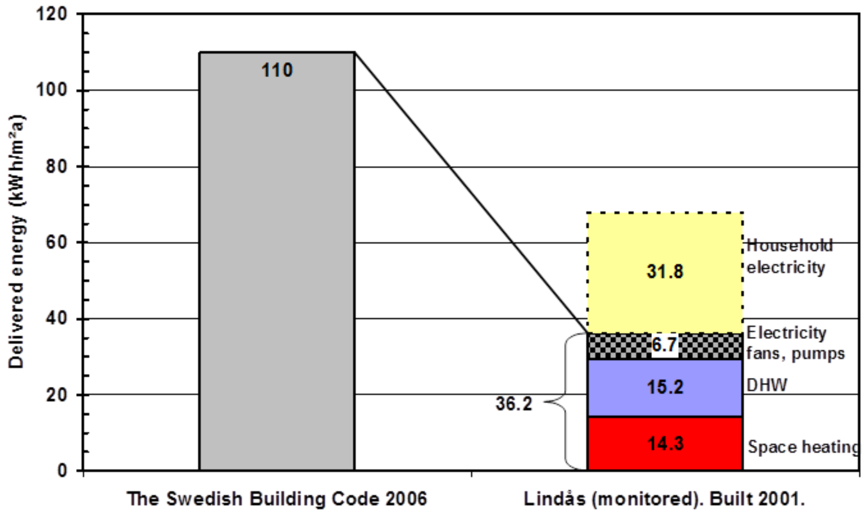
The development in Sweden started with the Lindås project

In 1997 a pre-study was carried out to find out if it would be possible to build a passive house in a Swedish climate. The study was made for the preliminary design of terraced houses in Lindås outside Gothenburg. The climate in Sweden is colder and less sunny than the Central European climate. This makes it harder to achieve the passive house standard. The pre-study showed that it would be possible to build passive houses in the Gothenburg area. A project team was organised and research funding secured so that the work could continue to design, construct, monitor and evaluate the building performance.

The passive houses were completed outside Gothenburg in Sweden in 2001. Twenty terraced houses were built according to the passive house standard (Figure 3). Monitoring and evaluation of the completed buildings showed that the average delivered energy requirement was 68 kWh/m²a, including DHW and space heating, electricity for fans and pumps and household electricity (Ruud & Lundin, 2004). This is approximately 40% of the energy demand for average single-family houses in Sweden (Wall, 2006; Hastings & Wall, 2007). The solar collectors contributed with 8.9 kWh/m²a to the DHW heating, which means that the total energy requirements for the houses were approximately 77 kWh/m²a.

Passive houses in Lindås, Gothenburg, built 2001. (Photo: Maria Wall).

The new Swedish building code (BBR, 2006) sets a maximum energy requirement for DHW heating, space-heating and electricity for mechanical systems at 110 kWh/m²a in the southern region, but the houses in Lindås only need approximately one third of this (36 kWh/m²a), see Figure 4. Thus, it is possible to build houses with a much lower energy demand than required by the new building code (five years newer than the passive houses!).



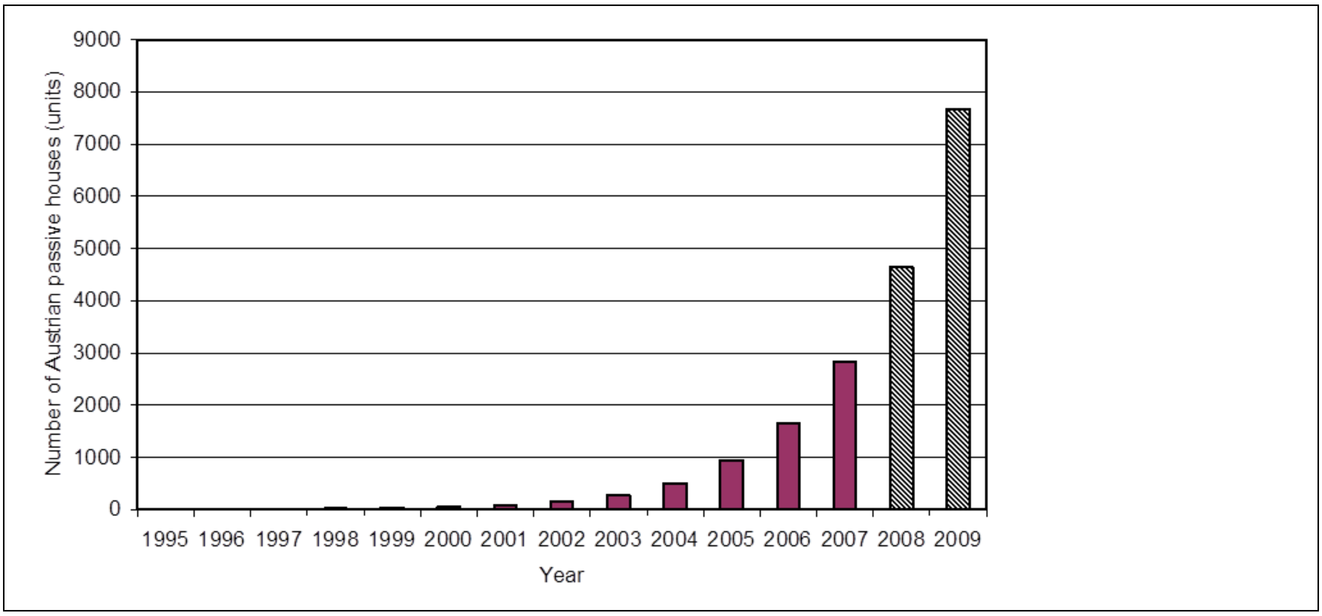
Monitored energy use for the terrace houses in Lindås (right). Delivered energy for DHW and space heating, and electricity for fans and pumps (36.2 kWh/m²a) is compared to the requirements in the new Swedish building code (left) for the southern climate zone (110 kWh/m²a).

The lessons learnt from this first project spread to new developers and led to new passive houses being planned and built. Ongoing research includes documentation of the construction of passive houses, such as the first single-family house in Sweden, new apartment buildings, and also a renovation project with apartment buildings from 1970 built in Alingsås (Brogården), in which the goal is to reduce the energy use by approximately 50% compared to today (Janson, 2008).

Passive house development in Austria

Austria was fast to import the passive house concept from Germany. The passive house market in Austria has rapidly increased since 1996 (www.igpassivhaus.at), see Figure 1. At the end of 2006, 4% of all new buildings were passive houses, and estimated share of passive houses in 2010 is 24% and in 2020 the estimation is 62%. The majority of Austrian passive houses are single-family houses. Vorarlberg has the highest density of passive houses in Austria. Also renovation to passive house standard is growing fast. Government housing subsidy programmes have direct impact on the number of residential buildings built as passive houses. E.g. in Vorarlberg, housing subsidies are granted only if the buildings meet the passive house standard.

The development of low energy buildings and renewable energy supply is supported by the Austrian “Program on Technologies for Sustainable Development” that funds future-oriented innovations and developments. This five-year research and technology program was developed by the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT). It initiates and supports research and development projects and the implementation of exemplary pilot projects. Three sub-programs exist: "Building of Tomorrow", "Energy Systems of Tomorrow" and "Factory of Tomorrow". More information can be found in: www.hausderzukunft.at/english.htm.



Documented passive houses in Austria since 1995 and predicted for 2008-2009 (data from www.igpassivhaus.at).

The city of Salzburg

The city of Salzburg is one of the cities included in the "Green Solar Cities" EU- Concerto II project. In Austria each federal state is responsible for its own subsidized housing. Since 1993 Salzburg uses an incentive scheme for energy-saving measures in buildings and the use of renewable energy. Based on the assignment of energy points, the system increases the subsidy funding. The reward system reaches a very high percentage of new constructed residential buildings. The achieved points depend on the energy performance and ecological quality of the building. Buildings are divided into 10 classes of standard and include passive buildings (see Deliverable 2.2: Reward system for ecologic housing in Salzburg. A point-based system for the funding of energy-efficient eco-buildings and the use of biomass and solar energy. Version 1, 23.05.2008). This reward system has proved to be successful in the implementation of energy-efficient and sustainable buildings.

As part of the EU-project "Green Solar Cities", the passive house project in Esshaverstraße 3 in Salzburg was the first completed residential building. The Concerto site is located in the Lehen district of Salzburg. The passive house building includes 12 rental apartments and was completed in June 2008. It promotes the improvement of energy-efficiency and the use of renewable energy. Salzburg supports such targets and declared the project to be a residential role model of the state. The apartment building meets the passive house standard class 10 according to the subsidized housing decree in Salzburg. Furthermore, it is one of the first social housing in Salzburg constructed as a passive house. The building will be monitored in detail to evaluate the performance.

The passive house apartment building in Esshaverstraße 3 in Salzburg. (From the brochure: CONCERTO II Green Solar Cities “Passive house Esshaverstrasse”, editor and publisher: SIR – Salzburger Institut für Raumordnung und Wohnen. Compilation: Inge Straßl).

Passive house development in Denmark

Rønnebækhave II

Denmark started the development of passive houses later than Sweden. The first Danish passive house building project, Rønnebækhave II in Næstved, south of Copenhagen, was finished in February 2006. It comprises a small housing block with eight apartments realised according to the German passive house principles (Figure 8).

To be able to live up to the German passive house criteria with a space heating demand not exceeding 15 kWh/m²a it was necessary to purchase low energy windows from Germany with a documented U-value of 0.8 W/m²°C, and an individual only 26 cm thick Ecovent heat recovery unit to enable a “dry” heat recovery efficiency of 85 % together with a very low electricity use. For two of the apartments ventilation air is preheated in the ground.

The apartments utilise a 28 m² shared solar DHW system and individual 240 litre DHW tanks. A ground coupled shared heat pump is used in combination with air heating and floor heating. This is matched by PV electricity from a 5 kWp PV system in the roof to achieve a CO_2 neutral heating design on a yearly basis . With a calculated energy use for heating and DHW of 23 kWh/m²a, only 23/3.5 = 6.5 kWh/m²a will be the electricity need for the heat pump with a COP of 3.5. This is the same as the yearly PV production of the PV-modules which is 4250 kWh or 6.6 kWh/m²a.

The experiences with the passive housing project in Næstved have been very good. Especially, the balanced HRV system is liked by the tenants and actually two families claim that they have avoided asthmatic symptoms since moving into the apartments.

Due to the limited knowledge concerning passive houses in Denmark at that time, and the general policy concerning energy, it was very difficult to get the project financed and it was also difficult to get funding for monitoring and follow-up. But monitoring from spring of 2007. Show that it has been possible to obtain results very close to what was predicted, with an energy use for heating and DHW near 20-25 kWh/m²a. And the actual COP value of the heat pump was measured at 3.2 – 3.4 which is reasonable compared to expectations.

50 m² PV-modules in Rønnebækhave II is mounted in the roof facing south in connection to a solar collector area of 28 m². Photo: Peder Vejsig Pedersen

Further development of passive houses in Denmark

Another passive house was finished in spring 2008; a single-family house “Langenklamp” in Ebeltoft (www.langenkamp.dk). This is the first Passive House Institute certified passive house in Denmark. New passive house projects are developing and more information can be found in Danish on e.g. the web sites: http://passivhus.aau.dk, www.altompassivhuse.dk and www.passivhus.dk.

Monitoring results of Vila Langenkamp passive house in Ebeltoft in Denmark by Kuben Management Energy Key monitoring system (funded by the Solar City Horsens EFP project).

From a monitoring period from May 2010 – March 2011 the following results can be presented:

1. The small Austrian heat pump used 2.420 kWh in electricity and delivered 5.740 kWh in heat equal to a yearly COP of 2,4.

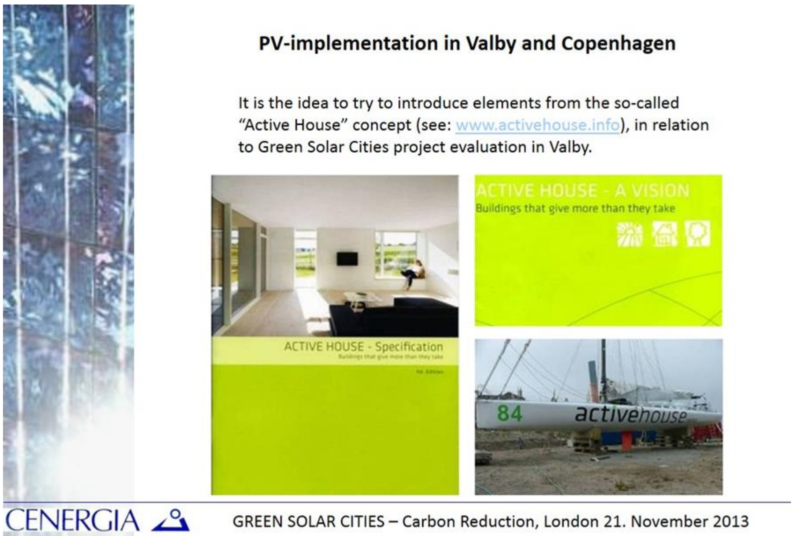
2. The electricity use for ventilation was between 42 W and 83 W for the used German HRV air heating system with a mean value of 56 W (the air flow in winter is higher than in summer)

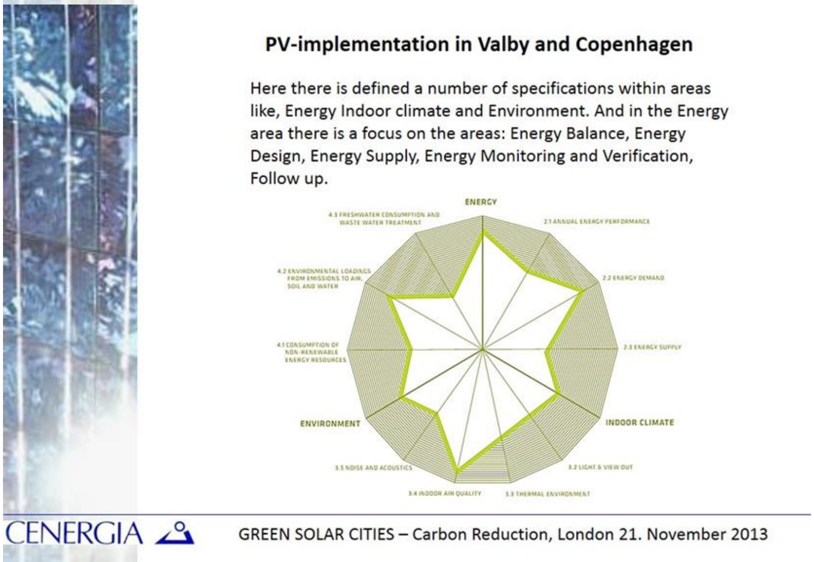
3. The room heating demand in the 10 month is quite low with 3.247 kWh (20 kWh/m²,year). But the domestic hot water use is high with 4.879 kWh of which the solar heating system covers 49%.

4. Overall the house seems to have functioned reasonable according to the intentions. With improved heat pump and ventilation systems reaching 3.5 in COP and max 35W in mean electricity use for ventilation, the electricity use for heating and ventilation could be reduced by 33 % leading to a yearly energy frame value of 36 kWh/m²,year, which is in this case is a little better than low energy class 1.

		
Various examples of extensive energy renovation with "1.3 and 5 litre" houses located in Ludwigs-hafen in Germany (head quarter for BASF group)	Makartstrasse, Linz after passiv house renovation	Allingsäshem in Allingäs in Sweden before passive house renovation

9. Active House Standard





PV-implementation in Valby and Copenhagen

Proposed evaluation of the Green Solar Cities project based on ”Active House Specifications”

Annual energy performance

	PARAMETER	EVALUATION METHOD AND CRITERIA
Quantitative	Energy and CO_2-calculation	Calculation of primary energy and CO_2-emissions shall be based on the national calculation methodology, using nationally adopted efficiency/conversion and emission factors, as well as climate data. The definition of the heated floor area shall follow the national definition.
	Annual energy performance	The annual energy performance shall be based on primary energy calculations and it includes calculation of the energy demand of the building, the energy demand of appliances and a calculation of the renewable energy being used. An Active House is classified according to the annual primary energy use, where: 1: ≤ 0 kWh/m2 for the building and appliances 2: ≤ 0 kWh/m2 for the building 3: ≤ 15 kWh/m2 for the building 4: ≤ 30 kWh/m2 for the building (modernization)

PV-implementation in Valby and Copenhagen

Energy demand

	PARAMETER	EVALUATION METHOD AND CRITERIA
Quantitative	Annual energy demand for the building	The annual energy demand includes energy demand for space heating, water heating, ventilation, air conditioning including cooling, technical installations and electricity for lighting. 1: ≤ 30 kWh/m2 2: ≤ 50 kWh/m2 3: ≤ 80 kWh/m2 4: ≤ 120 kWh/m2 (modernization only)
	Annual energy demand for appliances	The annual energy demand for appliances includes white goods, television, computers and similar equipment.
	Demand to individual products and construction elements	The requirements to individual products and construction elements (i.e. minimum thermal resistances, maximum thermal bridge effects, and air tightness) shall at least follow requirements set in national building regulations.
	Building management system	An Active House should be prepared for an easy and user- friendly control of the indoor climate and the energy use in the building.
Qualitative	Demand to individual products, construction elements and appliances	Have the chosen products and construction solutions been evaluated from a cost perspective and maintenance view and how was the decision about the individual products and construction solutions taken? Have the best energy performing solutions for appliances been chosen?
	Architectural design solutions	How is architectural design solutions used to reach a holistic approach of the building, as well as to reach a low energy demand?

Note: These demands are under revision.
For electricity use besides common use for ventilation and pumps there can be some restrictions to get hold of the data.

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PV-implementation in Valby and Copenhagen

Energy supply

	PARAMETER	EVALUATION METHOD AND CRITERIA
Quantitative	Annual energy supply	The annual energy supply from renewable energy and CO_2-free energy sources shall be calculated and divided into the different sources (PV, Wind, Heat pumps, Solar Thermal, Biomass, etc).
	Origin of energy supply	The renewable energy sources can either be used on the building, the site, in a nearby energy system or electricity grid. The energy supply can be a mix of the above and follow the classifications below: 1: 100% of the energy is produced on the plot 2: more than 50% of the energy is produced on the plot 3: more than 25% of the energy is produced on the plot 4: less than 25% of the energy is produced on the plot
	Sources of renewable energy	The definition of renewable energy sources follows the EU Directive on the promotion of the use of energy from renewable sources (2009/28/EC of 23 April 2009).
	Performance of renewable energy system	Requirement to performance of the individual renewable source shall follow the national requirement in building legislation. As an alternative to national requirements the requirement in the EU Directive on the promotion of the use of energy from renewable sources (2009/28/EC of 23 April 2009) can be used.
Qualitative	Design	How have you worked with integration of renewable energy as a part of the building design and typology on the building and the plot?
	Origin of energy supply	Has the energy supply been evaluated from a cost perspective and how was the decision about the origin of the energy supply taken?

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PV-implementation in Valby and Copenhagen

Energy validation

	PARAMETER	EVALUATION METHOD AND CRITERIA
Quantitative	Specification of figures	The calculation of the annual demand shall specify the energy demand for the individual areas, as specified in section 1.2: • space heating, water heating, ventilation, cooling and air-conditioning, electricity for technical equipment, electricity for lighting and electricity for appliances The annual energy performance evaluation shall specify the supply from: • individual renewable energy sources integrated into the building • energy supply from local energy system and the share of renewable energy as well as the CO_2 emissions from the local energy system
	On site control	In order to prove that the build energy solutions meet the designed level, an on site control of the used solutions and products must be established by a certified expert. The air permeability of the building and the thermal bridges must be evaluated during the construction phase.
	Monitoring	The energy used and the energy produced must be monitored on a yearly basis. Metering devices are to be used for all types of energy production/ consumption at the building level.
Qualitative	Quality control	What kinds of quality control of the energy performance have taken place, where and when was it done?
	Commissioning	How will the commissioning of the building take place and will the commissioning include user behaviour, number of users, heating and ventilation system, control of dynamic solutions and production of renewable energy? If the use of energy is different from the calculated values, what kinds of initiatives are planned to meet the calculated values?
	User guidelines	What kinds of initiatives have been taken to secure that the house owner and users of the building have the relevant information about the expected performance of the building and guidance to use and optimize the building?
	Energy control	What kinds of initiatives have been taken to secure the users' possibilities to control and optimize the use of energy?
	Maintenance	What kinds of initiatives have been taken to secure the users a possibility to maintain the technical equipment as well as other parts of the building that affect the energy performance?

***Sources and tools:** National calculation methodology, national primary factors and climate data, EU Directive on energy performance of buildings (2010/31/EC of 19 May 2010), EU Directive on the promotion of the use of energy from renewable sources (2009/28/EC of 23 April 2009), national test and evaluation methods, like Blower door test and thermograph photos.*

Note: For electricity use besides common use for ventilation and pumps there can be some restrictions to get hold of the data.

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PV-implementation in Valby and Copenhagen

Indoor air quality

	PARAMETER	CRITERIA AND EVALUATION METHOD
Quantitative	Standard fresh air supply	Fresh air supply can be evaluated by looking at CO_2-concentrations indoor at room level during occupancy. CO_2 is a good indicator for the amount of bio effluents, pollutants from humans, in the air. Hourly values and maximum levels of CO_2-concentration preferably are determined with a dynamic simulation tool. Assuming standard occupancy rates (e.g. two persons in a master bedroom) and standard CO_2-production per person assumptions. The limit values for indoor CO_2-concentration in living rooms, bed rooms, study rooms and other rooms with people as the dominant source and that are occupied for prolonged periods are: 1. 350 ppm above outdoor CO_2-concentration 2. 500 ppm above outdoor CO_2-concentration 3. 800 ppm above outdoor CO_2-concentration 4. 1100 ppm above outdoor CO_2-concentration Reference: EN 15251: 2007. Note that this standard also gives the fresh air supply rates (e.g. for living rooms and bedrooms) in l/s/m2 that are needed to comply with the CO_2-requirements above.
	Minimum fresh air supply	When dwellings are unoccupied a minimum air change rate of 0.2 ACH should be maintained, to remove pollution from material emissions, appliance emissions, etc.
	Dampness	In rooms with periodic damp production peaks (esp. kitchens, bathrooms and toilets) sufficient extraction must be guaranteed to avoid dampness and mould problems. The minimum exhaust air flow in these 'wet rooms' should be as specified in national building codes or guidelines. If these are not available, see EN 15251: 2007 for example design values (in 3 categories) for exhaust air flows in kitchens, bathrooms and toilets. Dampness problems furthermore are prevented by a building envelop that is well insulated and free of cold bridges. In order to prevent internal or surface condensation that could lead to mould growth and a deterioration of the air quality inside. Comply, also in renovation project, as much as possible with local building requirements for thermal insulation and e.g. temperature factor.
Qualitative	Individual control	It should be possible to manually influence the air change rate in the rooms (especially living room, kitchen and bed rooms), e.g. by opening windows. In case mechanical ventilation is installed, it should be possible to adjust the airflow rate at 3 or more levels. Additionally, the ventilation may be demand-controlled based with CO_2 or humidity sensors.
	Low-emitting building materials	Building components and materials (e.g. processed wood products, paints and sealants) should be evaluated with regards to chemicals emitted from them, and low-emitting components are preferred. Preferably use Indoor climate labeled materials. For example materials with the Danish Indoor Climate label, the Finnish M1 label, the German AgBB or GUT label or the French AFFSET label.
	User instruction	In case of complicated ventilation systems or unusual user restrictions (e.g. concerning interior materials that can be introduced by the occupants) an easy to understand 'indoor air user instruction' should be provided. This document should explain how systems work and what is expected of end-users (e.g. as far as operation of systems and maintenance is concerned).

Note: Will be utilised for some of the building projects

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PV-implementation in Valby and Copenhagen

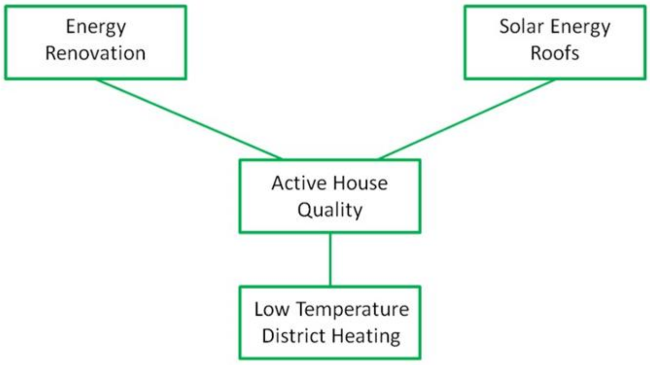
Cultural and ecological context

	PARAMETER	CRITERIA AND EVALUATION METHOD
Qualitative	Building traditions	How is the design of the building reflecting a relationship with the regional building traditions? E.g. regional materials, architectural typology and handcraft is analyzed and used as design parameters?
	Climate	How is the design of the building adapting to the potentials and constrains of the local climate? E.g. creating private outdoor spaces with a comfortable climate and access to sunlight that encourage to healthy active outdoor living?
	Street- and landscapes	How does the design impact on existing street- and landscapes? E.g. provision for children to play safely outside the house and supporting the public outdoor space for local behavior, needs and tradition?
	Infrastructure	How is the infrastructure supporting a healthy, comfortable and ecological transportation? E.g. connection and distance to nearest public transport for commuting, distance to school and supermarket and the possibly of easy and safe use of bicycles?
	Ecology and land use	How is the building optimizing the relationship with the local ecology and land use and at the same time minimizing environmental risks? E.g. maximizing surface for seepage of rainwater, minimizing use of land, preserving fauna.
	Climate changes	How is possible risks caused by climate changes (storms and flooding) identified and limited in the design of the building and landscape?

Sources and tools: *ISO 14040. ISO 14025. CEN TC 350*

Note: Will be handled as a general point for the realised demonstration projects.

PV-implementation in Valby and Copenhagen



There is a need for a new approach to energy efficient housing renovation showing how renewables can be introduced together with an optimised energy supply. The Active House Specification can be useful here.

PV-implementation in Valby and Copenhagen

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 realised building projects.

A good possibility here 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.

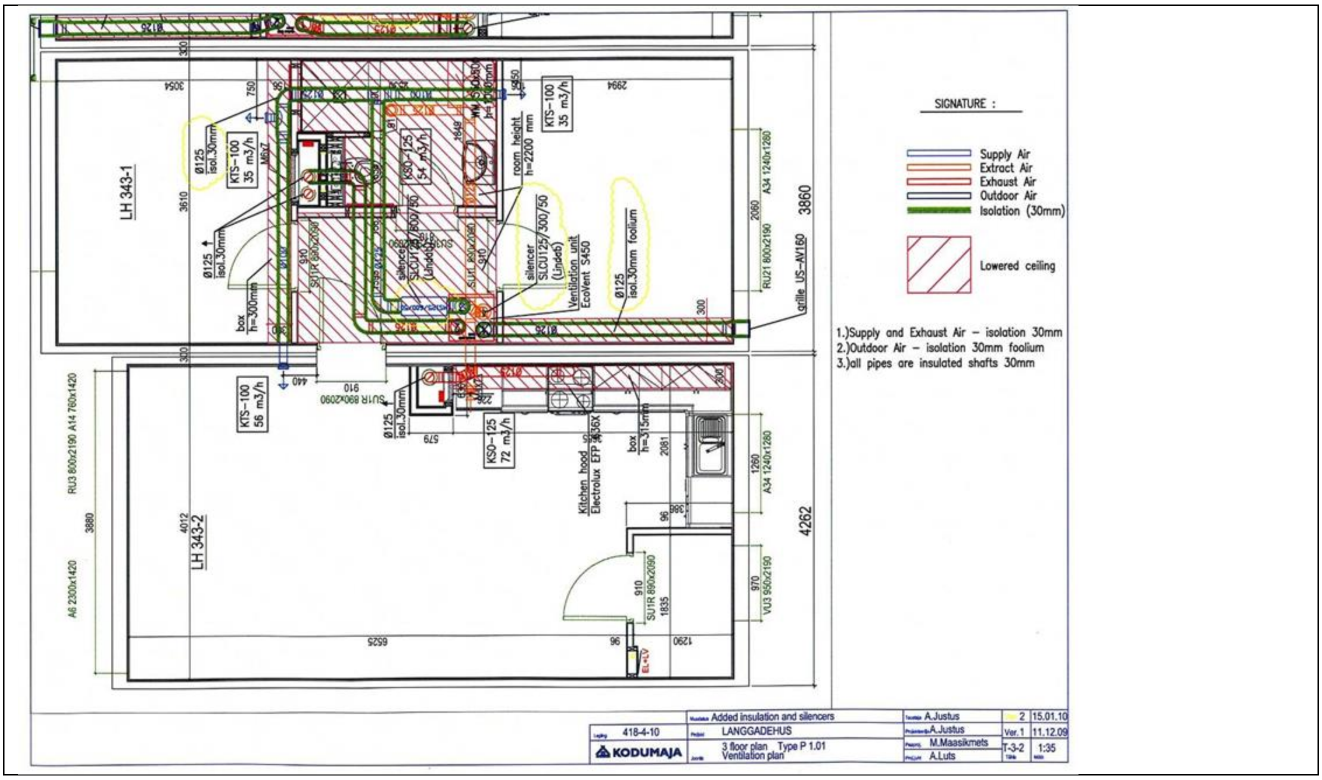
10. Improved ventilation with heat recovery

One of the most important tasks in the Green Solar Cities Concerto project has been to improve the quality of heat recovery ventilation (HRV) technology as stated in the contract.
Heat Recovery Ventilation or just HRV is considered to be the most important technology to secure a low energy standard for both new built and retrofit building projects to meet the improved low energy class 2015 and 2020 standards in Denmark, at the same time securing a good indoor air climate.
An important barrier to achieve good results, has however been that the so-called dry heat recovery efficiency of the existing HRV systems for the Danish and European market is quite low, with typical values of around 70-75%, while the electricity use at the same time is quite high, so it is difficult for most HRV systems to live up to SEL values of less than 1200 J/ m3 in electricity use for individual systems and 2100 J / m3 for larger common systems.
Due to this situation, RTD work in connection to optimised and low cost HRV technology with high heat exchanger efficiency and low electricity use has taken place in Denmark in a cooperation with the Danish ventilation companies Ecovent and Øland. E.g. in relation to the EU-Concerto project Green Solar Cities.
By March 2011 it was concluded that it has been possible to reach very good results concerning this, and at the same time it has also been possible to present good prospects concerning a completely new low cost HRV technology which especially is very useful for retrofit building schemes.
Heat recovery efficiencies as high as 90-93% were confirmed by use of an advanced calculation tool from the Technological Institute, and more important this has also been confirmed by practical testing of the technology-
For a long time the performed RTD work unfortunately also documented problems of obtaining a high air tightness of the HRV heat exchanger in practise. But in the end these problems were solved.
And now it is possible to give examples of several practical HRV tests with more than 90% HRV efficiency and with an extremely low electricity use. F. ex researchers from the University of Alborg have shown SEL values around 300- 400 J / m3 in connection to retrofit housing in practice, which is only 33% of the building regulation demands. And for a test in a one family house a total electricity use for both fans of only 13 W was monitored compared to normal values of 35-50 W.
In total these improvements alone can secure an extra saving of 11 kWh/m², year in the energy frame value, which is actually equal to 25% of the low energy class 2015 standard. To be able to document the very low electricity use in practice, RTD work has also been made to secure a continuous survey of this by a low cost internet connection for the users.
Finally it can be stated that the performed RTD work on the mentioned HRV systems has been of great importance for the project, and for the first large scale integration in Valby in Langgadehus very good results have been obtained.
Based on this it has been possible to document this high performance technology in several demonstration projects connecting to the Concerto project Valby and to document through energy survey that the aimed results are obtained in practice including documentation of the possibility of using very limited amounts of PV module areas of 1 – 2 m2 per housing unit to cover the yearly electricity use.

Use of outstanding HRV technology in EU-Concerto project in Langgadehus in Valby

In Langgadehus in Valby it was possible to use the new HRV technology with up to 90 % dry efficiency for the HRV heat exchanger together with a very low pressure loss.

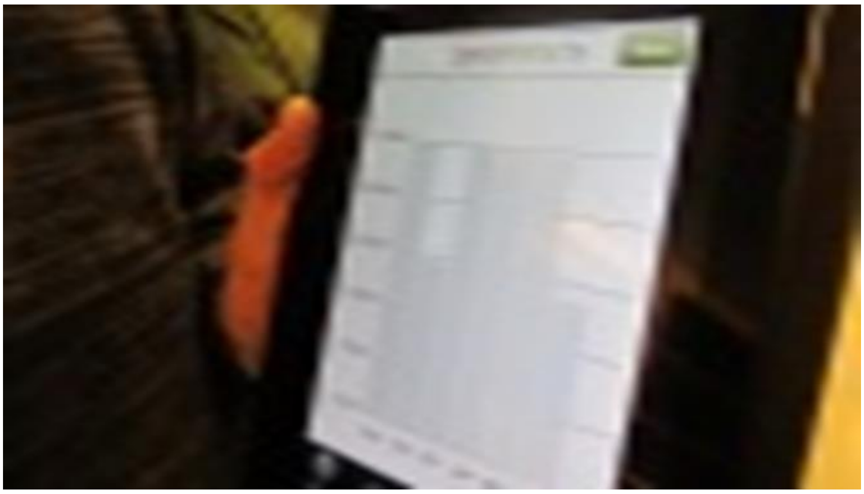
	Prefabricated rooftop dwellings in Langgadehus in Valby according to the Danish low energy Class 1 standard.
	In Langgadehus the Eco 450 model was installed in 2010. A data sheet of the further improved new Eco 500 model is enclosed in the annex.



Drawing of installed HRV system in prefabricated roof top housing unit in Langgadehus in Valby

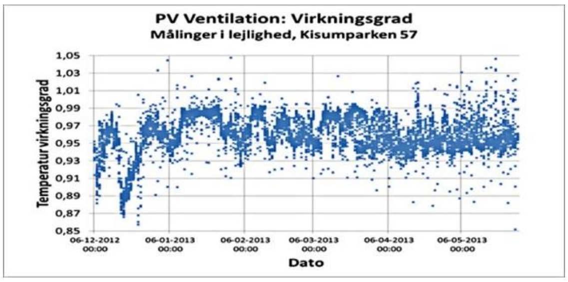
Detailed monitoring of the here mentioned HRV systems in Langgadehus has been made in cooperation with the Danish Building Research Institute including experiments with means of demand controlled ventilation.

In connection to this remote monitoring and an option for control via the internet have recorded the electricity use for some of the apartments. Intelligent survey and control equipment from the Danish company Zense Home has been introduced as an option for online survey and monitoring in several cases.

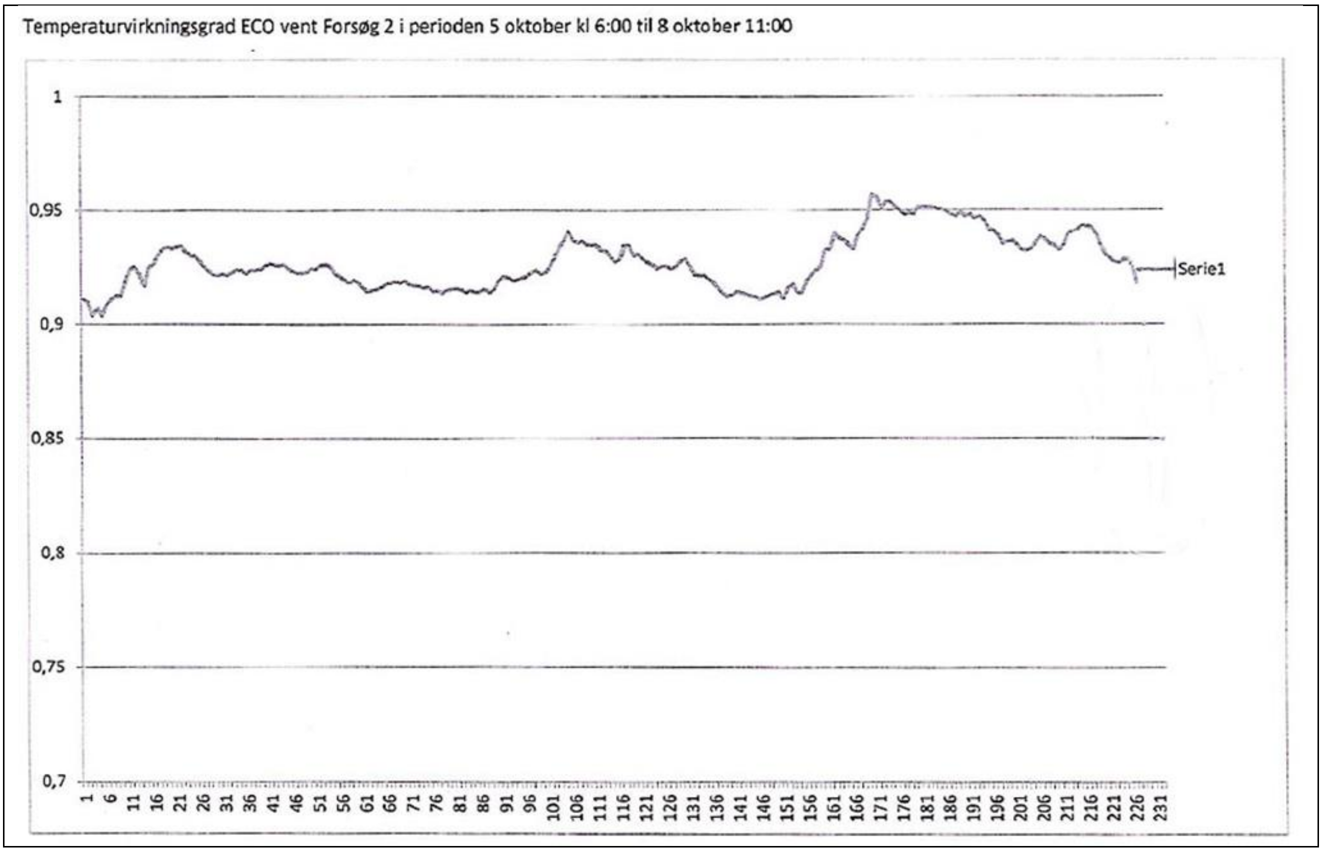


Remote control and survey of HRV systems by Zense Home equipment

Finally it should be mentioned that the used HRV technology has also been tested at VIA University College in Denmark, showing HRV efficiency over 90 %



Test set up at the VIA University College

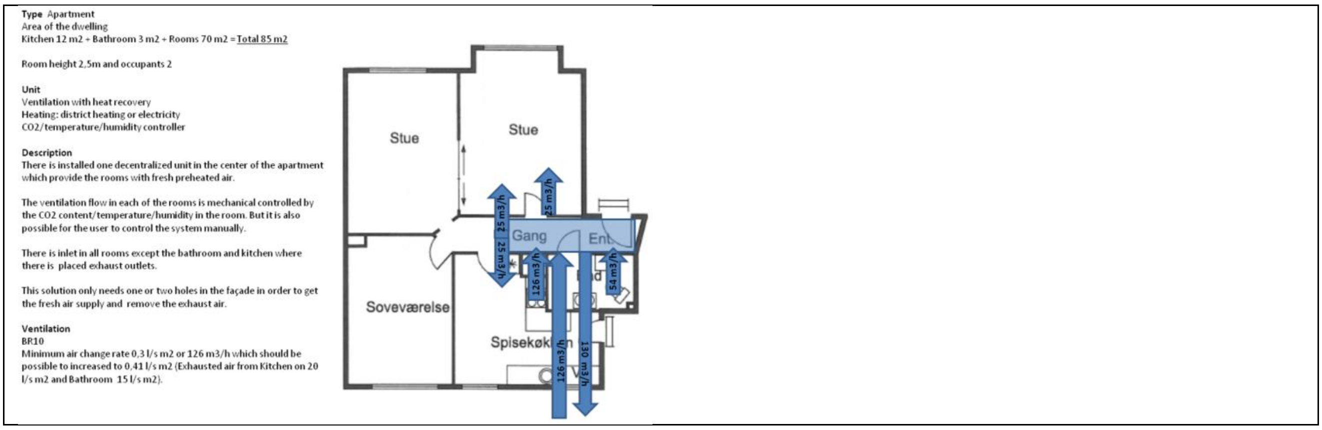


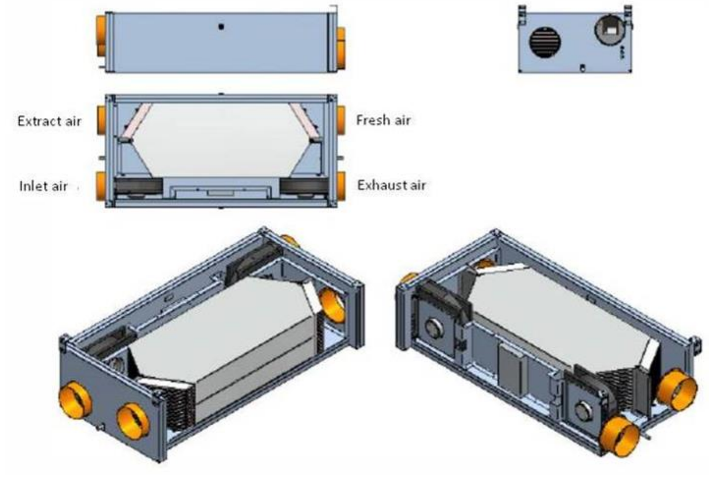
Monitored HRV efficiency at VIA University College showing efficiencies between 90 % and 95 %

In this “black box” test, it is not the dry HRV efficiency, which is tested. This will typically be 5% lower when good fans are used.

Decentralised HRV systems

There is in principle focus on two types of decentralised HRV systems. The most common solution is the decentralised heat recovery ventilation system with one HRV unit per apartment, where the HRV unit is placed under the bathroom loft. This solution alone can lead to a 28 % energy saving compared to a standard renovation.





CAD drawings of the EcoVent renovation model with the same HRV technology as in Langgadehus. Here the HRV is typically installed below the loft in the bathroom.
In the annex there is a brochure in Danish of the high efficient version which is sold by the Øland Company, AHU 250 is enclosed.

As an alternative it is possible to utilise HRV system which are room based with typical air flow volume between 40-80 m³/h.

In Valby a roof top extension has been made with a very innovative low cost decentralised HRV design.

Type Apartment

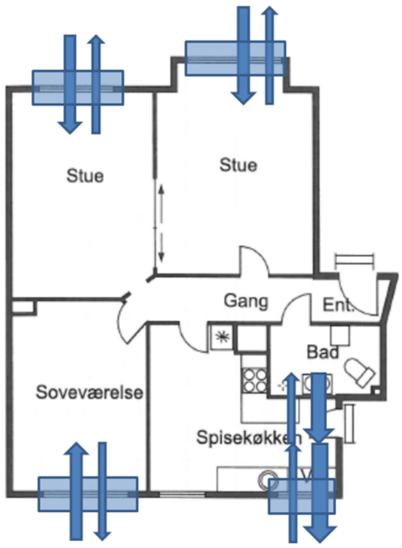
Unit
Ventilation with heat recovery
Heating: district heating or electricity
CO2/temperature/humidity controller

Description
Each room in the flat has a decentralized unit which provide the room with fresh preheated air.

The ventilation flow in each room is mechanical controlled by the CO2 content/temperature/humidity in the room. But it is also possible for the user to control the system manually.

In the bathroom and kitchen there should be an overpressure and in the other rooms an under pressure. This is in order to make sure that the rooms in the apartment never will be ventilated with air that is more polluted than what already is in the room.

In most apartments the bathroom is placed inside the apartment and therefore has no window or walls to the façade. This means that there often will be a need for passing ventilation ducts through a room that is neighbour to the bathroom.



Two HRV units are here integrated in the roof without any further ducting inside the housing unit.

New building integrated room based decentralised HRV solutions.

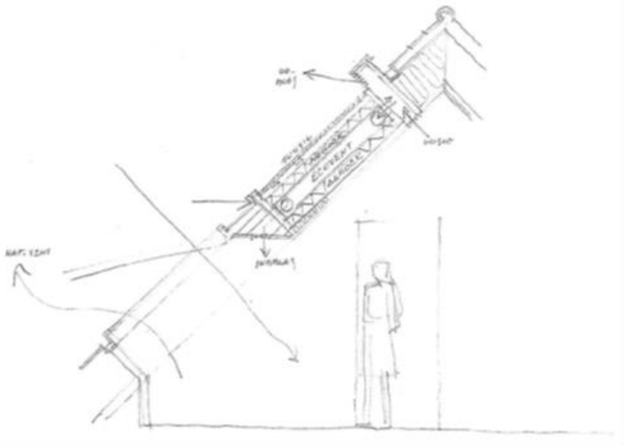
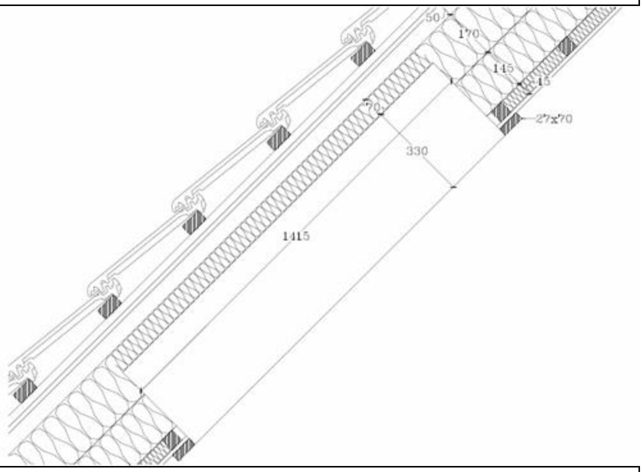
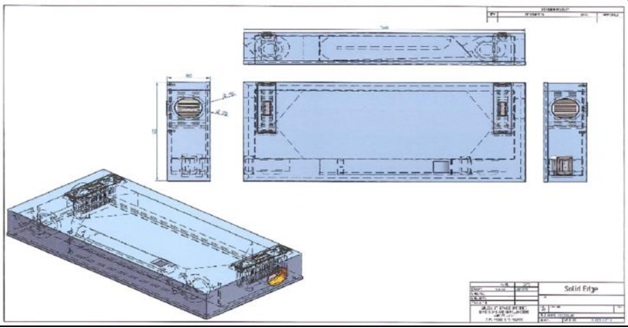
	
The one family house in Valby before and after establishment of roof top extension with innovative HRV technology. PV panels are used to match the yearly electricity use for ventilation.	
	
The HRV unit is integrated in the roof beside the VELUX roof window	Drawing of integration detail for the room based HRV unit

	Photo of roof integrated HRV unit used in Valby.
	Drawing of thin room based HRV unit used beneath the windows.

Heat Recovery Ventilation unit with radiator function.

To be able to overcome the other main barrier for the HRV technology in retrofit building projects, which are the extra costs, important RTD work on the so-called HRV radiator model has been made. Here the idea is to substitute a normal radiator by an integrated HRV radiator unit, which has the same size and which can contribute with heating as well as ventilation.

Examples of good functioning prototype systems are shown below. The main need for this technology is low or no noise, easy integration, a compact design as well as low cost. And for the prototype systems a noise level that you cannot hear has been identified together with an electricity use as low as 5W at air volume's around 60 – 80 m3/hour.

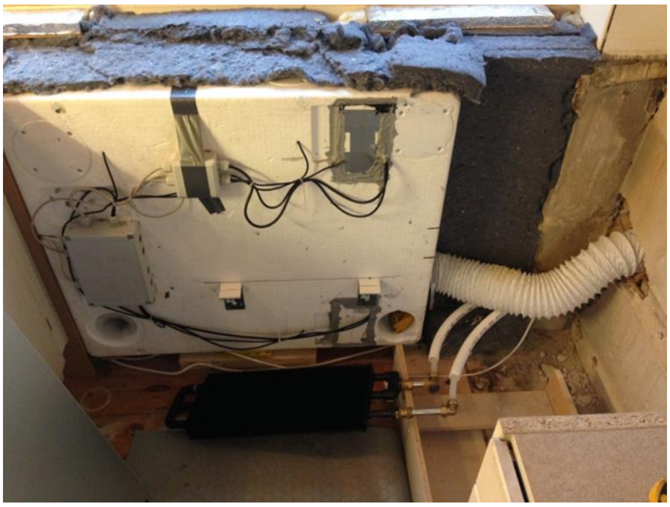
	

A very well-functioning example of window integrated heat recovery ventilation (HRV) was established at the P. Knudsens Gade housing area, administered by the housing association AKB, in Sydhavnen in Denmark situated in the Concerto area of the Green Solar Cities EU-Concerto project in Denmark.

The window integrated HRV module was placed besides a normal radiator, which is used for heat accounting. The HRV module is functioning with a radiator function as well and can provide either just room temperature or higher temperatures, so you can avoid a normal radiator.

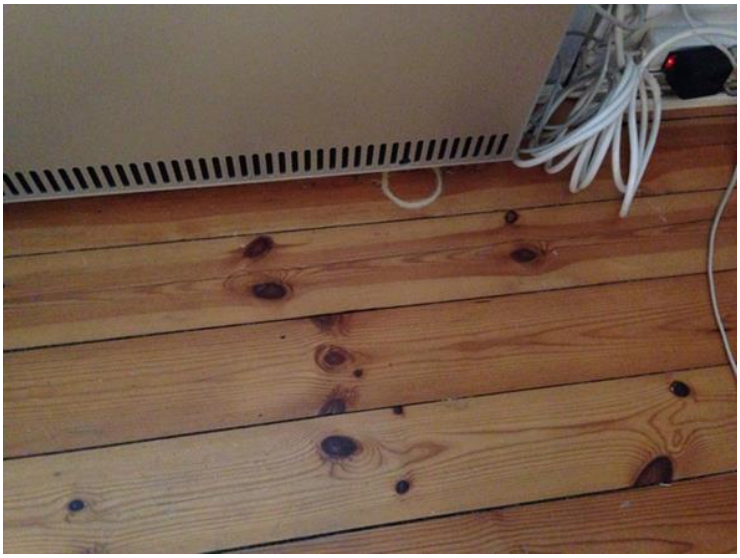
The new windows for the test apartment was supplied by the Danish EVD company with build in fresh air intake and used air exhaust integrated in the bottom of the window equal to ø140 mm.

The normal exhaust ventilation from the bathroom is controlled with an extra damper, so only a high moisture content or a 5 – 10 min. operation based on a user push of a bottom will operate the exhaust ventilation.



A view to the avoidance of coldbridges in the windows and the interior of the compact windowsill integrated low cost HRV unit in the kitchen, where you can see the built in heating convector in the bottom of the picture, as well as the extra inlet air function without heating connected to the neighbour bedroom. A build in thermostat controls the inlet air to the kitchen, so at least room temperature air inlet is always secured. With two HRV units, each of these will provide 50 – 60 m^3/h of fresh 90% preheated air for the quite small test apartment.

The cooker hood in the kitchen is changed to a recirculation cooker hood for simplicity.



When balanced heat recovery ventilation is provided to an old apartment it is very important at the same time to secure a good air tightness of the apartment. The main problem you have to attend here is to avoid air leakages through the old wooden deck construction.

For the test apartment this is done by introducing non toxic paper granulate insulation near the facade. The round hole in the picture shows one of the spots for this injection in practice.

11. Decision Support tool

Analysis of cost efficient alternative retrofit solutions with a combination of rational use of energy (RUE) and renewable energy sources (RES) for existing housing blocks in 3 different European climates by help of the ASCOT tool

The original Danish total economy calculation tool, “BYGSOL” developed by Cenergia has during the realisation of the EU-Concerto project Green Solar Cities been developed into a version in English language, “ASCOT” where a number of European climates have been added as basis of the CEN standard based calculation. The principle behind the calculations is the same as for the Danish Be10 calculation programme, but with an added database on costs for different alternative energy saving measures. (ASCOT is an agronym for Associated Costs).

The revised ASCOT tool has been send on a CD to the main partners of the project, and on the CD is also included an introduction to the use of ASCOT and a example of a total economic analysis which is also included.

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Below is shown an example of total economic calculations in Denmark with the ASCOT tool (can be downloaded from www.cenergia.dk and www.greensolarcities.com).

The basis calculation is made for Copenhagen and with Danish energy and materials costs, and in the build in data base you can introduce your own parameters for nearly everything.

The basis for the calculation is a 3 storey housing block with a low insulation level and with 24 apartments which will be renovated.

Here the windows area is 22% of the floor area distributed with 52% towards south, 4% towards west, 40% towards north and 4% towards east.

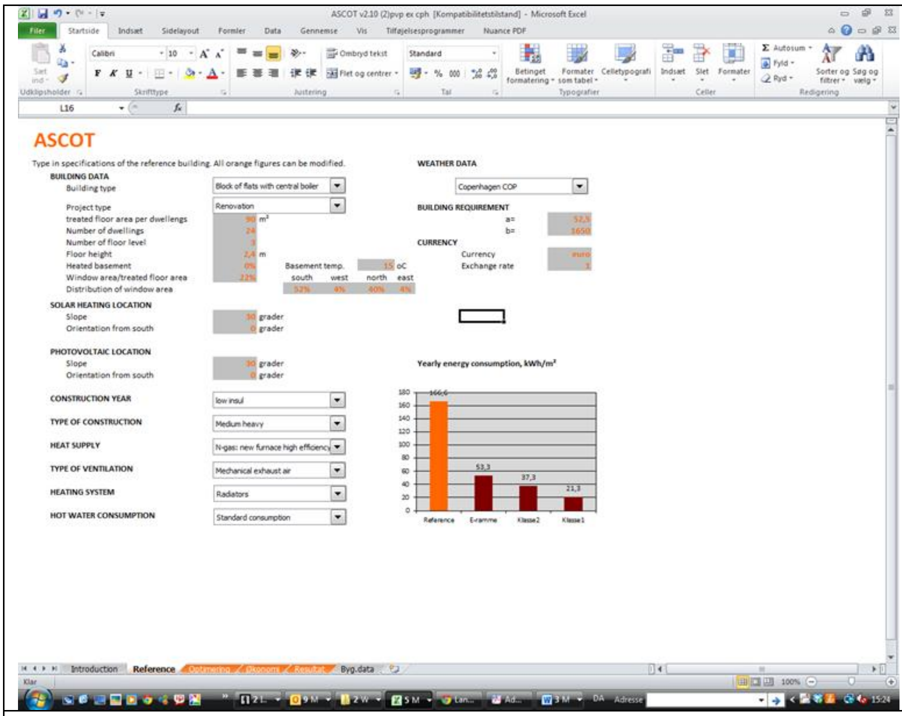
Solar heating and PV elements can be placed on a 30° sloping roof toward south.

For the reference situation there is used mechanical exhaust ventilation, heating with a gas based central boiler and radiators and a standard use of domestic hot water.

Based on this there is calculated a yearly energy frame value of 167 kWh/m², year of which 20 kWh/m², year is domestic hot water. This can be compared with a building regulation 2010 energy frame value of 53 kWh/m², year for new built, and low energy class 2015 and 2020 values of 37 and 21 kWh/m², year respectively.

Calculations with the ASCOT Sustainable Energy Decision support tool on total economy for RUE and RES solutions

Copenhagen Climate

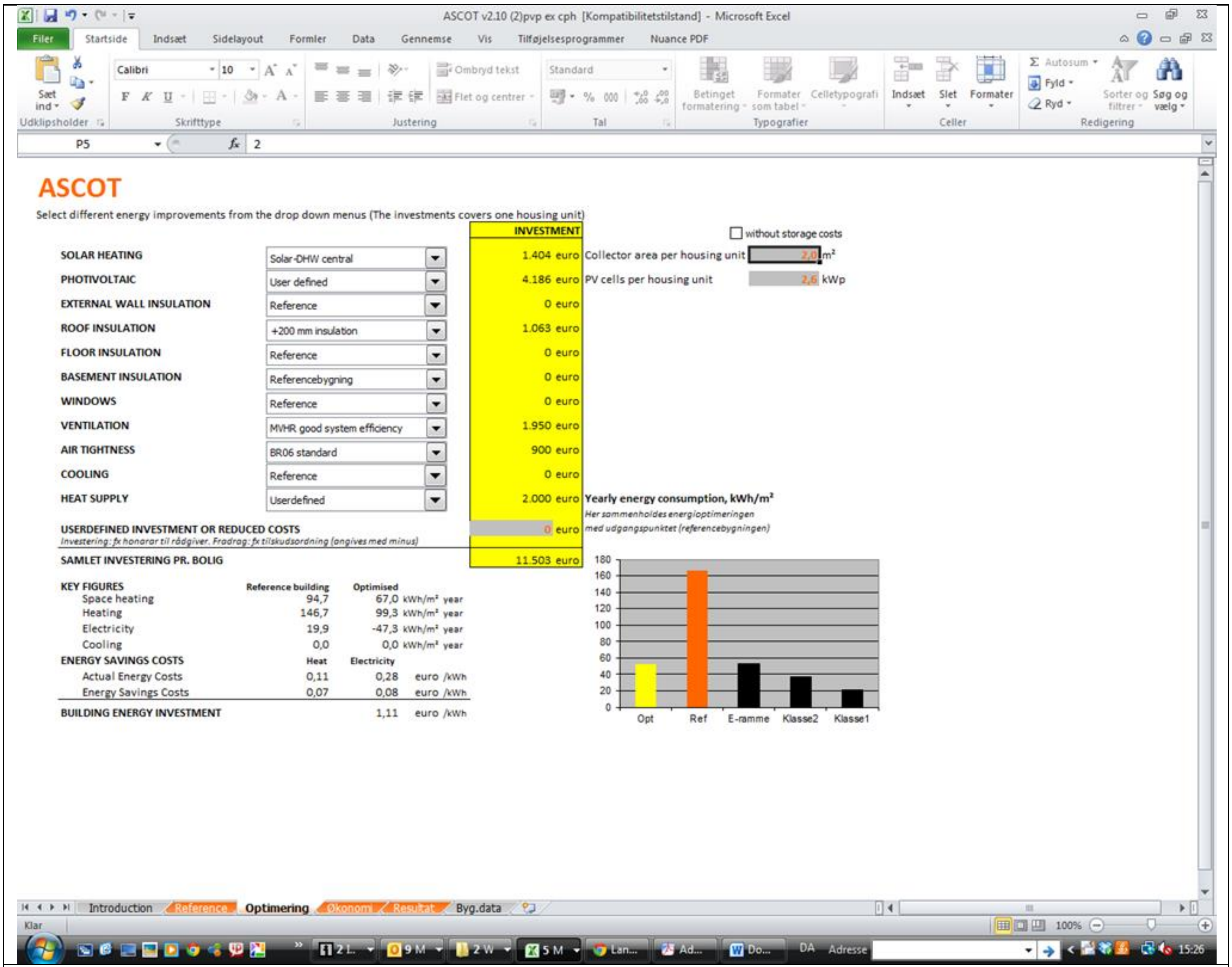


Reference calculation for Copenhagen climate

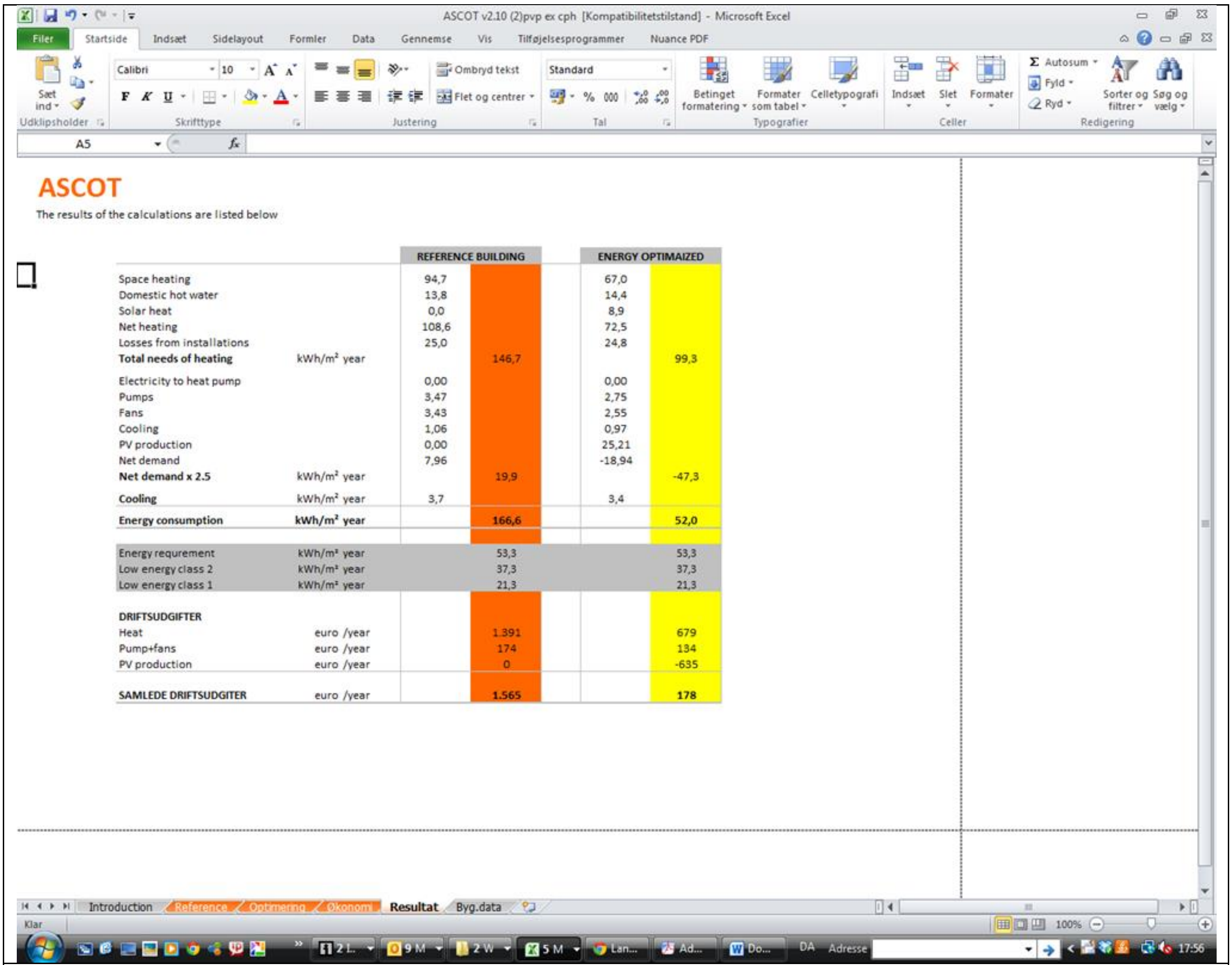
As a first part of an energy optimisation can be identified an energy saving package in relation to the renovation project where an energy frame value equal to a new built standard is aimed at.

The most economic solution seems to be a combination of extra 200 mm roof insulation, introduction of district heating, use of heat recovery ventilation and an improved airtightness. And to combine this with 2 m² solar thermal collectors for domestic hot water (DHW) and 2.6 kWp PV modules.

Due to new PV regulations with hourly based netmetering in Denmark the size of the PV system would be best to limit to around 1,5 kWp per housing unit to cover less than 40-50% of the yearly demand by PV, but these rules differ a lot between the different European countries.



ASCOT optimisation to meet new build building regulation standard



ASCOT

The results of the calculations are listed below

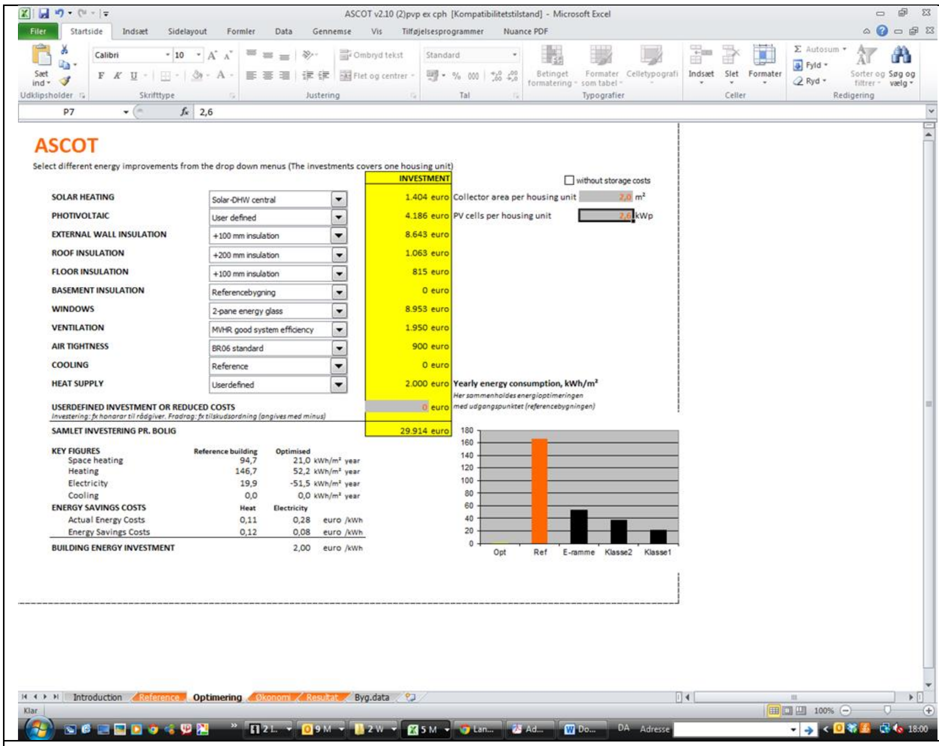
		REFERENCE BUILDING		ENERGY OPTIMAIZED	
Space heating		94,7		67,0	
Domestic hot water		13,8		14,4	
Solar heat		0,0		8,9	
Net heating		108,6		72,5	
Losses from installations		25,0		24,8	
Total needs of heating	kWh/m² year		146,7		99,3
Electricity to heat pump		0,00		0,00	
Pumps		3,47		2,75	
Fans		3,43		2,55	
Cooling		1,06		0,97	
PV production		0,00		25,21	
Net demand		7,96		-18,94	
Net demand x 2.5	kWh/m² year		19,9		-47,3
Cooling	kWh/m² year	3,7		3,4	
Energy consumption	**kWh/m² year**		**166,6**		**52,0**
Energy requrement	kWh/m² year		53,3		53,3
Low energy class 2	kWh/m² year		37,3		37,3
Low energy class 1	kWh/m² year		21,3		21,3
DRIFTSUDGIFTER					
Heat	euro /year		1.391		679
Pump+fans	euro /year		174		134
PV production	euro /year		0		-635
SAMLEDE DRIFTSUDGITER	euro /year		**1.565**		**178**

ASCOT results concerning Copenhagen climate and Danish building regs.

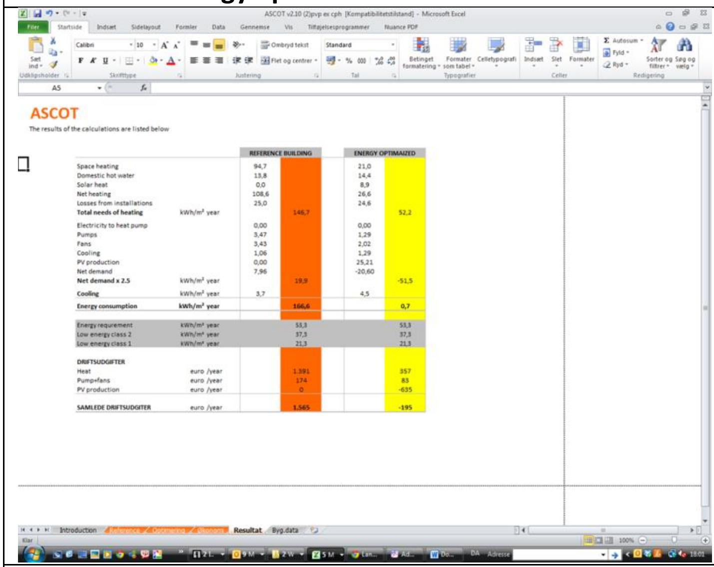
From the ASCOT calculation you can see that the total extra costs for this energy saving package is 11.503 EURO, while the yearly saving is 1565 – 178 = 1387 EURO so a pay-back time of 11.503/1387 = 8 year is obtained.

As a next step it is interesting to see what is needed to reach a completely zero energy standard.

Here one option is to include insulation measures for external walls and floors and combine with new 2 layer low energy windows.



ASCOT zero energy optimisation



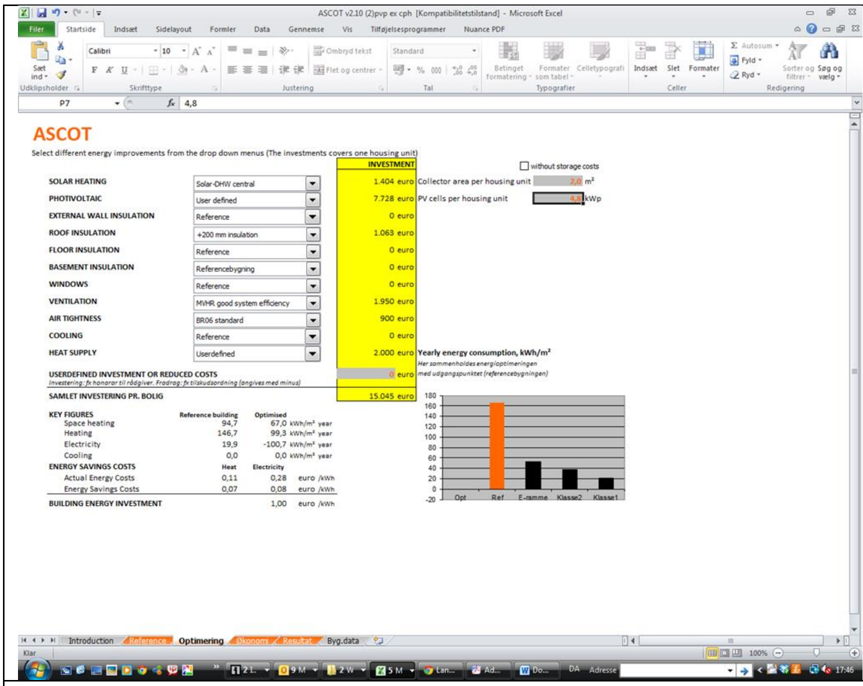
ASCOT zero energy results

According to ASCOT total extra costs will here be 29.914 EURO and the yearly saving will be: 1565+195= 1760 EURO, leading to a pay-back time of 17 years.

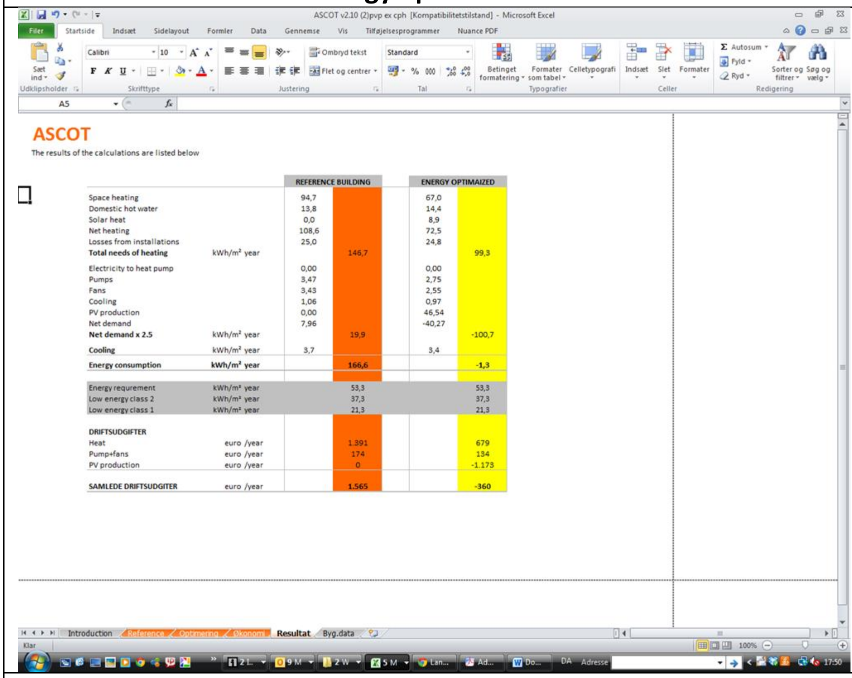
Here it should be mentioned that there will always be individual aspects with respect to maintenance costs etc. which is relevant to include to get the best possible analysis.

As an alternative you can also investigate a solution where you just increase the size of the PV installation to 4.8 kWp and avoid the before mentioned extra energy savings. And due to the much reduced PV costs the total investment of this energy saving package will only be 15.045 EURO with a yearly saving of:

1565+360 = <u>1925 EURO</u> according to the original Danish PV netmetering scheme so a pay-back time of <u>8 years</u> can be maintained. This is however very depended on the local PV regulation or f.ex rules concerning PV feed in tariffs.



Alternative ASCOT zero energy optimisation with more PV area



Alternative ASCOT zero energy results

12. Performance Documentation and Energy Quality Control

The area of performance documentation and energy quality control was from the beginning defined as one of the most important areas to work with in the Green Solar Cites , EU Concerto project. 6 years of experiences have shown that this is still a very important area. Due to this we here include first the introduction on the Green Solar Cities approach in the prepared, Green Solar Cities book by Earthscan, and combine with an introduction monitoring results and experiences from Sweden where performed documentation is already a demand in the building regulations.

12.1

The basic idea of the Green Solar Cities publication is to use many examples from practice, including experiences from the EU-Concerto project Green Solar Cities (2007-2013), to show that the whole idea of making low energy building to a large extent, is about introducing a quality agenda for buildings. In addition, to accept that without this approach, we will just see buildings and large renovation projects being made in the normal style, which means that they are leaking, full of coldbridges and have a quite poor indoor comfort for the users. The passive house movement in the 1990'es clearly showed the truth in this. Here it was clearly demonstrated, mainly in Germany and Austria, that if you were very clear about having high quality constructions without coldbridges and air leakages, and if you combined this with heat recovery of the ventilation air, then you could in principle make buildings with nearly no need for heating.

When the passive house results was first discussed in Denmark in a broader forum after year 2000, there had until then been an idea to go in the opposite direction, and mainly work with natural ventilation.

And since many architects were becoming familiar with this, the new passive house agenda was difficult to understand. As one of them asked, "Does that mean we will have to introduce mechanical ventilation again?"

This was actually the fact. However, like introducing passive house qualities in the constructions, it was here very important to communicate, that it was not just normal mechanical ventilation we needed, but also here a high quality version. That meant that the efficiency of the heat recovery should be high (more than 80 – 85 %) and the electricity use for the fans should be low (this was proved to be as low as 20 W per housing unit in several cases).

However, due to a lack of clear standards to document these things in practice, it has unfortunately proved very difficult to control this.

The experience is, that it is very difficult e.g. to ensure, that a mechanical ventilation system actually have a low electricity use, unless you can ensure a direct survey of this towards the users and building owners.

And this is actually here there exist a good background today to secure the next step of low energy buildings, which means buildings where you have easy access to all basic energy uses on a direct online basis. This is possible both when it comes to different electricity and heating uses, as well as for basic comfort indicators like indoor temperature and humidity, CO2 level and even daylight. With the latest Wi-Fi technologies, it can also be made at low costs, so it is possible to obtain proof of your overall energy quality, documenting that you will get what you actually have paid for.

If this can be introduced as a general approach for buildings, then we can create the same attitude to buildings as we know from e.g. cars, where there is a strong competition to deliver solutions which can run many kilometres on a certain amount of fuel.

In addition, it can at the same time create the basis of the final demand to create nearly zero energy buildings, which includes the integration of renewables, especially use of solar energy. To secure such a transformation is to a long extent also a matter of working with introduction of basic qualities. In this case, also qualities of integrating the solutions in a nice architectural way, so they can become a benefit to our cities at the same time ensuring, that they can fit well into the energy supply systems that we have.

The whole package described here is what you can together call the Green Solar Cities approach.

If it is possible to secure the necessary documentation of the qualities of energy and comfort qualities incl. the used renewable energy solutions, then it is not only in Denmark, which has the world's highest energy costs, that there will be a demand for this.

At the same time, it will then be an approach, which can appeal to countries, that have no or very limited taxes on energy like the UK and the US. This is because it at the end of the day is natural to demand as high qualities for your buildings and cities as possible, when it is possible in practice to document the performance, so everybody can understand it.

12.2 Monitoring Green Solar Cities - Evaluation of the main measurement results

Jappe Goud, Energy Consultant, W/E Consultants, Eindhoven, The Netherlands

Green Solar Cities is a consortium in which two EU-CONCERTO sites, Valby in Copenhagen and Lehen in Salzburg and a number of partners cooperate. 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 include 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 deliverable *Monitoring in Green Solar Cities - Evaluation of the main monitoring results* and other reports on monitoring.

We (W\E consultants) were designated as evaluator of the monitoring and measurement work that is done within the Green Solar Cities consortium.

<u>Monitoring results – heating</u>

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 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.

In 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 higher than the calculated values and also slightly higher than the CONCERTO goal. The goals for DHW were realised in theory and practice.

Reasons for the higher real energy consumption compared to the calculations include:

Start up effects

Cold winter of 2011-2012 in Copenhagen.

Higher indoor temperature than assumed in calculations.

Possibly higher heat losses and lower airtightness of the building envelop.

Measurements of more buildings and during the second year of use of the buildings will show how severe the effect of higher energy consumption will be.

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 average energy savings are €40 a month, so the net yearly costs for the tenants did indeed decrease by the renovation.

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 aquifer 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 monthly energy prepayments 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 caused by a difference between the actual behaviour of the tenants and the assumed behaviour for the calculations. Or, it might be that the deviations occur because the installation is not running fully optimized yet in this first year after completion of the project.

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 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 and collected an impressive data set. However, the collection of data has not finished yet , for several reasons:

    a. A considerable number of projects started later than initially foreseen. Therefore 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.

    b. 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 Salburg and Langgadehus in Copenhagen, as well as by our experience in The Netherlands. Also, for buildings like schools and swimming pools, with a 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.

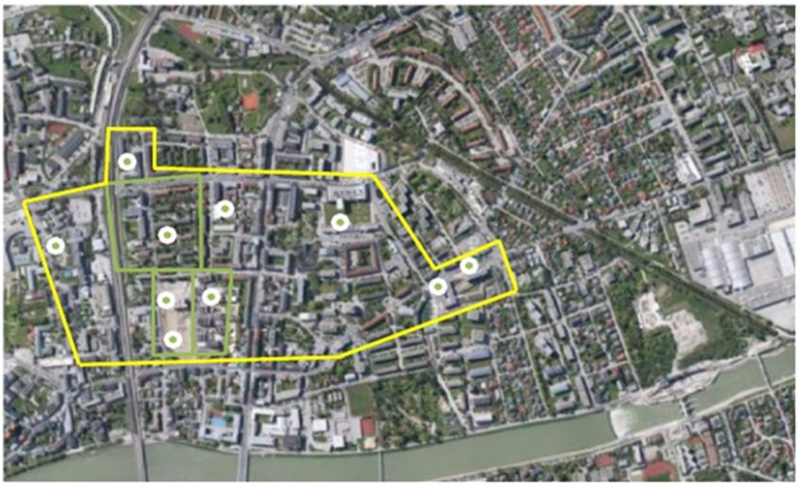
Recommendations

5. Expand the 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.

6. Standard energy performance methods prove to be 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.

7. 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.



The Green Quality Building Process.

Can be used to support the new Energy Performance Directive for Buildings in the EU member states.

t is consisting of:

1. Green Quality Classification with classes A, B, C, D, E .... →	*Based on performance demands e.g. for best available technologies*
2. Green Quality Points (e.g. based on Green Build system)	
3. Green Quality Evaluation →	*Check system concerning performance demands. Use of performance verifications procedure (PVP). Use of green quality model. Development of certification system.*
4. Green Quality Financiation (e.g. with special low interest rate options)	
Based on *a) total economy analysis /optimisation* *b) life-cycle quality of chosen solutions* }	*Economic energy saving packages can be realised Quality and Performance Optimisation.*
c) use of general sustainability *d) green quality points can be linked to obtain support for necessary process concerning quality measures:* }	*Necessary allocation of certain % of total investment for this and perhaps also item c).*
5. Training Activities.	*E.g. use of Green Catalogue system and best practice examples.*
6. Awareness Campaigns and general pro-motions:	*-Involving the users* *-Can be promoted more easily when it is possible to document good results and a transparent and reliable financing system.*
7. Demonstration Activities:	*Here can e.g. be shown an optimised balance between energy savings and a necessary high quality indoor air climate and adapted low cost energy supply solutions for low energy building.*
8. Implementation campaigns:	*Here a co-operation with recognised independent organisations can be useful like, WWF e.g. also in connection to certification.*

12.3 Performance documentation

Swedish experiences regarding calculated and measured energy consumption in newer low-energy buildings

Peder Vejsig Pedersen, technical coordinator of Green Solar Cities and 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 cannot 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 3 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).

Swedish experiences with demands on documentation of energy saving results in practice.
At a conference held in Malmö on the 7. April 2011 there was a very interesting presentation by the authority "Boverket", which is responsible for the building rules in Sweden. Here there was focus on the new Swedish building policy, which includes a demand for verification by monitoring concerning the energy quality of new building projects. This means that within a 2 year period after the realisation of a new building project, it is necessary to have at least 1 year of monitoring results by an independent energy expert to be able to make a final certification of the building project.
It is here the builder who is responsible for the verification and it is also here recommended to take into account the practical use of the building e.g. with respect to influence of indoor temperatures and hot water use in practice.
The new demands have led to almost a revolution in the attitude to practical energy savings in Sweden, so large building contractor companies is now in close contact with the builders implementing means for practical monitoring and documentation concerning use of heating, domestic hot water and electricity in new building projects.
At the same time a new standard concerning energy in building projects "SVEBY" has been developed.

This consists of 3 main elements:
1. Calculations (based on standardised energy data)
2. Agreement (energy demands and ways to handle non-performance concerning these)
3. Verification (method for monitoring, follow up and analysis)
It is still being discussed here, if the above mentioned should be combined with a more widely use of guaranteed key performance demands concerning individual technical solutions in the building projects to reach the energy saving targets in practice.
An important reason for the here mentioned practice in Sweden is experiences with much higher energy use (60 – 70%) in several new building projects compared to what was calculated.
One way to secure better results in practice is to insist on making energy calculations in all building phases' incl. predesign, design and realisation and when the contractor is made responsible for the results, they will also support this. Besides it will be important to use this practice also for large renovation projects.

13. Socio Economic Results

CONCLUSIONS AND RECOMMENDATIONS

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

Introduction

One of the main aims of the EU Concerto program is to introduce low energy solutions renewables in European cities. This target fits very well into the aims of the cities of Salzburg and Copenhagen which have high ambitions on for their cities goals on the climate agenda. Salzburg Land and Stadt has for a long period focused on low energy building and their famous "energy point system" has influenced the building and housing sector to use low energy solutions and widespread use of solar thermal power. Several multi-storeys passive house buildings (ex. Esshaverstrasse) have been constructed in the region and Salzburg has been and still is a frontrunner on implementing the European Energy Performance Directive and find low energy solution for cities. Copenhagen has ass well big ambitions and wants to be carbon neutral by 2025 and launched several plans to be able to fulfil the goal. The district heating system is turned over to become carbon neutral by using biofuels as well as the power generation and wind turbines. Both cities take part in smart cities initiatives to support their aims for carbon reductions and better city environments.

One part is to introduce low energy technologies and to do RTD work that can lead to new more efficient technologies and use of renewables, another is to get spread out and accepted by the stakeholders. The task of introduce and develop new low energy technology may seem difficult, and many things can go wrong in the process of introducing new technologies and new habits to the building sector, but getting the technology spread out and accepted is even a larger task.

The Green Solar Cities project has been an opportunity to overcome these barriers and to influence the building sector, the landlords, the tenants and users, the citizens and the politicians of Salzburg and Copenhagen. Many initiatives have been lunched and many results have been achieved.

Copenhagen; and the urban district Valby and Salzburg; with the Lehen area of the former Stadtwerk has to of course to different stories which are essential for development and the cooperation between the two cities areas.

The following section answers some of the questions which have been crucial in the Green Solar Cities project and give some recommendation.

Who are the stakeholders in support of sustainable energy and socio-economic quality and how is collaboration organized, with what formal and informal structures, which intensity of information exchange and about which type of decisions

Indicators are:

-Intensity of collaboration and capacities, decision power.

-Financial support, intensity of actions and support from citizens and effect on commitment.

The partners in Green Solar Cities in Copenhagen had and still have a strong connection. On the project level, new coalitions have to be started and developed and sometimes this seems not working out after several months. The open structure has to do with the rather limited role of the city government in finding demonstration projects of managing the participation process of the many involved stakeholders.

In Salzburg, all stakeholders have a role in the project structure and the rules have been set through the Quality Agreement, with a guiding role of the city administration. This works very well. The installation of the steering committee in Salzburg especially is judged very positively by all partners. The monthly meetings (every 1st Tuesday) of the partners' decision-makers and additional experts result in excellent communication which has a very positive effect on the quality of the project and the successful meeting of staged deadlines. The steering group is the responsibility of the city councillor and this is a positive aspect. It is recommended that the Steering Group is maintained (possibly at longer intervals).

The quality agreement in Salzburg was considered in the whole planning phase and all technical target values are reached and often surpassed. The solar solution with a 2000 m2 thermal collector area and integrated heat pump was planned exactly according to the set targets. The exact definitions of the targets, but also of the roles of the partners have proved very effective.

What is the quantity and quality, in terms of participation level, influence on decision making and output, of the involvement of citizens/occupants in the projects

Indicators are: Number of participants and type of decisions and Involvement, user orientation of plans, perceived quality

Despite good intentions and much study dedicated to participative planning, we have to conclude that the practical output of consumers on the planning process of new buildings and renovation plans is rather poor. Involvement in plans for the public domain is much better, and has a longer cultural history in the world of planners. The public domain is recognised as the best place to make people of different cultures meet, to level out socio-economic differences and to make a connection with plans, so parks and playgrounds and public squares or the "boulevard" is used well.

What innovations have been applied to make technical systems more user friendly and to give users feedback on energy performance and individual energy use

Indicators are: Number of measures and Impact on energy performance

Despite the poor practice of participative planning, all partners have a keen perception of the importance of user oriented design. In Copenhagen this leads to promotion of integrated design processes, in Salzburg this leads to relieving the occupants from complex and non-robust control options and all kinds of maintenance duties.

Exchange of experienced between the project partners has been very successful on the following innovations:

- Biomass integration in heat distribution networks
- Solar heat integration in heat distribution networks

- PV support schedules and integration
- Stimulation of higher energy performance quality
- User friendly heat recovery ventilation systems
- Monitoring and feedback systems
- Community action planning

Most of these innovations are out of the influence of users and even outside of the dwellings. Collective heat recovery has been favoured, meaning that the individual dwellings receive preconditioned air of good quality and in well controlled volumes. Individual surplus is possible through opening of windows or doors.

The newly developed innovative heat recovery ventilation systems in Denmark are rewarded for low acoustic levels, which is a major requirement in terms of user friendliness.

The monitoring systems focus on assurance that technical systems work properly, meaning in support of maintenance and cost management purposes. Despite reluctance to provide occupants with displays on energy use, including feedback on energy consumption, a test phase is in operation now. In April 2013 results become available, both about the user aspects of monitoring-with-feedback systems and also about the effect of monitoring-with-feedback on actual energy savings. More studies on the effect of user adapted energy behaviour are conducted in FP7 projects (for instance Beem-up). In some of these projects, the ambition is to reach 20% reduction due to adapted behaviour. Practical effects indicate levels in the range of only 5%, but sometimes and especially with collective systems, 20% has been reached, mainly through adding individual cost distribution (which is a technical measure with great impact on behaviour). In all projects, individual energy cost distribution is being applied, so this effect will be reached anyhow. We have to wait for evaluation results.

How satisfied are the occupants with the dwellings and related (energy) services

What contribution can be expected from energy conscious behaviour on energy use

Indicators are: Requests for advice Perception of users

The project Stadtwerk Lehen itself shows very high site qualities due to its central location, the only slight disturbance being the sound pollution from the railway and Gaswerkgasse. But the effects on the individual apartments when built are very low. The standard of the technical and facility quality is also very high. There are slight deficits as far as open space planning is concerned. Given the high urban density, high planning quality can be determined; the only negative aspect is the low water infiltration possibility due to the hard surfaces.

The housing manager reports no problems with indoor climate and control options. The major complaints have a social and communication background. We will have to wait for the socio-economic evaluation results in April 2013.

What has been realized to make energy measures more cost efficient

Indicators are: Type and amount of investments and Impact on market

Point of inspiration is the Energy Point system that subsidises energy measure more when energy ambitions are higher. The next step is the point system for sustainable performance, which is a wider approach than energy performance.

A major cost effective measure is moving the investment and management role of district heating and solar arrays to energy agencies. This is at first sight not cost effective, but will be better in the long run, because the financial risk is not a load for the housing association and also control and maintenance is supported with better expertise at a lower cost level.

The focus on integrative technical solutions can be considered as cost effective approach.

The focus on collective systems makes the investment cost higher and even the maintenance cost, but the quality will be guaranteed for a long period of time, so in the end thiks approach can be cost effective.

The passive house approach is considered as quite rigid. A more pragmatic approach will lead to more cost effective solutions, without reducing the energy ambition. The ventilation with heat recovery is considered as a positive application, but a more simplified system of controlled inlet directly from the façade and some central exhaust points could meet comfort standards and energy ambitions as well, while the user satisfaction could be higher. Investment and maintenance cost are lower than heat recovery ventilation; the overall energy use could be on the same level, as new insights reveal: low energy dwellings with many technical appliances are often leading to higher energy consumption than was calculated for.

The overall energy performance of the projects in Green Solar cities scores high, as is being told by project managers. The high energy values correspond to the set targets of the Concerto project Green Solar Cities. But this will be explained in other deliverables.

What is the level of (rent and) energy cost, compared to the reference situation

A surprising remark in most renovation projects is that the rent increase is much lower that the energy cost reduction. Even tenants are aware of the good deal when accepting the renovation. For new dwellings the rent level plus energy cost does not reveal the investments in high energy performance. Because of the great need of housing and especially social housing, all apartments are rented out without problems and tenants are pleased they have found an apartment. Higher rent than the reference situation is of low relevance.

Which innovative elements are useful for other cities

Indicators are: Success of new initiatives, number of projects and the level of activity, innovative quality of the projects.

As listed before the main list of innovative technical aspects is:

- Biomass integration in heat distribution networks

- Solar heat integration in heat distribution networks
- PV support schedules and integration
- Stimulation of higher energy performance quality
- User friendly heat recovery ventilation systems

The social and governance aspects can be listed as well:

- Monitoring and feedback systems
- Community action planning for promoting social ownership of the area and rainsing awareness on sustainable quality and the importance of adapted behaviour
- Energy point system
- The role of energy agencies
- The role of steering group and quality agreements

Some evaluations in Salzburg consider too much focus on energy, too little on traffic issues (mainly Lehen) and quality of the open spaces in high-density urban areas.

Recommendations

The community action strategy applied in Stadtwerk:Lehen and in Valby applies to a larger area and other cities. Community work needs a long time frame. However, more responsibility (and positive action) can be facilitated among the occupants of buildings. The future of participation is for creative and positive social active people, who can take responsibility for guiding projects and know how to realise high quality of urban social context. It would be great when the City recognises this and helps officials and administrators to support and facilitate this turnover to citizen-based developments.

Key Points and Future Actions

- Take action immediately after project initiative to prepare for co-production with citizens
- Involve representatives of occupants in planning teams
- Extend the borders of community action across the demonstration projects
- Give community information centers public support
- Connect top-down and bottom-up processes

- Apply new social media as means of communication and connect this to the need of physical meeting opportunities
- Reanimate the Quality Assessment working groups
- Continue with local Workshops and partnerships with other cities
- Make, as a city in the City Council, a statement about long lasting commitment to community action and sustainable quality.

Indoor climate and user satisfaction – Ventilation in dwellings

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 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 Osterreich 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 loft 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 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.

Fact Box

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 6 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.

14. User experiences

Indoor climate and user satisfaction – Ventilation in dwellings

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. What are the experiences from users and experts?

A change for 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?

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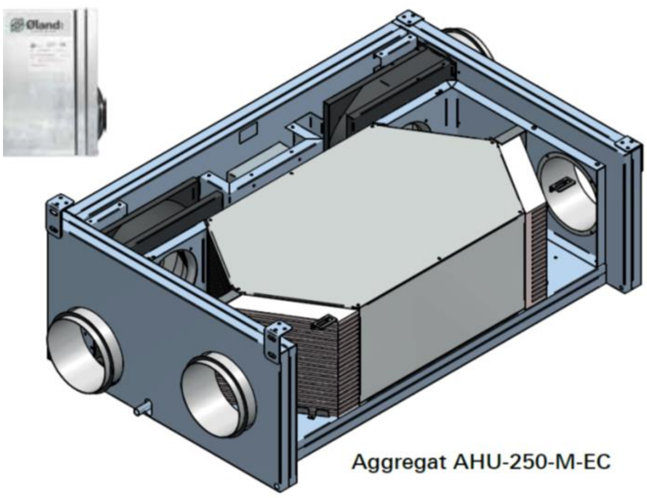

Compact Heat Recovery Ventilation unit for housing renovation, where electricity use is matched by Photo Voltaic. A test of the compact HRV unit from EcoVent / Øland shows a dry heat recovery ventilation efficiency higher than 85 %. Combined air inlet and heating - only 22 cm thick. Developed by EcoVent to fit into a cupboard or a wall

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Noise is a serious comfort issue in many mechanically 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 due to bad electrical fans. 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)).

The passive house in Esshaverstraße in Lehen, Salzburg

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Recommendations and new experimental ventilation solution

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.

Central ventilations systems seem to be more energy consuming due to pressure fall in the ventilations ducts and because of fire dampers. In general the landlords prefer the central solution because of easy access for maintenance and filter shift, but the central solution can cause more trouble and less user satisfactions because they are more complicated to adjust.

VHR is even more complicated when it comes to refurbishment of existing buildings. Space for both ducts and ventilation units are not easy to find, and good solution for fulfilling the needed ducts in the apartments are difficult and expensive.

In Green Solar Cities an experiment with a compact HRV unit has been tried out by placing the unit under the window and putting in a new radiator. This could be a rather cheap solution due to low cost of the unit and low cost for the installation, and by keeping the existing exhaust ventilation on the toilet and in the kitchen.

The results from the experiment seem promising but it is too early to draw the conclusions.

How much focus on user involvement?

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 centres 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 face-book 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.

15. Community training activities

Training within Green Solar Cities project has been following previously experienced good results from using a methodology based on stimulating urban management by use of demonstration projects – to raise project stakeholders’ and citizens’ awareness – and to help city politicians and municipal staff etc. to further new initiatives that will support sustainable urban efficiency and development.

Key persons involved in setting up Community Action Planning has been a main target group for the training sessions – and also local stakeholders for Concerto project implementation in both communities.

Training model being used is illustrated in following figure:
Sustainable Energy Community (SEC) approach:

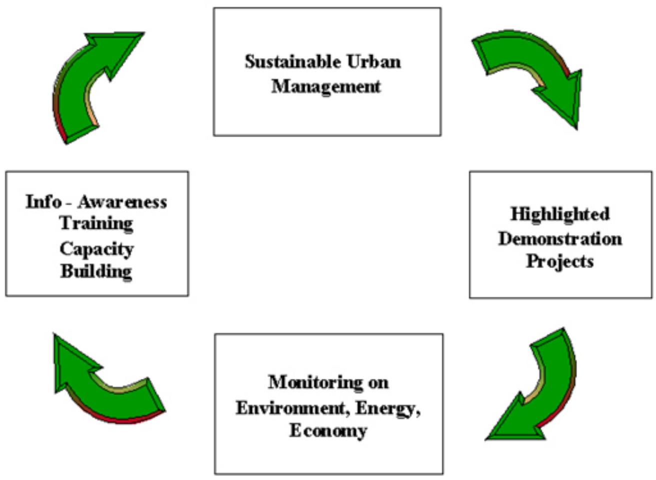


Figure 1 Community action plan implementation methodology:

1. *Highlight the demonstration projects as a way of improving the implementation of similar projects and gradually improve into SEC reality behaviours.*
2. *Monitor energy, environmental and economic effects into easy accessible results.*
3. *Provide information to citizens, companies, employees and managers within involved public and private departments/companies, politicians. Awareness is the first crucial step towards participation,*

learning, education, and training - which then produces capacity building and institutional strengthening for involved stakeholders.

4. *Involved citizens, politicians, city administration departments etc. will use experiences from the demonstration projects to further adjust/develop SEC objectives, strategies, action plans, actual projects and guidelines for the local SEC area - and thus improve sustainable urban management into SEC reality.*

As illustrated some of the "info" is being disseminated to create awareness, and some is used for training, but will both also often be part of the"dissemination" .

Training for key persons in RTD work took place in different workshops on 1 July 2010 in connection to partner meeting within Green Solar Cities project – and combined with excursion to low energy building projects in Malmö, Sweden, on following day 2 July 2010.

The training sessions relate to 3 important project groups in Green Solar Cities:

- Passive house and low energy standards
- Heat recovery ventilation and airtightness
- Cost effective building integrated PV

For each training session was prepared input and instruction from one or more partners – to give inspiration and experiences for following discussion and preliminary conclusions for the actual RTD theme. Final report on RTD theme work has been finished in autumn 2011.

Training of key persons involved in Energy Quality Control work has been linked closely to:

- Green Quality Building design methods
- Green Quality Building control methods

We carried out first training session in May 2009 focusing on design and control methods – as much design work in both Salzburg and Copenhagen was done during 2009 – 2010.

Second training session was in July 2010 with a main focus on energy survey in Salzburg and Copenhagen being basis for converting monitoring on individual demo project buildings into community level results regarding energy efficiency improvements from Concerto project.

Training on key persons involved in local design and implementation has been carried out in several training sessions:

- Study tour to Salzburg Oct 2008 (Copenhagen / Salzburg)
- Theme day: Innovative district heating for low energy building April 2010 (Copenhagen)
- Theme day: Solar energy and prefab low energy building May 2010 (Copenhagen)
- Workshop: Local sustainability Sept 2010 (Copenhagen)
- Symposium: More than renovation June 2010 (Salzburg)
- Workshop: Passive house academy Sept 2010 (Salzburg)

Also other training sessions have been carried out during this 5th and 6th reporting period:

In Copenhagen conference and training session was carried out on 7-8 October 2011 in Valby, where 120 participants in Valby Cultural Centre had presentation and discussion about energy efficiency in new-built and renovation based on some of Valby Concerto demo projects being presented. And next day connected exhibition on the "Climate Bazar" showed PV systems and heat-recovery systems etc.

On 25 November 2011 was arranged another theme-day and training session in Copenhagen about experiences with low-energy building and building certification systems, which was of highly interest for the 90 participants representing housing associations, architects, engineers etc.

Two training workshops with Copenhagen Municipality together with 5 other biggest Danish municipalities were carried out 1 March and 13 June 2012 focusing on municipal energy strategy planning.

This was kind of follow-up on several workshops during 2010-12 with a focus to remove barriers for sustainable urban development in the legislation for local planning documents. Green Cities arranged in cooperation with Association of Sustainable Cities & Building – and cooperated also with the Ministry of Urban Development about a concluding conference 26 March 2012.

In Salzburg several excursions were lead, so in September 2011 a group of Danish planners and members of housing associations and a Norway project group came to visit Lehen.

16. Speech by the coordinator

Concerto II Conference "Green Solar Cities" at Salzburg 16th of April 2013
"European Targets – local realization"
Aims and experience of implementation

Looking back at 6 years of collaboration
Experiences and results Copenhagen – Valby
Jakob Klint, Kuben Management

I am looking back on 6 years of work with great experiences and great results from the EU Concerto project "Green Solar Cities". Many things have been achieved in Lehen/Salzburg and Valby/ Copenhagen and the collaboration between all the partners have made steps towards lowering the consumption of energy and to more carbon neutral cities. There are still many steps to be taken during the coming years, no question about that, and new challenges have also been visible during the process and the year past. These words are a little story on these experiences, results and new challenges from a Valby /Copenhagen perspective.

We started out with a kick of meeting in Copenhagen 15th of November 2007, and I remember the conference at the town hall with the Landesrat Walter Blachfellner and Stadtrat Martin Panosch from Salzburg Land and Stadt, and Deputy Mayor Claus Bondam of Copenhagen.

I also remember the day before biking trough the western part of Copenhagen in a clear cold sunny day with a hard wind coming from west. We were freezing when we looked at urban renewal results of the 90'ties at the urban area of *Vesterbro*, latter visiting the old Carlsberg brewery and hearing about their plans for developing a new city on basis of old brewery buildings and infrastructure, and then continuing to "the villages of Valby" and heir their plans for the future.

Next year we came to Salzburg in October in a slightly warmer weather taking part in the conference on the development of Stadverk Lehen, hearing about experience on low energy buildings, thermal solar power and passive houses. At that time I think Copenhagen had so much to learn on low energy buildings from Salzburg, seen from a Danish perspective. How could we succeed and make results? Salzburg already had passive houses.

Opportunities and challenges

We have got the EU support to take action on climate issues, and City of Copenhagen took active part with ambitions on the climate agenda and by supporting the Green Solar Cities project. At that time the National Government had very small ambitions on climate issues, but more fatal was, the upcoming financial crisis. It very much closed down the boom of private builders and developers in Copenhagen. Many of the building sites and building projects in Valby was postponed, delayed and cancelled. We had to shift to other sites.

The buildings of Vildrose I and II was finished before the crisis. Prefabricated low energy buildings , and the first site of the affordable housing program targeting middle income families. This program has today been taken over by several social housing associations and spread national vide.

Langgadehus with nursing home for elderly people in the two first levels and private condominiums in the next two levels has to be change to social housing units instead.

We changed from focusing on private developers to public building and social housing because they were more independent on the economic trends. The former industrial site of Carlsberg and the F.L. Smith was changes to Dr. Ingrid Plejehjem (nursing home for elderly people), Hornemanns Vænge (retrofit of Social housing department) and Public Schools.

There were also opportunities. The implementation of the EU Energy Performance Directive (EPD) in the Danish national building code and the building crisis gave an opportunity for the builders to adapt to the new demands. Actually I think the crisis helped this development due to the competition among the builders, architects, engineers and other advisors. They have to fulfil the new energy demands to stay in business.

The upcoming UN COP 15 meeting in Copenhagen (United Nations Climate Change Conference) accelerated this development and the political agenda suddenly changed to energy savings and carbon reduction. Even though the results from the negotiations at the COP 15 meeting were rather weak it really raised the agenda on climate in the minds of everybody. Energy was suddenly an issue and was taken into consideration when you talked with officials in the municipality, the social housing associations, the private developers and people working in the building sector. New buildings had to lower the energy demands. Retrofitting of buildings had to incorporate low energy measures. Renewables as wind turbines, solar power and biomass was much more seriously considered.

The overall experience and result of the project can in my view be extracted to these bullets:

- The development on new low energy building is going fast – and the demands on reaching low energy performance are constantly being raised. That’s very good.
- There are snakes in paradise - the realized energy consumption in new building is higher than the calculated demand.
- There is a need for energy performance guaranties and procedures to follow up on monitoring.
- Quality control is important but is seldom done properly – building certification could be a solution.
- Overheating in summertime is often a problem due to solar radiation.
- Energy efficient balanced ventilation with heat recovery is still a challenge for both contractors and the end users.

- Energy control, energy management and “intelligent houses” could be solution to lower the consumption of energy.
- User behaviour has large influence on the ability to reach low energy performance – wrong user behaviour can raise energy consumption dramatically.
- Retrofitting of existing building, energy renovation and renewables is the overall most important measures to take into account to reach low carbon cities.

From the project start there were focus on the professionals and the large buildings, we also created commitment among citizens by a small program for supporting photo voltaic (PV) for single family houses. Many of the most enthusiastic citizens of Valby – the front runners – put up solar panels on their roofs. It created engagement, discussion, knowledge and local development, and made energy savings and renewables to something for ordinary people. It was now possible to think globally and act locally.

“European Targets – local realization”

Even though Valby and Lehen are very small urban projects, the initiatives have an important role in a situation where national and especially global initiatives seems to be rather stocked. Small successes are important and can balance large failures and give hope and development. You know - small is beautiful. Local engagement is essential for the continuation of the development and innovation on low energy solutions, technical, financial and organizational – know doubt about that. And even more important: It creates the opportunities to have nice dreams for the future – and it spreads like ripples in the water. If they can do, we can do - and we can even do better.

We did it and we did it together! Thank you for having the pleasure of taking part in EU Concerto program and thank you for a useful and important collaboration.

Edited speech given at the end conference Salzburg, April 2013

17. Replication projects

Below is given a short introduction to two activities, which has been initiated during the realisation of the Green Solar Cities project in Valby, Copenhagen. Besides can also be mentioned best practice work on BIPV in Copenhagen, together with building integration of PV at the Søpassagen housing project in Copenhagen (see page 46), together with plans for smart grid school renovation in Copenhagen.

17.1 Active House Renovation in Albertslund

Abstract

Due to foreseen large scale renovation for 3000 housing units in the city of Albertslund, west of Copenhagen in Denmark, it was decided that the municipality will only accept a renovation standard equal to the minimum standard for new build, but the aim is actually to be able to reach a much better standard aiming towards the aimed building standards for year 2015 or 2020 in Denmark. Also the possibility of meeting a 100 % zero energy standards based on solar energy combined heat and power, which can be financed by the local district heating company, is being investigated. This will at the same time support the aim to cover 10 – 15 % of all electricity use in Albertslund with solar power by year 2020.

The first Danish Zero Energy Housing Renovation project – The Hyldespjældet – test house in Albertslund with the prefabricated installation element on the roof, the SolarPrism, and with prefabricated construction elements, was realised in 2009 in a public private partnership also involving the large building component companies, VELUX, Rockwool and Danfoss together with the companies Kuben Management, Moe & Brødsgaard, Rubow Architects and Cenergia in cooperarion with The Danish Technological Institute and the housing association, Bo-Vest. This has at the same time supported the choice of Albertslund as the Energy Municipality 2011 in the 5 Nordic countries. VELUX and Danfoss are now promoting the Solar Prism technology as part of a common “Solar Solution” concept. (www.velux.dk/solarsolution).

RTD work in connection to large scale renovation in Albertslund

Background concerning housing renovation in Albertslund

In the municipality of Albertslund they have agreed that they want to become the Danish climate test site concerning energy efficient renovation of concrete housing areas, since many billions DKK will be invested during the coming years. In order to show that advanced energy solutions- which for instance live up to the Danish low-energy class 2015 or 2020 levels are possible to realise with a positive economy and improved comfort, it is, with supplementing founding from the Danish EUDP programme the plan to establish “example” renovation projects several places in Albertslund as a mean to identify the extra cost and total economy of these solutions. In Albertslund South (the southern part of Albertslund) the largest retrofitting project in the Danish history is currently in progress. The project is called “Master plan South”, it includes the retrofitting of a about 2200 dwelling, and it consists of three phases;

- 623 multi-storey dwelling – the construction work was initiated in 2007
- 552 terraced houses – the construction work will be initiated in 2012
- 1000 atrium houses – the construction work will be initiated in 2013

The Danish Housing Association, BO-VEST is responsible for this, the largest and most costly renovation plan for social housing in Denmark. BO-VEST represents the housing societies that own the 2200 dwellings (Albertslund Boligselskab and Vridsløselille Andelsboligforening). At BO-VEST, and in the municipality of Albertslund (as described above), there is a real devotion to optimise the renovation approach including a low energy renovation design with improved indoor air climate and an optimised energy supply solution. The occupants of the 2200 dwellings are also very eager to reach an ambitious level of energy efficiency when the dwellings are renovated.

Main results

The first demonstration project in Albertslund, which was supported by the Danish EUDP programme, The Social Housing Fund and Albertslund Municipality, was made in 2009 in the housing area Hyldespjældet. The basic idea was here to utilise prefabricated construction elements, together with a prefabricated installation module on the flat roof – the Solar Prism. The Solar Prism is a modular system developed by Cenergia and Rubow Architects in co-operation with VELUX and Danfoss. In Hyldespjældet it includes all installation elements, so you do not need to introduce installations inside the renovated dwellings. This can together with good financing possibilities based on municipal guaranteed loans for the social housing investments secure a reasonable balance for the tenants, between extra yearly capital costs and the value of the energy savings, so a quality up to 0-energy housing renovation can be utilised both in coming large scale renovation projects in Albertslund as well as in similar projects in other parts of Denmark. At the same time the concept has huge utilisation prospects in Europe according to VELUX and Danfoss, and the two companies is now including the SolarPrism technology in a common “Solar Solution” concept. In 2012 Cenergias involvement in the Hyldespjældet demonstration project lead to a contribution of the Energy Globe Award 2012 for Denmark

This project was in 2011 followed up by a demonstration project with 6 row houses in different energy qualities designed by Nova 5 Architects and Niras engineers, and during 2012 2 private owned houses will also be renovated as new demonstration projects in Albertslund.

The Solar Prism can combine different prefabricated modules according to individual needs.

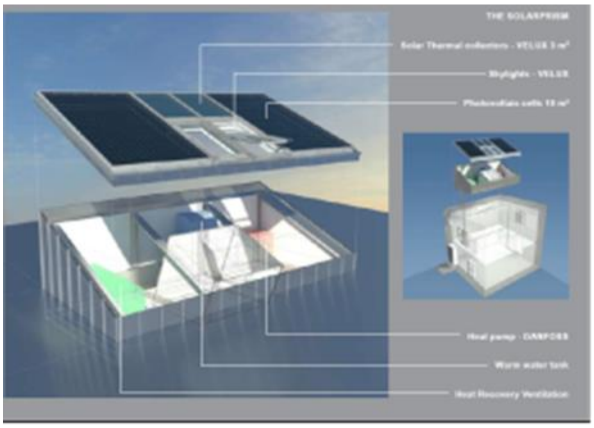


Illustration of the prefabricated Solar Prism and how it was utilised in Albertslund with a heat pump together with a solar domestic hot water tank and a heat recovery ventilation system. And towards the sun VELUX roof windows and solar thermal collectors together with PV modules.

		Energy investment (€)	Efficiency gain (kWh/m^2, year)	Energy investment / Efficiency gain
1.	Normal renovation	19.337	73	265
2.	Improved insulation and windows (excluding necessary change of floor construction, which is very expensive)	2.639	17	155
3.	HRV, airtightness and extra summer ventilation	6.199	38	163
4.	Solar energy combined heat & power	6.770	52	130
5.	Total optimised zero energy saving package incl. savings in connection to prefabrication approach and "decentralised comfort" solutions	12.441	180	69

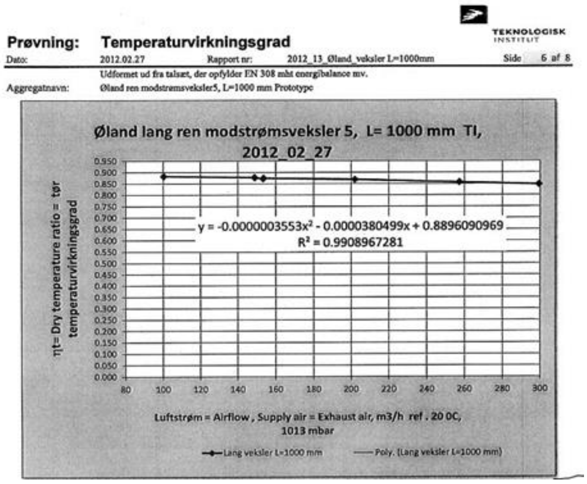
Albertslund South row houses – economy for different solutions compared to the cost of an integrated zero energy renovation concept.

The Solar Prism is placed on the flat roof and includes all installation elements.
Can be purchased from VELUX and Danfoss.

At Hyldespjældet the first zero energy housing renovation in Denmark introducing prefabricated construction elements from Rockwool and Solar Prism installation element.

Building integrated heat recovery ventilation ducting was tested with success in multi storey apartments in Copenhagen in 2008.

Example of decentralised heat recovery ventilation system in each apartment with building integrated components, low electricity use and very satisfied users. The same technology was used in the Solar Prism in Albertslund.

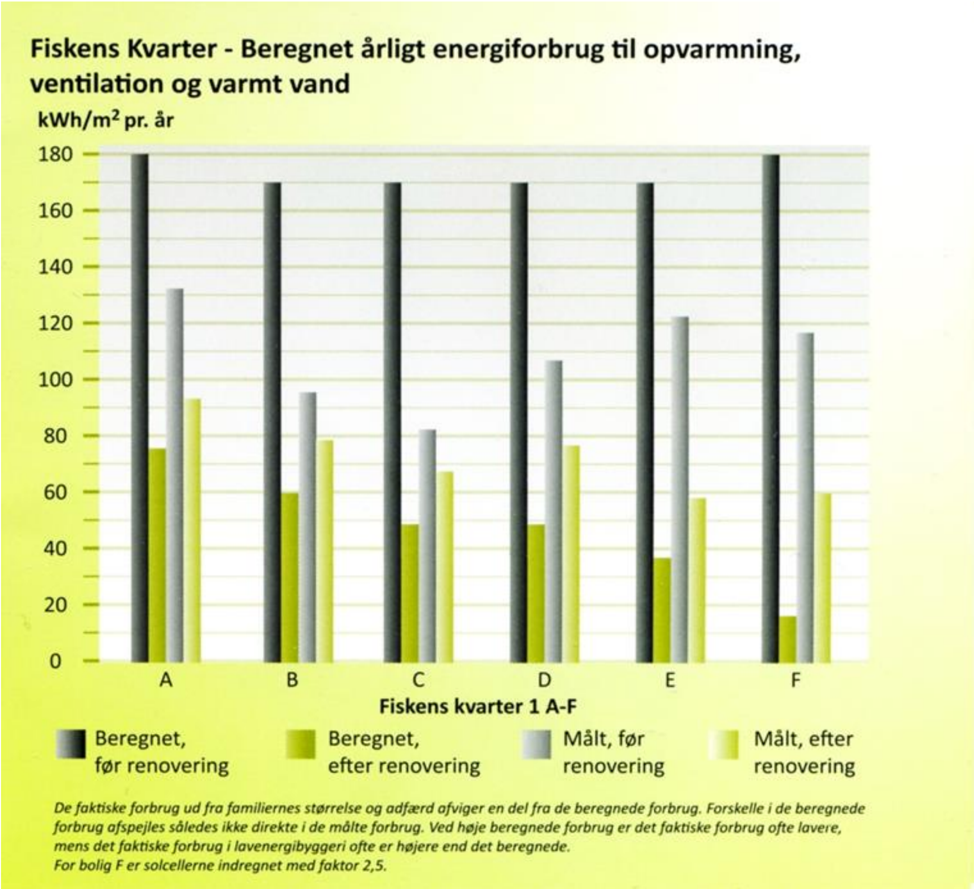


Test of compact HRV unit from EcoVent / Øland showing dry heat recovery ventilation efficiency higher than 85 %. This technology is used in the Solar Prism in Albertslund.


Test row houses finalised in different low energy standards by summer 2011.

Degnehusene in Albertslund will show cost optimised solar roofs in combination with roof windows for a private dwelling with flat roof. A more costly solution where the PV panels has the same tilt as the roof windows (15°) was developed into a cost optimised solution where most of the PV area is only 3-5° while only a small part of the roof with VELUX roof windows near the perimeter has a 15° tilt.

Illustration of PV and VELUX roof window integration in typical one family house from the 1960’es in Albertslund.



Comparison of calculated and measured energy use for 6 different renovated housing units with an increased low energy standard from A-F. Dark and light grey columns shows calculated and measured heating and hot water use before renovation, while dark and light green columns show calculated and measured heating use after renovation was done.

Active Roofs and Facades in Sustainable Renovation

The Nordic Built “Active Roofs and Facades” project has been supported by Nordic Innovation to be able to develop leading Nordic competences in the building renovation area in a strong way by creating transnational Public Private Partnership models to support the development towards nearly zero energy building solutions and associated performance documentation which is also demanded in the EU building directive.

The proposed cooperation with the building industry on developing models and demonstration of “Active House” based sustainable renovation is foreseen to create a strong Nordic cooperation in this area.

The project runs from 2014 to 2017 and will involve companies which are represented in the Nordic countries and involved companies from the international Active House Alliance, whereby the development will use the best transnational competences and network, creating large possibilities for export of technologies.

The background of the situation in both Nordic and European building renovation projects, where actual energy use is quite often 30 – 40 % higher in practice compared to what was expected from the calculations and where innovative solutions are only seldom used, is very much connected to the way the building industry is organised. Here consultants will normally only want to operate in a conservative way, because they are not only selling their expertise, but also the insurance that goes with it and also because consultants fees have been minimised considerably, so it is common to work with well-known large suppliers, who can contribute to large parts of the design process. This means that there is a clear tendency e.g. not to choose the most energy efficient solutions, but allow more mediocre and old fashioned solutions, that the suppliers prefer. And when it is common knowledge that detailed performance of equipment in practice is never controlled, then there is no incentive to perform better, and higher energy use will often be explained by the user behaviour.

In the proposes Nordic Built project a main issue will be to realise the involved renovation projects in a much better way and secure a positive involvement of consultants, so they can be more proactive, e.g. by full scale testing of innovative solutions before large scale implementation and by monitoring of key performance indicators also as basis of negotiating guaranties for performance results as part of the overall procurement process, something which also might be used to avoid normal tendering in connection to development of renovation projects.

<u>Ellebo Garden Room</u>

Winner of the Danish Nordic Built Challenge international architectural competition, “Ellebo Garden Room” by Adam Kahn Architects from London, aimed for realisation in Ballerup west of Copenhagen from 2014. Financiation by the Danish Social Housing Fund makes a high quality solution possible.

Isometric drawing, showing Ellebo with its environs in Ballerup

Ellebo today

There are examples of projects where façade or roof elements with integrated features have been used for renovation, e.g. in Austria, Germany, Denmark and Norway. In these projects the solutions have been developed case by case, and no general solution exists. As the existing buildings are always individual, the specific characteristics will have to be taken into account in any case, but the project team is confident that an ideal solution can be developed, which will integrate the most important features required in typical renovation projects. . The project will develop a concept that will fulfil the typical renovation needs of the Nordic buildings that are most often in need of renovation.

Cenergia has worked with Kuben Management, Copenhagen municipality and other partners on the large EU-Concerto project, Green Solar Cities with demonstration of low energy renovation and use of solar energy in Copenhagen and Salzburg (www.greensolarcities.com) .

Besides Cenergia and other partners from Denmark has since 2003 been involved in a cooperation with large Nordic companies like e.g. the VELUX group to develop zero energy building concepts with a special view to renovation, and has here been involved in development of best practice technologies like SOLTAG, the CO2 neutral rooftop apartment from 2005 (www.soltag.net) and SOLARPRISM from 2009 and 2012 (http://www.youtube.com/watch?v=RxgRDXaMH-M), the last mentioned as part of developing the so-called "Albertslund Concept" which was aiming at sustainable and energy efficient renovation of 4 – 5.000 housing units in Albertslund, west of Copenhagen. In 2012 this lead to Albertslund being elected as Nordic Energy Municipality 2013 (www.albertslund.dk – Politik – Politikker og Strategier – Klimaplan – Albertslundkonceptet). The solar solution has been further developed and has been used for renovating of 10 social houses in Montfort Netherland, moving those buildings from an energy classification of E to A++ according to the Dutch scheme.

Also experiences from the Plan C project on "Sustainable and Energy Efficient Renovation" (plan-c.dk) coordinated by Gate21 from 2010-2013 and with a total budget of 40 mio. DKK will be utilised.

VTT has been involved in the development of the façade element and the renovation of an apartment building in Riihimäki, Finland. In this project, windows, high level insulation and inlet air ducts were integrated in the timber element façade.

Many of the buildings built in big volumes in 1970's are or will soon be in need of renovation. In most Nordic countries, these buildings are built with similar technology, and therefore the solutions that can be applied in a typical building from that era have a great replicability potential. The Nordic cities are often owners of several similar buildings.

The proposed Active Roofs and Facades project will be able to develop leading Nordic competences in the building renovation area in a strong way by creating transnational Public Private Partnership models to support the development towards nearly zero energy building solutions and associated performance documentation which is also demanded in the EU building directive.

The proposed cooperation with the building industry on developing models and demonstration of Active House based sustainable renovation is foreseen to create a strong Nordic cooperation in this area which at the same time will have a large export potential.

It is aimed to cooperate with both the City of Copenhagen as well as other local stakeholders on the further development of the concepts developed in the EUConcerto Green Solar Cities project including use of prefabricated and system based BIPV solutions, use of innovative and low cost building integrated and decentralised heat recovery ventilation systems, use of advanced energy supply and Smart Grid solutions together with intelligent systems for survey and follow up on energy and comfort results.

In connection to social housing renovation there will in the project be a cooperation with the housing associations KAB from Denmark and Botkyrkabygge from Sweden which both are involved in the Nordic Built Challenge.

Besides Active House qualities there will here be a main focus on socio economic activities. E.g. how can you make housing renovation and keep the tenants in the apartments to avoid extra costs for rehousing. And education of tenants to be able to utilise the sustainable renovated housing units in the right way.

The basic idea of the "Active Roofs and Facades" proposal is to develop solutions that can be integrated into buildings and support a completely new way to renovate existing buildings, which is based on:

High quality insulation without coldbridges

New active facades with new glazing design and multifunctional windows

Use of decentralised heat recovery ventilation design integrated into the building envelope and windows

Use of building integrated PV (BIPV) on roof and facade

As part of an overall smart grid approach, for electricity and district heating

Use of integrated daylight solutions, optimizing the daylight in buildings and reducing energy for lighting

Use of integrated performance documentation focusing on all the requirements in the Nordic Build Charter

And finally use of the "Active House Specifications to document the performance of the solutions. "Active House" initiative (www.activehouse.info)

At present it is the idea to develop a number of both apartment building projects as well as school projects in the Nordic countries and renovate them with use of Active Roofs and Facades. The renovation follows the 10 parameters in the Nordic Built Charter as well as the Active Roofs and Facades workplan. The performance of the renovation will be documented using the Active House specification and evaluation.

A Nordic Innovation Initiative for development of Active Roofs and Facades as part of Sustainable Energy Efficient Renovation with Documented Performance

1. <u>There will be utilised an overall" Active House" design approach</u>
   - Introduction of "Active House" integrated energy and environmental design.

   - This includes confirmation of key performance indicators in full scale test rooms before implementation of demonstration projects.

2. <u>There will be a focus on optimised energy supply incl. advanced low temperature heating systems, use of renewable energy and Active Roofs and Facades</u>
   - Investigation of innovative solar energy combined Heat & Power systems
   - Building Integrated PV and Solar Thermal as part of overall innovative Active Roofs & Facades configuration concept.
   - Advanced district heating design based on low temperature operation and possibility for summer stop of operation to avoid district heating losses in periods with low consumption
   - Investigation of innovative PVT solutions.

3. <u>There will be developed, tested and demonstrated an optimised building envelope incl. decentralized ventilation and daylight</u>
   - Advanced and innovative prefabricated insulation solutions, according to a systemic approach avoiding cold bridges and air leakage based on passive house experience.
   - Utilisation of building mass
   - Advanced and innovative window solutions incl. solar shading and day lighting function.
   - Decentralised heat recovery and no noise intelligent ventilation design integrated in building and building envelope in correspondence with PV-assisted natural ventilation and removal of toxic particles by advanced filters.

4. <u>According to the Active House principles, there will be used an Integrated Performance documentation System</u>
   - Use of "Active House" specifications in connection to agreed "performance verification procedure" incl. use of energy signatures.
   - Access to main electricity use and heating and renewable energy data through the internet incl. e.g. lighting, ventilation, appliances, district heating, solar heating, PV electricity
   - Building and district energy data through BEMS information system
   - Control of possible problems with moisture

- Control of indoor air quality

5. <u>It is the idea to use an advanced lighting system.</u>
   - Use of LED technology
   - Utilisation of daylight
   - Optimised user control

6. <u>There will be worked with an overall Smart Building and Solar Energy approach with focus on guarantied energy saving results and lifetime optimised economy.</u>
   - Control of major key performance indicators
   - Continuous survey of energy performance e.g. via App's

18. Dissemination incl. professional articles, presentations and papers

During the 6 years project period from 2007 – 2013 and also after the Green Solar Cities project ended by June 2013, there has been a lot of articles, presentations and papers about the project.

Already in June 2007 there was a presentation at the Sustainable Building 07 conference in Torino. And at the Green Solar Cities, Concerto kick off conference at the city hall in Copenhagen, also in June 2007, there was an audience of 200 people in the "Celebration Hall" with several papers on the projects, both from Copenhagen and Salzburg.

In February 2008, there was a presentation and conference paper presented from Peder Vejsig Pedersen, Cenergia (DK) and Inge Straβl, SIR (AU) at the international Sola Cities 2008 conference in Adelaide, Australia.

Besides this, there has been regulary paper presentations on the half yearly project conferences in Copenhagen and Salzburg, where also large delegations have participated several times from the 2 cities.

In March 2010 a project presentation was given to a large Chinese delegation visiting Denmark and later that year in October a presentation on the project was given in Shanghai in China.

And also in October 2010 there has been a project presentation at the yearly conference of the European Housing Ecology Network, EHEN, which was held in Copenhagen.

And in December 2010, best practice results from the project was presented at a Solar City Copenhagen conference on BIPV in Copenhagen.

In March 2011 a poster presentation based on the project results and work on BIPV was given at the Ecobuild conference in London, and in October 2011 the Danish GSC Concerto team arranged a focus conference on energy renovation in Valby for a large audience.

And by the end of 2011 a book in Danish on Energy and Architecture was made by the "Architects Publishers" with Solar City Copenhagen and others including examples from Valby. By April 2012 a presentation on BIPV and experiences from Valby was given to participants from Aalborg University.

And in September 2012 Kuben Management arranged a thematic day on PV and BIPV in Valby in connection to the EU-Concerto project with many presentations based on the Concerto activities,.

In April 2013 the final Green Solar Cities Concerto conference was held in Salzburg with a number of partners from Copenhagen and other cities being present. Here the main results of the Concerto project was presented.

In 2013 the final EU-Concerto, Green Solar Cities project results has also been disseminated in the Pan European network publication, Government06 with the article "SunCities" and also in Government 07 with an article.

At the same time information has been introduced with Pan European Network at their homepage as well as in their www.horizon2020projects.com website under Energy.

Besides project information has been presented at the GovToday, Carbon Reduction 2013 conference in November 2013 in London.

And when the Green Solar Cities book is published by Earthscan publishers by September 2014, there will also be a presentation of this at the Carbon Reduction 2014 conference in London in October 2014.

19. Partner organisations

EU CONCERTO project: **Global Renewable Energy and**

Environmental Neighbourhoods as Solar Cities

Proposal acronym: **Green Solar Cities**

Type of instrument: Integrated Project

List of participants

No.	**Participant organisation name**	**Participant short name**
1	Coordinator Kuben Management (DK) Project Manager Jakob Klint jk@kubenman.dk Tel.: +45 6029 6035 Fax : +45 3542 3522	Kuben
2	Cenergia (DK)	Cenergia
3	City of Salzburg (AU)	Salzburg City
4	Gswb (non profit housing association) (AU)	Gswb
5	Heimat Österreich (non profit housing association) (AU)	Hö
6	Salzburg Institut für Raumordnung & Wohnen (AU)	SIR
7	Salzburg AG - biggest energy supply company in Salzburg (AU)	Salzburg AG
8	Steinbeis Institut - energy research institute in Stuttgart (DE)	Steinbeis
9	Die Salzburg (non profit housing association) (AU)	DS
10	Green Cities	Green Cities
11	DONG ENERGY (DK)	DONG
12	Grøn Valby (Municipal Environmental Organisation) (DK)	Green Valby
13	Valby City Council (DK)	Valby City Council
15	University of Lund (SE)	University of Lund
16	TU Delft (OTB Research Instutute) (NL)	OTB
17	WE of Delft (sustainable building) (NL)	WE
18	EMI (Hungarian Building Research Institute) (HU)	EMI
19	Prisma	Prisma

Green Solar Cities publication
To be published by Earthscan by September 2014




Integration of solar thermal and PV systems together with low energy new build and renovation projects in Valby Copenhagen

Photo by SIR www.sir.at

Central solar heating system with buffer storage, heat pump and microgrid together with low energy building projects in Lehen Salzburg

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Green Solar Cities

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