



## Rooftop PV Systems Installed on 300 Danish Houses

### Summary

The SOL-300 solar energy project was launched in Denmark in 1998. Photovoltaic (PV) systems have been installed on the roofs of 300 single-family houses in Denmark. The systems range from 0.9 to 6 kW, with a total installed capacity of 750 kW.

The first systems were installed during spring 1999, and electricity was produced from all 300

installations by summer 2000. Each house has a PV meter showing the system's electricity production and the household's purchase and sale of power. All data from SOL-300 installations are available on the Internet. The project has realised new mounting techniques, contributed to the lowering of the costs of Danish solar cells, and increased quality assurance for grid-connected solar systems.

### Highlights

- ▼ PV panels integrated into eight categories of residence
- ▼ Innovative mounting techniques
- ▼ The annual electricity production is about 500 MWh/year
- ▼ Website listing of power data for each house

The SOL-300 project has focused on special mounting systems, including: (1) roof integration onto newly-built houses; (2) integration of PV modules in an extension of a single-family house; (3) solar cells mounted in half of the roof panels as a replacement; and (4) PV and solar heating plant combined on the roof.



## Project Background

In Denmark, as in other industrialised countries, photovoltaics are used to supplement the ordinary (grid-connected) power supply. The main purpose of the SOL-300 project is to contribute to increased utilisation of solar cells in the Danish electricity sector by:

- contributing to a continued reduction in the price of solar systems connected to the grid;
- stimulating Danish developments within installation technology;
- contributing to the formation of quality assurance schemes;
- developing and extending the electricity sector commitment to solar technology as a future business area;
- increasing general knowledge about PV technology.

## The Project

The houses participating in the SOL-300 project are situated in eight areas in Jutland and on the island of Funen. From each of these areas, a local distribution utility is participating in the project. These utilities have selected specific areas and chosen individual houses of typical Danish design to participate from their areas. In addition, Domus Arkitekter, an architectural company, provided technical advice and assistance in the selection of eight particular categories of residence for the project, namely: terrace houses, one pre-1960 residential area, two post-1960 residential areas, one post-1980 residential area, one village area, and a group of post-1980 houses for experimental and innovative systems.

Once the individual houses were selected, the architects decided on the best position for the PV modules on the houses. Apart from aesthetic

considerations, the owners' wishes and the optimal location in relation to the sun were also taken into account. Most of the systems are mounted on standard fittings, but the architects have also developed an entirely new mounting system. In each area, the same supplier has implemented the PV systems. The PV modules are supplied by three consortia, each consisting of a partnership between major foreign and smaller Danish suppliers of PV systems. In this manner, SOL-300 has contributed new knowledge in the area of PV technology in Danish companies.

SOL-300 builds on the experiences from an earlier Danish project, called 'Sun City', in which 30 single-family houses were equipped with solar cells (see the CADDET Technical Brochure No.94). This project highlighted the need for R&D into new solar cell technologies, such as installation techniques. Therefore, for SOL-300, there was a special focus on the



Map showing the areas participating in the SOL-300 project.

methods for mounting the PV modules. Most of the units were installed on standard systems, but a number of special solutions were developed in order to test new techniques and construction methods. For example, the project examined ways of integrating PV modules into a new building, a refurbished building, as well as experimenting with unusual modules and installation materials.

Another result of this project is the development of a quality control system for solar systems connected to the grid (known as the Kvalitets Sikrings Certifikat (KSC) scheme). This scheme is administered by SolenergiCenter Denmark and covers systems, components and installation. Training materials for certification of KSC technicians were prepared by the project management. The project has also lead to the formation of a PV group for Danish electricity companies (Elselskabernes Solcellegruppe) which aims to advise and collects information about the use of solar cells.

## Performance

PV meters are installed in all the houses participating in SOL-300, to inform the residents how much power is being produced, bought and sold in their individual houses. Providing continuously updated information on their power consumption has made the families more conscious of their electricity use and has inspired them to save electricity. Many families have chosen a central location for the PV meter in order to monitor whether, for example, a light is burning and

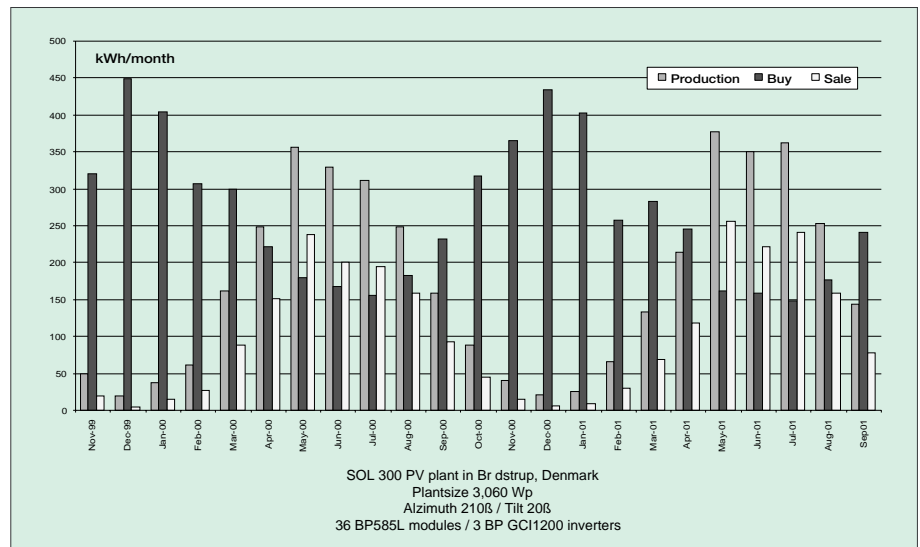


Figure 1: Monthly electricity production for a house in Brødstrup.

might be switched off. Thus the PV meter acts as an energy guardian, which in many cases has resulted in electricity savings. In the Sun City project, electricity consumption was seen to fall by 10-20% after the PV systems were installed.

In 2001 the project demonstrated a measured average yield per installed kWp of up to 800 - 820 kWh. The solar energy installations operated steadily without no appreciable technical problems. Response from the customers were positive. Furthermore the project demonstrated that in Denmark the position of the PV modules in relation to the sun is not of vital importance for the electricity production.

Data from SOL-300 are available on the Internet at <http://www.sol300.dk>. The website contains comprehensive data from all the houses in the eight participating areas. It also includes information on the size and make of the individual PV systems, and the inclination and orientation relative to the sun of each system. House

owners have an individual code for checking their own energy consumption. Participants have access to data from all the houses, allowing them to compare the electricity production in their house with similar systems in different areas. Figure 1 shows, as an example, the monthly electricity production for a house in Brødstrup.

## Environment

In 2001 the PV generated electricity production from the SOL-300 project was about 500 MWh which corresponds to annual CO<sub>2</sub> savings of about 375 tonnes.

## Economics

The budget for the SOL-300 project is DKK 49 million (where DK is the Danish krone), financed partly by the grid manager Eltra and the Danish Energy Agency, and partly by a consumer payment from the families living in the 300 houses (corresponding to 25% of the installation costs).



The other special mounting systems used in the SOL-300 project are (left) a newly-built pergola, and (right) a new extension using thin film solar cells.

SOL-300 has contributed to a reduction in the costs of Danish solar cells, helping to make PV systems connected to the grid more commercially attractive. The prices for the SOL-300 PV systems were DKK 40/W<sub>p</sub> (installed effect), which is 20% lower than the prices of the PV systems in the Sun City project. This means that the SOL-300 prices are low by international standards, too.

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#### International Energy Agency

The International Energy Agency (IEA) is an autonomous body established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. Member governments have agreed to share energy information, to co-ordinate their energy policies and to co-operate in the development of rational energy policies. More information about the IEA is available at [www.iea.org](http://www.iea.org)

#### CADDET

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