Faglig slutrapportreing / Final report

1.1 Project details

Project title	Integrated solar cells in commercial buildings
Project identification (program abbrev. and file)	64014-0187
Name of the programme which has funded the project	Energiteknologisk Udviklings- og demonstrationsprogram (EUDP)
Project managing company/institution (name and address)	EUROWAY Aps, Skolegade 85, 6700 Esbjerg
Project partners	Racell A/S, CRH Concrete A/S, TEKT A/S, Co2Pro Aps, EUROWAY Aps
CVR (central business register)	32349080
Date for submission	April 04th

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1.2 Short description of project objective and results

The aim of the project is to develop, demonstrate and commercialize new competitive building systems for commercial buildings based on the concept of combining concrete building components with solar cells that contribute to energy efficiency as well as new architectural opportunities.

Formålet med projektet er at udvikle, demonstrere og kommercialisere nye konkurrencedygtige byggesystemer til erhvervsbygninger, baseret på en kombination af betonelementer med solcellepaneler, der bidrager til såvel energieffektivitet som til nye arkitektoniske muligheder.

1.3 Executive summary

The project has resulted in a new construction system consisting of solar panels mounted on steel and mounted directly on concrete elements. The system is particularly suitable for industrial buildings with large vertical surfaces in production and storage halls. However, the system will also be relevant for larger residential buildings. The system contributes significantly to the energy supply of the building in question and allows a new and exciting architectural expression. In spite of the additional cost in relation to a traditional construction, payback period of 5 to 7 years is realistic.

1.4 Project objectives

Originally, the plan was to develop the BIPV solutions on thin film solar cells. The expectation then was that thin film solar cells would dominate the future market for building systems that we were working on.

For several reasons it showed up not to be the right technology to rely on. First of all the cost of crystal solar cells has declined dramatically during the time of the project. Also crystal solar cells are estimated to be more durable than thin film solar cells. In addition our tests at Esbjerg during the spring and summer 2015 showed that we would not reach our ambitions for an architectural expression on a high level using thin film solar cells. Much of the research then focused on mounting systems among others to make room for the junction boxes behind the panels, and systems that would make it easy to mount and replace panels without making it easy for unauthorized to remove panels. Thickness of the panels including the mounting system (60 – 80 mm) would be a challenge for stability and structure of the concrete elements in cases where parallel surface among concrete elements and solar panels were demanded for architectural reasons.

Midway in the project we came aware of the Danish manufactory of solar cells, Racell, also very much known by EUDP. Panel products from Racell counters nearly all aspects of the disadvantages of thin film solar cells. Using crystal solar cells the panels are more durable. Racell has developed technology by which the company can produce panels in different colours and structures. Especially two aspects: the ability to produce large panels (3 x 4 m) and the replacement of junction boxes with diodes integrated in the panels, meant that we will be able reach high ambitions on the architectural expressions. The diode technology means that the company can produce very slim panels (6 – 8 mm) also meaning that the needed recess of the concrete elements is significant lower compared with a traditional solution which again lower the challenge for stability and structure of the elements. Our goal is that solar cells are not to be seen as such but be an integrated part of the architectural expressions. Racell has shown that on more constructions but had no experiences in mounting solar panels on concrete element, which are widely used especial in commercial buildings.

Forwardly the project worked ahead developing systems based on panels from Racell on concrete elements from CRH Concrete. Much of the issues was concerned about at what stage of the production and delivering process the solar panels should be mounted on concrete components: (1) in the production process of the concrete element, (2) retrofitted at elements at the factory (3) mounted at the building side. Especially: what are the advantages/disadvantages of these strategies seen from a logistic, economical and architectural point of view. Significant part of the development dealt with how to handle the electrical components through the concrete element, depending on the different purposes of the construction.

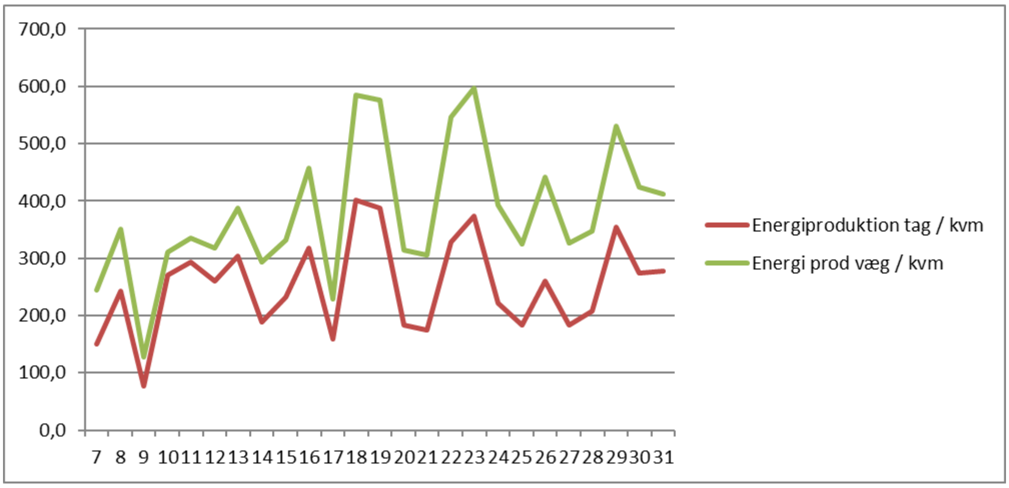
Often Racell uses glass or aluminum as the bearing material on the back of the solar panels. In solutions where solar panels are screwed directly on the concrete – which now is the main idea – the glass or aluminium have to be replaced by a material which works in nearly the same way as concrete in changing temperatures and weather conditions. Steel has such properties.

So the main BIPV solution of the project is solar panels mounted on steel and screwed directly on concrete elements. To glue the panel on concrete was also consideret, but at this stage no one will guarantee that it lasts.

Two times during the project combination of solar panels on concrete elements has been testet. First time at Esbjerg from February to August 2016 with a focus on thin film solar cells mounted on concrete elements and compared to crystal solar cells.

On the roof are crystalline solar cells mounted at a 45 degree angle relative to the sun to the southwest. The wall panels consist of thin film solar cells facing west and southwest. The fluctuations in energy production are followed over the period, but the solar cells on the roof produce well 50% more per. sqm than the wall panels. In a building, as a rule of thumb, 50% more square meters of thin film solar cells must be considered to offset energy production in a roofing solution based on crystalline panels.

Temperatures in roof and wall solutions are also adhered to. However, in general, the temperature in the wall panels is higher than the roof tiles, which may be due to the fact that the concrete elements isolate more than the roofing on wood, even though the solar radiation on the roof is significantly higher than on the walls. Outdoor temperatures and solar radiation are monitored, especially in relation to roofing.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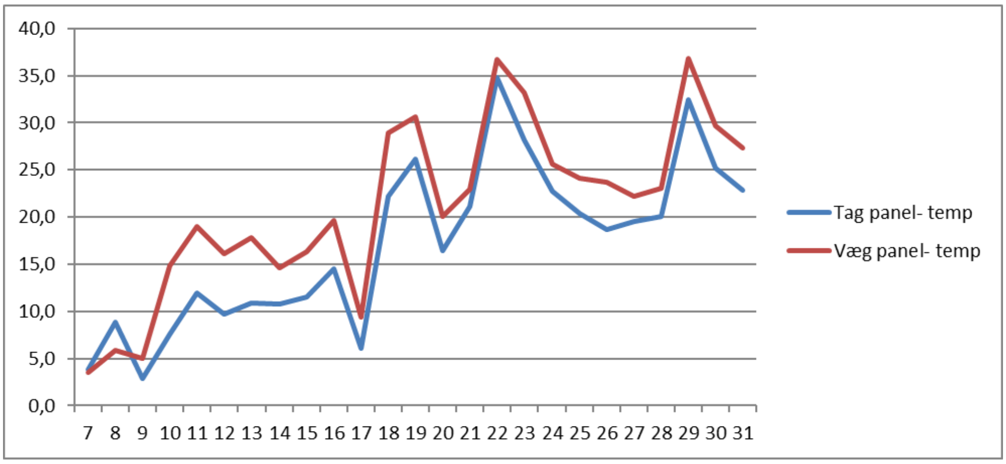
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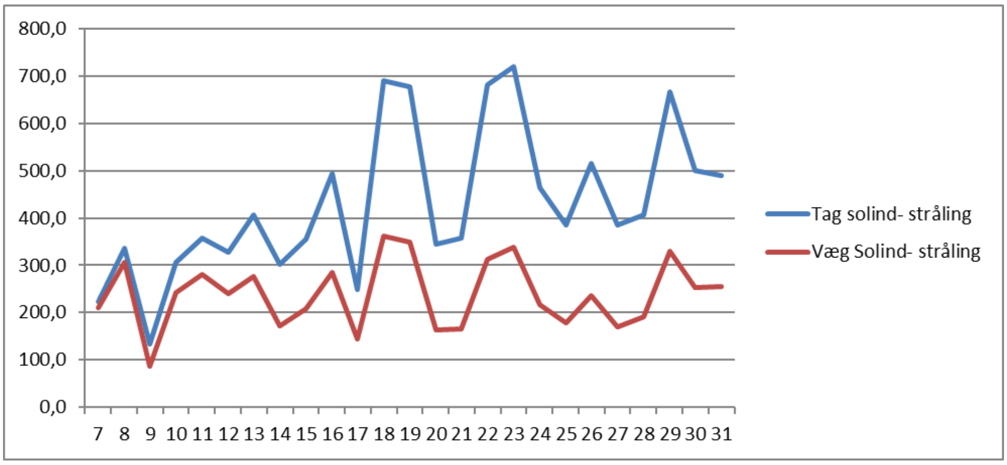
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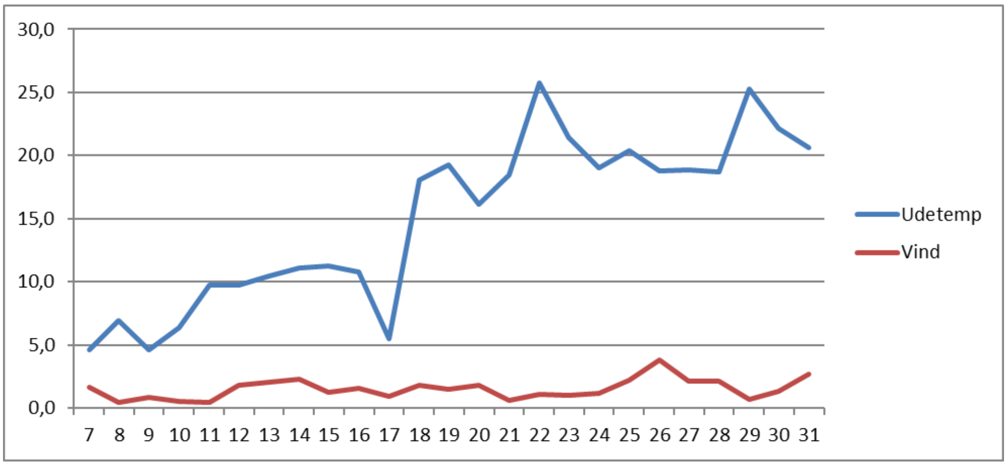
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Second time a test was setup at DTU (Danish Technical University). The aim at this test is to estimate in which degree the concrete element will absorb heat produced by the solar cells. That's important because more head at the panels will lover the effect delivered.

The test at DTU is not final at the end of the project due to delays in the delivery of solar panels. However, theoretical calculations show that the concrete elements roughly speaking can absorb approximately 50% of the heat from the solar cells [1]

The investment rate of the developed BIPV-solution: crystal solar cells with steel as bear material and mounted directly on concrete elements has been evaluated using the structure and the energy consumption of the Danish Company Hytor A/S. This company is a typical example of companies witch the BIPV-solution is mend for.

The calculations on a given example using a BIPV solution at Hytor A/S show that a payback period of 5-7 years is a realistic option compared with a traditional construction

With precaution of the DTU tests the project implementation develop as foreseen, meaning that we ended up with a solution that very much fulfils the expectations at the beginning of the project, as well from a technical, production economy and architectural point of view. But for several reasons we did not develop fully as foreseen according to milestones agreed up.

The project has been significantly delayed in relation to the original plan. The main reasons was a bankruptcy of a partner in the first part of the project, delays in delivering of technical components for test purposes and periods, and especially in 2017 bustle due to high demand at some of the partners.

1.5 Project results and dissemination of results

The main activities of the project have been development and testing of different combinations of concrete elements and solar panels comprising mounting systems and handling of the electronic component for the flow of electric power.

The technical result is a building system based on concrete elements mounted with solar panels on steel and glass or foil on surfaces.

Economical analysis shows that at payback time on 5 – 7 years are realistic depending on the building construction, energy consumption, orientation towards the sun etc. Therefore the commercial expectations are great.

The project succeeded in realising its objectives with the exception that the test work was not completed during the project period and that the marketing will only take place after the end of the project. We expect the parties to colaborate on test and marketing after the completion of the EUDP project

For reasons mentioned above the project has not yet resulted in increased turnover, exports, employments etc. But the parties have great expectations in this respect.

[1] Miljøministeriet, Miljøstyrelsen, Varmeakkumulering I beton, Teknologisk Institut 2007/ Ministry of the Environment, Environmental Protection Agency, Heat accumulation in concrete, Institute of Technology 2007

Inspite the delays the project ended up with very satisfactory solutions both in terms of architecture, green energy and economy. Still we have to know the demands from the market, but the potential should be great.

The project result has been disseminated in a common web-site: www.bipb.info which also will be used for marketing purposes

1.6 Utilization of project results

The participants expects to utilize the result in marketing and selling of buildings system based on the results of the project to architects, consultancy engineers, builders, trade organizations and so on. Common business plans may be part of this.

In future context the results are expected to be part of more products e.g. building systems comprising heat pump and for cooling purposes, which already are known technologies at Racell.

The market potential should be great taking into account the opportunity of great architecture, low energy cost in the long run, short payback time and contribution to green environmental impact.

On the short run there will be no competitors.

More of the solutions are based on patents already taken by Racell. But based on the results of the project as such the participants does not expect to take out patents.

Use of build system based on the results of the project contribute to realize energy policy objectives in form of more green energy.

1.7 Project conclusion and perspective

As a new building system that both contributes to energy supply, reducing CO2 emissions and giving new, sophisticated architectural expressions and a reasonable economy, the building system has a great potential in future construction. In addition, there is also good reason to work on materials and assembly systems and tests and other experience, especially regarding heat handling from the panels.

Annex

The result of the project is presented at the web-site: www.bipv.info