

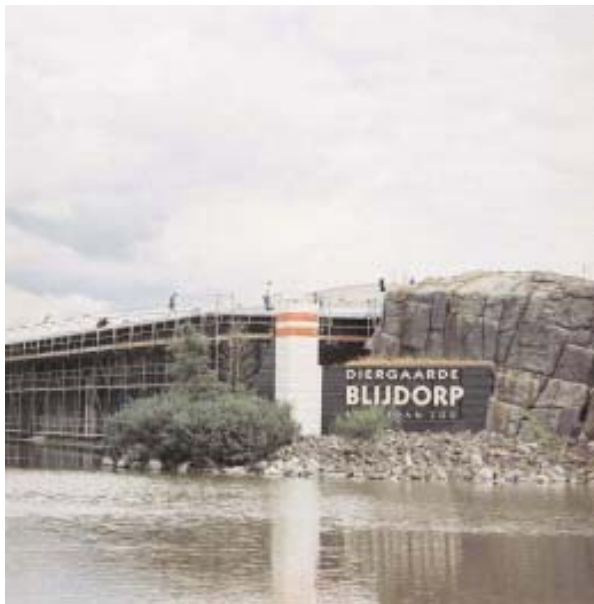
## **500 kWp solar power plant on the Oceanium of the Rotterdam Zoo** *The largest solar roof in Dutch urban area*

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### **Introduction**

The Sunport project to implement this solar plant was created in cooperation with the Rotterdam Zoo (Diergaard Blijdorp) under the initiative of ENECO Energie and the municipality of Rotterdam. The solar current generated by the system integrated into the roof of the Oceanium is meant to cool the King penguins' enclosure. In the run-up to this project ENECO Energie took the lead in obtaining the load bearing structure and the necessary subsidies in order to define a feasible project plan.

ENECO Energie is one of the larger energy companies in the Netherlands in the area of electricity, gas and/or heat. ENECO Energie pays special attention to the generation of sustainable energy and development of environmentally friendly products and services such as Ecoström® and solar energy systems.

With more than 1.5 million visitors a year the Diergaard Blijdorp is one of the top attractions in the Netherlands. The most important objective of the zoo is to make a tangible contribution to nature conservation, which includes nature conservation education. The Sunport project combined with education gives the zoo the opportunity to make visitors aware of the importance of sustainable energy and a cleaner environment. What is more, it forms an important step forward in the quest for sustainable development.

The Rotterdam municipality attaches great importance to promoting the use of sustainable energy and assumes the role of trendsetter. The municipality is one of the largest consumers of green electricity in Europe, invests in various sustainable energy projects and stimulates the sense of responsibility of residents and businesses.

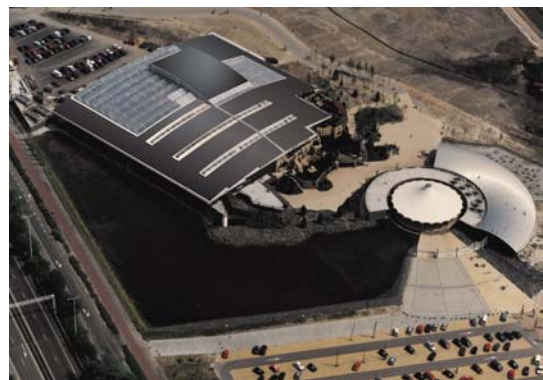
Siemens Netherlands is actively involved in environmentally friendly power generation with co-generation plants, biomass plants and wind and solar energy, but also in the optimization of transport and distribution. Siemens implements large utility-interactive turnkey projects such as solar power plants on the roofs of exhibition halls and also supplies the SUNIT solar power system for homes and businesses.

The Sunport technical concept is reliable for PV installations. Using this concept, Siemens already implemented a 1 MWp installation at the trade fair grounds in Munich in 1997 and the solar roof on the Floriade, which with its more than 19 000 panels and installed photovoltaic generating capacity of 2.3 MWp forms the largest solar roof in the world.

Sunport Blijdorp has a number of unique characteristics compared to earlier solar power plants, which are explained in more detail in this publication. These characteristics include the specific roof integrated application, integration and interaction with the technical installations already present at the Oceanium and the extensive system for remote management and control.

The implementation of this project was carried out by European tender with a clear technical and commercial specification on which various advisors worked based on ENECO Energie's instructions.

Implementation and operational handover was carried out under the responsibility of ENECO Energie and ENECO Energie and the zoo carefully tested the supplies and the system with the help of specialists.



## Design and engineering

In response to ENECO Energie's specifications Siemens, as main contractor of the Siemens & Shell Solar consortium, developed a PV installation for the project based on the available space, capacity and yield, low costs and adequate warranties.

This resulted in the selection of the single-crystalline solar panel, type SP150 (150 Wp). To ensure optimum production of the 500 kW installation the successor to the SP150 was used in the roof structure: the SQ160. This panel has a higher installed capacity.

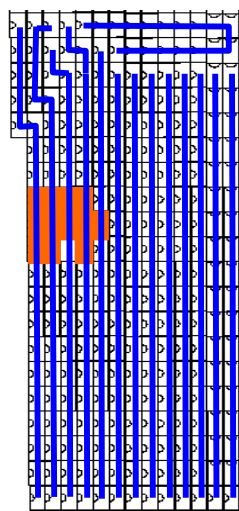
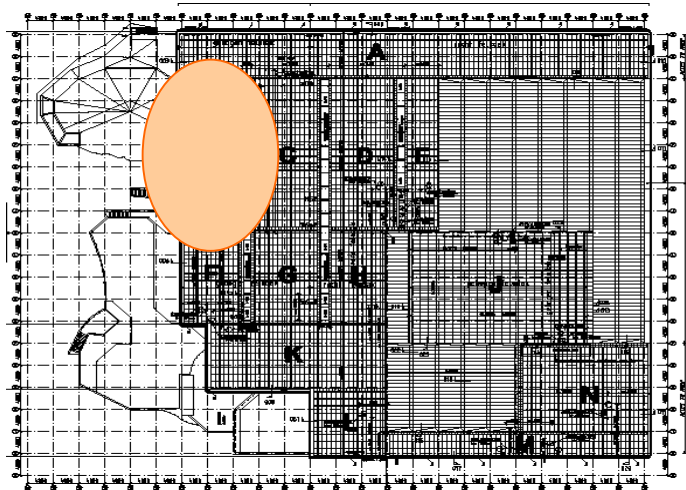
Because of the critical pitch angles of the roof in terms of pollution and also from a cost point of view, the frameless version was selected. The attachment method selected for the panels, namely by means of laminate terminal clamps on an aluminum substructure on slanted roofs, has since become a proven method.

The Siemens SINVERT Solar inverters were deployed as the essence of the PV system in line with other larger and more compact PV systems. Together with the monitoring software PPSolar and the display application WEB-direct, the system complies with the requirements of the specification and provides the necessary system characteristics in order to ensure the guaranteed yield.

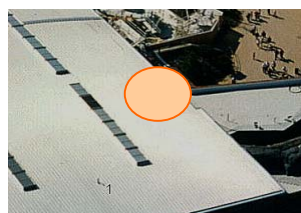
Once the tender was awarded, the configuration was specified in more detail.

To ensure optimal use of the roof surface an extensive analysis of the roof surfaces and shadow effect caused by existing obstacles was carried out. The purpose was to maximize the yield of solarization within the framework of the basic conditions.

The variable solarization due to the curved shape of the roof with its different orientations was included in the calculations.



These analyses were then used to determine the optimal detail configurations for the various roof sections.



The areas on the roof sections that received a lot of shadow effect and limited solar radiation were left out of the equation when the solar panels were divided up (orange). These areas were utilized to make provision for access to the roof for the fans, ventilation windows, etc. and were used as pathways to this end.

To attain optimal electrical concatenation, series of 18 solar panels were linked together.

## Solar panels

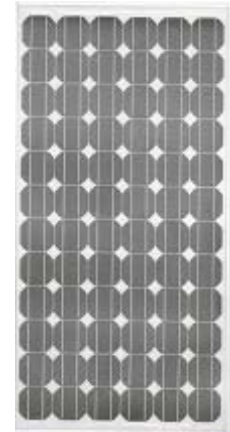


Shell Solar has single-crystal solar panels specifically for the purpose of larger utility-interactive PV systems with a high installed capacity per panel: the SP150. Silicon PowerMax solar cells were used here, which still provide excellent yields even in poor lighting conditions such as an overcast sky for example.

Due to the method of production and suitability for high voltages, these panels are excellently suited as lamination for larger utility-interactive and roof integrated PV systems.

A host of examples and references of this are available. Relatively large-scale applications of laminates are the 1 MW extension of the 'Messe München', the Floriade, but also the 10 kWp system that was installed in a private residence in Zeeland in 2001 for example.

The high capacity per module (115 Wp/m<sup>2</sup> –SP150 and 120 Wp/m<sup>2</sup> –SQ160) and the larger dimensions enable attractive savings via a light and simple construction and installation thereof. This contributes to the low cost per kWh yield (as a result of the high yield of the single-crystal cells in relation to the investment costs per installed capacity).



Using solar cells from Camarillo (USA) the panels were laminated specifically for this project by Shell in Evora (Portugal) to form solar panels. The panels were divided into three classes before dispatch in order to minimize the capacity distribution within the strings and to optimize the entire system to the yield.

## Aluminum load bearing structure



The aluminum truss construction for this lightweight solar roof is a combination of various techniques from the cabinet and façade construction fields.

Six special Kalzip terminal clamps per square meter were placed on the existing Kalzip roof to facilitate sufficient attachment between the Oceanium roof and the new load bearing structure.

30 000 of these Kalzip terminal clamps were used to attach the more than 3 400 solar panels.

The load bearing structure consists of 15 000 meters of aluminum profiles that originate in the façade construction field.



Oskomera Solar Power Solutions B.V. designed these profiles specifically for this project and had the strength of the construction verified by TNO. The panels were attached to the load bearing structure with special clamps.

To meet the requirements of the Amenities Committee the fascias and the terminal strips and the walkways were powder coated in the same color as the solar panels. Furthermore, dummies were placed around obstacles on the roof (shadow effect) which have an identical pattern and color shade as the other solar panels to create a visually uniform appearance.

Production, supply and installation of the load bearing structure and the attachment of the solar panels to the load bearing structure, including connection, was carried out by Oskomera. Siemens was responsible for close cooperation with Cegelec who was responsible for the supply and installation of the cabling, placing of the junction boxes and placing of the inverters.

### **Inverter concept**

The solar panels are electrically connected to each other in strings. These strings are made up of 18 solar panels in series whereby a nominal system voltage of 560 V DC is generated. The solar roof consists of a total of 190 of these series.

To ensure easy connection of the panels, factory fitted special solar cabling with fully shrouded connectors were provided.

The cabling for five to six solar panel strings come together in a junction box which contains the protection devices against overvoltage. From these junction boxes that are located on the roof under the walkways, the cabling runs via the roof throughfeed of the roof superstructure to the inverters in the technical room.

In the midst of the climate control installations in the technical room of the Oceanium there are four Siemens SINVERT solar inverters that work on the basis of the master/slave principle. The system engineering was designed to take into account the peculiarities of the roof surface of the Oceanium. This gave rise to a solution involving subsystems so that optimum energy can be achieved every time. Two master and slave inverter units were selected for subdivision because this solar roof has a southwest/northeast orientation.

The inverters each have a nominal capacity of 100 kVA and convert the generated direct current (DC) 560 VDC into alternating current (AC) of 3 phases 400 VAC. The AC cables use cableways throughout the Oceanium to feed the transformers of the 10 kV connection of the Zoo. They enable a top yield of 96% to be achieved and thanks to active filters, have grid-enhancing qualities.

## Yield and maintenance

A two-year test operation period commenced on January 1, 2004. During the test operation ENECO Energie will be responsible for the installation, and the zoo will be the owner. In addition to the operational handover of this power plant Siemens will take care of the maintenance for a period of 20 years. The deliverables in terms of service and management and warranties have been laid down. Certain values have been agreed for yield versus the actual measured solarization for the 20-year period. The forecast annual yield is 325,000 kWh.

When the roof was equipped particular attention was paid to accessibility of the roof for maintenance, inspection and cleaning and walkways were created to this end. Moreover, the essential fall protection facilities were integrated with the walkways as far as possible in order to avoid additional shadow effect.

The service consists of preventive maintenance such as receiving fault messages, inspections and planned preventive maintenance such as cleaning, and once required, corrective maintenance. An extensive system for management and control has been provided to react quickly and adequately to any faults, error messages and changes to the deliverables.

## Management and control

From the outset the project participants ENECO Energie, Diergaarde Blijdorp and the Rotterdam municipality had a vision of an attractive and primarily functional solar power plant. The envisaged requirements and needs pertaining to the installation were contained unambiguously in the specifications. It also included a clear indication for the detailed specifications of the management and control system to be used.

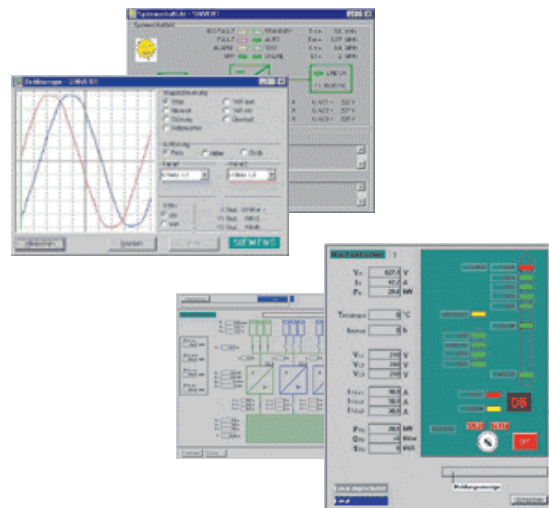
The operation and deliverables of the system are monitored remotely and are reported on on a daily basis. The ratio between the radiated solar energy and the actual generated solar power is important. The solar roof is therefore also equipped with radiation sensors for this purpose.

The Sunport management and control system is state of the art for solar power generation plants. The program provides detailed information on the operation of the entire installation.

Data is collected daily from the SINVERT inverters and is reflected in an internet environment, and this information can be used to create simple graphs and overviews for management purposes.

Automatic e-mail messages are generated daily which reflect an overview of the deliverables and messages.

These e-mail messages are sent to the zoo, ENECO Energie and the Siemens service department.



## Project participants



Customer	ENECO Energie
Owner	Stichting Diergaarde Blijdorp
Main contractor	Siemens Nederland N.V.
PV modules	Shell Solar GmbH
Aluminum structure and installation	Oskomera Solar Power Solutions B.V.
Electrical installation	Cegelec Ridderkerk
Inverters	Siemens AG, Automation & Drives
Design and system integration	Siemens Nederland N.V.
Maintenance	Siemens Nederland N.V.

Project costs including development and maintenance for 20 years:

EUR 3.9 million

The Sunport Blijdorp project was made possible in part through subsidies received from Novem and the South Holland province.

### Summary of technical data:

- Roof surface 5,000 square meters
- 2880 SP150 and 540 SQ 160 solar panels
- Laminates integrated in roof surface
- Installed capacity of 500 kWp
- 400 kVA power plant SINVERT inverter systems
- Annual yield of 325,000 kWh

