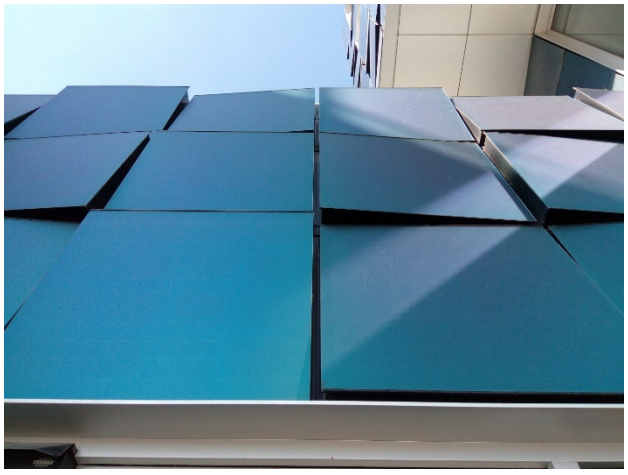
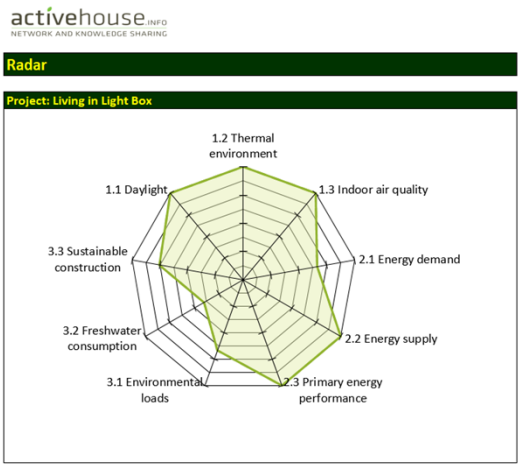
Slutrapport

Smart Grid School-et EUDP BIPV Project

j. nr. 64013-0113





Peder Vejsig Pedersen and Miriam Sanchez-Mayoral
November 2018

CENERGIA

En del af KUBEN MANAGEMENT

1.1. Project details

Project title	Smart Grid School Renovation
Project identification (program abbr-and file)	EUDP-13, j.nr.64013-0113
Name of the programme which has funded the project	EUDP programme
Project managing company/ institution (name and address)	Cenergia (DK)- Now part of Kuben Management. Ellebjergvej 52,2450 Kbh SV Peder Vejsig Pedersen
Project partner	Cenergia, Gaia Solar, Leapcraft, Racell, Ecovent, Energimidt, Copenhagen City Properties, Technological Institute, Kuben Management, Gate 21
CVR	71195414
Date for submission	December 2018

1.2. Short description of the project objective and results

The EUDP BIPV project, Smart Grid School Renovation has been made in connection to a special agreement of realizing a number of BIPV RTD projects between 2013-2015.

The main reason for giving support to the project was due to the agreed plans of BIPV implementation in the city of Copenhagen.

A serious problem for the realization of the project in connection to the foreseen large school renovation programme was however a sudden political change from the government concerning the rules for PV implementation, because PV implementation in households had become too popular so it affected the tax payments from electricity use. And since an old rule in the electricity production regulation stated that municipalities who wanted to make investments in electricity production systems had to handle this in separate companies, it was decided that this also was necessary for small PV systems in municipal buildings.

This new situation had a serious effect on the plans for use of PV in Copenhagen. And here in 2018 it is still a problem, which have had the effect that PV is only used to meet energy saving demands, e.g. to live up to the low energy class 2020 level for new buildings and the 2015 renovation classes in buildings.

A solution concerning how to handle these problems in practice was the agreements between the project partners and Copenhagen City Properties, to realize a small CO_2 neutral test house in Copenhagen with use of BIPV in combination with a PV battery. At the same time it is made according to the international Active House Standard, and can also be used as a test of the so-called " solar garden" concept , which was developed in connection to a Nordic Built supported project, " Living in Light". Due to this, it was decided to name the test house "The Living in Light Box", and to secure part of the finalization from EU concerto project, " Green Solar Cities".

The test house was delivered by “Husfabrikken” in cooperation with Nordic Flexhouse and was exhibited at the Architectural School in Copenhagen in connection to the realized “ Living in Light” conference in May 2017.

And here, the PV manufacturer, Racell supplied their newest BIPV technology, both for the integration in the roof and the integration in the special façade systems delivered by the Norwegian Solar Thermal producer, Aventa.

Since then, the test house has been moved to a quarter improvement area at Kulbanevej in Valby Details about this as well as other results from the “ Smart Grid School Renovation” project is being presented in the same project dissemination website as was used for the other Nordic Built project, “ Active Roofs and Facades in Sustainable Renovation” , www. activehouseroofsandfacades.com

In the project there has been a cooperation with Copenhagen City Properties on BIPV implementation in general, e.g.in connection to the renovation of the Grøndalsvængets School in Copenhagen NV, where also special test class rooms had installed new types of ventilation systems. Here PV was used, but only for the new built part of the school, due to the before mentioned regulations. The PV manufacturer company Gaia Solar has mainly used the EUDP project to help on the follow up on their winning entry on a BIPV design for urban renewal with new roofs for Landsdommergården in Copenhagen NV, together with Henning Larsen Architects.

After the bankruptcy of Gaia Solar in 2017 it was however necessary to find an alternative solution, and a new tender was made by Solarplan with 9 different BIPV suppliers. The best solution was from Solar Elements who suggested a Swizz BIPV design for red titles roofs with a terracotta colour in the used PV glasses and a SolRif mounting System

In the EUDP project, the Nordic Flexhouse company has been very active in promoting the results from the CO_2 neutral “ActiveHouse” test house both to the Nordic Countries as well as towards China.

As mentioned there has been serious problems of realizing “Smart Grid School Renovation” with BIPV in practice, but important RTD work has been made on several aspects which support this agenda in Copenhagen, and one of the most important results has been the cooperation with Copenhagen. International School, CIS in Nordhavn, which is a private new school, that uses BIPV on all facades besides the ground floor.

In connection to this Cenergia, who is now part of Kuben Management has made Active House Labelling of the school, with the result that CIS was chosen as the Active House Award 2018 global winner at the yearly Active House Alliance symposium, which was held in Lecco in Italy.

Finally can be mentioned important work concerning developing methodologies for zero emission, Active House City areas of the future, where it is also possible to refer to the work on BIPV and also advanced energy solutions for Køge Nord, located south of Copenhagen, see also enclosed e-book on this.

Short Description in Danish

Ligesom for Nordic Built Projektet, ” Active Roofs and Facades in Sustainable Renovation” anvendes hjemmesiden, www.activehouseroofsandfacades.com, også som formidlings platform for ” Smart Grid School ” EUDP projektet.

I det følgende gennemgås de overordnede resultater for EUDP projektet i en relativ kort rapport form som er suppleret med en række bilag. Disse kan samtidigt findes på den nævnte hjemmeside.

På grund af barrierer for anvendelse af solceller på kommunale bygninger, især med hensyn til kravet om etablering af selskaber ved implementering af solcelleprojekter, har man resigneret i Københavns Kommune og endt med at få placeret en række solcelleanlæg i et nyt selskab. Situationen har udviklet sig til at man kun vil etablere solceller, når det er nødvendigt for at leve op til energirammerne.

Da agendaen for EUDP projektet var at udvikle nye BIPV løsninger til skolerenovering i en helhedsorienteret sammenhæng, blev det af projekt gruppen i samarbejder med København Ejendomme besluttet, at bakke dette op ved en fuldskala opbygning af optimerede BIPV løsninger fra Gaia Solar og Racell, og her etablere et "Smart Grid" samspil, som kan hjælpe med at udvikle teknologien og demonstrere dens muligheder, samtidig med at Københavns Ejendomme fortsætter sit arbejde med løbende udvikling af skolerenoveringsprojekter i kommunen.

Baggrunden for " Smart Grid School" projektet var dels det i 2013 igangsatte nordiske samarbejde omkring, "Nordic Buildt Active Roofs and Facades", hvor der var medfinancering fra EUDP (j.nr.64013-0578) samt Energimyndigheden i Sverige og Rannis i Island, og dels samarbejde med Københavnsjendomme om at lave en EU- Horizon2020 ansøgning på området.

Det er stadig meget relevant at arbejde med BIPV løsninger når målet er at prøve at nå de gældende LEK 2020 krav, som er standarden i Københavns Kommune, ligesom det er relevant i forhold til de nye renoveringsklasser i BR 2015.

På basis af dette har der i samarbejde med Københavns Kommune været enighed om værdien af at få etableret et CO2 neutralt prøvehus med brug af BIPV løsninger i samspil med en batteri løsning og online overvågning og dokumentation, så man opnår et optimeret samspil med el-nettet og eget elforbrug. Dette er detaljeret beskrevet i brochuren om "Living in Light Box", som har været udstillet ved Arkitektskolen i København og efterfølgende er overført til et kvarterløft projekt ved Kulbanevej i Valby.

Det er således et af hovedresultaterne for projektet, at det er lykkedes at få udviklet det CO2 neutrale prøvehus "Living in Light Box", som anvender flere innovative solcelleløsninger fra firmaet Racell. Nordic Flexhouse, som er en af partnerne i projektet, har formidlet opgaven med at få fremstillet det præfabrikerede testhus af Husfabrikken. Afsluttende arbejder, som også omfatter et SMA kombineret inverter og batteri system er gennemført.

Racell har anvendt deres nyeste BIPV teknologi, dels til indpasning af solceller i taget og dels til indpasning i facade montagesystem fra den norske producent Aventa, som foreskrevet af Svendborg Arkitekter, og der sker separat måling af de to forskellige solcelleløsninger på hhv. 4,9 kWp på tag (50% øst og 50% vest) og 3 kWp (lodret) (se også vedlagte brochure, som både omtaler arbejde med AktivHus mærkning af huset og online måling v. firmaet Visility)

Også på andre områder har der været et løbende samarbejde med Københavns Ejendomme og Københavns Kommune i projektet.

Til Grøndalsvænge Skole anvendes solceller, men på grund af solcellereglerne kun til den nybyggede del. Og til Lykkebo Skole er der udviklet en særlig solcelledrevet udsugningsventilation til et prøveklasserum som et supplement til den naturlige ventilation.

Der har også været en dialog med Grundfos om hvordan, deres pumper kan indgå i en Smart Grid sammenhæng bl.a. i relation til Aventas teknologi, som anvendes til det udviklede prøvehus.

Gaia Solar har generelt kunnet udnytte EUDP projektet til at støtte arbejde med BIPV løsninger, herunder opfølgning på indsats ifm. Landsdommergården i Kbh. NV.

Samtidigt har firmaet Nordic Flexhouse været meget aktivt mht. at anvende det udviklede AktivHus testhus i internationalt formidlingsarbejde, både til de nordiske lande og til Kina.

Resultater:

Nordic Flexhouse har i 2018 indgået en kontrakt med Changsha i Kina i Hunan provinsen om opbygning af en Eco-village på 200.000 m2. Her vil Living in Light huset sammen med urban farming vær et centralt element sammen med solceller samt batteri fra Visblue.

Link til rapport om CO_2 neutral ventilation med en række udførte eksempel projekter.

Disse løsninger kan laves med meget fin økonomi i dag på grund af lave solcelle panel priser.

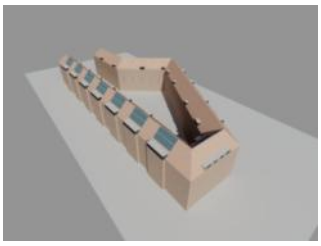
http://www.activehousebipv.com/wp-content/uploads/2018/07/Rapport-Solceller-til-CO2-neutral-ventilation.pdf

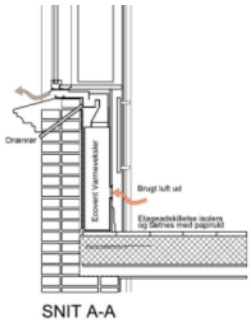
Gaia Solar skulle ifm. EUDP projektet støtte arbejde med BIPV løsninger, herunder opfølgning på indsats ifm. Landsdommergården i Kbh. NV. Efter konkursen er resten af deres budget over-ført Cenergia der nu er en del af til Kuben Management således at der er gennemført et udbud i samarbejder med Solarplan rettet mod 9 forskellige leverandører, som er endt med realisering af en løsning fra Solar Lightning.

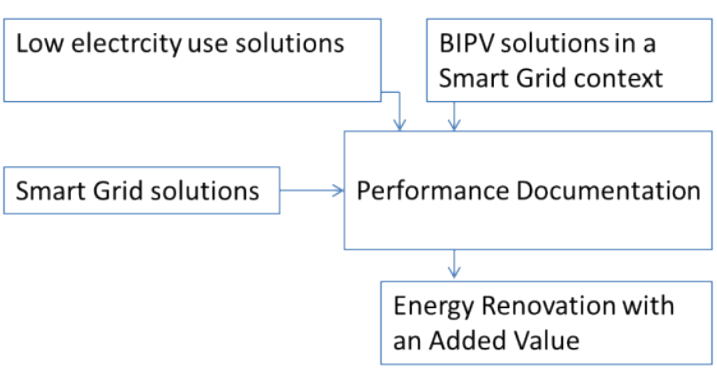
1.3. Project objectives

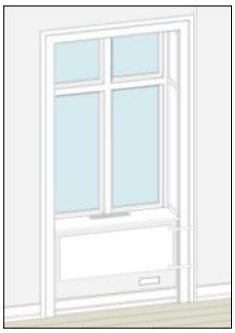
A short version of the EUDP Proposal is shown in the following; at the same time utilizing work to present an EU Horizon 2020 proposal in the area:

Smart Grid School Renovation in Copenhagen









In Denmark the Danish Government will in cooperation with the established “Network for Energy Renovation”, launch an Energy Renovation Strategy by June 2013.

In the brutto version of the “Initiative Catalogue” from the Network for Energy Renovation by February 2013, the area “Active Roofs and Facades” is presented as an important initiative on how to implement local renewable energy solutions, where both the roof and the façade shall be developed in a completely new way, so it is possible to meet the existing demands that is requested from a roof or a façade, while it at the same time includes integrated solutions for producing solar energy, giving access to daylight, ensuring local ventilation and possibly also being combined with sustainable design solutions like working as a green roof or a green facade.

In connection to this it is very interesting that the city of Copenhagen now wants to focus on building integrated PV, BIPV, in connection to a Smart Grid policy, now that a plan for climate renovation of the first 16 schools have been secured for the coming years, reaching 50 schools before year 2020.

Here it is important to be aware of the fact, that the idea of realizing low energy renovation in practice is not simple. Experiences from realized demonstration projects in the Valby, city part of Copenhagen in connection to the Green Solar Cities, EU Concerto project (www.greensolarcities.com), have e.g. documented very clearly, that it is nearly impossible to obtain an overview of individual electricity uses for ventilation, lighting, pumps, appliances etc. since normal practice in building projects are to mix these electricity uses in local electricity boards. Due to this it is very difficult to control if e.g. electricity use for ventilation or lighting is as low as expected, and the results is that in practice it has no consequences what solutions the contractor deliver here. The vision is now that if it is possible to document these figures very clearly then the possibility to obtain a real low energy function is much better. At the same time the documentation of the individual electricity uses on an hourly basis gives a good possibility to introduce a

Smart Grid strategy or moving part of the electricity use to low cost hours. This will at the same time be coupled with a strategy to increase electricity use at sunny hours when you can have a local PV capacity available, and possibilities to use electricity storage solutions like local batteries can also here be an option to secure a better economy for PV production and also a higher PV percentage of the total electricity consumption.

Here it can be noted that funding schemes for use of batteries in connection to PV projects are e.g. being implemented in Germany in the spring 2013.

To ensure the right Smart Grid solutions and that a low electricity use will be obtained in practice it is planned to develop 2 low electricity use classrooms based on a Smart Grid operation strategy for 2 different schools which can be full scale tested prior to full scale "Climate" and energy optimized renovation in new school renovation projects in Copenhagen, where it can be proven how Smart Grid oriented use of BIPV can be coupled together with Smart Grid optimized electricity use.

In practice this means that for a school renovation project that is already in the pipeline for renovation, 2 classrooms will be tendered and realized based on "Smart Grid" measures, so monitoring can reveal the difference between the reference building and the Smart Grid based classrooms.

Based on the obtained results here it will then be possible for Copenhagen Real Estate to make a full optimized Smart Grid Renovation project for coming school renovation projects (with a rate of 6-8 schools per year)

In cooperation with the City of Copenhagen and Copenhagen Real Estate there will be initiated full scale tests of 6 different types of BIPV solutions (total capacity of 200 kWp), incl. local PV storage options for 2 different schools, where there at the same time will be made full scale tests of 2 innovative low electricity use classrooms for each school with detailed internet based survey of the electricity use for ventilation, lighting, computers, appliances and pumps, so analysis can be made on how to obtain a Smart Grid operation strategy including movement of electricity consumption, both by the involved specialists as well as in cooperation with the users.

In the proposed "Smart Grid School Renovation in Copenhagen", EUDP project, it is the vision to secure development of both optimized BIPV solutions as well as documentation of innovative low electricity use technologies together with an overall Smart Grid approach aiming at a possibility to optimize both the PV production as well as the reduced electricity use, so it fits into the electricity production system in an improved way.

It is our belief that if it is possible to prove good results for the individual solutions and technologies, then this can for one thing be utilized to introduce demands for this quality in new tender materials for school renovation projects which will lead to a much improved security to obtain high energy savings in practice as well as to secure an optimization of the overall electricity use consumption into a Smart Grid context.

Besides the mentioned strategy will at the same time promote the use in practice of the best possible BIPV solution as well as the low consumption electricity using technologies, e.g. in relation to the large plan for school renovation in Copenhagen with more than 350.000 m² and with links to other plans for public building renovation in Denmark. In this way a strong exhibition window for Smart Energy Renovation will be created.

In the project it is the aim to develop and test in practice two innovative configurable roofing systems where the PV modules are functioning as the climate shield in this way securing lower total investment

costs and a better total economy aiming at creating a possibility of making PV being a normal building element.

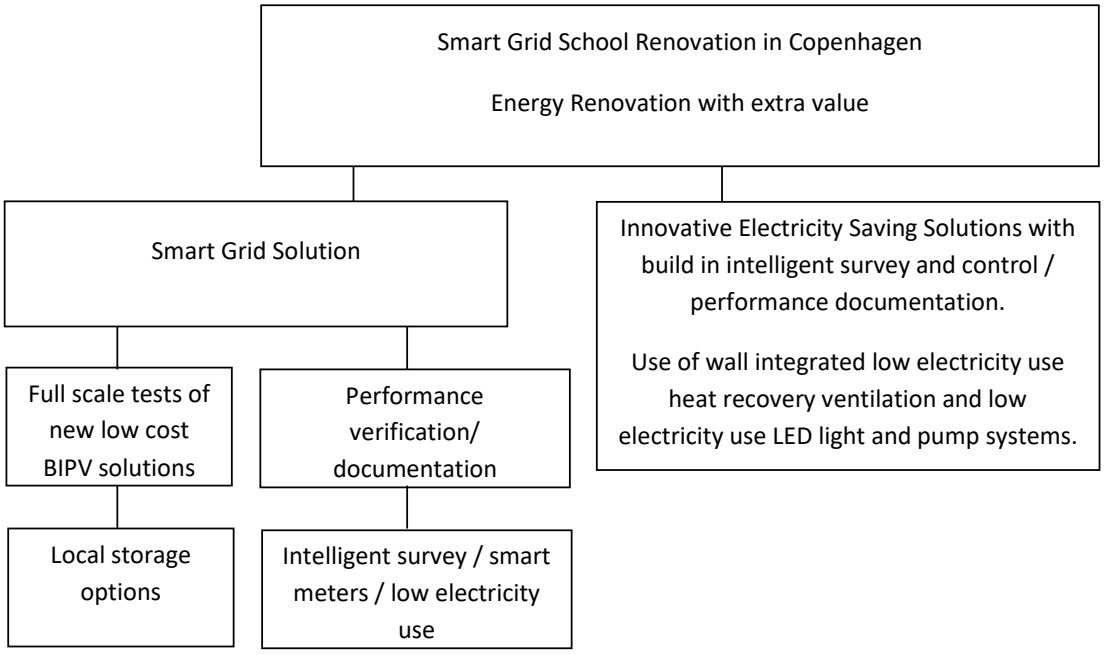
Gaia Solar will develop a solution where configurable PV modules are substituting normal tile roof areas leading to reduced investment costs when you are changing the roof, so PV will be a natural choice in future roof exchange programs.

Racell will work along the same lines for flat roof systems. Here their up to 12 m² large modules with or without a build in thermal function (PVT) will secure a much longer service life for the asphalt layer under roof, since it is not deteriorated by the sun over the years.

At the same time the actual electricity use which needs to be used in renovated classrooms will be significantly lower than normal and still with a good comfort for the users. This is following the same design philosophy as the new extension of the city hall in the city of Skive, where they wanted to avoid high amounts of electricity use for ventilation, which is often a problem especially for centralized ventilation systems. Here it was chosen to use small wall integrated heat recovery ventilation (HRV) fans from Germany which only use a few W's for operation.

In the EUDP project it is the idea to integrate a new kind of HRV system, with very low electricity use, which can be mounted under the windows and still secure the quite high amount of ventilation air which is necessary for school classrooms.

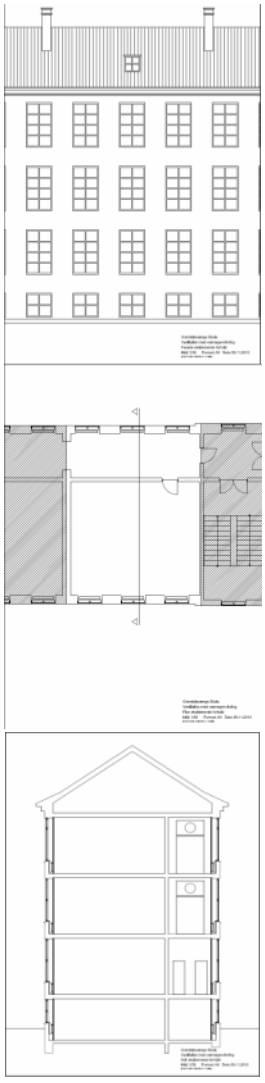
Combined with advanced LED lighting and low consumption pump systems it will be possible to reduce the classroom electricity by at least a factor of 4 compared to normal. And integrated with intelligent control and performance documentation it will be possible to develop a model where you can have a continuous analysis of the energy balance of the school, even incl. the renewable energy contribution from the PV systems, and work with Smart Grid operation models where electricity consumption is reduced for selected periods and PV electricity is stored for other periods.



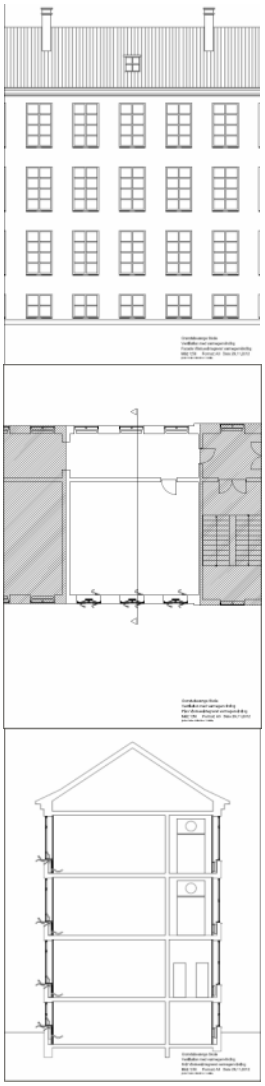
Cenergia will have a special task of connecting project results to the international “Active House” alliance (www.activehouse.info) and will utilize the Active House Specifications in the project, especially on Performance Documentation.

Grøndalsvænge School: illustration showing ventilation solutions to be tested and demonstrated in Copenhagen. Decentralized ventilation will secure a much lower electricity use as well as a better comfort for the users.

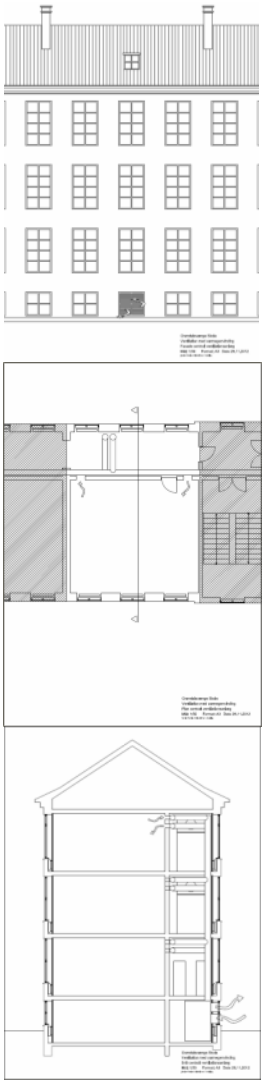
Existing situation for School

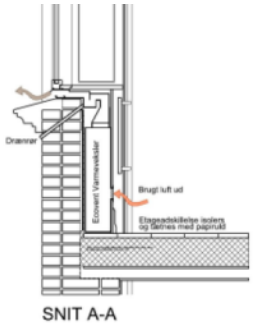


School renovation with decentralised ventilation



School renovation with centralised ventilation





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The building integrated window integrated heat recovery ventilation solution with low electricity use will be compared to centralized ventilation and to other existing types of classroom ventilation.

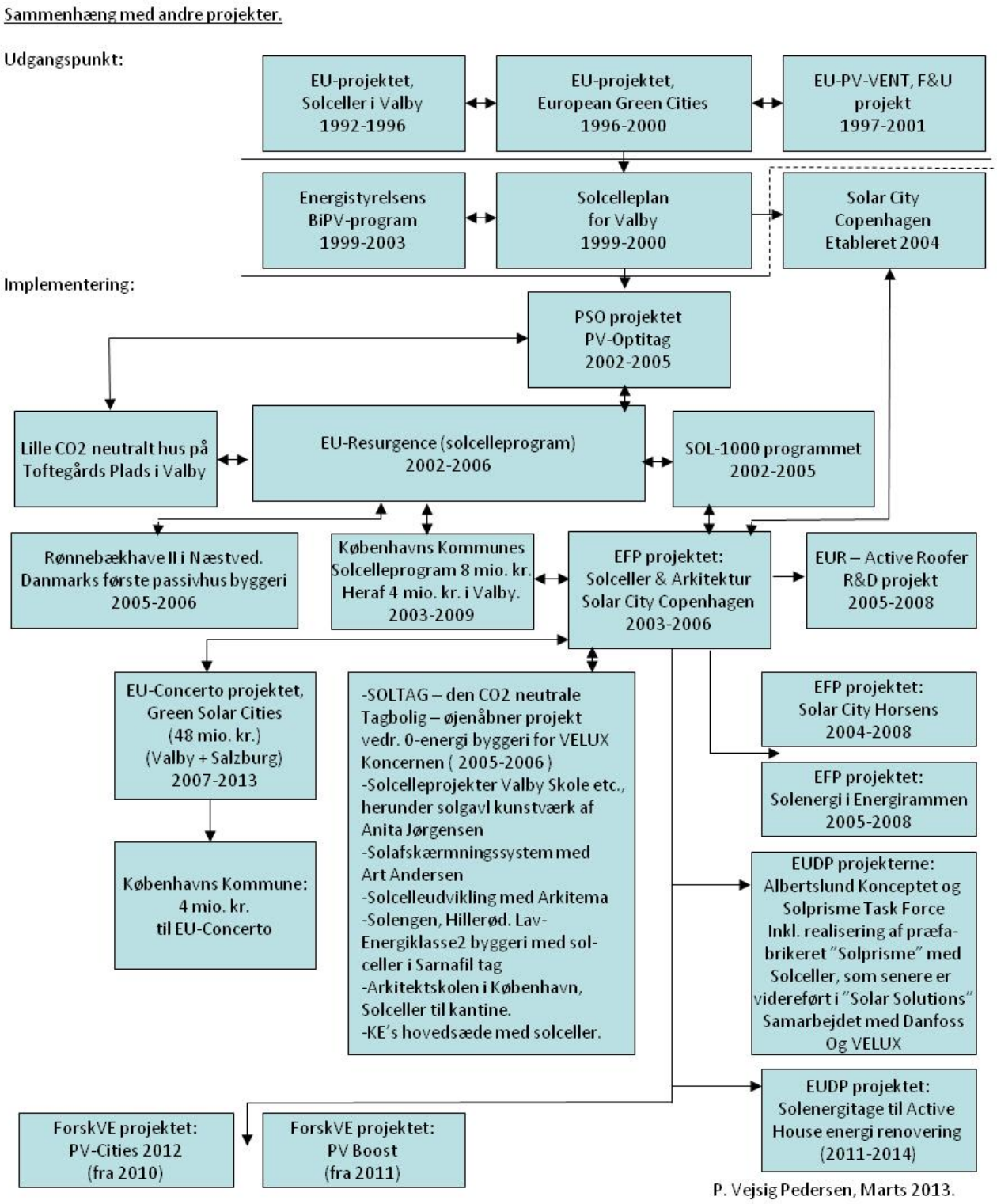


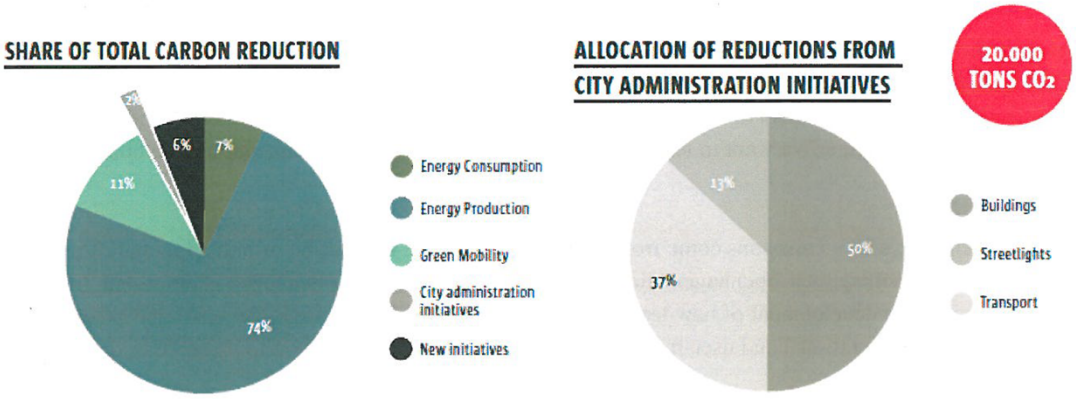
Illustration of BIPV related projects since 1992 that Cenergia has been involved with.

Copenhagen Carbon Neutral by 2025

www.kk.dk/climate

CPH CARBON NEUTRAL BY 2025

Copenhagen has an ambition to become the first carbon neutral capital in 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 by 2025. The goal of a 20 % reduction by 2015 was already achieved in 2011, when CO_2 emissions were reduced by 21 % compared to 2005. With the climate plan, the Danish capital combines growth, development and a higher quality of life with a reduction in Carbon emissions of around 1.16 million tons.



The City of Copenhagen must raise the bar as to what it is possible to achieve in terms of CO_2 saving and energy efficiency. In this way by 2025, the City of Copenhagen will have reduced energy consumption for running municipal buildings by 40 %.

The municipality's large purchasing volume will be used actively to move the market in a climate-friendly direction. The municipality will, as a developer and property owner, build low energy and climate-adapted buildings and gather experience of the particular building processes and solutions for energy retrofitting and user behavior.

A major item of expense is energy retrofitting and climate adaptation of municipal buildings. The cost of energy retrofitting and adaptation will, by 2025, be a total of about 1.4 bn, giving an operating savings of about 0.6 bn over the period.

The City of Copenhagen Climate Plan for year 2025

In Copenhagen, the City of Copenhagen has a very strong Climate plan aiming at CO2 neutrality by year 2025 as the first city in the world. To support this it is aimed to obtain a 20 % energy saving in year 2020 for the public buildings as a total.

And due to this funding has been allocated to realize energy renovation of 12 schools in the coming 3-4 years to identify the most economic energy renovation methods aiming at new building standards already agreed for year 2015 and year 2020.

The membership of the Copenhagen region PPP organization Gate21 is very important to realize these plans and ensure a close cooperation with the building industry where there are already many partners in Gate21 (www.gate21.dk).

Also the Kuben Management organization which is the leading actor in relation to renovation of housing and public buildings in Denmark is an important partner which will also contribute with experience on organizing energy savings and use of renewables e.g. by help of ESCO models. And in connection to this Kuben Management will continue its cooperation with the energy specialist company Cenergia, which is technical coordinator of the on-going EU-Concerto project, Green Solar Cities in Copenhagen and Salzburg (www.greensolarcities.com).

Here with a much higher focus on demonstration of innovative technologies and necessary RTD support for this.

Finally, it seems reasonable to make a quote from the Climate Plan of the City of Copenhagen, which really underlines the real devotion towards developing a world leadership in energy renovation of public buildings:

“Copenhagen has reduced CO2 emissions by more than 20% up to year 2009. And the aim is to reduce the CO2 emissions by an additional 20% between 2005 and 2015. Besides it is our vision is to make Copenhagen the world’s first carbon neutral capital by 2025.

Our goal and vision are absolutely clear.

That is why we will undertake annual accounting. If things aren’t moving quickly enough, we’ll step up the climate initiatives. We want to make Copenhagen the Climate Capital of the world.

It is true that this has a cost now. But it is an investment with good returns. Financially speaking – and in terms of health, performance and wellbeing, for all of us who live, work and stay in Copenhagen. Over 70% of the world’s CO2 emissions come from cities. Cities hold the key to the global climate challenge. We want to lead internationally with our Climate Plan, and inspire others to follow suit.

Copenhagen aims to obtain an efficient energy management for all municipal buildings.

We focus on climate both in new construction projects and in renovation projects. Energy conservation must be a requirement for buildings which the municipality rents. We will advise owners of private and public buildings, consultants and trade workers about energy conservation in buildings. Advanced heat sensitive photographic techniques will be used to visualize heat losses from buildings.

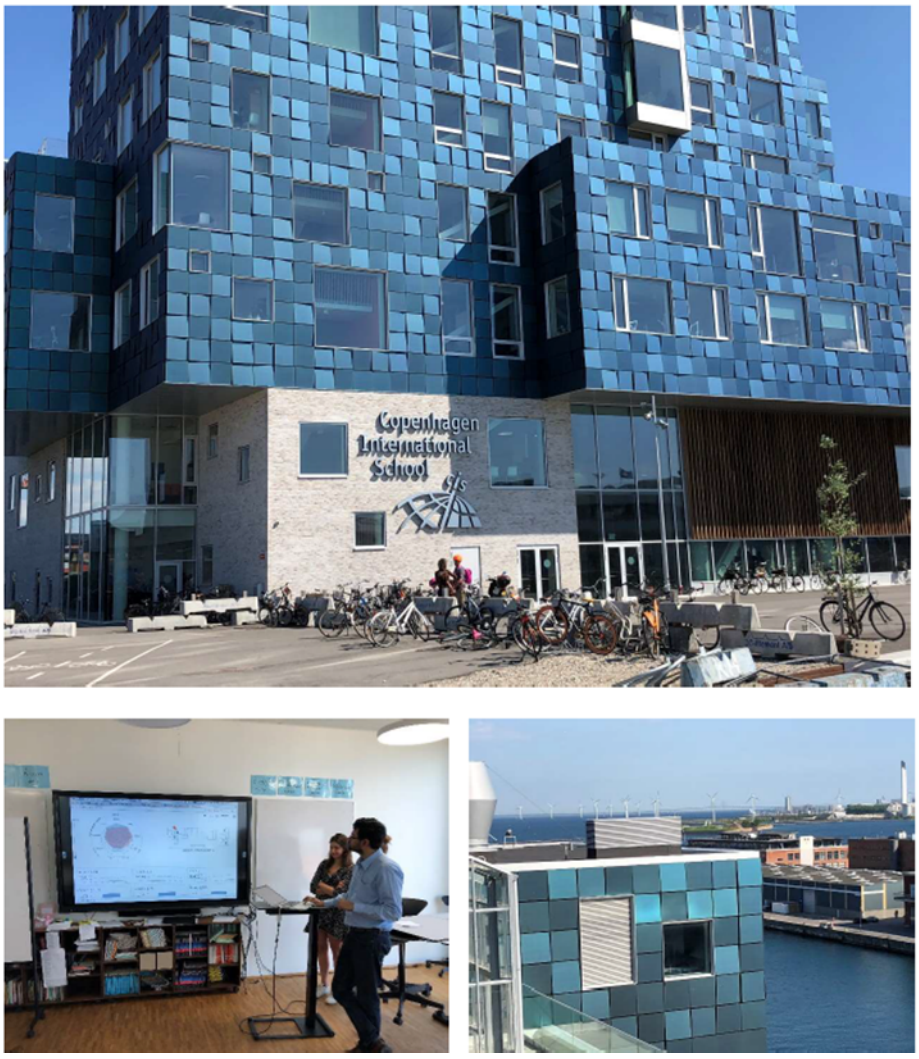
Renovation of Copenhagen’s extensive real estate holdings requires big investments – from both public and private sources. But the technical solutions are available and well proven, and there are huge savings to be retrieved from energy conservation in buildings.

This makes energy conscious renovation and management a good investment – for wellbeing, climate and finances.

Goal: The city of Copenhagen will achieve 10% of its total CO2 reduction by 2015 through construction and renovation projects. This is equivalent to 50,000 tons of CO2"

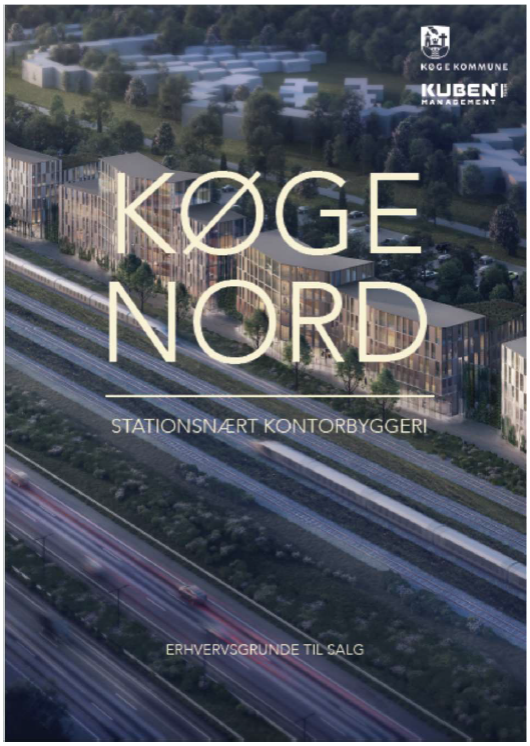
1.4. Project results and Dissemination of results

A main result from the project has been the realization of the Living in Light Box, Active House test house, which has also been Active House labelled, see project brochure in annex 1.
Cenergia has since the project start worked on realizing a combined focus on Active House qualities, like energy, comfort and sustainability together with use of BIPV, and in several cases also actual Active House labelling have been made, according to the international Active House standard. (www.activehouse.info)
The most prominent example project has been the Copenhagen International School (CIS) in Nordhavn in Copenhagen with BIPV on all facades above ground level, comprising 12.000 m^2 PV panels integrated in an architectural optimized way (720 kWp in total). Here there was made both Active House labelling and at the same time use of an Active House online "Radar" showing the energy, comfort and sustainability qualities based on 3 selected parameters for each of these focus areas.
The results was presented at a site visit on 23. May 2018 linked to the Nordic Clean Energy Week.



BIPV facade at CIS and presentation here of online Active House radar by Leapcraft

Besides this, a large effort has been made in connection to urban development of a new city area at Køge Nord, where it has been possible to support integration of BIPV solutions as part of the development of the sales material for 50.000 m² commercial building towards developers.



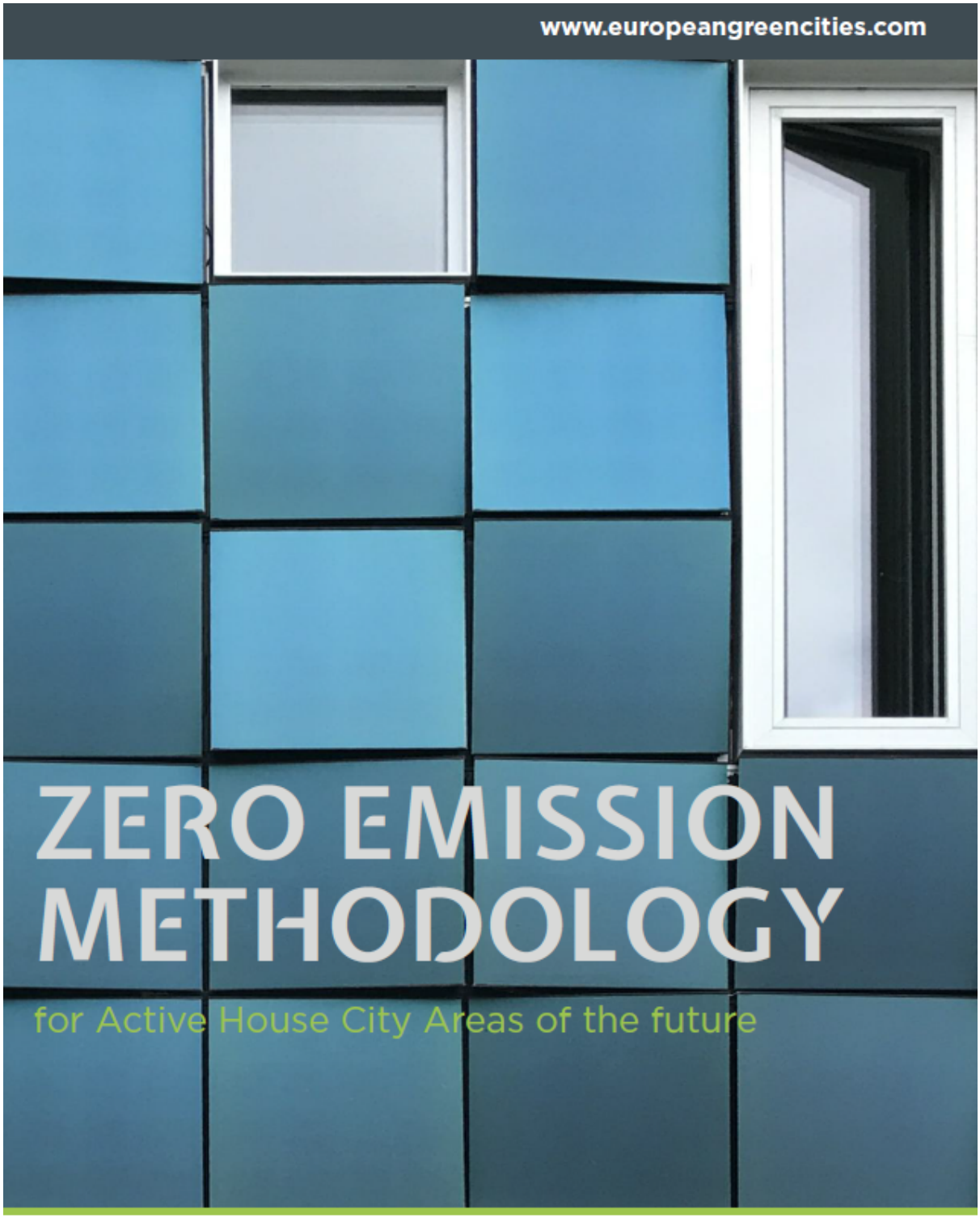
For new urban development at Køge Nord the architectural design work included BIPV, which is now integrated in the sales material for developers.

As another example of working towards a city oriented approach for Active House quality and use of PV technology can also be mentioned preparation work connected to Green Energy Island development, where a 100% renewable energy supply is aimed for in connection to new housing development.
There have also been an ongoing cooperation with the urban renewal department of Copenhagen in connection to use of BIPV in urban renewal projects. From 2017 this has incorporated a special focus on Copenhagen NV, where several BIPV projects are being prepared, as part of a special supported 1 MWp BIPV plan here.
In the EUDP project special support has been given to the “Landsdommergården” BIPV development project in Copenhagen NV, which had a special focus on use of PV in red tile roofs.

Dissemination in Nordic Built website

Concerning dissemination can also be referred to the www.activehouseroofsandfacades.com, website where there is a special part on the present project and a link to a “living in Light” video film https://vimeo.com/rasmusdegnbol/review/218014029/bf08747bc6

Zero Emission Methodology for Active House City Areas of the future



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ZERO EMISSION METHODOLOGY FOR ACTIVE HOUSE CITY AREAS OF THE FUTURE

13th Conference on **Advanced Building Skins**
1-2 October 2018, Bern, Switzerland

IMPLEMENTATION OF 100% ZERO ENERGY BUILDING STANDARDS

How is it possible to obtain a common standard for energy efficient buildings, which both aims high for new buildings, and can also be used on existing buildings.

The best source for this discussion is the EU-Building Directive and the connected "Nearly Zero Energy Building" standard.

For new building projects, in many cases, it is possible to establish a 100% zero energy building standard. Even though it is demanding with respect to optimising the architecture, it is possible with the help of new types of energy producing facades and roofing materials.

For renovation projects, similar solutions will in many cases also be possible, especially if you are dealing with significant renovation involving the updating of roofs and facades.

THE INTERNATIONAL ACTIVE HOUSE STANDARD

If the above-mentioned policies are to be implemented in the best way, then it is an obvious choice to combine these with use of the international "Active House" standard. This has a combined focus on energy, comfort and sustainability, based on 3 criteria for each of these areas, and with possible use both for new buildings as well as renovation projects.

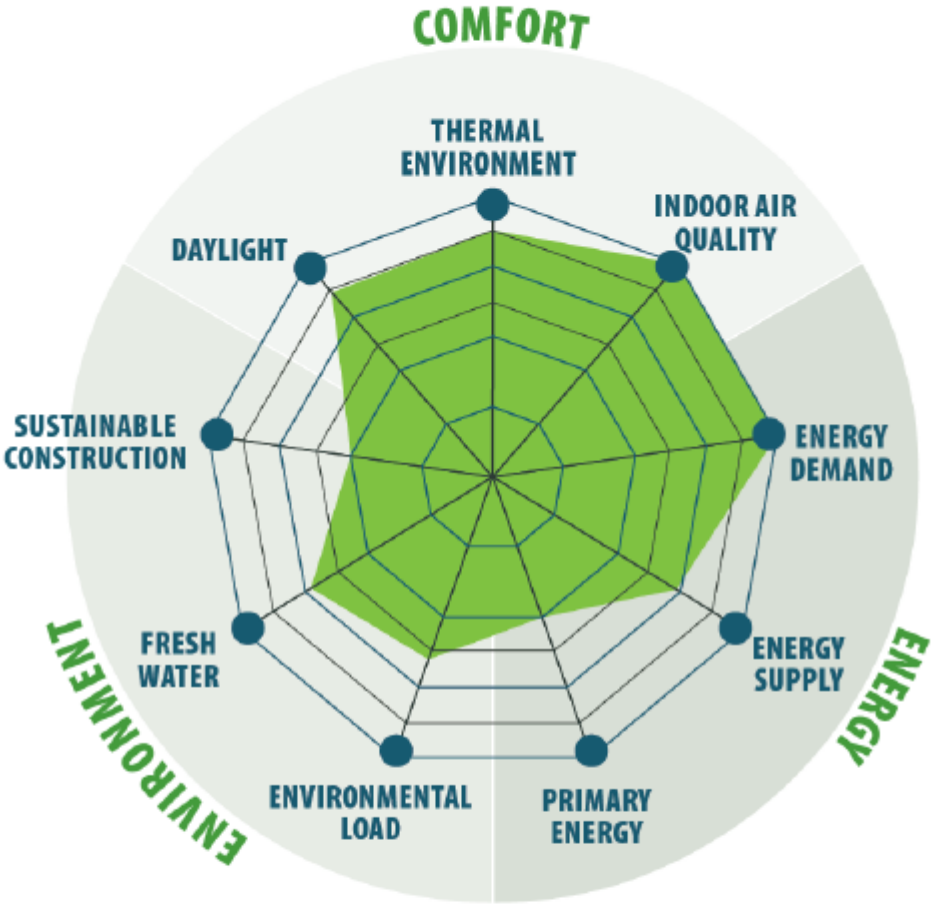
Before a building can get the official Active House label, the Active House standard demands that all parameters are evaluated and verified. See also www.activehouse.info and www.aktivhusdanmark.dk, where the benefits of working with a global oriented standard is illustrated, with a strong focus on indoor air climate – something which is not handled effectively in the EU building directive.

It could be suggested to adapt the Active House Standard to include a focus on user satisfaction and performance in practice, as well as different levels of zero emission standards using renewable energy.

And what could really have a large impact is the development of a methodology concerning how to organise such a standard, not only for one building but for whole city quarters as part of a Smart City and Smart Grid development.

In connection to the Nordic Built Active Roofs and Facades project (www.activehouseroofsandfacades.com) example projects with BiPV and Active House labelling has been documented. These are also possible to find in the European Green Cities database in English (www.bæredygtigebygninger.dk)

ACTIVE HOUSE RADAR FOR COPENHAGEN INTERNATIONAL SCHOOL



USING DIFFERENT LEVELS OF ZERO ENERGY BUILDINGS AS A DRIVER FOR PRACTICAL IMPLEMENTATION OF BUILDING INTEGRATED PV SOLUTIONS (BIPV)

Here it is suggested to use f.ex. prosumer level 1,2,3, and 4, to show how much your building measures up to the zero energy building standard alongside the general energy quality of the building.

RESULTS	
Comfort	
1.1 Daylight:	5.1%
1.2 Thermal environment:	Better level
1.3 Indoor air quality:	≤ 500 ppm
Energy	
2.1 Energy:	30.1 kWh/m²
2.2 Energy supply:	21.7 kWh/m²
2.3 Primary energy:	14.9 kWh/m²
Environment	
3.1 Environmental loads:	Good level
3.2 Freshwater:	28% savings
3.3 Sustainable construction:	Good level

COPENHAGEN INTERNATIONAL SCHOOL, CIS

Copenhagen International School, CIS in Nordhavn, Copenhagen has the largest building integrated PV installation in Europe, covering all façades above ground level helping it to generate 50% of its yearly electricity from solar energy. Cenergia which is now part of

Kuben Management has made Active House labelling and combined this with the implementation of an online Active House Radar. See this at: http://labs.leapcraft.dk/cis/.

CIS is a good example of the Prosumer building of the future. It has BIPV on all facades and is also an aesthetically pleasing piece of architecture due to the specially designed PV panels. With around 39% of the total electricity use (inclusive el-apparatus) produced by the PV modules, CIS is a good example of an almost zero energy building.

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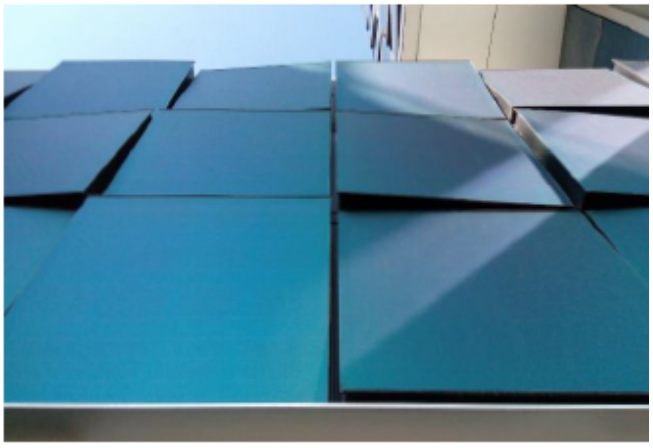
The randomised tilt of the PV panels on the facades of CIS. The PV modules were produced by SolarLab as 60 W green chromatic coated hardened glass panels 700mm x 716mm, with 16 monocrystalline PV cells (6") and bypass diode. Each group of 8 panels is coupled to a micro inverter which is easily accessible through the ceiling of the rooms. Architectural design was by C.F.Møller Architects.



ATES GROUNDWATER COOLING AND HEATING

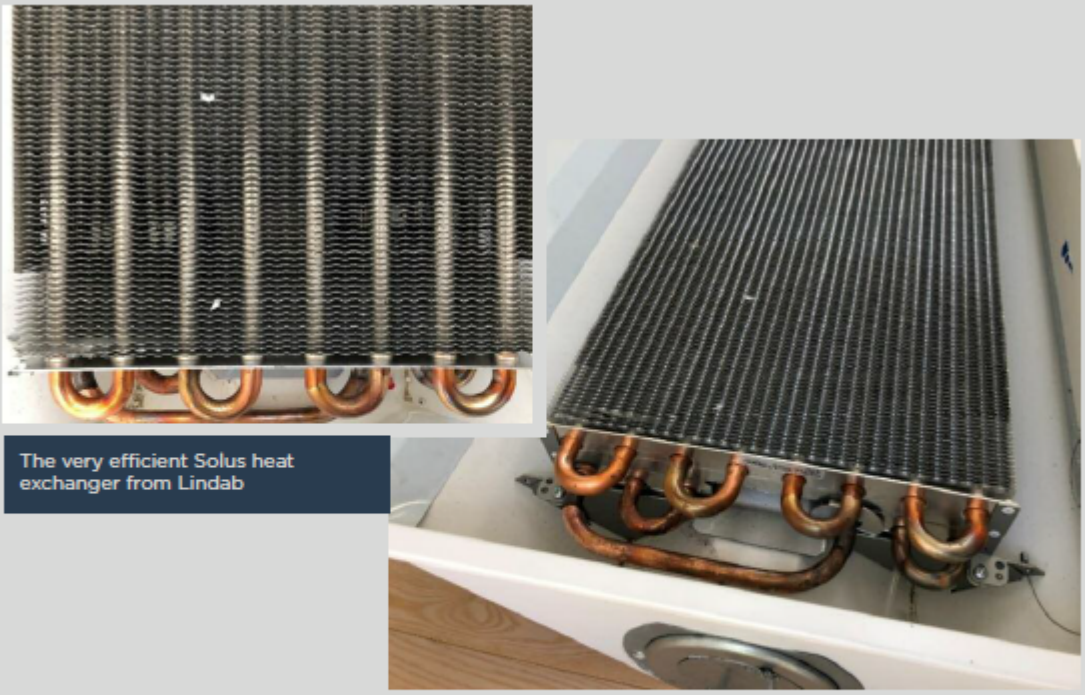
The Bisperberg Hospital in Copenhagen uses Aquifer Thermal Energy Storage or ATES groundwater based cooling as a cheaper alternative than district cooling from HOFOR, the Copenhagen Energy Company.

The yearly energy saving is 75% and more than 90% of heat stored during the summer can be recovered. 2 stage heat pumps from Sabroe are used. In winter, district heating is base load and heat pumps deliver the peaks. (Only from November to March).

In Denmark it has been proven that ATES systems can be used in close proximity to drinking water pumping stations, but it is a requirement that the ground water temperatures are never heated by more than 0.5°C in the vicinity.

Two important positives – there has never been any net consumption of water, and there is no noise from the system, compared to normal compressor cooling systems, which have a clear noise problem from the condenser in the roofs during the summer.

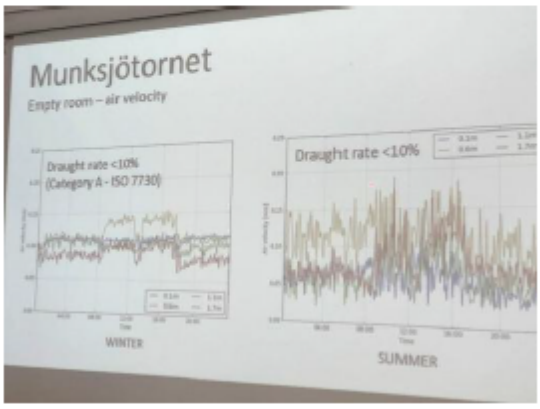
From the ATES system developer Enopsol's point of view, the new and innovative SOLUS heating/cooling system, from Lindab with 19°-24°C operation temperatures, is really interesting. This means a large part of the heat pump operation, with its quite high electricity use, can be avoided, if the ground water temperatures can be raised somewhat in summer periods, and still with a thermal balance over 1 year.

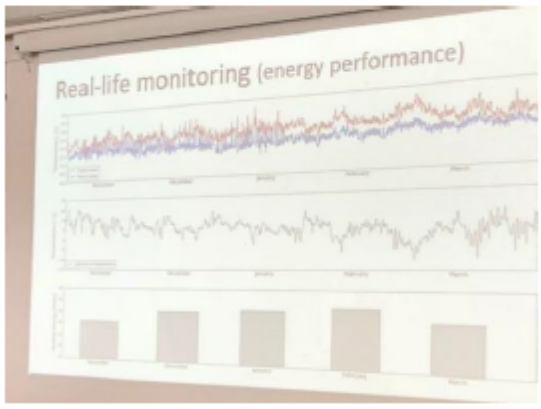


The very efficient Solus heat exchanger from Lindab

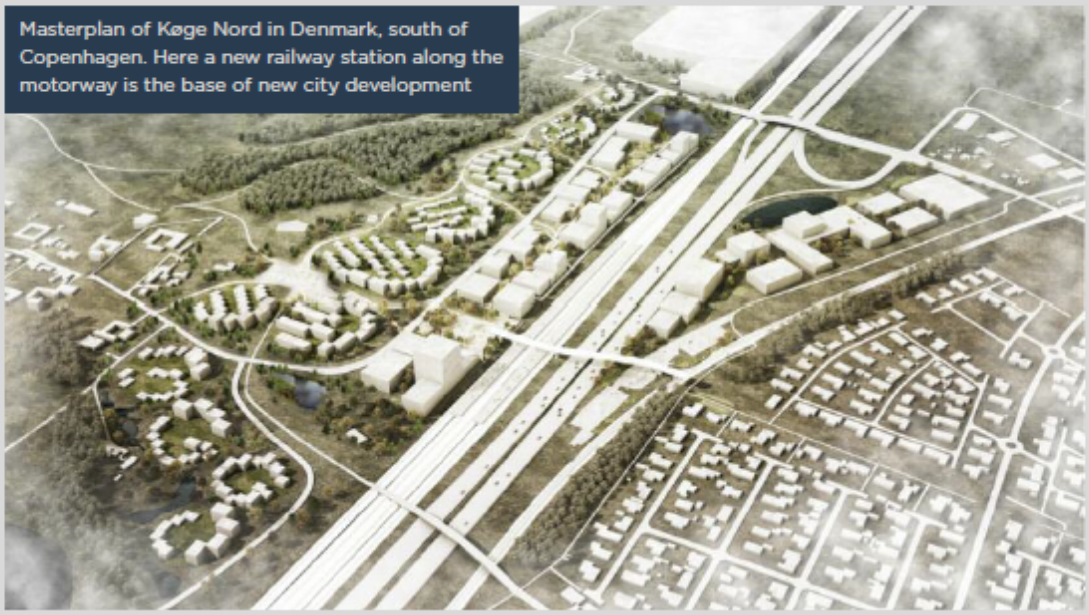
Munksjøtårn in Jønkjøbing, Sweden was used for a full scale demonstration

Solus beams in Munksjøtårn



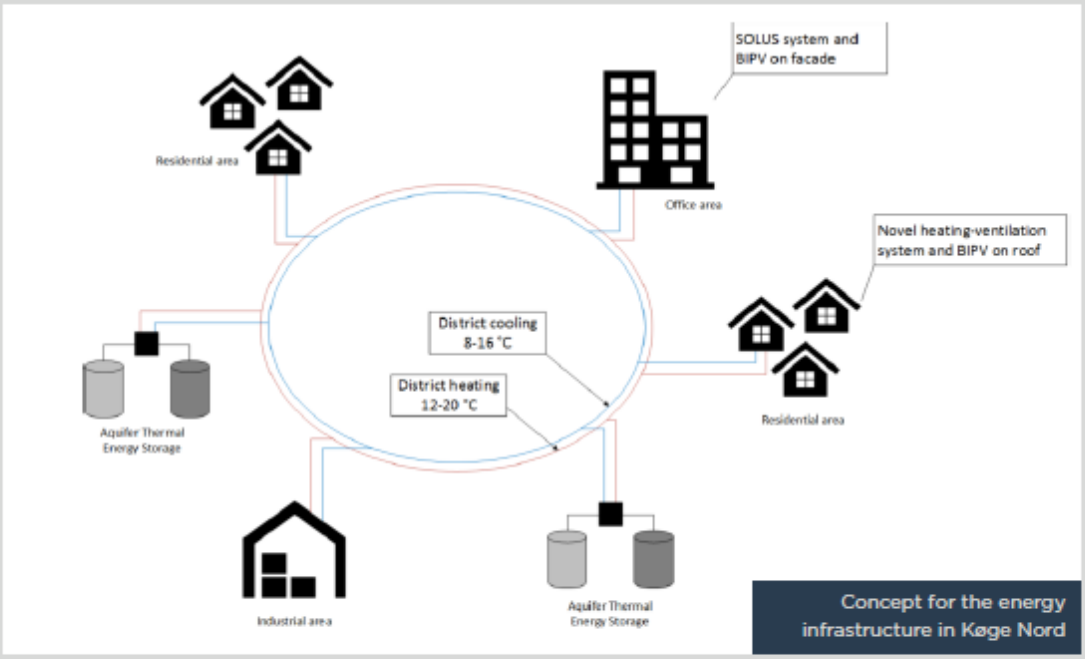


Solus measurements by SBi/Aalborg University confirms good operation in practice



Masterplan of Køge Nord in Denmark, south of Copenhagen. Here a new railway station along the motorway is the base of new city development

For a new city development area, Køge Nord, south of Copenhagen it has been agreed to implement an advanced low temperature bidirectional district heating solution, which can be ideally combined with the above mentioned technologies, and new types of BIPV facades for a large commercial building development area.

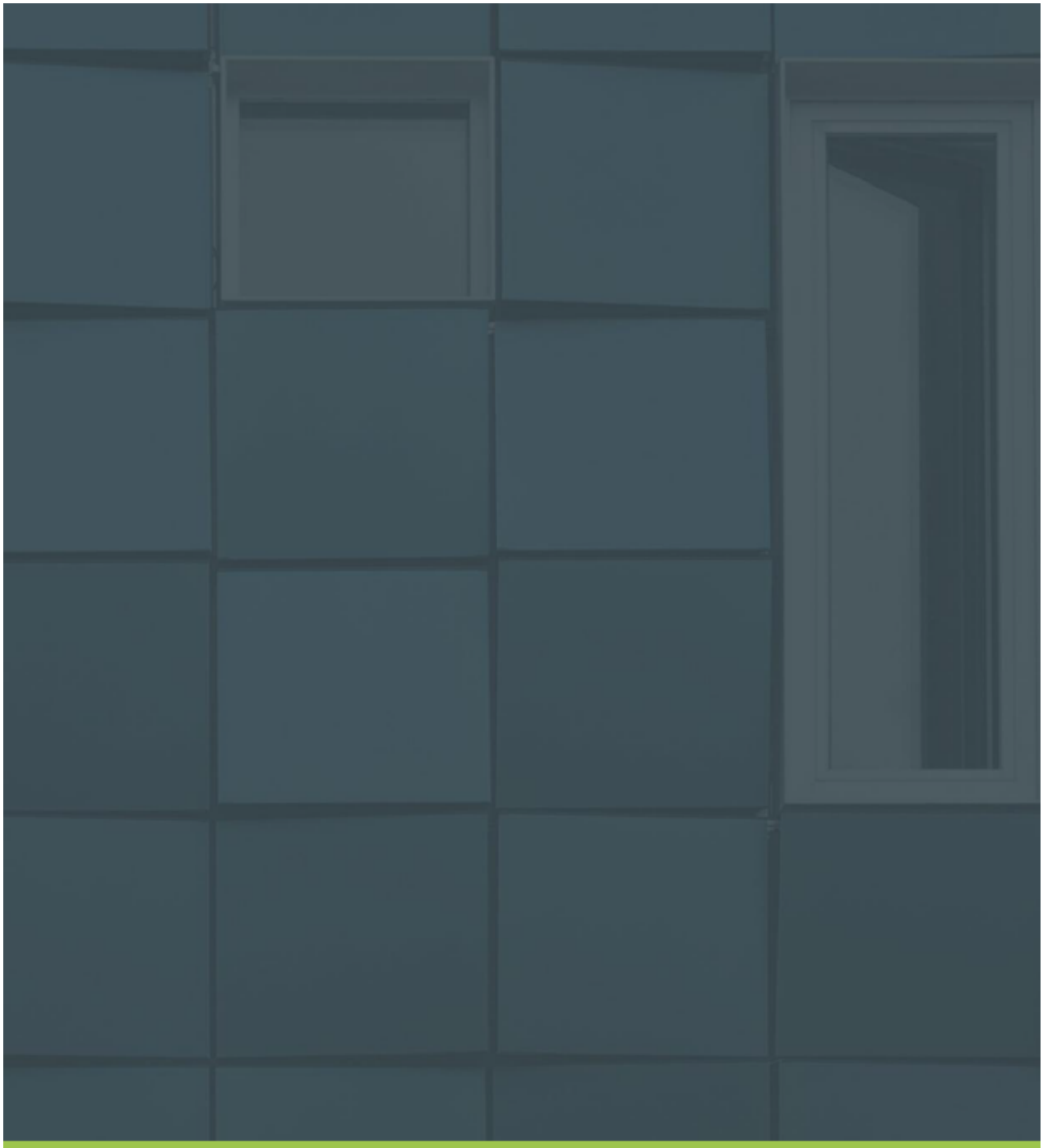


Concept for the energy infrastructure in Køge Nord

REALISATION OF BIPV DEMOSITE AT THE TECHNOLOGICAL INSTITUTE IN TÅSTRUP

BiPV companies in Denmark have exhibited their building integrated PV solutions at a common demonstration area at the Technical Institute in Tåstrup near Copenhagen. This includes: Komproment, Solarpartner, Solar Elements, Solar Lab, Ennogie, Danish Solar Energy, Racell, Solar Opti and Solar Tag.

New BIPV technology from Danish Solar Energy, with light grey panels in the middle and with Rock panel façade, was demonstrated by Solarplan, showing PV production quite near normal crystalline PV modules



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www.kubenman.dk | www.activehouseBIPV.com | www.activehouseroofsandfacades.com

En del af

1.5. Utilization of project results

Use of BIPV in combination with Active House labelling

It has a mentioned not been easy to work on BIPV solutions for schools in Copenhagen due to the special rules for use of PV in municipalities.

On the other hand, it has been possible to realize a lot of important work in the project, with form on BIPV implementation in Copenhagen.

Here is also shown a first proposal on this solution made by the Norwegian Architect company "Reiulf Ramstad Architects", here with a minimalistic building proposed for the center of Copenhagen or Copenhagen NV. (See annex 3)

Here the realization of the "Living in Light Box" was an important results also in connection to the used "Active House" labelling. Details on this can be found in annex 4.

In the following is shown some extra documentation on the Copenhagen International School and the realized Active House labelling (where you can find the detailed result in annex 10), including the handing over ceremony to the school representatives as well as the handing over of the international Active House Award 2018 based on Cenergia's Active House labelling work.

In the following is a quote on this from Peder Vejsig Pedersen, which was used in several social media.

" Due to BIPV oriented funding in Denmark from the EUDP and ForskVE RTD programmes (see: www.activehouseroofsandfacades.com), it was possible for Cenergia now a part of Kuben Management to make an agreement with Copenhagen International School to realize an Active House labelling for the school, and to include an online Active House radar by assistance from the company Leapcraft.

Copenhagen International School, CIS is a unique building project, which it has been a pleasure for me and my colleagues, Miriam Sanchez and Vickie Aagesen to work with. The cooperation also included Karin Kappel from Solar City Denmark, which have made an amazing work on promoting best practice BIPV architecture since 2004, and Gate21 who was an engaged collaborator in relation to the ForskVE realization. For my organization, I hope that winning the Active House award will support the idea of working with the Active House standard in practice, since it has many benefits and is not costly to work with. In relation to ForskVE it has been possible to include several Active House labelled projects in the Danish sustainable building database which can now also be viewed in English. See www.bæredygtigebygninger.dk .

The idea of working with performance documentation has always been a part of the Active House approach and with demands for this in the EU Building Directive it becomes more and more relevant, and something that will be supported by the development towards more digitalization in buildings.

CIS is a good example of a school building with a strong focus on a healthy indoor climate, which had a strong focus in the design process, also based on special demands from the builder, e.g. on using decentralized ventilation systems. This is in a situation where problems with a bad indoor climate is a

general problem in Danish schools. It is our hope that the indoor qualities documented in the online Active House radar will help to ensure a continuous focus on the indoor climate.

I agree that homebuyers can use Active House documentation to help on securing the quality also due to reasonable low costs for the use. A good advice could be to try to cooperate with other sustainable building quality systems. In the Nordic countries we e.g. have the Nordic Swan Label which one of the leading contractors (NCC), use for all their housing projects.

My advice for the future is to focus on really new and unique projects, which support the Green Transition, and here try to work with engaged builders like what we saw for the CIS building. CIS is a really good example of what a determined builder can do in practice. Here the driving force was one of the board members of the school who at the same time was a designer and secured full scale BIPV Mock Ups on the actual building site to identify the best possible BIPV design (in cooperation with the experienced BIPV manufacturer, Solar Lab). This actually lead to the withdrawal of the architect (C.F. Møller), for a short period, due to risks they saw in connection to the use of a completely new technology for almost all facades. In the end, they came back and was deeply engaged in securing the qualities in practice of many of the technical and architectural solutions".

Active House label being handed over to CIS in May 2018, by Miriam Sanchez Mayoral and Peder Vejsig Pedersen from Cenergia, which is now part of Kuben Management.

Presentation of Active House Award 2018 to CIS based on the Active House labelling made by Kuben Management.

www.europeangreencities.com

FROM VISION TO REALITY

Copenhagen International School (CIS) in Nordhavn, Copenhagen has the largest building integrated PV installation in Europe. It was delivered by Solar Lab and covers all facades and supplies 50% of its yearly electricity use with solar energy, and was a request from a dedicated builder (ECIS) to C.F Møller Architects.

Cenergia, which is now part of Kuben Management, has made Active House labelling, and an online Active House radar. Based on this, an application for the Active House 2018 Award secured CIS as the overall winner and labelling catagory winner (see www.activehouse.info)

www.activehousebipv.com | www.activehouseroofsandfacades.com

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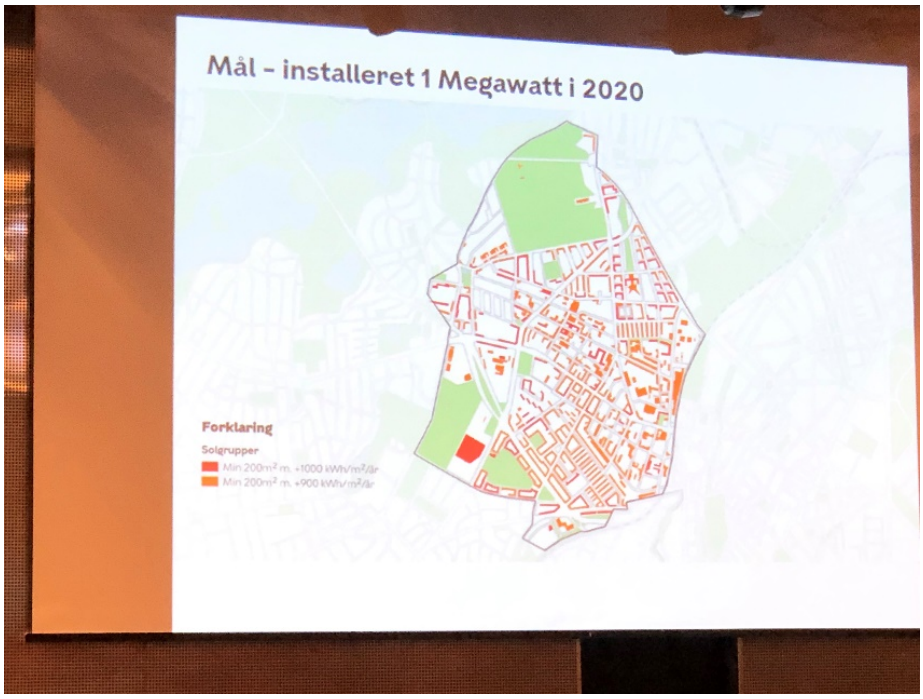
1 MWp BIPV plan for Copenhagen NV

In the following is shown illustrations from a well-visited “citizen” meeting at the Culture House NV in Copenhagen on the eleventh of December 2018. Here was also presented the realized work on BIPV for the red tile roofs incl. the preparation for the “Landedomergården” project.

Visualization of PV for Landsdommergården in Copenhagen NV

Citizens meeting at Copenhagen NV Cultural House on 11th of dec. 2018



It is aimed to have installed 1 MWp PV in Copenhagen NV by 2020

A special allocation of 10,5 mio. DKK was made in urban renewal funds for BIPV in Copenhagen NV.

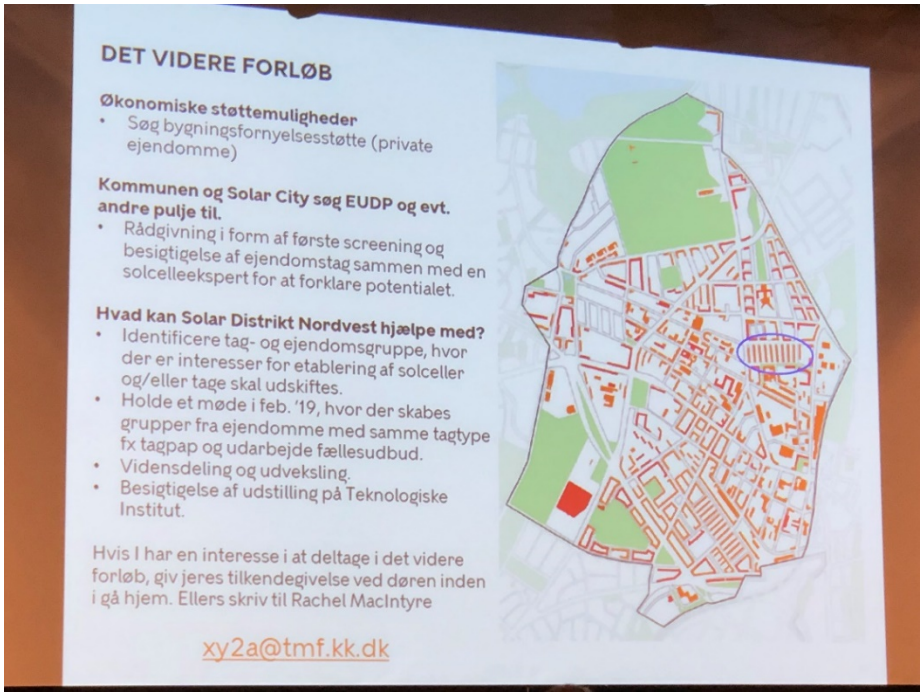
Example of new “Coloured BIPV” technology from Danish Solar Energy.

A well-attended meeting.

Example project for PV in court yard has lead to plans of combining with batteries

Both the Climate Unit and the Urban Renewal office in Copenhagen were represented together with Solar City Denmark

New BIPV modules from SolarTag



Further plans was presented also with focus on securing extra financiation

1.6.Conclusion and Perspectives

It can be concluded that the “Smart Grid School Renovation” project since 2015 when it was supported has been an important basis of securing the continued work on BIPV in the city of Copenhagen even though new rules for use of PV in municipalities in Denmark created a lot of barriers for the practical use.

Important results by the end of 2018 has both been the continued support to use BIPV in Copenhagen NV with the “ Landsdommergården” as the most interesting example project for use of BIPV in red tile roofs. This was also forming the basis for a new 1 MWp BIPV implementation programme in Copenhagen NV.

At the same time the city of Copenhagen has realized PV in connection to large scale new building and renovation of schools. E.g. in the Grøndalsvænge School in Copenhagen NV, where PV was used for the new built part to live up to the strict Low Energy Class 2020 standard.

Besides that it has been possible to realize important work on use of “Active House labelling” both for the “Living in Light Box”, which was realized and exhibited in 2017, and now has a permanent address in Valby. And not the least the Active House labelling of the Copenhagen International School in Nordhavn, Copenhagen, which is a private school with the largest BIPV solution in Europe (by 2017), with 12.000 PV modules in all covering all facades above the ground story. And based on this the choice of this solution as the overall Active House Award winner for 2018.