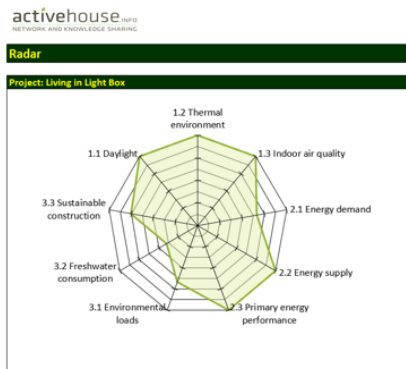
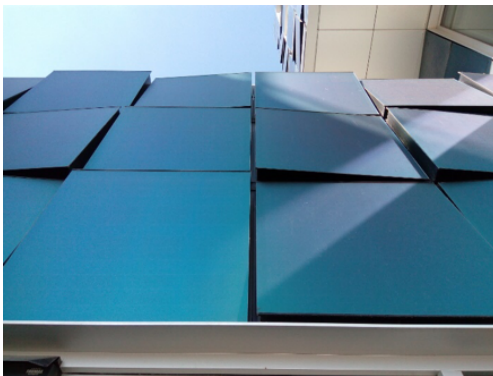


# Slutrapport Smart Grid School-et EUDP BIPV Project

j. nr. 64013-0113



Peders Vejsig Pedersen and Miriam Sanchez-Mayoral  
November 2018

## 1.1. Project details

<b>Project title</b>	Smart Grid School Renovation
<b>Project identification (program abbr-and file)</b>	EUDP-13, j.nr.64013-0113
<b>Name of the programme which has funded the project</b>	EUDP programme
<b>Project managing company/ institution (name and address)</b>	Cenergia (DK)- Now part of Kuben Management. Ellebjergervej 52, 2450 Kbh SV Peder Vejsig Pedersen
<b>Project partners</b>	Cenergia, Gaia Solar, Leapcraft, Racell, Ecovent, Energimidt, Copenhagen City Properties, Technological Institute, Kuben Management, Gate 21
<b>CVR</b>	71195414
<b>Date for submission</b>	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 concerning realization of 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, then 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<sub>2</sub> 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 Active House test house “The Living in Light Box”.

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 system 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.activehouserooofsandfacades.com](http://www.activehouserooofsandfacades.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 tiles 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<sub>2</sub> neutral “ActiveHouse” test house both to the Nordic Countries as well as towards China. Besides they have contributed with an informative article in the FBBB thematic magazine on “BIPV for the energy system of the future”. See this in the annex.

As mentioned there has been serious problems of realizing “Smart Grid School Renovation with BIPV” in practice. But very important RTD work has been made on several aspects which support this agenda in Copenhagen. And one of the cost 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 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](http://www.activehouseroofsandfacades.com), også som formidlings platform for ” Smart Grid School ” EUDP projektet.

I det følgende gennemgås de vigtigste resultater for EUDP projektet samtidig 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 Kom-mune og endt med og fået 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 helhedsorien-teret 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 i gangsatte nordiske samarbejde om-kring, ” Nordic Buildt Active Roofs and Facades” hvor der var medfinansiering fra EUDP ( j.nr.64013-0578) samt Energientydigheden i Sverige og Rannis i Island, og dels arbejde sammen med Københavns Ejendomme 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 reno-veringsklasser 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.

Som tidligere nævnt, er 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 her formidlet opgaven med at få fremstillet det præfabrikerede testhus til Husfabrikken. Afsluttende arbejder, som også omfatter et SMA kombineret inverter og batteri system, er nu gennemført, med en blivende placering ved Kulbanevej i Valby, som led i område fornyelsesprojekt her.

Racell har benyttet 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 (50% øst og 50% vest) og 3 kWp (lodret) (se også den vedlagte brochure, som både omtaler arbejde med AktivHus mærkning af huset og online måling v. firmaet Visility)

Der har 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 meget aktiv mht. at anvende det udviklede AktivHus testhus i internationalt formidlingsarbejde, både til de nordiske lande og til Kina.

Resultater:

Som tidligere nævnt, er 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 til Husfabrikken. Afsluttende arbejder, som også omfatter et SMA kombineret inverter og batteri system, blev igangsat ifm. overførsel fra udstillings sted på Arkitektskolen på Holmen til en blivende placering ved Kulbanevej i Valby, som led i område fornyelsesprojekt her. (Huset er også AktivHus mærket hos Cenergia)

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Nordic Flexhouse har i 2018 indgået en kontrakt med Changsha i Kina i Hunan provinsen om opbygning af en Eco-village på 200.000 m<sup>2</sup>. Her vil Living in Light huset sammen med urban farvning vær et centralt element med solceller samt batteri fra Visblue.

Der har været et løbende samarbejde med Københavns Ejendomme og Københavns Kommu-ne i projektet.

Til Grøndalsvænge Skole anvendes solceller, men på grund af solcellereglerne kun til den ny-byggede del. Og til Lykkebo Skole er der udviklet en særlig solcelledrevet udsugningsventilation til et prøveklasserum som et supplement til den naturlige ventilation. Arbejde her har bl. bygget på tidlige udviklingsarbejder på området.

Link til rapport om CO<sub>2</sub> neutra ventilation med en række udførte eksempel projekter.

Disse løsninger kan laves med meget fin økonomi i dag 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 opfølg-ning på indsats ifm.

Landsdommergården i Kbh. NV. Efter konkursen er deres budget overført til Cenergia der nu er en del af Kuben Management, således at der er gennemført et udbud i samarbejder med Solarplan rettet mod 9 forskellige leverandøre.

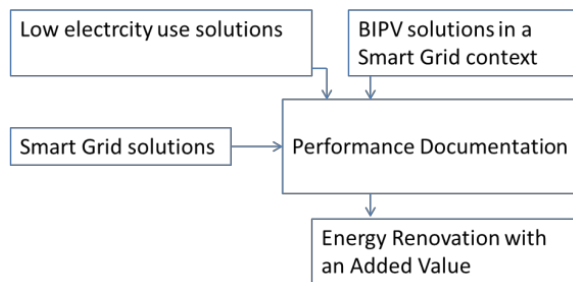
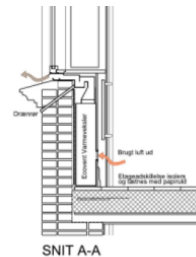
Samtidigt har firmaet Nordic Flexhouse meget aktiv mht. at anvende det udviklede AktivHus testhus i internationalt formidlingsarbejde, både til de nordiske lande og til Kina.

### **1.3. Project objectives**

Short version of EUDP Proposal

[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 realised demonstration projects in the Valby, city part of Copenhagen in connection to the Green Solar Cities, EU Concerto project ( [www.greensolarcities.com](http://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 m<sup>2</sup> 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 m<sup>2</sup> 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.

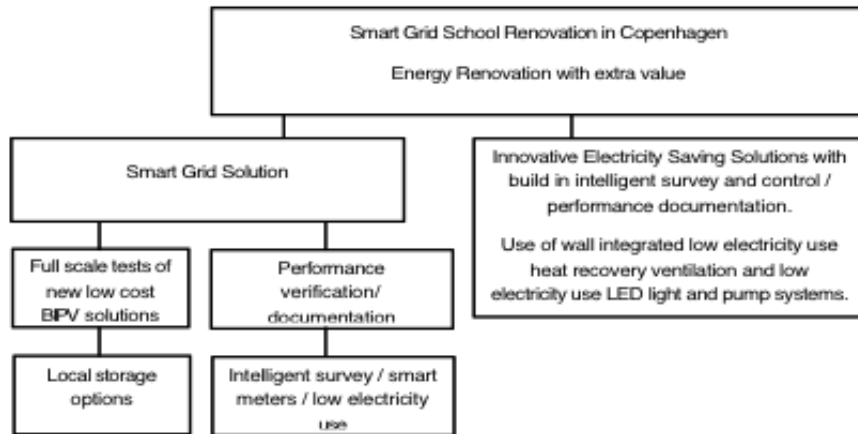
At the same time the actual electricity use which needs to be used in renovated classrooms will be significantly lower than normal and still with a good comfort for the users. This is following the same design philosophy as the new extension of the city hall in the city of Skive, where they wanted to 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,



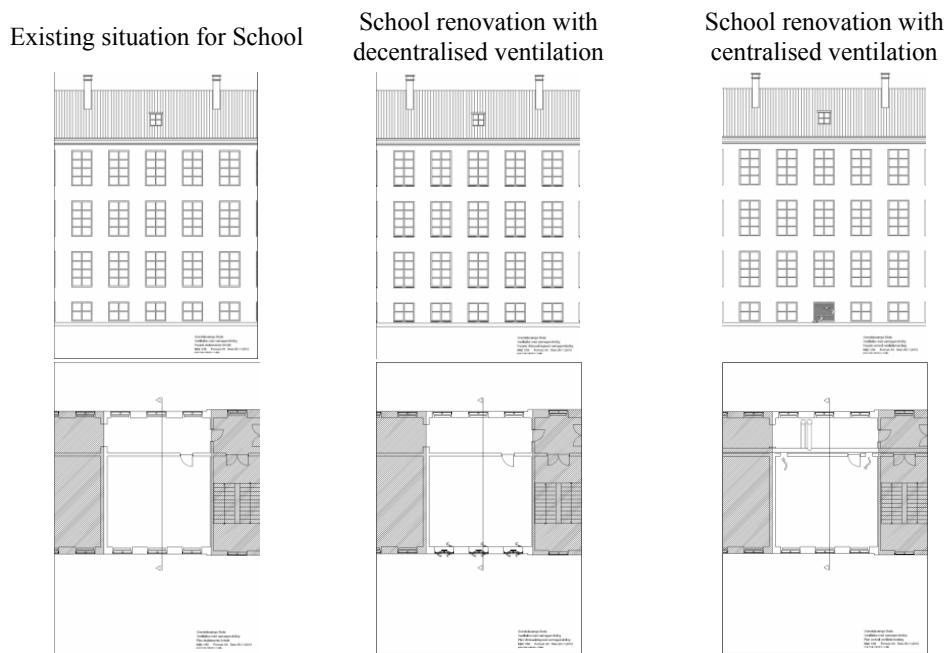
which can be mounted under the windows and still secure the quite high amount of ventilation air which is necessary for school classrooms.

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](http://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.

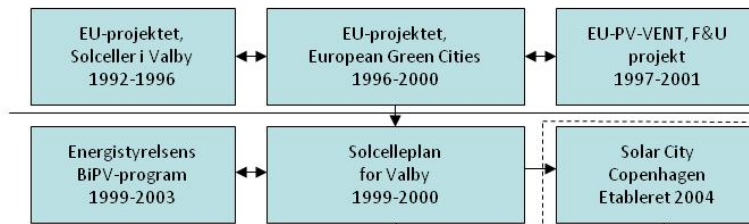




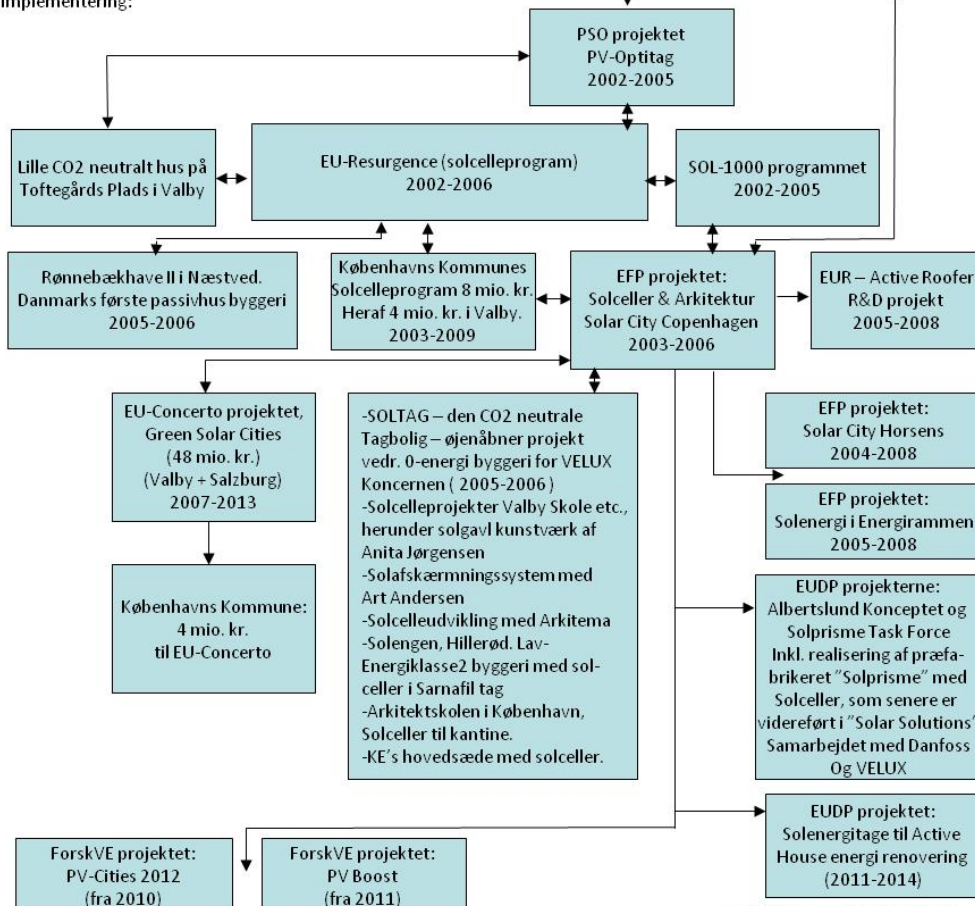
The building integrated window integrated heat recovery ventilation solution with low electricity use will be compared to centralized ventilation and to other existing types of classroom ventilation.

Sammenhæng med andre projekter.

Udgangspunkt:



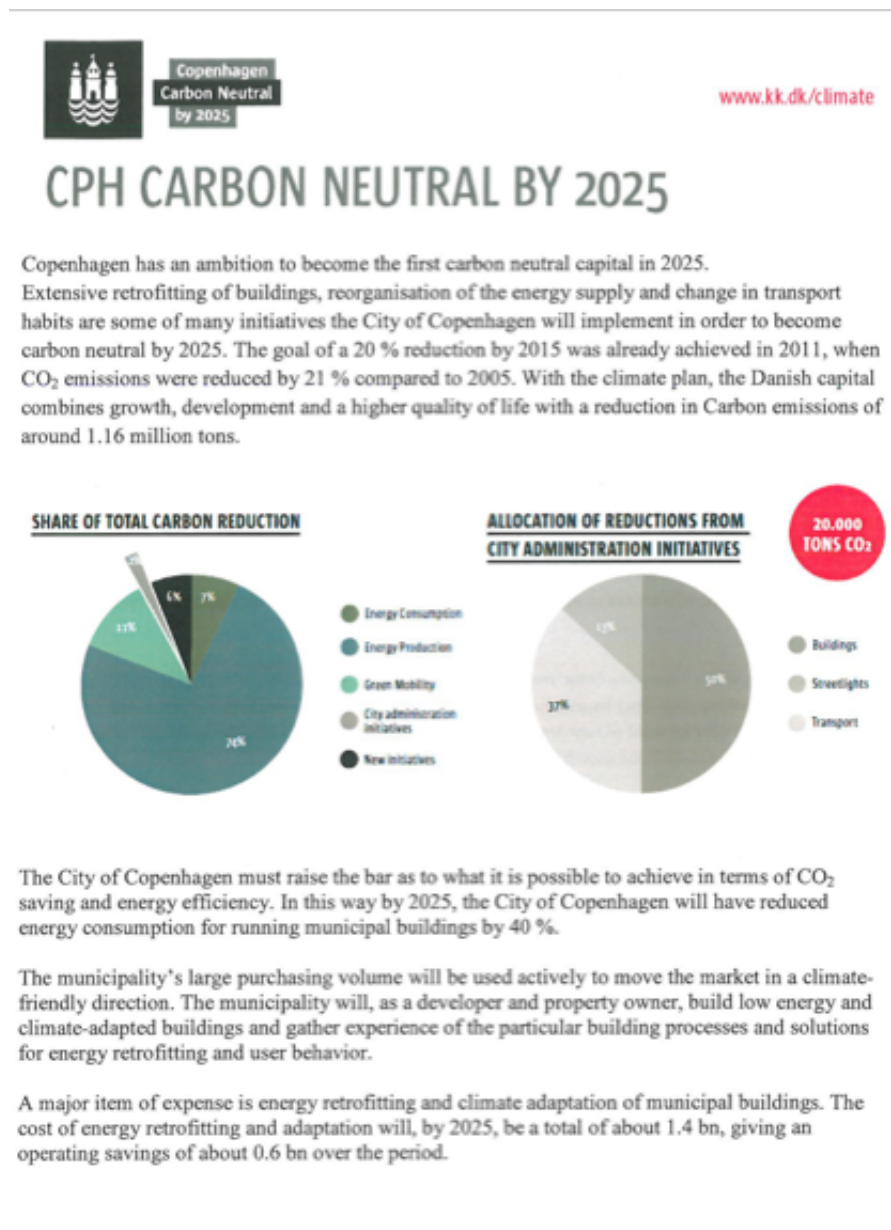
Implementering:



P. Vejsig Pedersen, Marts 2013.

Illustration of BIPV related projects since 1992 that Cenergia has

been involved with.



### **The City of Copenhagen Climate Plan for year 2025**

In Copenhagen the City of Copenhagen has a very strong Climate plan aiming at CO<sub>2</sub> 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 realise 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 organisation Gate21 is very important to realise these plans and ensure a close cooperation with the building industry where there are already many partners in Gate21 ([www.gate21.dk](http://www.gate21.dk)).

Also the Kuben Management organisation 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 organising 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](http://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 CO<sub>2</sub> emissions by more than 20% up to year 2009. And the aim is to reduce the CO<sub>2</sub> 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 CO<sub>2</sub> 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.

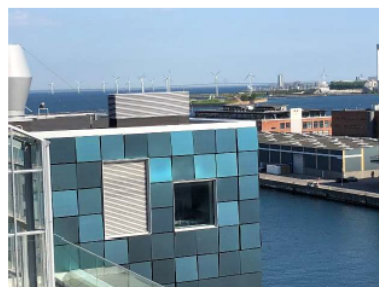
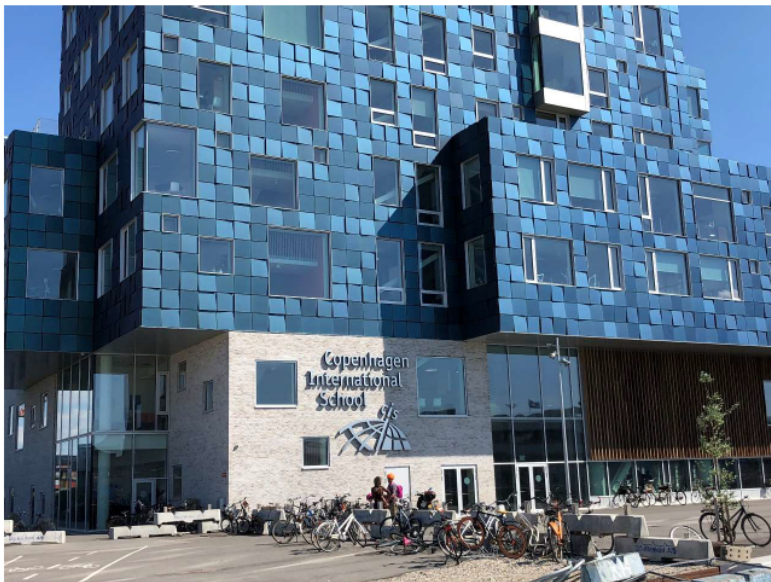
Goal: The city of Copenhagen will achieve 10% of its total CO<sub>2</sub> reduction by 2015 through construction and renovation projects. This is equivalent to 50,000 tons of CO<sub>2</sub>”

#### 1.4. Project results and Dissemination of results

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.

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<sup>2</sup> 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 m<sup>2</sup> 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.

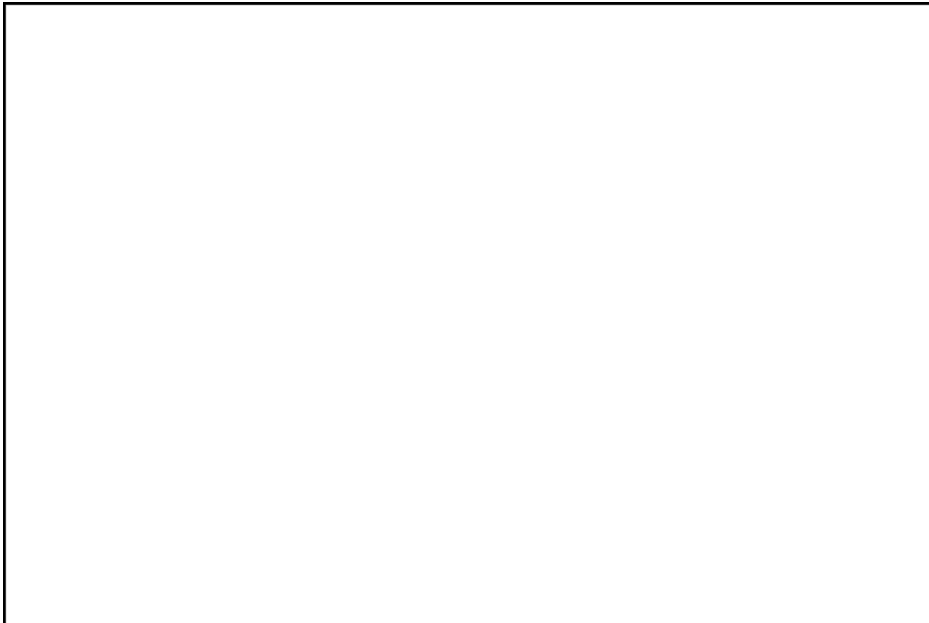


As another example of working towards a city oriented approach for Active House quality and use of PV technology can also be mentioned preparation work connected to Green Energy Island development, where a 100% renewable energy supply is aimed for in connection to new housing development.

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.



Active House label being handed over to CIS in May 2018.



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





[www.europeangreencities.com](http://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 category winner (see [www.activehouse.info](http://www.activehouse.info))

[www.activehousebipv.com](http://www.activehousebipv.com) | [www.activehouserooofsandfacades.com](http://www.activehouserooofsandfacades.com)

**KUBEN**<sup>NRG</sup>  
MANAGEMENT

CENERGIA



**KUBEN**<sup>NRG</sup> En del af  
MANAGEMENT