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Large-scale PV System on an Older Residential Building

Summary

During 1996–97, the Municipality of Kolding and the Danish Ministry of Housing and Urban Affairs carried out a large-scale photovoltaic (PV) retrofit project on Solgaarden, a five-storey residential block in the town of Kolding, which has a population of 60,000. In 1998, the PV system produced a total of 76.3 MWh of electricity, almost half of the building's overall electricity consumption. Solgaarden itself used 27 MWh of the PV-generated power; the surplus was sold to the local utility. The PV production in 1999 was 77 MWh.

Highlights

- **1,000 m^2 architecturally-integrated PV panels**
- **Meets almost 50% of the building's electricity consumption**
- **Annual production of around 80–90 MWh**

View from the roof of Solgaarden after the retrofitting of the PV panels.

Photograph: Byfornyelsesselskabet Danmark

Project Background

Solgaarden, which means "sun court" in Danish, is a five-storey residential building dating from the late 1930s. It contains 80 apartments with a total floor area of 5,681 m^2. The PV installation formed part of a wider urban renewal project involving comprehensive building improvements, the introduction of energy-efficient elevators and remodelling of the surrounding area. Particular care was taken to ensure that the PV system integrated well with the existing architecture.

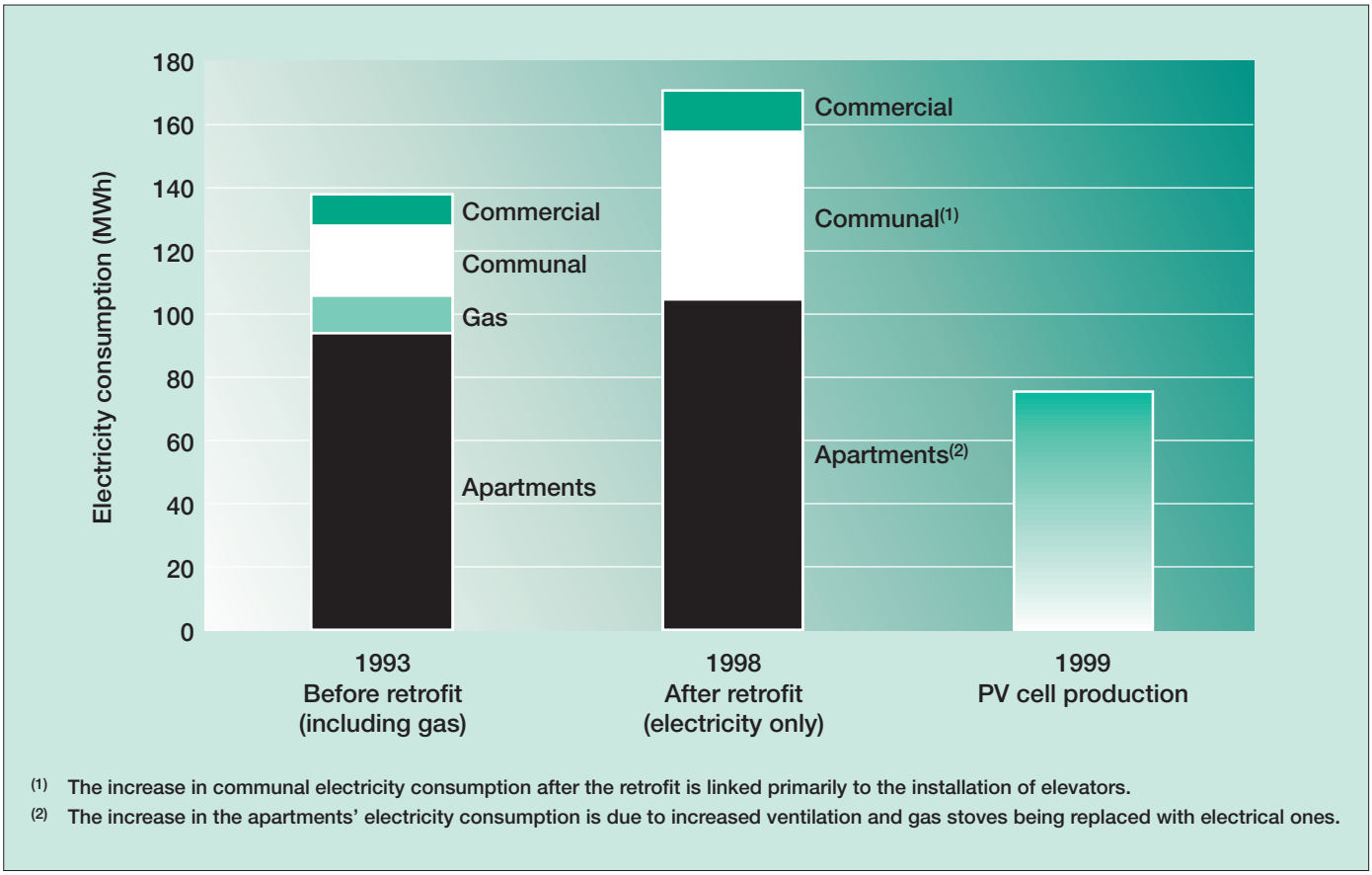
The project aimed both to reduce the amount of fossil fuel consumed by a residential housing block and to improve Denmark's knowledge of PV technology. In particular, the objectives for installing the PV system, which comprises almost 1,000 m^2 of PV panels, were:

- to demonstrate the potential for PV in an older, multi-storey residential building;
- to overcome the architectural and technical challenges involved in integrating PV panels within an older building;
- to identify the extent to which PV can meet the annual energy requirements of a large residential building;
- to gather information about operating a large-scale PV system with regard to performance, maintenance, durability, consumer response and accounting principles.

The Project

Owing to both its size and its orientation, Solgaarden was well-suited to an experiment with PV. The PV system is divided into two main parts: a 757 m^2 system installed on the roof and a smaller 175 m^2 system integrated into the eight balcony enclosures on the building's southern façade.

The roof-mounted system is formed by four continuous bands of semi-transparent, mono-crystalline PV panels with a steel support structure. It is made up of 846 PV modules with a maximum output of 89.5 kW_p. The eight glazed-tower structures that enclose the balconies carry a total of 80 PV modules with a combined maximum output of 16.5 kW_p.



(1) The increase in communal electricity consumption after the retrofit is linked primarily to the installation of elevators.

(2) The increase in the apartments' electricity consumption is due to increased ventilation and gas stoves being replaced with electrical ones.

Figure 1: Overview of electricity consumption before and after the renovation project.

The whole system is linked to the local electricity grid through 105 small inverters, which provide 230 V AC. Much of the PV-generated energy is used within the Solgaarden complex and the system now meets around 50% of Solgaarden's electricity needs.

Surplus energy generated by the PV system is sold to the local power utility KOE. In 1998, the PV system produced a total of 76.3 MWh; Solgaarden used 27 MWh, leaving a surplus of 49.3 MWh, which was sold to KOE. During 1998–99, Kolding had fewer hours of sunshine than in an average year. It is therefore expected that in a normal year the PV installation will generate around 80–90 MWh.

Whether the PV-generated electricity is used within the building itself or sold to the grid depends to a large extent on the PV buy-back tariff available from the electricity company. The Danish government requires that, for the period 1998–2002, the tariff should be the same as the price of conventional electricity. If the PV tariff drops below the price of conventional electricity in future, there will be an incentive for the residents of Solgaarden to maximise their in-house use of the PV power and save on green taxes levied on conventional power.

PV meters have been installed in each of Solgaarden's 80 apartments to optimise energy savings by making tenants more aware of their consumption. Each meter displays:

- the given apartment's current share of PV-generated electricity consumption;
- the apartment's share of electricity sold to KOE;
- the apartment's share of electricity purchased from KOE.

Solgaarden's residents have formed a PV Guild to administer PV electricity consumption and sale of PV-generated electricity to KOE.

Performance

The Solgaarden project has found it difficult to achieve Denmark's national objective of halving the fossil fuel consumption of residential buildings. This is because the project has also included lift installation, introduction of electrically driven ventilation and improved lighting. These items have actually contributed to an increase in annual electricity use in Solgaarden from 126 MWh to 170 MWh, primarily as a result of greater electricity consumption in communal areas.

The total yield of Solgaarden's PV system corresponds to around 50% of the electricity needs of the complex. The project has shown that large-scale retrofitting with PV panels of older residential buildings can help to reduce fossil fuel-based energy consumption and that the design of a PV-based energy system can be integrated successfully within an existing urban environment.

The project leader, Byfornyelsesselskabet Danmark, and the Municipality of Kolding have each received several awards as a result of the project, the latter receiving an award from the Danish Energy Agency for its use of solar power in urban renovation.

Economics

The total cost of the Solgaarden urban renewal project was DKK 76 million (where DKK is the Danish krone). The installation of the PV panels amounted to around DKK 22.3 million, of which DKK 9.1 million has been spent on the PV panels and electrical equipment, and the remainder on balance-of-system costs such as the support structure.

The project received a special grant of around DKK 30.5 million from the Ministry of Housing and Urban Affairs. Since the project's focus was on fulfilling the PV potential of the building rather than on cost-effectiveness, it is not meaningful to calculate a payback period for the project.

Environment

The PV-generated electricity at Solgaarden in the low-sunlight year of 1998 amounted to 76,300 kWh, which corresponds to CO_2 savings of 53.4 tonnes (based on Denmark's average electricity generating mix). In a year with more typical weather, CO_2 savings could be 67.5 tonnes. These savings are for the PV installation only and not for the scheme as a whole. They do not take into account the electricity used, for example, by the new electrical stoves, elevators and ventilation incorporated in the project.

Photograph: Byfornyelsesselskabet Danmark

Elevation of the Solgaarden building with PV installation.

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