- En del af

Final report

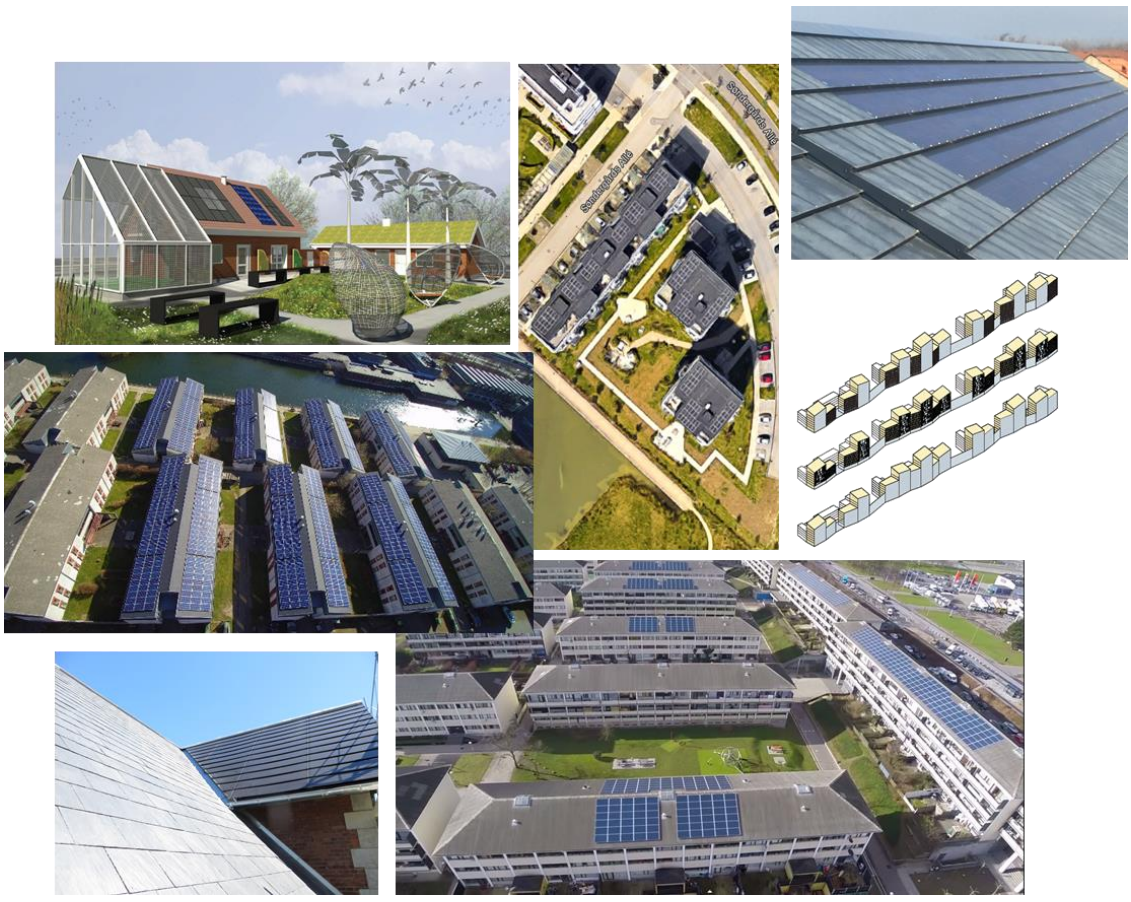
PV Active Roofs and Facades

Gate21 in cooperation with Cenergia

ForskVE project no. 2014 – 1 -12178

The aim of the project has been to work with Danish housing associations, which are very professional organised, to help changing the existing reluctant attitude towards building integration of PV solutions (BIPV), including solutions where PV modules ideally can form the roofing surface.

The total proposed implementation for roof exchange, housing renovation and new built housing association projects was focusing on at least 2.6 MWp BIPV capacity.



01. November 2017

Final report

1.1 Project details

Project title	PV Active Roofs and Facades
Project identification (program abbrev. and file)	Energinet.dk project no. 2014-1-12178
Name of the programme which has funded the project	ForskVE
Project managing company/institution (name and address)	Gate21 Vognporten 2 2620 Albertslund
Project partners	Cenergia, Solar City Denmark, FBBB, Eniig, Teknologisk Institut, Aalborg University (AAU)
CVR (central business register)	32112846
Date for submission	**1. December 2017**

1.2 Short description of project objective and results

The aim of the PV Active House and Facades project has been to change the reluctant attitude in Danish housing associations towards building integration of PV solutions (BIPV).

Main activities
Demonstrate plans for BIPV as part of roof and total renovation of at least 2,6 MWp; Present existing best practice; Countrywide innovative sketch projects; 10 frontrunner projects; A common vision for BIPV in Denmark.

Main results
Demonstration of more than 2,6 MWp installed capacity; 15 sketch designs; 10 front runner projects; A common recommendation for BIPV in strategic energy planning; Market analysis for BIPV; Results has been disseminated via a range of activities. In September 2017 a final conference was held, attracting a broad range of Danish stakeholders.

(Dansk)
Målet med projektet PV Active House and Facades har været at ændre boligforeningers holdning til at implementere bygningsintegrerede solceller (BIPV).

Hovedaktiviteter
Demonstrere BIPV planer i forbindelse med tag- og totalrenovationer for mindst 2,6 MWp; Præsentere eksisterende best practice; Landsdækkende skitseprojekt aktiviteter; 10 frontrunner projekter; En fælles vision for BIPV i Danmark.

Overordnede resultater
Mere end 2,6 MWp installeret kapacitet; 15 skitseprojekter; 10 frontrunner projekter; En fælles anbefaling for BIPV i strategisk energiplanlægning; Markedsanalyse for BIPV; Resultaterne er succesfuldt formidlet via en række aktiviteter. Blandt andet via den afsluttende konference i september ´17, hvor værdikædens interessenter var bredt repræsenteret.

1.3 Executive summary

The aim of PV Active Roofs and Facades has been to work with Danish housing associations to help changing the attitude towards building integration of PV solutions (BIPV), including solutions where PV modules ideally can form the roofing or facade surface.

The Danish housing associations regard PV and BIPV technologies as an interesting option in relation to coming projects with roof renewal, overall renovations and new built of housing association schemes. The sector represent a large part of the Danish building stock and therefore a large potential concerning energy savings and sustainable energy production with PV technology.

The main objectives of the project have therefore been to investigate the potentials of BIPV technology in the housing association sector via:

1. 10 front runner projects
2. 30 sketch design projects
3. Installation of 2,6 MWp PV in cooperation with the sector.
4. Developing of a common vision on how large scale PV and BIPV larger roof and housing renovation can be utilised in connection to strategic energy planning

PV Active roofs ad facades met its project objectives as follows:

1. Investigation of the potentials of PV and BIPV technology in the housing association sector via front runner projects, sketch design projects and the installation of 2,6 MWp PV in cooperation with the sector.
2. Dissemination of project results to the houing association sector and other relevant stakeholders. This includes the FBBB database www.bæredygtigebygninger.dk and thematic magazines.
3. Development of a common vision on how large scale PV and BIPV in larger roof and housing renovation and new built housing projects can be utilised in connection to strategic energy planning.

When the project started in 2014, cooperation agreements were made with both the KAB housing association, which holds 10% of all social housing in Denmark, and AL2bolig, which had plans for large scale PV implementation.

During the project period we have experienced a range of changes to the regulations, that have had a more significant impact on the housing association sector than expected when the project was developed. A main obstacle has been the need for a new virtual metering system for whole housing estates, in order to avoid large investments changing metering systems, especially in multiple multi-storey areas. Until end 2016 it seemed possible to have a model for a new virtual metering system accepted, being promised by the Ministry of Energy, Housing and Climate, but later changes in PV legislation have not supported this solution, to the concern of the sector. Due to this kind of obstacles, it has not been so easy to realise the project in the same way as it was proposed. It turned out to be difficult to convince housing associations to test new BIPV technologies, and many demonstration projects have ended up being traditional on-top-of-roofs BIPV installations. In 2016, a new regulation effectively stopped most of the development of new PV projects in the sector.

The changes in regulations have made it difficult to recruit new front runner projects and sketch design projects and has meant, that some of the project objectives have not been met entirely. The project has, however, reached the objectives of installed capacity of 2,6 MWp. The project has also developed 10 front runner projects and 12 sketch design projects. And a common recommendation for the instalment of large scale PV on rooftops and BIPV solutions has been proposed by the project partner AAU.

AAU has reported on the effects of the changing regulations for the housing association sector. Also a market analysis for BIPV in Denmark and internationally has been developed

within the project and formed a basis for discussions of the market growth and export potentials of BIPV solutions. The project has benefitted from the general development in the PV and BIPV market, where PV costs have kept being reduced, while new BIPV solutions have penetrated the market. And especially the BIPV sketch designs has benefitted from this, also based on a decision to combine several projects into large packages of BIPV sketch design work.

The knowledge and experiences developed within these activities have been disseminated via a range of workshops, two FBBB magazines and other dissemination activities aimed at the housing association sector and other relevant stakeholders. In September 2017 a final conference was held, attracting a broad range of stakeholders, local and national politicians, municipalities, suppliers, developers and researchers. Here, the role of rooftop PV and BIPV in both the Danish energy system and as export potential was discussed.

1.4 Project objectives

1.4.1 *Description of the project objectives*

The PV Active Roofs and Facades project has been supporting the area of building integrated solar energy systems, which both Peder Vejsig Pedersen from Cenergia and the company Eniig has been involved in for more than 25 years, and which since 1999 also have included the urban renewal part of Kuben Management, which at that point joined the vision of creating whole city areas, where PV technologies were integrated into the architecture in a positive way. Something which in year 2004 lead to the creation of Solar City Denmark, which since then have supported the idea of building integrated PV (BIPV) in cities.

Supported by the ForskVE programme since 2011, there has now been realised 3 cooperative dissemination oriented projects supporting the BIPV agenda in Denmark, with Gate21 as the coordinating party and with Peder Vejsig Pedersen as initiator and technical project leader at the same time involving both Kuben Management, Eniig, Solar City Denmark, The Danish Association of Sustainable Cities FBBB, Technological Institute, Solarplan and AAU.

The cooperation started with the PV-Boost project, which was finalised in 2015 and from 2013 to 2017 there was realised a cooperation wiith cities in the BIPV Quality Cities project, and now also the PV Active Roofs and Facades project from 2015, which had a cooperation with primarily housing associations, have been finalised in a situation, where the PV market in Denmark is still very fragmented, but still with better and better solutions being created in the BIPV area.

The PV Active Roofs and Facades project has to some extend been successful in supporting this development by cooperative initiatives like supporting the revision of the FBBB database www.bæredygtigebygninger.dk, so it had a strong focus on BIPV and Active House building and also working with the Technological Institute and Solarplan on realisation of an actual BIPV Demosite, which can exhibit the latest developments in the area.

The aim of PV Active Roofs and Facades has, as mentioned, been to work with Danish housing associations to help changing the attitude towards building integration of PV solutions (BIPV), including solutions where PV modules ideally can form the roofing or facade surface.

Many danish housing associations have, and still do regard PV and BIPV technologies as an interesting option in relation to roof renewal, overall renovations and new built of housing association schemes. The sector represents a large part of the Danish building stock and therefore a large potential concerning energy savings and sustainable energy production with PV technology.

When the project was developed, there was a common understanding, that the housing association sector lacked knowledge of the potential of BIPV solutions. A number of barriers for installing BIPV solutions at housing associations were identified:

- A lack of knowledge about what the sizing and placement of the PV projects shall look like also in connection to local meters, the electricity use patterns and the overall housing scheme, including more knowledge on how much PV electricity you should aim at consuming within the hour of PV production, and what this means for the size of the PV system.
- A need of presenting the energy and economy implications in relation to other energy saving options including a view to lifetime issues and reliability of the systems.
- Front runner and example projects to document and monitor the performance of new and innovative reasonable cost BIPV modules.

The main objectives of the project were therefore to investigate the potentials of BIPV technology in the housing association sector via front runner projects, sketch design projects, and the installation of 2,6 MWp BIPV in cooperation with the sector. The knowledge and experiences developed within these activities should be disseminated via a range of workshops and other dissemination activities aimed at the housing association sector and other relevant national and local stakeholders. Furthermore the project wanted to develop a common vision on how large scale BIPV in larger roof and housing renovation and new built housing projects can be utilised in connection to strategic energy planning.

The project was structured around 9 work packages with the following objectives:

WP1	Presentation of housing association example projects for a. Roof renovation with BIPV b. Total housing renovation and new built projects with BIPV. Special focus on integration details and total economy.
WP2	Countrywide sketch design projects for roof renovation and total housing renovation and new built with BIPV. At least 30 projects in total.
WP3	Detailed design of 10 BIPV frontrunner projects as basis of plans for large scale implementation in cooperation with housing associations. Here a special view to where do you best place the optimised amount of BIPV capacity the best way; on one, a few or all housing blocks or e.g. as cover over the parking area. Quality Agreement will be defined
WP4	Investigation and vision on how large scale PV and BIPV in larger roof and housing renovation and new built housing projects coordinated by Danish housing associations can be utilised in connection to strategic energy planning.
WP5	Demonstration plan for BIPV used for roof renovation in Danish housing associations (minimum size 1000 apartments each 1 kWp equal to 1,0 MWp PV (7 - 8.000 mD) Total investment of 12 mio DKK supported by 10 % or 1,2 mio DKK, based on Quality agreement.
WP6	Demonstration plan for BIPV as part of total housing renovation and new built projects by Danish housing associations (minimum size 1600 apartments each 1 kWp as a mean equal to 1,6 MWp PV (11 - 12.000 mD) Total investment of 19,2 mio DKK supported by 10 % or 1,92 mio DKK, based on Quality agreement.
WP7	PV and BIPV quality control and monitoring / follow up on PV production. Results from a previous ForskVE project using a special "Solar Watch" system will be utilized.
WP8	Dissemination of project results
WP9	Project coordination

The objectives and results of each work package will be elaborated in section 1.5

1.4.2 *Description of the implementation of the project. How did the project evolve?*

1.4.2.1 Describe the risks associated with the project.

There has been identified three main risks and barriers with the project:

1) As the project was developed, the Danish PV regulations were changed, affecting the business case and thus the willingness to install new PV solutions in the housing association sector. At the time of the project development, the partner group estimated that the changed regulations would not influence the PV/BIPV implementation in the sector significantly, partly due to huge international decreases in the price of PV technology. Though, together with uncertain signals from legislative actors, and the PV legislation being changed continuously during the project period, it has shown that the market for PV installations in the sector in Denmark decreased abruptly in 2014 and 2015 and stalled completely in 2016.
2) A main technical obstacle during the project period has been the need for a new virtual metering system for whole housing estates, in order to avoid large investments changing metering systems, especially in multiple multi-storey areas. Until end 2016 a model for a new virtual metering system seemed possible, being promised by the Ministry of Energy, Housing and Climate, but later changes in PV regulations have not supported this solution, to the great concern of the sector.
3) It has been a clear experience, that most actors in the housing association sector as well as finance institutions preferred a conservative policy regarding PV implementation, and thus the risk appetite in the sector was smaller than expected. Testing new integrated BIPV technologies and solutions with uncertain/theoretic business cases was difficult, affecting the amount of innovative BIPV front runner projects installed and tested as part of the project.

The changes in regulation thus seriously affected the business cases for PV projects in the housing association sector despite decreasing technology costs, and represented therefore a main barrier to the development of new innovative solutions in the sector in Denmark. Few projects were still implemented – as more traditional, thoroughly tested solutions on roof tops, or as part of a BR15 or BR20 strategy for the whole building envelope. This, combined with the experienced small risk appetite in the sector, meant that the project group refocused the demonstration activities to more traditional BIPV solutions, but still kept a focus on new innovative solutions in sketch projects and communication activities, so as to support the sector for eventual more favourable regulatory changes.

1.4.2.2 Did the project implementation develop as foreseen and according to milestones agreed upon?

In overall the project developed according to the milestones with some delays and changes to certain activities.

Minor activity changes:

- The vision and a roadmap for BIPV in Denmark in relation to strategic energy planning was published in September 2017 in connection to the final conference and not as planned in february 2016, partly due to changes in the PV regulations, the partner group wished to analyse further. The report was co-financed with the project Low Cost Active House BIPV (PO: 2015-1-12308) for more comprehensive and efficient data collection purposes.
- Frontrunner projects were promoted during the entire project period, and not only during 2015, via the FBBB database www.bæredygtigebygninger.dk.
- Furthermore, the project period has been extended with 3 months, from September 1st to December 1st 2017, in order to finalise the communication of project results, including the conference in September 2017.

Major activity changes:

- In general it was a challenge to recruit front runner projects and sketch design projects, which we assume is due to the risks and barriers concerning changing regulations during the project period. It was therefore decided at partnergroup meeting in December 2016 to change focus from many sketch projects to fewer but more comprehensive, as reported in Interim report 2016-2. This decreased the number of expected sketch projects from 30 to 15. WP 2 and 3 therefore remained active throughout the whole project period.

- In the WP plan it was planned to make a demonstration plan for BIPV used for roof renovation in Danish housing associations (minimum size 1000 apartments each 1 kWp equal to 1,0 MWp PV (7 - 8.000 mD), with a total investment of 12 mio DKK supported by 10 % or 1,2 mio DKK, (WP 5) in the period Jan. 2015 – Feb. 2017 and a demonstration plan for BIPV as part of total housing renovation and new built projects by Danish housing associations (minimum size 1600 apartments each 1 kWp as a mean equal to 1,6 MWp PV (11 - 12.000 mD), with a total investment of 19,2 mio DKK supported by 10 % or 1,92 mio DKK (WP 6) in the period Jan. 2015 – Feb. 2017, respectively. However, it has not been possible to follow this thorough plan in detail. WP 5 and 6 also remained active throughout the whole project period.

Deviations from milestone plan:

- Two FBBB magazines were published in june 2016 and november 2017 respectively, and not solely in may 2016 as originally planned (milestone 4), in order to include articles on some of the major results of the project. The November 2017 edition is co-financed with the ForskVE Low Cost Active House BIPV (PO: 2015-1-12308)
- The number of workshops held was decreased, as described in Interim report 2016-2. As a result of the feed back from participants at the workshops and the general situation in the sector, the partner group decided half way through the project to re-focus the project resources on communicating results via other channels than workshops, with the final conference as the major dissemination activity. This meant that 10 workshops were held instead of the planned 12. Out of the 6 planned workshops according to the milestone plan, the 2 first workshops were held accordingly. The conference was also held according to the milestone plan, and incorporated the most important of the planned at themes from the originally planned milestone workshops.

1.4.2.3 Did the project experience problems not expected?

As mentioned under section 1.4.2.1, regulations were at first only expected to have a minor negative effect on the project objectives. During the project period the sector experienced a range of changes to the regulations, that have had a much more significant impact on the housing association sector than expected at first. In 2016, a new regulation effectively stopped the development of new PV projects in the sector (see graph below from the report developed under WP 4:).

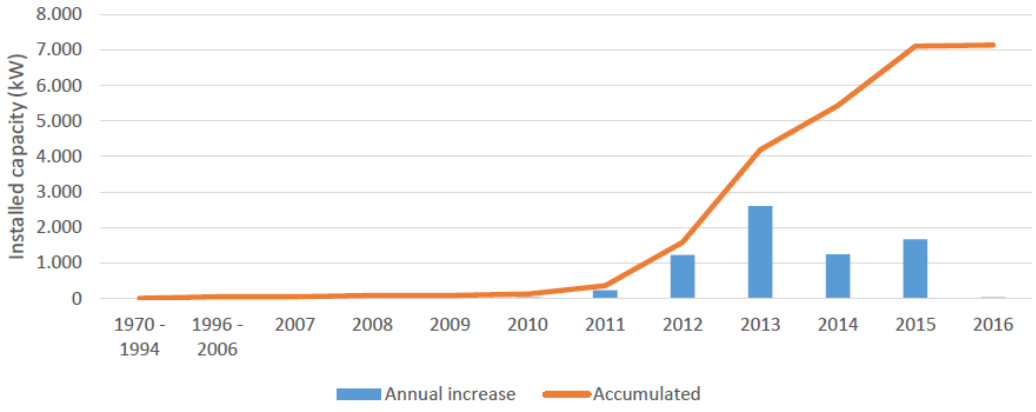


Figure 46: The annual development of the installed capacity of PV installations owned by public housing associations (columns) and the accumulated capacity. The development from 1970 to 1994 and 1996 to 2006 are summed as the development are insignificant. It should be noted that the data for 2016 only includes the first half of the year. The figure is based on data from Energinet.dk extracted medio 2016.

The report developed under WP 4 has highlighted the effects of the changing regulations for the housing association sector in chapter 8: (http://www.energyplan.eu/pv/)

This made it very difficult to convince the sector to test new innovative BIPV technologies, meaning that most demonstration projects ended up being more traditional on-top-of-roofs installations. In spite of this, the partner group has succeeded to reach the objectives regarding installed capacity.

1.5 Project results and dissemination of results

Description of main activities and technical results in the project, as well as description of commercial results and expectations of the project.

1.5.1 *Did the project succeed in realising its objectives? If not, why?*

In the following, the results of each work package will be presented. Afterward a conclusion on how the overall objectives of the project were met will be summarized.

WP 1

There has been an important work gathering example projects regarding PV and BIPV projects from the housing association sector, especially regarding data gathering and presentation regarding performances and economics. Example projects have been presented in the FBBB database, as well as used as case presentations at workshops, in articles, in report developed under WP 4, and so forth. Example projects counts among others:

Roof renovation with BIPV:

- Søpassagen housing renovation with BIPV Copenhagen roof
- Villa in Hellerup utilising the same technology
- BIPV roof for Ringgården in Aarhus
- BIPV in connection to Steni roof plate system
- BIPV roof for Måløv Park

Total housing renovation and new built projects with BIPV:

- Hosing renovation in Sønderborg
- New build Active House dwelling near Aarhus
- Living in Light Box in Copenhagen
- Design for Gl. Jernbanevej housing renovation in Valby
- Design for Ellebo Garden Room with BIPV and new individual electricity metering
- BIPV for a whole city area in Køge Nord

WP 2

During the entire project, the partner group has made an ongoing effort recruiting sketch projects at workshops and through communication activities. It has however not been possible to recruit the proposed 30 sketch projects and the number has during the project been decreased to 15. When asked, most housing associations had a great interest in the sketch projects offered through the project, but primarily stated the aforementioned regulatory conditions for PV in social housing as a main reason for not considering developing BIPV projects at the moment. The final number of sketch projects the partner group managed to recruit through the project is as shown below reaching the aimed at 15 sketch projects. Generally, the sketch projects developed have shown more innovative BIPV-solutions than the demonstration projects have been able to do.

Promotion activities for the sketch projects include:

- The sketch projects have been presented at a range of activities, either as a subject of discussion or as general information.
- Solar City Denmark has been invited to present the sketch project plan in several municipalities (eg. Egedal, Copenhagen) and at external activities, (eg Teqnic).
- The sketch project plan has been mentioned in mails and invitations of similar subjects.
- The sketch project plan is described at Solar City Denmarks (www.solarcity.dk)
- Announced in the member magazine of FBBB. Announced by Næstved Municipality in Næstved Tidende
- Some municipalitites have distributed information internally (Høje Tåstrup, Egedal, Furesø).
- Solar City Denmark and Gate 21 have sent information on the sketch project plan by letter, to housing associations across the country.

PV Active Roofs and Facades – List of sketch design projects:

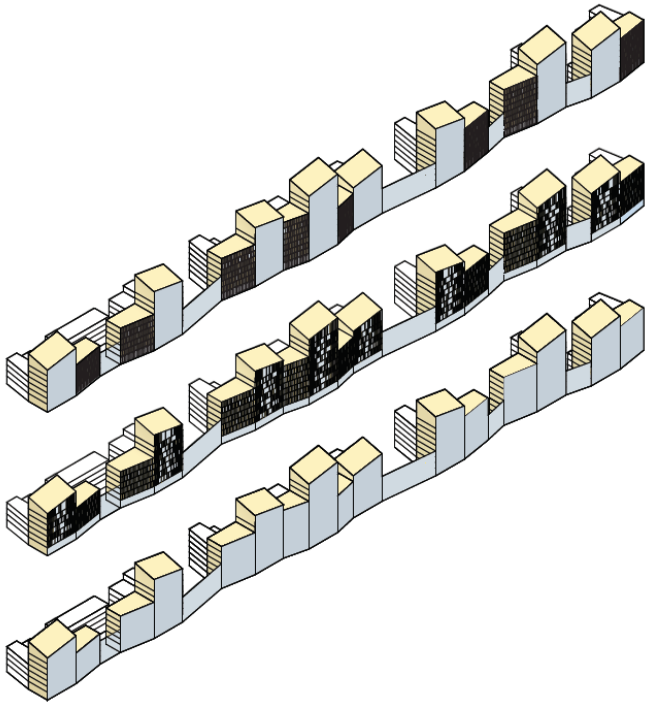
- Housing association Søbo, Sønderborg (already started in connection to BIPV QC project)
- Housing association SAB, Sønderborg (already started in connection to BIPV QC project)
- KFS boligbyg, Active House labelled one family house near Aarhus
- BIPV roof at Ringgården, Aarhus
- "Storehus" at Avedøre
- Revised housing renovation Kildeparken, Gladsaxe
- Hvidovrebo housing association, Hvidovre
- Villa in Hellerup
- Housing block renovation Gl. Jernbanevej, Valby with Domus architects
- PV for Ellebo housing renovation in Ballerup
- PV for Living in Light Box
- PV for protected building at Christiania
- BIPV for washing house at Måløv Park
- PV for Panum Institute, Copenhagen
- Large project for Køge Nord, Reiiulf Ramstadt Architects
- BIPV for Bonava housing, Furesø municipality
- BIPV for Huskompagniet, Furesø municipality

City oriented BIPV planning for Køge Nord

Below is shown material from Reiiulf Ramstadt Architects (RRA) from Norway has made a large BIPV sketch design project for Køge municipality on the Køge Nord area, which shall be developed around the new trainstation, Køge Nord, which is linking the new railway and the motorway, where a sales prospect for commercial buiding now includes solar integration assessment as a completely new thing for a large urban development project.

SUN PANELS

THE SHAPE CAN STILL BE ONE OF THE THREE ALTERNATIVES. BUT IN THE EXPERIMENTS WITH SUN PANELS ONLY ALTERNATIVE 1 IS REPRESENTED. THREE DIFFERENT VARITATIONS OF SUN PANELS HAVE BEEN DEVELOPED.



Based on this, the basis for a new prosumer level approach has been created as basis for an almost zero energy standard for the future.
It was a unique opportunity to realise this city scale oriented BIPV sketch design project, which has been cofinanced by the PC Active Roofs and Facades project and the Low Cost Active House BIPV project. The results will be discussed at a special Solar City Denmark workshop in the spring 2018

RRA drawings for Køge Nord. Commercial building with BIPV working as noise barrier in front of new large housing area.

Analysis from RRA and Cenergia concerning available solar energy façade area for the commercial buildings at Køge Nord has shown, that it is possible to cover 50% of the energy supply by renewable energy equal to a prosumer level 2 in the international Active House standard.

WP 3

Results concerning frontrunner BIPV projects and implementation plans of the PV Active Roofs and Facades project.

From the start of the project, there was contact with a large number of housing associations concerning housing renovation projects with BIPV.

Here can be mentioned KAB housing association with Søfryd in Måløv and Ellebo in Ballerup. And "Storehus" in Avedøre, Hvidovrebo in Hvidovre, Måløv Park in Måløv, Living in Light urban renewal at Gl. Jernbanevej in Valby, housing renovation in Sønderborg, large scale renovation of Langlærparken with AL2bolig in Tilst near Aarhus and Kildeparken renovation with GAB in Gladsaxe.

But due to the long negotiation between BL (Danish corporation of housing associations) and the ministry for Climate, Housing and Energy on introducing principles for "virtual metering", especially for the more "park" like housing estates, which in the end did not lead to any useful results, it was not realistic to realise PV for several of these projects in a costeffective way due to high costs concerning metering.

This lead to a need to work on a revised BIPV implementation plan with more focus on more ordinary roof renovation projects, while the more holistic oriented projects had problems to be realised with BIPV and especially to follow the quite strict time schedule.

The result was, that most of the actual implemented BIPV projects was realised in connection to roof renovation except some smaller projects at Frederiksberg, Christiania and Hellerup. Also prepared holistic renovation projects at Langkærparken with 1MWp and at Ellebo with 260 kWp was introduced in the Low Cost Active House BIPV project instead.

As a result new agreements was made with the international kollegium in Albertslund in connection to roof renovation, which meant that there was still around 2.100 kWp BIPV, realised with frontrunner partners in the housing sector.

This was supplemented by advanced BIPV solutions with Innogie, which also was a partner at the final conference and also PV for the Panum Institute renovation, so more than 2.600 kWp has been relaised in 10 frontrunner projects as aimed at in the contract.

From the start of the PV Active Roofs and Facades project it has been a general experience, that real building integration of PV installations is still regarded as a market niche, and one among many solutions to be considered – even when the whole roof is to be renewed. The reason for this might be a different business case than implementing standard PV modules on existing roofs, as well as a lack of market solutions – the market in Denmark is still represented by pilot projects and tailor-made, individual solutions, from (many) different small or medium sized PV installation companies. Therefore a BIPV demosite at the Technological Institute in Taastrup was established as part of the project in cooperation with the projects Low Cost Active House BIPV and also ongoing EUDP projects. The BIPV demosite supports the dissemination of BIPV qualities towards architects and building owners as a technological "show room". The preparation for the BIPV demosite has been worked at since Interim report 2016-2, and the implementation plan was finally approved June 22nd 2017 by ForskVE.

The BIPV Demosite at the Technological Institute is currently being established in cooperation with Solarplan, and will continue to be developed after the PV ARF project ends. The partners at Technological Institute has used their budget to support this, also with necessary monitoring. The BIPV demosite can support the dissemination of BIPV qualities towards architects and building owners, and a small publication from Solar City Denmark will support this initiative, showcasing the different BIPV solutions, that at present can be delivered in Denmark. It is aimed to continue the Solar Watch activity for the installed BIPV systems, mainly with IQ Energy creating the platform for this. In addition, initiatives to secure these data for a reasonable time span have been made.

WP 4

AAU has made a comprehensive report concerning a vision and a roadmap for BIPV in Denmark in relation to strategic energy planning. The analysis has been developed and coordinated with the vision work in the project Low Cost Active House BIPV.

The report "The role of Photovoltaics towards 100% Renewable energy systems – Based on international market developments and Danish analysis" focuses on the contribution of solar photovoltaic in a fossil-free energy scenario in Denmark, as well as the transitions that are necessary in the building sector to support this change. In summary, it consists of:

- A review of global trends on the development of costs and capacities for PV;
- The expected future developments of PV installations in Denmark and the past development
- An energy system analyses of the role of PV in Denmark;
- An analysis of the potentials for rooftop PV in Denmark using GIS (Geographical information systems) divided upon ownership, municipalities and building sizes;
- Comparison of land use and renewable energy from PV and wind power;
- An international review of global trends for public regulation and support schemes;
- A historic review of public regulation for PV in Denmark and the effects on PV capacity development;
- Case studies for the economics of PV in Denmark for different stakeholders;
- A discussion and evaluation of different support schemes and PV market construction in Denmark;
- Recommendations and ideas for new public regulation for PV in Denmark.

Abstract

For many decades, solar photovoltaics has been labelled as an expensive technology with low potential of expansion. In the recent years, this technology experienced a fast increase in capacities correlated with an abrupt decrease in costs, which could make photovoltaics have an important role for the future energy mix. The purpose of this report is to describe what will be role of photovoltaics in a future 100% renewable energy system in Denmark towards the year 2050, but also to propose how the future public regulation schemes should adapt to intake the correct type and capacity for PV.

The report builds on a literature review of the global and Danish trends in capacity, costs and types of support schemes, but also develops a GIS and energy system analysis supported by a set of economic calculations to inquire on the recommended pathway for the future investments in photovoltaics in Denmark.

The review and analysis are focused on the integration of photovoltaics from a system perspective, analysed in the light of socio-economics. By building on this approach, a set of recommendations is proposed, which are structured on the system benefits and feasibility of photovoltaics, the land use and not the least on public regulation schemes and gradual increase in capacities.

Presentation

The AAU report was presented at the final conference on September 26th and was also published on www.energyplan.eu/pv. Furthermore the report and its results were communicated and mentioned in the following channels:

- **Altinget.dk**: Ny analyse: Vi har brug for solcellerne – og solcellerne har brug for ny politik
- **Ingeniøren**: Rapport: 5.000 MW solceller på danske tage i 2050
- **Energy Supply**: Ny analyse lægger op til 5.000 MW sol
- **Dansk Byggeri**: Solceller - et opadgående marked
- **Byens Ejendom**: Behov for flere tagbaserede solceller
- **P1 orientering (17:15)**: Solcellerne har brug for ny politik
- **Nordjyske**: Lyset helt slukket for solceller
- **EnergyWatch**: Ny rapport anbefaler op mod 10.000 MW sol i 2050
- **Energiforum Danmark**: Ny analyse anbefaler ny lovgivning på solcelleområdet

A short presentation of the recommendations from the report has been made, and distributed to national stakeholders and politicians from the Energy Committee of the Danish government. (see also annex)

WP 5 and WP 6

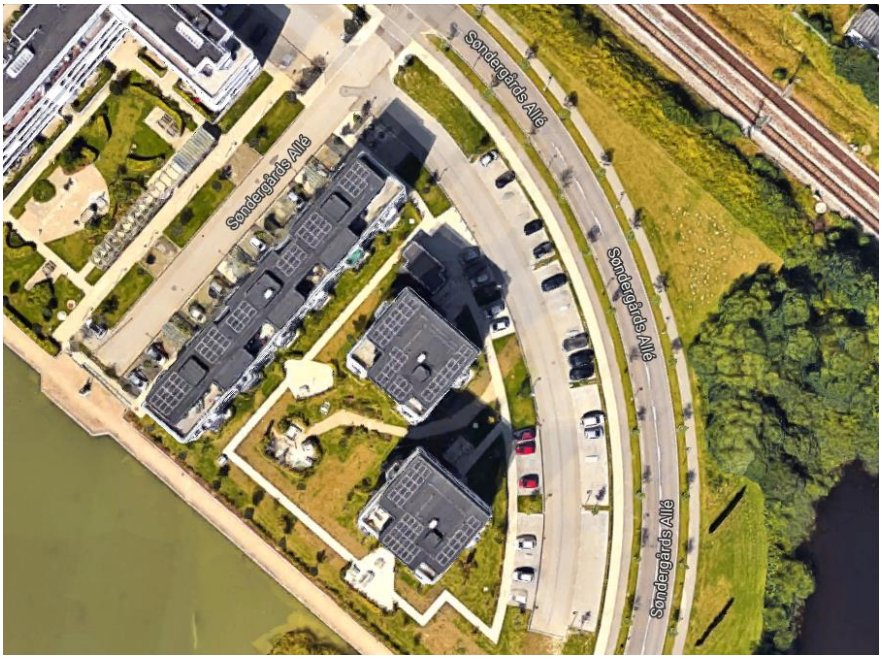
It has not been possible to achieve the planned at allocation between WP 5 and 6, meaning a total investment of 12 mio DKK of roof renovation for Danish housing associations with "minimum size 1000 apartments each 1 kWp equal to 1,0 MWp PV (7 - 8.000 mD), and a total investment of 19,2 mio DKK of total housing renovation and new built projects with "minimum size 1600 apartments each 1 kWp as a mean equal to 1,6 MWp PV (11 - 12.000 mD)" respectively.

However, the total implementation in the PV Active Roofs and Facades project has been 2713 kWp, a little higher than the total aimed at BIPV implementation in the project, being 2600 kWp.

Housing association	City	kWp installed
AAB Skovlunde	Ballerup	138
KAB Søfryd	Måløv	100
Gammel Kongevej byfornyelse Maskinebygning	Frederiksberg/Christiania	25
Taastrupgård	Høje Taastrup	850
Danmark Internationale Kollegie, DIK	Albertslund	367,36
Sønderborg Andelsboligforening, SAB	Sønderborg	460
Søbo Boligselskab	Sønderborg	160
Panum Institut/Mærsk Tower	København	211
Innogie, BIPV	DK	333
Jobcenter Roskilde	Roskilde	69
I alt		**2713,36**

Examples of supported PV and BIPV systems in the PV Active Roofs and Facades project:

PV installation at Taastrupgård



KAB, Søfryd buildings in Måløv with implemented PV

PV on the International Dorm in Albertslund.

Design of BIPV solution for Sundhøj Energihus in Tåsinge, made by Innogie – models to be used for house and terrace house housing associations as well.

WP 7

Solar Watch activities, regarding data for monitoring and evaluation, have been installed and monitored for several of the housing association with whom agreements have been made.

The needed data for benchmarking PV installations in the housing sector (performance documentation) are continuosly extracted from the existing monitored projects in IQ Energy and the first analysis has been conducted.

The work with analysing the data extracted from IQ Energy has begun, and the relevant external factors to include in the analysis have been identified. A first draft for a guide targeted plantowners and operating staff has been made. The purpose of the guide is to qualify the operation and monitoring of the performance of the plants.

The foundation for this work has been established, and the final analyses will continue under the Low Cost Active House BIPV project.

The socalled Solar Watch initiative started already in the now finalized ForskVE project BIPV Quality Cities. Performance data on a weekly basis is send to key partners and the BIPV investors. This includes several of the realised PV ARF demonstration projects.

WP 8

A communication strategy was developed and revised throughout the project with focus on:

- Communication of a common vision: BIPV as a part of a vision for 100 % renewable energy based energy system in 2050 (most importantly, communication from WP 4)

- Recruitment communication: communication focused at recruiting sketch projects, frontrunner projects and demonstration projects, i.e. workshops, letters, newsletter, and homepage communication
- Case communication: communication based on technical results and experiences from example projects, frontrunner projets and demonstration projects (and Solar Watch activities), i.e. workshops, FBBB database, articles and end-conference
- Result communication: communication of project results, primarily end conference and end communication

As part of the recruitment and project communication, the project partners have held all together 10 workshops, seminars or promotion activities, of which 3 were financed solely by PV Active Roofs and Facades. The other 8 were co-financed by other projects and organisations, but PV ARF contributed with promotion material and information on funding opportunities via the sketch design projects.

Workshop name	Place and date	Focus
Building Green 2014	Solar City Denmark, Gate 21, Cenergia	Promotion of funding opportunities via sketch design projects.
IbrugTag	FBBB Odense June 4, 2015	PV ARF Workshop on active roofs and facades in housing associations
Building Green 2015	Solar City Denmark,	Promotion of funding opportunities via sketch design projects aimed at housing associations.
Ekskursion for almene boligselskaber	Solar City Denmark, Copenhagen, November 24, 2015	Cofinanced with BASE, promotion of sketch design projects
Temamøde: BIPV Bygningsintegreret Solenergi	Solar City Denmark, Ørestad, May 5 2016	Promotion of the possibility to conduct sketch projects with 60% grants from the project.
Solceller i Sønderborg – temamøde + ekskursion	Solar City Denmark, October 5 2016, Sønderborg	Presentation of best practice projects and promotion of the possibility to conduct sketch projects with 60% grants from the project. BIPV Q-CITIES
Workshop om den gode business Case	Kuben Management, Gate 21 Copenhagen October 12 2016	PV ARF Workshop on how to create a good business case when implementing BIPV at social housing buildings
Seminar om fremtidens klimaskærm	FBBB Building Green, november 11 2016	PV ARF Workshop on barriers and possibilities for BIPV solutions in the energy system of the future.
Seminar om solenergi	Solar City Denmark, Building Green, november 11 2016	Article in conference magazine on the possibility to conduct sketch projects with 60% grants from the project.
Temamøde: Solceller og fremtidige tagløsninger	Solar City Denmark, 2016	Presentation by Solar City Denmark on the possibility to conduct sketch projects with 60% grants from the project.

Furthermore, the following dissemitation activities have been conducted:

- A fact sheet with information on the project has been developed (https://www.gate21.dk/project/bygningsintegrerede-solceller/), and an article has been printed in Gate 21's magazine "Insight" https://www.gate21.dk/netvaerk-videndeling/publikationer/insight-21/insight-21-22-2016/.

- 3 magazines from FBBB; *Climate Cover*; *Quality Cities* published in cooperation with the project BIPV Quality Cities, *PVs in the future energy system* published in cooperation with the projects Low Cost Active House and Nordic Built Active Roofs and Facades (http://fbbb.dk/publikationer)
- The project/case results have been communicated through the FBBB database, with special focus on the BIPV technology and business cases. Furthermore, the performance documentation through the IQ energy data will also be communicated in the FBBB database.
- The technology example catalogue has been prepared by Solar City Denmark and Cenergia.
- The AAU report has been published and the press initiatives were highly successful (see WP 4).
- A new analysis of the current state of the PV and BIPV markets internationally and in Denmark has been conducted in collaboration with the projects BIPV Quality Cities and Low Cost Active House BIPV. The analysis was conducted by DAMVAD Analytics as a consultant to Gate 21, and presented at the conference. The results was furthermore communicated via press releases and a Gate 21's newsletter:
    - BygTek**:** Solcelleenergi vil overhale vind, gas og kul inden for 15 år
    - Licitationen: Rapport: Danmark taber solcelle-terræn
    - Berlingske**:** Solceller: Dansk konkurrence til Elon Musk
- The conference on September 26th was a great success. It was held at the National Museum and had 116 registered attendants. Among the speakers were representatives from the BIPV industry, municipalities, research community and national politicians (see appendix for program, attendents and links to presentations).
- The conference, the AAU report and the Damvad analysis resulted in a large amount of articles (as mentioned under WP 4 and above) and outreach on twitter. See appendix for the full list of articles and the twitter outreach connected to the conference.

1.6 Utilization of project results

The PV Active Roofs and Facades, ForskVE project, started by 1. September 2014 with a focus on a cooperation with housing associations and cities. The overall scope was to realise 2,6 MWp PV systems with a special focus on supporting BIPV holistic solutions and a so-called Solar Watch activity concerning quality control and follow-up, something which is also supported by sketch design activities.

When the project started in 2014, it was the hope that it would be possible to cooperate with housing associations on a large scale on PV and BIPV solutions in practice. Cooperation agreements were made with both the KAB housing association, which holds 10% of all social housing in Denmark, and AL2bolig, which had plans of large scale PV implementation.

The aim of supporting the housing associations with respect to be involved in use of PV technology has however not been a clear success. As a main obstacle was identified the need for a new virtual metering system for whole housing estates, if you should avoid large investments in change of metering systems, especially in more park like housing association areas. Until last year it seemed possible to have this accepted, since it was promised by the Ministry of Energy, Housing and Climate, but later changes in the PV legislation did not support this solution any way.

Due to this kind of obstacles, it has not been so easy to realise the project in the same way as it was proposed, but based on what has been possible, rather good results have been obtained anyway. The work plan has been realised even with some new measures not foreseen from the beginning, at the same time as the aimed at PV and BIPV implementation was possible to reach in practice with 2,6 MWp PV in total.

At AAU investigations on how to include PV in the Danish energy system in the best way, has taken place based on a GIS model of all available roofs areas in Denmark, here looking at

example PV installations for different sectors. AAU has finalized the analysis concerning a vision and a roadmap for PV in Denmark in relation to strategic energy planning. The analysis has been developed and coordinated with the vision work in the project Low Cost Active House BIPV. The AAU report was published on www.energyplan.eu/pv and successfully presented on the final conference of September 26th. These results will continuously be integrated with strategic energy planning projects and activities in Gate 21, targeting 39 member municipalities in the Greater Copenhagen Region.

The project partners identified during the project a need for renewing the public debate on the existing regulatory barriers, and to give new political perspective on the market and energy potentials of BIPV solutions.

In cooperation with some of the most important actors in Denmark, such as Dansk Solcelleforening, Dansk Byggeri, and Danske Ark, among others, the agenda and the project results were presented at the final project conference on September 26th, 2017 in Copenhagen. We have seen signs that the debate in fact has been influenced by the project results and the conference. Partners and participants keep communicating and participating in the public debate, referring to the agenda and results of the project.

Also, Aalborg and the surrounding regions have during the project made several initiatives, both to make a cooperation with local housing associations through the local Kuben Management office, with a special view to combine use of BIPV with the Active House labelling scheme. On the 29. August 2016 a special event on building certification and labelling was held with Aalborg municipality and FBBB, which also included inputs on use of BIPV and the Active House Standard.

At Kuben Management, work on registrating electricity consumption profiles was made for the "Landsdommergården" housing block at Copenhagen NV, where BIPV will be installed in red tiles roofs. Besides a cooperation with the housing association KAB aimed to show hourly electricity consumption data for the large "Farum Midtpunkt" housing scheme as basis of optimising an investment in BIPV solutions here. It is the idea to present this kind of results in the new FBBB database: www.bæredygtigebygninger.dk, where it is also aimed to be able to present all PV-Active Roofs and Facades projects, when the last implementation projects are also introduced.

It has been a general experience in the project, that real building integration of PV installations is still regarded as a market niche, and one among many solutions to be considered – even when the whole roof is to be renewed. The reason for this might be a different business case than implementing standard PV modules on existing roofs, as well as a lack of market solutions – the market in Denmark is still represented by pilot projects and tailor-made, individual solutions, from different small or medium sized PV installation companies.

To meet this barrier, a BIPV demosite at the Technological Institute in Taastrup was established as part of the project in cooperation with the projects Low Cost Active House BIPV and ongoing EUDP projects. The BIPV demosite supports the dissemination of BIPV qualities towards architects and building owners as a technological "show room". The BIPV Demosite at the Technological Institute has been established, and will continue to be developed after the PV ARF project ends.

Solar Watch activities, regarding data for monitoring and evaluation, have been installed and monitored for several of the housing association with whom agreements have been made. The needed data for benchmarking PV installations in the housing sector (performance documentation) has been extracted from the existing monitored projects in IQ Energy and the first analysis has been conducted (see appendix). The work with analysing the data extracted from IQ Energy has begun, and the relevant external factors to include in the analysis have been identified. Therefore, the foundation for this work has been established, and the final analyses will continue under the Low Cost Active House BIPV project.

1.7 Project conclusion and perspective

The PV Active Roofs and Facades ForskVE project has been realised in a good way even though there are still different barriers for PV implementation in the housing association sector.

It was an expectation, that the project could boost the Danish market for new and innovative BIPV solutions through front-runner projects, sketch projects and largescale demonstrations plans. The project has, however, not achieved commercial results as expected. Throughout the project period, the partner group have conducted market dialogues with firms in Denmark developing BIPV solutions. Most of the firms can be characterised as small, creative firms, with a large focus on product development. However, most of the firms have focused their sales abroad due to the Danish regulatory barriers.

The Damvad analysis has however identified specific strengths for a Danish based BIPV market: Danish solutions are typically system-oriented, meaning that they can be adapted to be fitted with the needs of the overall energy system. At the same time, there is a huge focus on architectural adaptation, as most cities in Denmark are older cities with strong architectural protection policies. This could give Denmark a huge opportunity for acting as international test-bed for architectural adapted solutions, being adapted to local grid needs at the same time. The project has established a strategic cooperation between Bloxhub and Dansk Solcelleforening to strengthen the cities as testbeds for the innovative architectural solutions. Also, Dansk Byggeri has taken on the role as sponsor of the agenda of developing and implementing BIPV solutions across the value chain of the building sector. The project has handed over the torch to the actors that focus on market development and export. The Damvad analysis was presented for the different stakeholders at the project conference, and the above-mentioned themes discussed throughout the conference.

It is the partner groups conviction from the experienced dialogue with the sector and other important stakeholders, that there is a huge opportunity for a BIPV-based market in Denmark, that at the same time could be export-oriented focussing on special Danish competences, should the PV regulations become more system oriented as suggested by the AAU analyses (WP 4). The barriers regarding the low risk appetite in the housing association sector could be overcome through front-runner projects in other sectors showing positive business cases and good performance documentation from innovative BIPV solutions, i.e. the municipal sector. Also, the BIPV demosite at the Technological Institute in Taastrup, as well as a continued sketch developing program, with a stronger economy to include both technical and the architectural aspects, could help to overcome these barriers.

The project results and recommendations will continue to be communicated by the project partners, targeting political stakeholders.

Annex

Relevant links

- http://www.energyplan.eu/pv/
- www.bæredygtigebygninger.dk
- https://www.gate21.dk/project/bygningsintegrerede-solceller/
- http://www.solarcity.dk/Tilskud/Skitseprojekter

Annex can be found at: https://www.dropbox.com/sh/wzd4f938wjvrvhz/AAAP_Mmdm6XJ9uynkeNIDJaBa?dl=0

Bilag, Cenergia – en del af Kuben Management

(Indhold på dansk)

- Solcelleplatform TI
- BIPV database ugerapport (Eniscope)
- Quality Cities temablad
- Solenergi i Hørsholm Kommune
- Eniscope oversigt
- PV-system beregning Søfryd, KAB
- Udstillingsplatform, BIPV på TI
- Tåstrupgård el-arbejder, KAB

- AT Solar, Sønderborg
- Øvrigt materiale, BIPV Sønderborg
- BIPV til Smart Energy CO_2 neutral AktivHus byområder
- Dansk Solcelleforening, Solcellepotentiale i Danmark (maj 2017)
- R. Ramstad Arkitekter, Solcelleanalyse Køge Nord
- Gate21 brochure for PV ARF og Low Cost AH
- BIPV brochure, Cenergia
- FBBB database med BIPV løsninger
- Energimessen 2017, Bjerringbro, temadebat
- PV Active Roofs præsentation, AAU
- Forslag til BIPV til CO_2 neutrale byområder
- BIPV eksempel samling rettet mod BIPV Demosite
- Building Green / Solar City Denmark 2016
- Temamøde april 2017, SCD, Solenergi og Boligforeninger
- BIPV annonce, tillæg til Børsen
- Oplæg 6. by samarbejde
- Forslag til AAU analyser
- Forslag til Grøn omstilling
- Danmarks første energineutrale etageboliger (artikel)
- 100% VE i 2050
- Smart Active House Building
- Solpaneler er ved at vokse helt ind i tagpladerne (artikel)
- Solenergi kraftvarme til Hvidovrebo
- Status PV ARF, august 2015
- Building Green Learning Sessions, Forum 3/11-2016 – Forslag til fjernelse af barrierer for anvendelse af solceller (PP)
- Møde om ForskVE projekter 6. april 2017
- Guide til PV projekter
-

Bilag, Gate 21

- Programme Final
- Deltagerliste
- AAU Anbefalinger (pamflet)
- Konference_presse og twitter (oversigt)
- Solceller En del af Fremtidens energisystem (mail)
- Solceller Fem nye anbefalinger (mail)

Bilag, FBBB

- FBBB_medlemsmagasin_solceller_en_del_af_fremtidens_energissytem_2017_web