

# SWEDEN

## PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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### GENERAL FRAMEWORK

The Swedish PV market has experienced a significant growth over the last couple of years, although from a very low level. The growth rate levelled out during 2008, with about as much installed capacity as 2007. The reason for the market growth is the investment subsidy for PV systems on public buildings that was introduced in 2005. The support programme ended on December 31, 2008, with an estimated total installed PV capacity of 7 MW. The results of this first support programme for PV installations in Sweden is that it has given a significant boost to the Swedish PV market and it has put focus on larger, grid-connected and building integrated systems. It has also created some media attention and it has raised awareness within sectors that previously have not been exposed to PV. An important result is also that a number of new important actors have established themselves throughout the Swedish PV value chain. In the budget for 2009 the Swedish government has announced plans for a new support for installation of PV systems.

There is a stable PV market for stand alone systems in Sweden. However, the market for grid-connected PV systems relies fully on supporting incentives. The main market mechanisms for introducing renewable energy sources in Sweden are the national renewable electricity certificate system and a tax on CO<sub>2</sub> emissions. But neither of these has an impact on the deployment of PV systems.

The aim of the Swedish energy policy is to secure the supply of electricity and other forms of energy at internationally competitive prices, both in the short and the long term. The way to accomplish this is to create favorable conditions for efficient use of energy and cost-efficient energy production with minimum negative impact on health, environment and climate.

Carbon emissions from the Swedish electricity production (approximately 150 TWh per year) are very low. About 50 % is generated by nuclear power and hydropower accounts for 40–45 %, depending on precipitation). Wind power is growing rapidly at the moment and there are ambitious targets for the expansion over the coming years. Although, the total contribution of wind power to national electricity supply is still only about 1 %.

### NATIONAL PROGRAMME

The Swedish Energy Agency ([www.energimyndigheten.se](http://www.energimyndigheten.se)) is the national authority for issues regarding the supply and use of energy. Its main task is to implement the Swedish energy policy programme, which is decided by the Swedish Parliament. The aim of the programme is to develop a more sustainable energy system and to secure energy supply. The main emphasis is on energy efficiency and on the development and promotion of renewable energy such as biomass, hydropower, wind power and PV.

PV is part of the national long-term energy research programme, which is managed by the Swedish Energy Agency. The budget was increased for 2009 to about 100 MEUR. The agency provides funding for PV research, co-financed technological development, demonstration and business development. The budget for PV is in the range of 2–2,5 MEUR per year, depending on which projects are currently running. Additional funding for PV R&D in Sweden can be



*Fig. 1 – A total of 109 kWp has been installed on the roof and on the facade, as well as above the windows as sunscreens at the House of Ecology, Lund University. The different parts of the system demonstrate different ways of PV architectural integration.*

received from e.g. the Swedish Research Council, the Nordic Energy Research programme, the Agency for Innovation Systems and private foundations.

In addition to international cooperation through the IEA PVPS, Sweden is participating in PV-ERA-NET ([www.pv-era.net](http://www.pv-era.net)), which is an EU-funded network for national programme owners. The objective of the project is to increase collaboration and coordination between the national PV R&D programmes in the European Research Area.

### RESEARCH, DEVELOPMENT AND DEMONSTRATION

The thin film CIGS research at Uppsala University has been going on since the 90s ([www.asc.angstrom.uu.se](http://www.asc.angstrom.uu.se)). The spin-off company, Solibro AB, was launched in 2003 and the technology resulted in commercial production during 2008 (see Industry Status below). The aim of the university research is to achieve high performance and simultaneous cost reduction whilst utilising processes and materials that minimise the impact on the environment. For the development of the next generation CIGS technology, elimination of cadmium from the buffer layer, minimization of the thickness of the active layer and increased process speed are the main objectives.

There are several research projects in Sweden around 3<sup>rd</sup> generation PV concepts. Many of these projects receive funding through the Swedish Research Council's call for basic research. One specific field that stands out is polymer solar cells, where research is conducted at several Universities in Sweden.



Fig. 2 - 64 kWp PV system on the roof of Andersberg Centrum and on the triangular roof of the nearby Andreas' Church in Gävle (photo Anders Holmsten, Gavlegårdarna).

Another field with world class research is molecular solar cells, where different research groups from Uppsala University, the Royal Institute of Technology and the public-private partnership company Swerea IVF AB are connected through The Center of Molecular Devices ([www.moleculardevices.se](http://www.moleculardevices.se)). The aim is to develop nanostructured dye-sensitized solar cells and modules that can be manufactured at very low cost. Basic research is aimed at finding new combinations of dyes and electrolytes, which can increase the cell efficiency and stability in order to reach the long-term objective of manufacturing efficient and inexpensive solar cells for large scale electricity production.

At the division of Energy and Building Design at the University of Lund, research is conducted primarily on solar energy integration into buildings. One of the research themes is low concentration PV and hybrid systems with combined PV and solar thermal systems. The division for Environmental Systems Analysis, Chalmers University of Technology in Gothenburg are for example studying innovation systems and policy issues. The research group has e.g. studied the effects of support mechanisms for emerging energy technologies like PV.

The SolEI programme is a national R&D programme with a focus on PV systems and their applications. The programme is financed by the Swedish Energy Agency, Swedish utilities, manufacturing companies (PV and other) as well as building companies and property owners. A new period of the programme started during 2008 and will continue until 2011 with a budget of approximately 0,4 MEUR per year. The programme is managed by Elforsk AB, which is the Swedish electricity utilities' R&D company ([www.elforsk.se](http://www.elforsk.se)).

The main objectives of the SolEI programme are to support technological development, demonstration of applications, analysis of performance and costs of PV systems (both technical and non-technical) as well as information dissemination.

As a part of the information dissemination effort, the SolEI programme follows and reports to Swedish organisations on the international development of PV, and serves as a reference group for participation in the IEA PVPS. The programme is used as national forum for exchange of information about PV.

A first call of the new period was held during 2008. Examples of projects funded by the programme are studies regarding grid connection and new electricity meters, new ways of implementing PV systems, various activities for raising the awareness of PV, as well as monitoring of the performance of grid-connected systems ([www.elforsk.se/solenergi](http://www.elforsk.se/solenergi)).

The interest in the programme from the building industry has increased during the last couple of years, due to the rapid international development of building-integrated photovoltaics (BIPV), and also because of a general trend to profile themselves as environmental friendly companies. This has led to a shift of focus towards BIPV, with planning tools for architects and builders being developed. Other examples of projects and activities are regional PV seminars, international study tours, handbooks and guidelines.

## IMPLEMENTATION AND MARKET DEVELOPMENT

The market for PV in Sweden has traditionally been dominated by domestic stand-alone PV systems. The majority of these systems are small and predominantly used to supply electricity to recreational homes where grid-connection is not available. Apart from the off-grid domestic market, there are off-grid non-domestic systems, supplying electricity for telecommunication systems, lighthouses, etc., and a few grid-connected systems. Until May 2005, the lack of market support for PV resulted in a comparatively slow development of the PV market in Sweden. Total cumulative PV power installed amounted to approximately 4 MW, whereof 226 kW were grid-connected. These grid-connected systems are mostly demonstration projects intended to test and display the PV technology in general or for the purpose of research.

Things changed in May 2005 when an investment subsidy for the installation of PV systems in public buildings was introduced. The support programme was active until the end of 2008. It was an investment support of 70 % subsidy and limited to a total amount of about 15 MEUR. The interest for the subsidy has been good and the cap was reached early 2008, the cap was then lifted but that have not resulted in a large increase of additional systems due to the time constraint that the systems had to be completed by the end of 2008. The subsidy scheme has jump-started the domestic market for PV in Sweden and resulting in about 3 MW of installed capacity since the start. Hence the total installed PV capacity in Sweden almost doubled in three years time and the installed capacity of grid-connected BIPV applications increased more than tenfold. Many new actors have come in contact with the PV technology as a result of the subsidy and this is important since an important motive for the programme was to promote the development of professional know-how among installers, architects, project developers, etc. An important result is also that PV advocacy groups are beginning to form. The Scandinavian Photovoltaic Industry Association (SPIA) was formed much as a consequence of the support programme and during 2008 SPIA merged with the Swedish industry association for solar heating, Svensk Solenergi ([www.svensksolenergi.se](http://www.svensksolenergi.se)), to create a common industry association for solar energy in Sweden.

During the autumn of 2008, the Swedish Government presented the budget proposition for 2009 and it included a new support for installation of PV systems with about 5 MEUR per year for another three year period. The decree for the new subsidy was not finished at the end of 2008, but it will probably be similar to the previous support programme but with the major difference that it will be available for all applicants.



*Fig. 3 - The system is the first in Sweden with CIGS modules from Solibro, a company that was founded as a spin-off from thin film research at Uppsala University. The system is installed at the Swedish University of Agricultural Sciences in Uppsala (photo Julio Gonzalez, SLU).*

There are still very few grid-connected residential systems in Sweden, mainly due to the high prices of PV systems, the high cost of grid-connection and the lack of financial support for private PV installations. However, the issue of the cost for grid-connection has been debated in the PV community and the government is aware of these problems and an assessment of possible solutions was performed during 2007 and delivered early 2008. Among the recommendations related to PV are for example to waive the demand to measure energy delivered by the hour for systems with an output of up to 63 A and also to allow net-billing on a monthly basis for these systems. The recommendations from this assessment are at the moment being processed by the government.

#### INDUSTRY STATUS

The Swedish PV industry has grown significantly over the last couple of years. Today, there are five companies in Sweden that produce PV modules. All of them buy cells from abroad and assemble modules, which to a large extent are exported. **Gällivare PhotoVoltaic AB (GPV)** was the first module manufacturing operation set up in Sweden. GPV was earlier owned by the German company Solarworld, but in early 2008 a majority of the shares were sold to the Swedish renewable energy investment company Borevind AB. There are two module manufacturers in Gällivare, the other one is called **ArcticSolar AB**. In 2006, there was even a third factory, **n67 Solar AB**, established in the same region of northern Sweden. **PV Enterprise Sweden AB** is one of the younger module manufacturing companies in Sweden, it was started in 2002 by the former head of GPV. **ScanModule AB**, which is a subsidiary of the Norwegian Renewable Energy Corporation (REC), commenced its module production in 2003 and has undergone rapid expansion to become the largest module manufacturer in Sweden. This has been possible thanks to the supply of cells from the sister company **REC ScanCell AS** in Norway. The expansion to 100 MW production capacity during 2007 continued during 2008 to a total of 150 MW per year.

Total production capacity in Swedish module factories was about 190 MW for 2007, with only 70 MW actually being produced. Despite the new investment subsidy, the annually installed PV capacity in Sweden only constitutes a small fraction of the produced modules. A growing number of small to medium-sized enterprises exist, which design, market and sell PV products and systems. There are currently no feed-stock or cell manufacturers in Sweden, but there are plans for production of thin-film CIGS cells by the company **Midsummer AB** (see below).

The company **Solibro Research AB** conducts development of large scale processing and module integration of CIGS thin-film solar cells. Solibro was originally founded as a spin-off from the thin-film solar cell group in Ångström Solar Center. In November 2006 a joint venture with German solar cell manufacturer Q-Cells GmbH, called **Solibro GmbH**, was announced and **Solibro Research AB** was founded as a result to continue the R&D activities in Sweden. A full-scale manufacturing facility was constructed in Thalheim, Germany and operation was commenced in the beginning of the summer 2008. The construction of a second factory at the same location was initiated during the autumn 2008. Q-Cells also provided funding for investments at the research facilities in Uppsala.

Independently from Solibro AB, another company, **Midsummer AB**, has developed another production process for CIGS solar cells. The founders of Midsummer AB have experience from e.g. the thin film and semiconductor industries. Their aim is to reduce the production cost of CIGS cells by combining knowledge from these industries, experience from mass production and an unconventional manufacturing process. Large scale cell production is planned to start during 2009.

Low-concentrating combined photovoltaic/thermal systems are a Swedish niche, in which research and development has been conducted for more than ten years. Recently, the company **Arontis Solar Concentrator AB** has been established to commercialise this technology. Arontis's first product is an 8X concentrating, east-west oriented, sun tracking PV/T system that produces electricity and hot water simultaneously.

#### FUTURE OUTLOOK

The high costs of grid-connection and obligatory metering are obstacles for the deployment of PV in Sweden. The recommendations from the assessment of grid-connection of renewable energy sources suggest improvements in the conditions for grid-connection of PV systems in Sweden. These improvements are crucial for the development of a market for residential systems in Sweden and would be an important complement to the new support programme that is planned. However, changes are not likely to be implemented before July 2009.

2008 was a year of uncertainty for the Swedish PV market since it was unclear, until very late, if there would be a continuation of the support programme after the year. The new programme will secure the market for another three years and with about the same amount of money dedicated for each year as in the earlier subsidy it is likely that there will be a sustained but limited growth of the market. Activities will probably be low in the beginning of 2009 until the new decree is finalised. In the long run it is very important with long term plans from the Swedish government for the development of the PV market.

2009 will also be an interesting year for **Midsummer AB**, that will start with their first deliveries of CIGS solar cells to customers during the coming year.