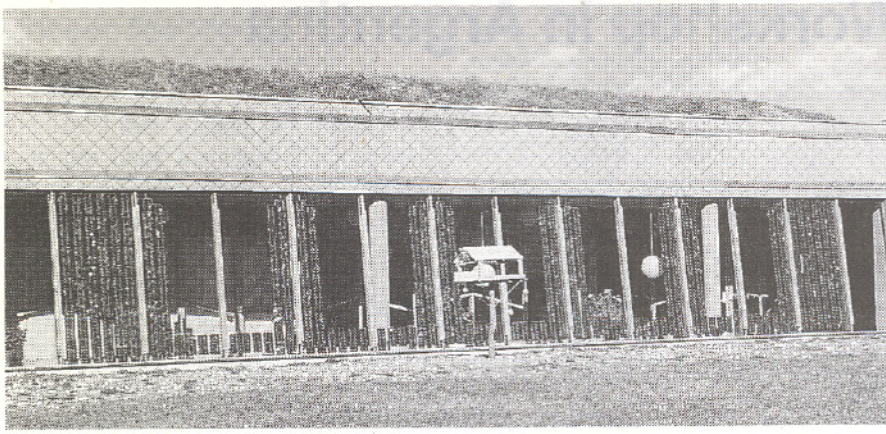


# Solar-Cell in the View



**Facade decoration, sun shade, and electricity production. These 3 are the benefits of integration of solar cells into windows. 22 solar-cell integrated windows will produce 2100 kWh/year in Denmark.**

*By: Lars Yde, Folkecenter for Renewable Energy, Denmark*

The Folkecenter just finished the construction of Denmark's first window-integrated photovoltaic system. The project was carried out in co-operation with the companies GAIA SOLAR and Midtglas, with financial support from the Danish Energy Agency.

## Roof vs Window

Window integration eliminates expenses for the steel frames necessary to support the photovoltaic panels when the latter are placed on the ground or on a roof. Furthermore, cases and covers become unnecessary, because the frames and glass of the window take their place. These factors reduce construction costs.

On the other hand, window-integrated solar panels must be custom-made, which increases costs. The total price for the window-integrated system was DKK 120 per W<sub>peak</sub> (20 \$US), whereas the average price for mass-produced solar panels is around DKK 40/W<sub>peak</sub> (6\$US), including supporting frames

*The table shows the technical specifications of the two solar systems at Skibsted Fjord Training Centre in Denmark.*

	Canteen wing	Training wing
Cell type	Mono crystalline	Poly crystalline
Cell dimensions (mm)	102,5x102,5	125,0x125,0
Rated power per cell	1,47 - 1,55 Wp	1,88-1,95 Wp
Efficiency (av.)	14,4%	12,3%
Number of cells	692	572
Total rated power	1045W	1095W
No-load voltage at -10 oC	229,7 V	190,2 V
Voltage at full load at 20 °C	167,8 V	135,9 V
Inverter input voltage range	125 - 250 V	125 - 250 V
Inverter nominal output	700 W	700 W
Ratio between nominal power of inverter and of solar-cells	0,67	0,64
Estimated annual production	1012 kWh	1087 kWh

*Windows with integrated solar cells at the Folkecenter for Renewable Energy in Denmark.*

*Photo: Jane Kruse, Folkecenter.*

and installation. The price difference is due to the fact that this new installation is the first of its kind in Denmark, and therefore incurred quite a lot of development costs. However, even if future installations will be cheaper, window-integrated systems are still going to be more expensive than mass-produced panel options.

It must be emphasized that window-integrated and ground- or roof-mounted solar panels are two very different alternatives. Window-integrated, custom-made systems offer some architectural possibilities that are not present when using standard panels.

## Architectural Integration

The solar system forms part of the glazed facade of Skibsted Fjord Training Centre near the Folkecenter. The building itself is dug into a south-facing slope, offering a tremendous view of the Fjord.

The integration of solar cells in the glazed facade of the Training Centre presented us with a basic conflict between the need for electricity production and the wish to preserve the beautiful view. Furthermore, it is important that the solar cells be like an ornament, something that enriches the facade by bringing life into the slightly dull look of a large glazed surface. The design of cell patterns must meet not only practical, but also aesthetic goals.

Clustering the cells together in a few windows would be the cheapest and simplest thing to do. This would also preserve most of the view. Aesthetically, however, it would be a bad solution, breaking up the facade in an odd way. Regarded from the outside, the best solution would be a singular pattern repeating itself for each, or for every second window. This kind of pattern unfortunately would disturb the view to an unreasonable extent.

The final solution therefore was a compromise between the two extremes: An ornamental pattern plus some windows covered with cells at places where the view is disturbed the least.

## Shadows

The importance of shadows should not be underestimated. This regards not only the shade from trees and other buildings, but especially the shade effects due to the building itself. There are shadows from eaves above the entrance as well as from the supporting wall at the eastern gable of the house. These are the most important shadows. Furthermore, there is a number of smaller, local shadows deriving from the detailing of the windows themselves.

The first kind of shadows makes certain windows entirely unsuited for solar-cell integration. The second kind mean that certain areas in each window must be kept free of solar cells. There is a left, right, and top margin in each window that is unsuited for the purpose, and hence the suitable area is limited rather radically.

## Cell Types Match

The task now was to match the architectural ideas with the electrical possibilities. This proved to be a long process entailing

a lot of compromises. From the start of the project, there was a wish to combine round and square cells, and cells of different colour, e.g., mono - and polycrystalline. Because of the necessary wiring in each window, this idea was soon abandoned. It would not have been a pretty sight with all the tinned copper strips inevitable in connection with such combinations. The final solution distributes the cells on 12 and 10 windows for the two wings, respectively.

The rated output of 1045 and 1095 W<sub>peak</sub>, respectively, may seem a little high for an inverter of 700W. However, this is not the case. This is due to the fact that the system will very seldom produce its maximum output, and that a better overall efficiency is achieved by choosing a smaller inverter. A 700W inverter thus works at a higher efficiency at an output of, e.g., 100W, than would a 1000W inverter.

## Perspectives

There is no doubt about it: The architects are going to love this new possibility for

**Mono crystalline cells** consist of one big crystal, forming a totally uniform black or bluish black surface.

**Poly crystalline cells** are made up of a lot of small crystals. Light can sparkle across the crystalline structure of the resulting surface. Therefore, the poly crystalline cells are by far the more beautiful ones, whereas the price per Watt is about the same for the two types.

decorating glazed surfaces. They produce renewable energy in the form of electricity, and at the same time limit the often too intensive solar exposure. We must only hope that the price will drop to a level where also house constructors will find window-integrated solar cells attractive as well.

*Folkecenter for Renewable Energy,  
Kammersgaardsvej 16, Sdr. Ydby, 7760  
Hurup, Thy, Denmark.*

*Ph: +45-97 95 66 00,*

*fax: +45-97 95 65 65,*

*e-mail: larsydefcenergy@www.nvm.dk.*