National Survey Report
of PV power applications in Sweden
2011

IEA PVPS

A 6 kW system near Stora Bjällösa. Courtesy of Perpetuum Automobile.

Prepared for the IEA PV Power Systems programme
Funded by the Swedish Energy Agency

INTERNATIONAL ENERGY AGENCY

CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task 1

Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications in Sweden 2011

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The making of this report was sponsored by the Swedish Energy Agency

2012-05-29

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Definitions, Symbols and Abbreviations

List of abbreviations

PV	Photovoltaic
BIPV	Building integrated PV
CIGS	$Cu(In,Ga)Se_2$
FiT	Feed in tariff
SEK	Swedish Krona
VAT	Value added tax
W_p	Watt peak
R&D	Research and development
EU	The European Union
CD	Compact Disc
DSC	Dye-Sensitized solar cell
OPV	Organic Photovoltaics
DSO	Distribution system operator
Nord Pool	Nordic electricity retailing market
CMD	Center of Molecular Devices
SIDA	Swedish International Development Cooperation Agency

For the purposes of this and all IEA PVPS National Survey Reports, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 W or more.

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m^2, cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Rated power').

Rated power: Amount of power produced by a PV module or array under STC, written as W.

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

CPV: Concentrating PV

Hybrid system: A system combining PV generation with another generation source, such as diesel, hydro, wind.

Module manufacturer: An organisation carrying out the encapsulation in the process of the production of PV modules.

Off-grid domestic PV power system: System installed to provide power mainly to a household or village not connected to the (main) utility grid(s). Often a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications) via a 'mini-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV power system: System used for a variety of industrial and agricultural applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

Grid-connected distributed PV power system: System installed to provide power to a grid-connected customer or directly to the electricity grid (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be on or integrated into the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed for support of the utility distribution grid. Size is not a determining feature – while a 1 MW PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

Turnkey price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated with storage battery maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be excluded. (E.g. If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. Equally the additional transport costs of installing a telecommunication system in a remote area are excluded).

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Demonstration Programme: A programme to demonstrate the operation of PV systems and their application to potential users/owners.

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. These may be implemented by government, the finance industry, electricity utility businesses etc.

Final annual yield: Total PV energy delivered to the load during the year per kW of power installed.

Performance ratio: Ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per kW of installed PV power.

Currency: The currency unit used throughout this report is SEK (Swedish krona).

PV support measures:

Enhanced feed-in tariff	an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh somewhat higher than the retail electricity rates being paid by the customer
Capital subsidies	direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost
Green electricity schemes	allows customers to purchase green electricity based on renewable energy from the electricity utility business, usually at a premium price
PV-specific green electricity schemes	allows customers to purchase green electricity based on PV electricity from the electricity utility business, usually at a premium price
Renewable portfolio standards (RPS)	a mandated requirement that the electricity utility business (often the electricity retailer) source a portion of their electricity supplies from renewable energies
PV requirement in RPS	a mandated requirement that a portion of the RPS be met by PV electricity supplies (often called a set-aside)
Investment funds for PV	share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends
Income tax credits	allows some or all expenses associated with PV installation to be deducted from taxable income streams
Net metering	allows PV customers to incur a zero charge when their electricity consumption is balanced by their PV generation, to be charged the applicable retail tariff when electricity is imported from the grid and to receive some remuneration for PV electricity exported to the grid
Net billing	the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity account is reconciled over a billing cycle
Commercial bank activities	includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems
Activities of electricity utility businesses	includes ‘green power’ schemes allowing customers to purchase green electricity, operation of large-scale (utility-scale) PV plants, various PV ownership and financing options with select customers and PV

	electricity power purchase models
Sustainable building requirements	includes requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy foot print or may be specifically mandated as an inclusion in the building development

Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The 22 participating countries are Australia (AUS), Austria (AUT), Canada (CAN), China (CHN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia (MYS), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission, the European Photovoltaic Industry Association, the US Solar Electric Power Association and the US Solar Energy Industries Association are also members.

The overall programme is headed by an Executive Committee composed of one representative from each participating country or organization, while the management of individual Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual Trends in photovoltaic applications report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the Swedish National Survey Report for the year 2011. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org also plays an important role in disseminating information arising from the programme, including national information.

1 EXECUTIVE SUMMARY

1.1 Installed PV power

The PV power installation rate in Sweden continued to increase in 2011 and a total of 4.3 MW_p was installed, compared with 2.7 MW_p in 2010. The off-grid market grew slightly, from 580 kW_p in 2010 to approximately 730 kW_p in 2011, due to lower module prices and a growing interest in PV. As in 2010 the large increase of installed systems occurred within the submarket of grid-connected systems. Around 3.6 MW_p was installed in 2011 which is 1.5 MW_p more than what was installed in 2010. Many of these installations were feasible due to the direct capital subsidy that was in place in 2011.

1.2 Costs and prices

The prices for both modules and complete turnkey system has decreased rapidly the last couple of years in Sweden and typically prices in 2011 were at about half of those of similar systems only two years ago. At the end of 2011 the typical price for a single module was 19 SEK/ W_p, exclusive value added tax (VAT), compared with 27 SEK/ W_p in 2010. The price for a typical roof mounted system on a private house decreased from 45 SEK/ W_p in 2010 to about 32 SEK/ W_p at the end of 2011. The major reason for the large system price reduction in Sweden is the influence of the international market, where module prices dropped in 2011. Furthermore, a number of new installation companies have entered the marked in 2011, adding to the competition in the Swedish market and thus pushing the prices down.

1.3 PV Production

In 2011 there were five silicon module producers in Sweden. The world production capacity outgrew the world demand in 2011 with a high price reduction on modules as a result. A lot of big international module producers struggled and some went bankrupt in this tough market. This was also the case for the Swedish module producers as some had to let some employees go and one company, former PV Enterprise was put into liquidation in 2011. This in combination with REC's decision to move their module production from Sweden to Singapore at the end of 2010 made the module production numbers drop significantly in 2011. A module production of totally 40.4 MW was reported for 2011 compared with 180.8 MW in 2010.

1.4 Budgets for PV

The total public budget for PV applications was approximately 121 million SEK in 2011. Of this, 60 million SEK belongs to the direct capital subsidy. 61 million SEK went to research and development which is almost the same amount as in 2010.

2 THE IMPLEMENTATION OF PV SYSTEMS

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W_p or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries.

For the purposes of this report, **PV installations are included in the 2011 statistics if the PV modules were installed between 1 January and 31 December 2011, although commissioning may have taken place at a later date**.

2.1 Applications for photovoltaics

Historically, the Swedish PV market has almost only consisted of a small but stable off-grid market where systems for recreational cottages, marine applications and caravans have constituted the majority. This domestic off-grid market is still stable and is growing slightly. However, in the last five years more grid-connected capacity than off-grid capacity has been installed and Sweden now has more grid-connected PV capacity than off-grid capacity. The grid-connected market is almost exclusively made up by roof mounted systems installed by private persons or companies. So far only a couple of relative small systems can be seen as centralized systems.

2.2 Total photovoltaic power installed

In 2011 another 4.31 MW_p of PV power was installed in Sweden which caused the installation rate to grow 60 % compared with 2010. Grid-connected system accounted for most of the installed capacity and the largest increase, but the off-grid market also grew a little bit. Although the installation rate increased in 2011, the Swedish PV market is still very small and represents only a tiny fraction of Swedens total electricity production.

2.2.1 Methods and accuracy of data

Almost all of the gathered data used in this report comes directly from company representatives. It is usually not a problem to acquire data from the industry but for this report one company have refused to submit data. Therefore the numbers regarding installed PV power do contain one estimation done by the author. Furthermore, the quality of the data acquired from different companies varies. Most companies provided very accurate data while a few only provided estimations. Furthermore, some unrecorded installation has probably been carried out that fall outside this report. The accuracy of the data for annual installed power is therefore estimated to be within ± 5 %.

The numbers for the cumulative installed capacity in Sweden are more uncertain. It is impossible to know how many of all off-grid systems that still were in use in 2011. The situation for grid-connected system is slightly better, and a number of systems that have been reported to be taken out of operation have been withdrawn from the figures. Since a PV system typically has a lifetime of 25 years it is likely that most of the reported cumulative capacity is still up and running. However, the numbers of the cumulative installed PV capacity should more be seen as numbers over the total off-grid PV power installed over the years rather than the total PV capacity in place and running today.

Table 1: PV power installed during calendar year 2011 in 4 sub-markets.

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	Total
PV power installed in 2011 (MW_p)	**0.71**	**0.02**	**3.48**	**0.11**	**4.31**
Amount of CPV in the above (MW_p)	0	0	0	0	0
Amount of PV in hybrid systems (MW_p)	0	0	0.10[1]	0	0

[1] Low concentrating combined PV and solar thermal power generation systems.

Table 2: PV power and the broader national energy market.

Total national PV capacity as a % of total national electricity generation capacity	New PV capacity as a % of new electricity generation capacity	Total PV electricity production as a % of total national electricity consumption
0.04	0.39	0.01

A summary of the cumulative installed PV Power, from 1992-2011, broken down into four sub-markets is shown in 3.

Table 3: The cumulative installed PV power in 4 sub-markets.

Cumulative installed capacity as at 31 December					
Year	Off-grid domestic (MW_p)	Off-grid non-domestic (MW_p)	Grid-connected distributed (MW_p)	Grid-connected centralized (MW_p)	Total (MW_p)
1992	0.59	0.21	0.01	-	0.80
1993	0.76	0.27	0.02	-	1.04
1994	1.02	0.29	0.02	-	1.34
1995	1.29	0.30	0.03	-	1.62
1996	1.45	0.36	0.03	-	1.85
1997	1.64	0.39	0.09	-	2.13
1998	1.82	0.43	0.11	-	2.37
1999	2.01	0.45	0.12	-	2.58
2000	2.22	0.47	0.12	-	2.81
2001	2.38	0.51	0.15	-	3.03
2002	2.60	0.54	0.16	-	3.30
2003	2.81	0.57	0.19	-	3.58
2004	3.07	0.60	0.19	-	3.87
2005	3.35	0.63	0.25	-	4.24
2006	3.63	0.67	0.56	-	4.85
2007	3.88	0.69	1.68	-	6.24
2008	4.13	0.70	3.08	-	7.91
2009	4.45	0.72	3.54	0.06	8.76
2010	4.95	0.80	5.40	0.29	11.43
2011	5.66	0.82	8.87	0.40	15.75

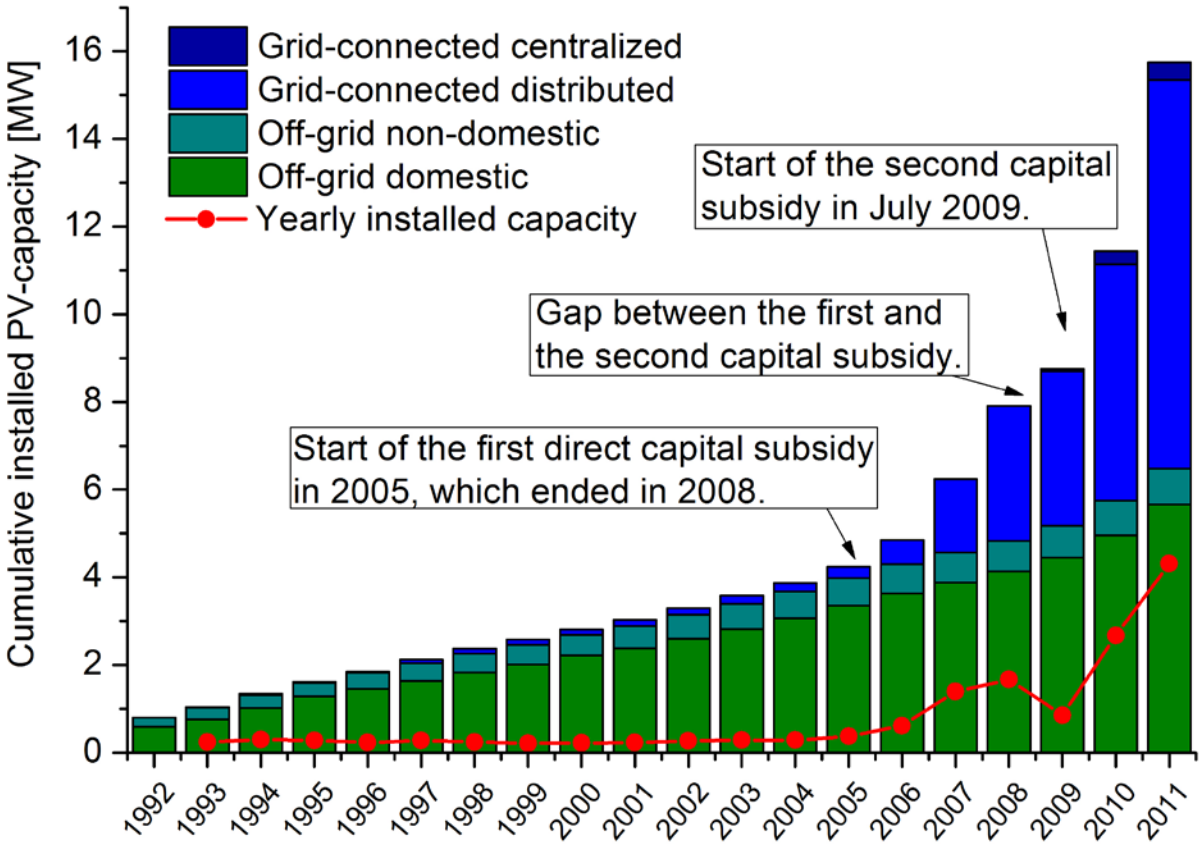

Figure 1. The cumulative installed PV power and yearly installed capacity trends.

2.3 PV implementation highlights

The year of 2011 saw an accelerated change in the utility companies' interest in the issue of surplus electricity produced by small scale renewable systems, like PV. In 2010 the only utility company buying surplus electricity was Bixia, which offered the Nord Pool spot price. Under 2011 a number of utility companies launched different compensation schemes, ranging from the Nord Pool spot price to fixed FiT prices of 1.0 SEK/KWh. Some grid-owner companies have even introduced net metering, although there is a question if this is legal under the current tax laws. More information on this topic can be found in section 4.3.

2.4 R&D activities

2.4.1 Academic research

Solel 08-11

SolEl 08-11 is a national R&D program for PV systems that is financed by the Swedish Energy Agency (Energimyndigheten), utilities, the real estate industry and companies with an interest in photovoltaic applications. The program has been running in various stages for over 15 years and an extensive network has been built around the program. The program has become an important platform for dialogue between the building and property sector, the government, industry, utilities and solar energy companies.

In 2011, several projects with focus on building integrated PV (BIPV) as well as projects about grid connection and standardisation issues were finalised and reported. 2011 was the final year of the programme, and the planning for next phase 2012-2015 is ongoing. The plan is to continue with topics such as PV in the future smart grids and sustainable cities and building related PV-questions.

Center for Molecular Devices

The research constellation, Center for Molecular Devices (CMD), has become one of the world leading scientific centers for research and development of dye-sensitized solar cells (DSC). The center is a collaboration between Uppsala University, the Royal Institute of Technology (KTH) in Stockholm and the industrial research institute Swerea IVF in Mölndal. CMD has at present about 30 members and the activities include basic physical chemistry research for fundamental understanding of the components, interfaces and devices, organic synthetic chemistry for design and preparation of dyes, inorganic synthetic chemistry for design and preparation of nanostructured metal oxide materials as well as electrolyte systems, and engineering research for up-scaling and process development. Immaterial property rights generated by the center are handled in the company Dyenamo AB. As a highlight during the last year CMD has made the breakthrough of using 1-electron transfer redox systems such as Co-complexes. This opens up a path to increase the efficiency significantly. With the recent world record of 12.3 % using Co-complexes by Grätzel and co-workers the main direction of the research field is now to explore this path.

Uppsala University

Energy is a strategic focus area at Uppsala University and the solar cell activities are important parts of this research. At the Ångström Laboratory research is pursued within several different aspects of solar cells.

At the Ångström Solar Center the emphasis is on thin film solar cells using either $Cu(In,Ga)Se_2$ and $Cu_2ZnSn(S,Se)_4$ as absorber materials. In addition to material synthesis, also extensive materials and electro-optical characterization is performed. The material parameters obtained from characterization are used as input in electrical modeling. $Cu_2ZnSn(S,Se)_4$ is a new material for light absorption. Also in the other part of the solar cells, like substrates, back contact and front contact, new materials are evaluated. Here the group is internationally recognized for the work on Cd-free buffer layers. Highlights from 2011 include 18.6 % efficiency for a $Cu(In,Ga)Se_2$ thin film solar cell with a CdS buffer layer and 18.2 % for a similar device with a Zn-Sn-O, Cd-free buffer.

In the Built Environment Energy Systems Group (BEESG) at Solid State Physics, integration of new energy technologies into the built environment is studied from a systems perspective. Major research topics related to PV are solar energy potential in the built environment, integration of distributed PV into the power system, utilization of on-site PV generation in buildings and design of net-zero energy solar buildings.

Furthermore, the Physical Chemistry group and the Interface Science group at Uppsala University are involved in the research platform Center of Molecular Devices (see above).

Chalmers

At Chalmers University of Technology Foundation research in many different PV associated areas is carried out, such as design of polymer, organic and hybrid solar cells, plasmons for enhanced light absorption in solar cells, electrolytes and quatum dots for DSC, lifecycle analysis and BIPV.

One of the larger projects is Sunflower which is a collaborative research project of 17 partner institutions from science and industry. Its goal is the development of highly efficient, long-lasting, cheap and environmentally friendly printed organic photovoltaics.

Another big project is PRIMA: Plasmon Resonance for Improving the Absorption of solar cells. This project aims to enhance the performance and reduce cost of different solar cell technologies, including crystalline Si, organic and dye-sensitized solar cells, by use of metal nanostructures that enhance the optical absorption.

Furthermore, a team from Chalmers will participate in a Solar Decathlon competition in China 2013, where universities from all over the world are going to design and build a self-sufficient home with solar as the only energy source.

KTH

At the Royal Institute of Tehcnology, KTH, both the Organic Chemistry group and the Inorganic Chemistry group are involved in PV research within the Center of Molecular Devices collaboration (see above).

Lund University

At University of Lund the division of Energy & Building Design is studying energy-efficient buildings and how to integrate PV and solar thermal into such buildings. International work is ongoing within IEA SHC Task 41; "Solar energy and architecture" which includes integration issues for both PV and Solar Thermal systems, good examples of building integration, and methods and tools used by architects for solar design at early design stages. This Task will be finalized in 2012.

At the departments of Chemistry and Physics, Lund University research on light induced processes in novel types of solar cell materials and solar cells, Grätzel solar cells, plastic solar cells and solar cells based on semiconductor nanowires are conducted. The aim of the research is to understand light induced processes like energy transport, charge generation and charge separation and transport, as well as how these processes are related to material properties and morphology. An overall aim is to obtain new knowledge that can lead to better and more efficient solar cells. Research is also conducted to understand the processes that are the basis of artificial photosynthesis for generation of so called solar fuel.

Linköping University

Developments of polymer based organic photovoltaics (OPV) in the collaboration between Linköping and Chalmers University during 2011 include synthesis of isoindigo based alternating copolymers with thiophene, rendering improved energy conversion efficiency after optimization of materials nanostructure by processing of polymer/fullerene blends.

Furthermore, development of alternative device architectures for OPV using metal cathodes in the form of stacks of metal/metal oxides on substrates, later coated by active materials from liquid and a top transparent polymer electrode can now be produced with performance equivalent to the traditional geometry with evaporated metal cathodes, and with superior stability.

Högskolan Dalarna

The Solar Energy Research Center (SERC) at Högskolarna i Dalarna carry out research on PV systems, mainly PV-hybrid and stand-alone PV systems. The small group is doing both simulations and practical testing of systems and has several test and demonstration facilities along with a lab where standalone, grid connected and micro grid system can be tested. The group is also involved in a SIDA project about PV-hybrid systems in developing countries.

Mälardalens Högskola

Mälardalens Högskola is conducting research in projects regarding development of the energy system with a high fraction of solar electricity for energy effective buildings, PV plus district heating respectively PV plus heat pumps, enabling buildings as an active component in the future energy system, and increased consumer influence on the Nordic Energy market. The group is also involved in three projects financed by SIDA (Styrelsen för Internationellt Utvecklingssamarbete), see section 4.2.5.

Karlstad University

The materials physics research group at Karlstad University has been running research projects on polymer-based photovoltaics since 2002. The work is focused on morphological studies of solution-processed thin films of blends of electron-donating conjugated polymers and an electron-accepting fullerene derivative, using microscopy, depth profiling, and photoelectron spectroscopy techniques. Film morphology has significant influence on the device performance of bulk-heterojunction solar cells. The group collaborates with Chalmers University of Technology.

2.4.2 R&D companies

Solibro Research AB

The CIGS thin film solar cell company Solibro is since 2009 fully owned by the German company Q-cells. The two productions factories are located in Germany, but the process development remains in a pilot factory in Uppsala Sweden under the name Solibro Research AB. Solibro started as a spin-off company from Uppsala University and there is still a close collaboration between the company and the university. Solibro Research AB managed in December 2011 to make a 16 square centimeter CIGS thin film module with an efficiency of 17.4 %, which at that time was the highest efficiency ever achieved by a CIGS module.

NLAB Solar

Dye-Sensitized solar cells (DSC) have the potential to achieve a low cost per Watt, but have so far lacked conversion efficiency on an industrial scale. The company NLAB Solar has addressed this problem and has demonstrated two solutions that improve the efficiency of the dye-sensitized solar cells without losing the possibility of mass production. The planning for the building of a 20 MW capacity DSC pilot line was initiated in the second half of 2010. The year of 2011 was dedicated to installation, testing and integration of individual process steps. Overall test runs will start in the end of 2012 and the plan is to have developed the production methods with full prototyping by the end of 2013.

Solarus AB

Solarus is a solar energy company with three different solar panel product lines: one thermal, one combined PV and solar thermal and one PV only. Their systems use modules that in part receive direct sunlight and in part receive focused light from a reflective trough mounted underneath the module. The heat generated by the PV module from the sunlight is collected by water pipes and/or solar cells on the backside and on top of the modules. An advantage of using both concentrated and non-concentrated sunlight is that the system performs better under diffuse light conditions. The company plan to have their production facility in Älvkarleby up and running in May 2012.

Global Sun Engineering Sweden AB

Another Swedish company that has developed a technique for low concentrating combined PV and solar thermal power generation is Global Sun Engineering. Their product use several flat mirrors forming a facet disc that focus the sunlight on solar panels made up of solar cells and heat exchangers that generate heat by circulating water that absorbs heat radiation from the sun. The system has a 2-axis tracking function which allows it to follow the sun. Global Sun Engineering is planning to launch their commercial unit in the second quarter of 2012.

Sol Voltaics AB

The nanotechnology company Sol Voltaics AB idea is to fabricate a high efficient nanowire photo-voltaic material which can be used by existing solar cell producers to enhance performance. The spin-off company from the Nanometer Structure Consortium of Lund

University is using a production method based on guided self-assembly of nanowires in gas phase. Nanowire solar cells have the potential to reach a high efficiency since they are not limited by the same physics as regular planar solar cells and to be cheap since they can be deposited as a thin film on larger surfaces. The company is currently trying to raise funds for a pilot production line.

2.5 Public budgets for market stimulation, demonstration / field test programmes and R&D

2.5.1 Budgets for market stimulation

The budget for the direct capital subsidy program distributed by the Country Administrative board (Länsstyrelsen) was 60 million SEK in 2011. However, 79 million SEK was granted to different PV systems and 80 million was disbursed within this scheme in 2011, which is partly capital from previous year's budgets.

2.5.1 Budgets for PV research

The majority of the Swedish Government's funds to PV research are distributed by the Swedish Energy Agency (Energimyndigheten) which is responsible for energy related issues in Sweden. Other organizations that can dispense governmental money to PV related research are The Swedish Research Council (VR), The Swedish Governmental Agency for Innovation Systems (VINNOVA) and The Swedish Foundation for Strategic Research (SSF).

Table 4: Public budgets for R&D, demonstration/ field test programmes and market incentives.

	R & D	Demo/ Field test	Market incentives
National/federal	61	-	60 million

3 INDUSTRY AND GROWTH

3.1 Production of feedstocks, ingots and wafers

Sweden did not produce any feedstock or wafers in 2010 and there are currently no plans for this kind of production in the future.

3.2 Production of photovoltaic cells and modules

In 2011 there were five module producers in Sweden that fabricated modules from imported silicon solar cells. The overall production in 2011 was 40.4 MW, which is considerably lower than the 180.8 MW that was produced in 2010 and the lowest number since 2004. However, the production still outnumbers the installations in Sweden.

The acceleration of PV module price reductions on the world market in 2011 comes from a huge imbalance between the demand and a higher world production capacity. The Swedish module manufactures struggled along with the rest of the module production industry in the world in this harsh market. One company, PV Enterprise, closed down and the rest of the module producers report lower production than in 2010. A newly formed company called Solar Design has taken over the facilities of PV Enterprise, but has not reported their production for 2011. However, the main reason for the huge drop in production in Sweden was REC's decision in the end of 2010 to close down their module production factory in Glava and move their module production to Singapore. A newly formed company SweModule AB has taken over REC's facilities and has started ramping up production. However, they only produced 10 MW in 2011, compared with the 137.5 MW that REC ScanModule produced in 2010.

Sweden also hosts a small production of combined low-concentrating PV and solar thermal power generation products. The production quantities are still very small but are slowly increasing.

Total PV cell and module manufacture together with production capacity information is summarized in Table 5 below.

3.2.1 Production companies

Eco Supplies Solar AB

The company former known as Gällivare Photovoltaic AB was reconstructed in 2010 and got a new owner in form of Eco Supplies Europe AB. In this process the company changed their name into Eco Supplies Solar AB. The company produces modules out of multicrystalline or monocrystalline cells imported from several different manufacturers, mostly from Germany and Asia, and the completed modules were exported mainly to the European market. Eco Supplies Solar AB's module production decreased slightly in 2011 compared to 2010.

Arctic Solar AB

The multi crystalline silicon module producer Arctic Solar AB had a constant demand under 2011 and produced almost as much as in 2010. The company is owned by the Finnish company NAPS and the German company Alfa Solar. All of the Artic Solar AB's products are taken by their partners and most modules are sent to the big markets in Europe.

Latitude Solar AB

Latitude Solar AB is a Swedish company that assembles modules with imported polycrystalline solar cells. As many other solar module producers, Latitude Solar was also affected by the current price pressure on the module market, and this in combination with seasonal changes in the market meant that some employees had to go in November 2011.

The company produced, despite that, almost as much as in 2010. The main product is Latitude P6-60/6, a standard silicon module, mostly exported to European markets such as Germany, Italy, France, Belgium, United Kingdom and Denmark. Under 2011 Latitude Solar also started to develop some specialized architectonic modules.

SweModule AB

SweModule AB was formed in 2011 after the closure of the REC ScanModule AB factory in Glava and the company took over most of ScanModule's facilities and equipment. SweModule AB produces multi crystalline silicon modules with solar cells from the company's major shareholder Norwegian Innotech Solar. The company had 24 employees and produced about 10 MW in 2011 which is much less than the 330 employees and 138 MW productions that REC ScanModule AB had in 2010. However, the company expect to considerable increase their production in 2012.

PV Enterprise Sweden AB

The polycrystalline module manufacturer PV Enterprise Sweden AB was put into liquidation on the 1st of November 2011 by a decision at an extra annual general meeting due to the harsh condition on the module production market with the fierce competition and price pressure from the Chinese producers. The company did not produce anything in Sweden during 2011.

Solar Design AB

Solar Design is a Swedish company specializing in building integrated photovoltaic systems, known as BIPV, which they both manufacture and install. Solar Design became in 2011 Sweden's only supplier of complete photovoltaic systems with solar panels adapted to fit specific needs and requirements by combining the production knowledge from the former production company PV Enterprise Sweden AB with the installation knowledge from the installation company Energikonsulterna i Sverige AB. Both the company's standard multicrystalline and monocrystalline modules along with the custom made PV modules are manufactured in a production facility in Vilshult in southern Sweden that used to belong to PV Enterprise.

Absolicon Solar Concentrator AB

A section within PV, which has potential become something of a Swedish specialty, is combined low-concentrating PV and solar thermal power generation. Absolicon's combined PV and thermal system consists of a cylinder-parabolic reflector that concentrates the light of the sun ten times onto the receiver. It is equipped with a solar tracking system so that the sunlight always is focused onto the cells. Their system yields about five times as much heat power as electrical power. In 2011 the company received an expansion loan of 8 million SEK from the Swedish Energy Agency and recruited more production and installation personnel and increased their production capacity. Absolicon sold and installed systems with a total electric power of 125 kW_p under 2011, of which 100 kW_p was in Sweden.

Table 2: Production and production capacity information for 2011

Module manufacturer	Technology	Total Production (MW_p)		Maximum production capacity (MW_p/ yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Eco Supplies Solar	Mono/Poly-Si	-	8	-	48
Arctic Solar	Poly-Si	-	9.4	-	34
Latitude	Poly-Si	-	13	-	40
SweModule	Mono/Poly-Si	-	10	-	100
Solar Design	Unwilling to give out information				
Total		-	*40.4*	-	*222*
Low-concentrating combined PV and solar power generation manufactures					
Absolicon		-	0.125 electrical (0.5 thermal)	-	0.5 electrical (2.5 thermal)
TOTALS		**-**	**40.5**	**-**	**222.5**

3.3 Module prices

The module prices in Sweden followed the world market trend with falling prices in 2011. Typical single module prices are now below 20 SEK/W_p which is below half of what it was in 2009.

Table 3: Typical module prices (SEK/ W_p, excl. VAT) for a number of years.

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Typical standard single module prices	70	70	70	65	63	61	50	27	19
Best price	26	26	32	30	28,5	25,5	18	20	12

3.4 Manufacturers and suppliers of other components

ABB

ABB, with origin in Sweden, is a global company group specialized in power and automation technologies that operate in around 100 countries. At an international level ABB produces and provides a wide range of products for all types of solar systems, from small domestic installations to large power plants. Products for the solar industry include inverters for photovoltaic systems, components for trackers, low voltage components and accessories. ABB also offers products and solutions for the manufacture of solar modules and solar cells, equipment for connection to the medium or high voltage grid and delivers global turnkey photovoltaic system with unit sizes of 1 MW. In Sweden ABB Cewe-Control manufactures contactors, miniature circuit breakers, residual current devices, surge protectors and electricity meters, which all can be used in photovoltaic systems.

Midsummer AB

The former solely R&D company Midsummer AB inaugurated in September 2011 their CIGS thin film solar cell prototype production line. The production of complete CIGS modules is however small and the company's main business is to market their compact turnkey manufacturing equipment and they sold one production line in 2011. Traditionally, the CIGS technology involves square meter size glass substrates that are deposited with thin layers and the cells are then defined by patterning to form the complete module. Midsummer has however a different approach which is heavily influenced by the CD manufacturing technology. Instead of the conventional use of glass substrates and the evaporation process for the CIGS absorber layer, Midsummer uses stainless steel substrates and the faster sputtering process. The substrates are also much smaller and the result is cells with 12 % conversion efficiency that are in the same size as the traditional crystalline silicon cells. These are then stringed together, following the principles in ordinary silicon module manufacturing.

Eltek Valare AB

Swedish Eltek Valare AB is part of the global corporation Eltek Group that provides products and solutions within power electronics and energy conversion. The company has R&D divisions in Sweden and Norway that develops and constructs inverters for both grid connected and off-grid systems, which are then manufactured in China. Very few inverters from the company are sold in the small Swedish market but typical prices from the company are within the price range 1.4 SEK/W for central grid inverters (100kW-500kW) and 3.3 SEK/W for smaller string inverters (2-5kW) with conversion efficiencies around 95-96%.

SolarWave AB

SolarWave AB provides solar driven water purification systems and desalination systems. The target market is mainly developing countries in Africa where the company's stand alone system is sold by authorized distributors.

Swedish Electroforming Technology AB

Sweltech is a company that is developing grid, CdS and ZnO deposition equipment and processes for the PV industry.

3.5 System prices

In Sweden the prices for grid-connected systems are depending on two factors, the global market for modules and balance-of-system components and the size of the Swedish market. In 2011 the market for grid-connected systems in Sweden was relatively high due to the direct capital subsidy and at the same time the global prices for systems continued to

decrease. This led to that the cost for complete turnkey PV systems decreased remarkably under 2011, especially under the autumn. The turnkey prices presented in table 7 are prices typical at the end of 2011 and do not represent the overall pricing during 2011. The lowest system price reported in 2011 was around 18 SEK/W_p.

Table 4: Turnkey Prices of Typical Applications (SEK/ W_p, excl. VAT)

Category/ Size	Typical applications	Price in 2011
OFF-GRID Up to 1 kW	Roof mounted system for a vacation house	45
OFF-GRID > 1 kW	Roof mounted system for a vacation house	32
ON-GRID Specific case	Roof mounted system on a private house	32
ON-GRID up to 10 kW	Roof mounted system for a commercial building	28
ON-GRID > 10 kW	Roof mounted system for a commercial building	25
ON-GRID > 10 kW	Utility-scale plant	-

Table 8: National trends in system prices (SEK/ W_p, excl. VAT) for small off-grid and big on-grid applications.

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
OFF-GRID Up to 1 kW	165	100	100	100	100	95	90	80	70	45
ON-GRID > 10 kW	-	200	-	60	60	60	67	47	35	25

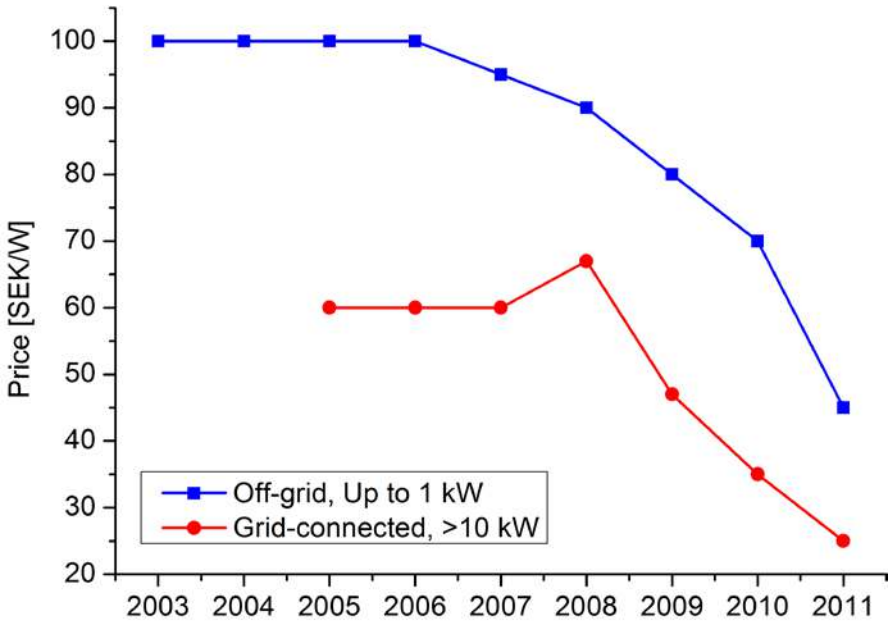

Figure 2. Swedish typical PV system price development over the years (exclusive VAT).

3.6 Labour places

The number of people with a job related to the PV market in Sweden decreased with some 280 persons in 2011 and is now approximately 560 persons. The reason for the decrease in PV related employments in 2011 was the closer of the REC's ScanModule production where 330 employees lost their job. SweModule that took over the facilities employed about 30 persons in 2011, which is considerable less than the original working force.

Even if it has been a big decline in this sector, most of the people working with PV in Sweden, about 180, are working at Sweden's five large module producing companies. The number of people working with PV has in 2011 increased in all of the other sectors. University and governmental based research is the second largest employment group. This workforce is slowly growing because of long running research programs that continue to expand. Due to the direct capital subsidy system and price drops a number of new installation and distribution companies have entered the market and the established actors have increased their work force resulting in that there are now more people working within this sector than previously.

Table 9: Estimated PV-related labour places in 2011

Research and development (not including companies)	91
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	281
Distributors of PV products	16
System and installation companies	58
Electricity utility businesses and government	5
Other	5
Total	456

3.7 Business value

In table 10 some very rough numbers of the business value of the Swedish PV market can be found. The PV business value in Sweden is dominated by the module production due to the fact that 40.4 MW is being produced, but only 4.3 MW is installed.

Table 10: Value of PV business

Sub-market	Capacity installed in 2011 (MW)	Price per W	Value (SEK)	Totals Value (million SEK)
Off-grid domestic	0.71	45	31 950 000	
Off-grid non-domestic	0.02	45	900 000	
Grid-connected distributed	3.43	30	102 900 000	
Grid-connected centralized	0.11	25	2 750 000	
				~ 138.5
Export of PV products				~ 810
Change in stocks held				n/a
Import of PV products				~ 500
Value of PV business				**~ 1448.5**

4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

4.1.1 State subsidy for solar cells

A direct capital subsidy for installation of PV systems (ordinance 2009:689 has been active in Sweden since 2009. This subsidy was planned to end the 31st of December 2011 but was in October 2011 prolonged for one more year and a budget for 2012 was allocated.

The subsidy is valid for any type of grid-connected PV system that commenced on or after 1st of July 2009 and is completed by the 31st of December 2012 and is targeted to companies, public organizations and private individuals. The support can also be used for solar power/heat hybrid systems.

Under 2011 the subsidy covered 60% (55% for big companies) of installation cost of PV systems, including both material and labor costs. In the new ordinance for 2012 this has been lowered to 45% to follow the decreasing system prices in Sweden. The subsidy in 2011 had an upper limit in cost at 2 million SEK per PV system and a maximum of 75 000 SEK plus VAT per installed kW_p. These numbers have also been lowered in the 2012 ordinance and are now 1.5 million SEK per PV system and a maximum of 40 000 SEK plus VAT per installed kW_p. Solar power/heat hybrid systems are allowed to cost up to SEK 90 000 plus VAT per installed kW_p.

In 2011 58.5 million SEK were granted to different system applications, which makes the total amount granted from the start of the program in 2009 212 million SEK. The budget for 2012 is 60 million SEK.

The fact that subsidy is only prolonged with one year at the time makes the prospect of the Swedish PV market quite uncertain and makes it hard for the system installers to plan for the future. There has for some years now been a proposal from the PV industry to introduce a monthly net-billing system in Sweden. The proposal is now being investigated by the government for the third time, this time by the Ministry of Enterprise, Energy and Communications (Näringsdepartementet).

4.1.2 The green electricity certificate system

In 2003, a tradable green electricity certificate system was introduced in Sweden to increase the use of renewable electricity. The objective is to increase the electricity production from such energy sources by 17 TWh from the 2002 level until 2016. The basic principle of the system is that producers of renewable electricity receive certificates from the government for each MWh produced. Meanwhile, electricity supplier companies are obliged to purchase green certificates representing a share of the electricity they sell, the so-called quota obligations. The sale of certificates gives producers an extra benefit in addition to revenues from electricity sales. The energy sources that are entitled to receive certificates are wind power, some hydro, some biofuels, solar, geothermal, wave and peat in power generation. In 2011, the quota obligation for Electricity supplier companies was 0.179 or 17.9 %.

On the first of July in 2010 the government presented a legislative amendment for an evolved electricity certificate system. The electricity certificate system will now continue until the end of 2035 and the new target for the production of renewable electricity is an increase of 25 TWh by 2020 compared with 2002 levels. New quotas will be valid from 2013.

At the end of 2010 it was also decided that Sweden and Norway as from 2012 will have a common electricity certificate market. The ambition of the common system is that 26 TWh of new renewable electricity production will be installed between 1st of January, 2012 and 2020. At the same time the Norwegian Petroleum and Energy Ministry submitted its proposal for the Norwegian electricity certificate act which is basically a copy of the Swedish act.

In 2011 the average price for a certificate was 247 SEK/MWh.

The electricity certificates can in the present shape give some economical contribution to existing solar installations. However, in 2011 there were only 52 PV installations that benefited from the possibility of certificates. This indicates that the certificate system of today does not provide any significant financial support for photovoltaic installations in Sweden. There are two reasons why it has been difficult for PV to take advantage of the certificate system. Firstly, it is difficult for small producers to reach a production of 1 MWh of electricity. Secondly, the meters that register the electricity produced at a building are often placed at the interface between the building and the grid. This means that it is only the surplus electricity of a PV system that can generate certificates and the electricity produced and used internally in the building is never included if not the extra cost for an internal meter is paid.

4.1.3 Guarantees of origin

Guarantees of origin indicate the origin of electricity and are an EU directive intendant to provide energy customers the ability to choose electricity suppliers from an environmental aspect. Guarantees of origin are electronic documents that electricity producers gets from the State for each produced MWh of electricity, which can be bought and sold on the open market. The Swedish Energy Markets Inspectorate (Energimarknadsinspektionen) announced in October 2011 new directions on how guarantees of origin should be handled. However, the new regulations do not take full effect until 2013 and it is still very unclear how much a PV-system owner can benefit from this system.

Table 5: PV support measures in place in Sweden 2011.

	On-going measures	Measures that commenced during 2011
Enhanced feed-in tariffs	Offered by some utilities	
Capital subsidies for equipment or total cost	National	
Green electricity schemes		
PV-specific green electricity schemes		
Renewable portfolio standards (RPS)	National	
PV requirement in RPS		
Investment funds for PV		
Income tax credits		
Net metering	Offered by some utilities	Yes
Net billing		
Commercial bank activities e.g. green mortgages promoting PV		
Activities of electricity utility businesses	Various offers to micro producers	Yes
Sustainable building requirements		

4.2 Indirect policy issues

The Swedish government has decided on a national policy that Sweden shall reduce its greenhouse gas emissions by 40 percent in the non-trading sector until 2020 and in 2050 Sweden will have no net emissions of greenhouse gases.

4.2.1 Grid-connection legislation

For grid-connected PV systems the Distribution system operators (DSO's) are required to install a meter with associated collection equipment at the point where the electricity producer's electricity is fed into the national electricity grid. As a general rule, the producer pays for the cost of metering equipment and installation. Small systems that are not able to deliver more than 1 500 kW are however excluded from paying the cost of meters and installation. The producer also needs to pay a grid tariff that is decided by the DSO's. However, new regulations that were set in 2010 make exceptions for small systems. A producer that has a fuse at a maximum of 63 A and is producing electricity with a power of maximum 43.5 kW will no longer need to pay for the grid tariff as long as the producer during one calendar year draw more electricity from the national grid than the producer feeds in.

4.2.2 Taxes

In Sweden taxes and fees are charged at both the production of electricity and at the consumption of electricity. Taxes that are associated with production of electricity are property taxes, taxes on fuels, taxes on emissions to the atmosphere and tax on nuclear power. For consumption it is mainly the energy tax on electricity and the related VAT, but there are also charges to fund agencies. In addition, utilities pay the state income tax (28 percent corporate tax on profit before tax) as all other companies do.

The industry paid in 2011 0.005 SEK/kWh in energy tax and the rate for residential customers was 0.283 SEK/kWh. However, the government decided in 2011 to increase the energy tax for 2012 so that residential customers in Sweden have to pay 0.29 SEK/kWh. Additionally, value added tax is applied on top of the regular tax.

Altogether, roughly 45 % of the total consumer electricity price was taxes, VAT's and certificates in 2011.

4.2.3 New bidding areas

The Swedish electricity market is from the first of November 2011 divided into four bidding areas by decision of Svenska Kraftnät. The reason for this is that northern Sweden has a surplus of electricity production compared with demand while there is more demand than production in southern Sweden. That has resulted in transmission capacity problems and the borders between the bidding areas have been drawn where there are congestions in the national grid. The idea of the four bidding areas are to make it clear where in Sweden the national grid for electricity needs to be expanded and where in the country increased electricity production is required in order to better meet consumption in that area and thus reduce the need to transport electricity long distances.
The average deviation between area 4 (Malmo) and area 3 (Stockholm) was 0.04 SEK/kWh and the deviation between area 4 and area 1 and 2 (Lulea / Sundsvall) was just over 0.05/kWh during the two months that the areas existed in 2011.
This may in the future influence the distribution of PV systems over the country and the southern part of Sweden will likely be more beneficial for PV, both due to solar irradiation levels and higher electricity prices.

4.2.4 Emissions trading

The EU system for emission trading began on the first of January 2005. Emission trading is one of the so-called flexible mechanisms defined in the Kyoto Protocol. The purpose of the trade is to cost-effectively reduce greenhouse gas emissions in the EU. Countries and companies are able to choose between implementing measures to reduce emissions in their own country / company or to buy allowances which generate reductions in emissions elsewhere. This will lead to the least expensive measures being implemented first so that the total cost of meeting the Kyoto Protocol is as low as possible. In Sweden, the carbon dioxide tax has already led to that many of the least expensive measures have been implemented and there are only more expensive measures left.

The first trading period ran from 2005 to 2007. The current trading period runs from 2008-2012, the same as the Kyoto Protocol commitment period. The next trading period will start in 2013 and expire in 2020. For each trading period the total emissions cap in the system is lowered. So far, the emission allowances have been handed out free of charge to operators, but as from 2013, allowances to all electricity production facilities shall be auctioned instead. In the energy sector, all individual plants with a capacity greater than 20 MW_p or district heating systems, where plants together have a greater effect than 20 MW_p are covered by the system, which currently are about 700 plants in Sweden.

The price in 2011 went down from about 15 €/tonne in the beginning of the year to about 10 €/tonne. An applicable rule of thumb is that a price of 10 €/tonne results in a spot price of almost 0.08 SEK/kWh at the Nordic electricity retailing market (Nord Pool).

4.2.5 International spread of environmental technologies

The Swedish Energy Agency is managing the Clean Development Mechanism (CMD) and Joint Implementation (JI) Programme of the Swedish Government. The programme supports international climate projects by purchasing emission reduction units that have been created under the flexible mechanisms of the Kyoto Protocol. The financial support to climate change projects from the Swedish CDM and JI Programme is conducted through bilateral agreements directly with the project developers and via multilateral CDM and JI funds. The Swedish Energy Agency supports a number of solar photovoltaic (PV) projects in China and Thailand, by participating in the two CDM funds administered by the Asian Development Bank (the Asia Pacific Carbon Fund and the Future Carbon Fund). Two of the projects in China are PV power plants, both with an installed capacity of about 10 MW. The other projects in China are building integrated solar photovoltaic (BIPV) projects at different locations with installed capacity ranging from about 2 MW up to 6,5 MW. The project in Thailand is a PV power plant with an installed capacity of about 55 MW.

Furthermore, SIDA is financing several projects in developing countries that involve PV. For example Högskolan Dalarna is involved in a project about PV-hybrid systems in developing countries and Mälardalens Högskola is involved in the following projects, developments of mini grids for rural areas in Africa, development of concentrating PV/T system for Mozambique, and development of PV-supported irrigation system for China.

4.3 Interest from electricity utility businesses

The utility company Sala-Heby Energi's FiT scheme for the local PV community Solel i Sala & Heby continued as planned in 2011. The power utility company has agreed to buy all the electricity that the PV community produces for ten years to come to a price of 3.71 SEK/kWh. A third system, with a peak power of 36 kW, was in 2011 installed making the total production capacity of 161 kW_p. The initial profits for the community will be spent on increasing the production capacity but after five years part of the profit will be distributed to members according to number of shares. The community is slowly expanding with more

members from all over the country and is planning for a fourth system that will be installed in 2012.

Several utility companies started in 2011 to introduce compensation schemes for buying surplus electricity produced by small-scale PV systems. Below is a list of a number of these compensation schemes that where introduced in 2011 and available at the end of the year. Since then several other utilities has followed and there are now many more compensations schemes on the market.

4.3.1 Net metering offers

DinEl started in 2011 to offer net metering on an annual basis. In their solution the client has a fixed kWh price settlement with DinEl where the surplus production is balanced with the consumption. The requirements are that the client is an annual net consumer and the system may not exceed 6 kW.

Utsikt is a DSO company that started to test a net metering on monthly basis scheme.

Mälarenergi is a DSO company that introduced a monthly net metering scheme in 2011 for clients within the company's grid network. The client needs to be net consumer on a yearly basis and has a fuse lower than 63 A. The client doesn't have to buy the electricity from Mälarenergi. No compensation is given for the surplus electricity if the client produces more than the demand in a month.

4.3.2 Feed-in tariff offers

Öresundskraft started in 2011 to buy surplus electricity at a price of 1 SEK/kWh as long as the client is connected to the grid of Öresundskraft, buy the electricity from Öresundskraft, is a yearly net consumer and has a fuse of maximum 63 A.

The DSO companies **Dala Energi Elnät**, **Borlänge Energi Elnät**, **Falu Elnät**, **Hedemora Energi**, **Malungs Elnät**, **Smedjebacken Energi Nät** and **Envikens Elnät** purchased surplus electricity at a price of 1 SEK/kWh. The demand is that the client belong to their grids, that the client is a net consumer of electricity in a year and that the system and the fuse don't exceed 43.5 kW 63 A respectively.

Lunds Energi also purchased surplus electricity at a price of 1 SEK/kWh in 2011. They demand that the client that is a net consumer on a yearly basis and belong to the grid owned by Lunds Energi. Furthermore, the system may not exceed 10 kW_p and the client must have Lunds Energi as a supplier of electricity.

EgenEl purchased in 2011 surplus electricity at a price of 0.5 SEK/kWh on the condition that the client bought the PV-system from EgenEL and used ETC as their electricity supplier.

4.3.3 Nord Pool spot price offers

Bixia continued in 2011 to offer the Nord Pool spot price per hour to all, without any deduction and without requiring that the customer had to switch to Bixia as their electricity supplier.

Fortum Distribution, the DSO part of the large utility company, started in April 2011 to buy surplus electricity from generators within the Fortum's grid area with a maximum fuse of 63 A. Fortum pays the Nord Pool spot price minus 0.04 SEK per kWh. The client doesn't have to change to Fortum as the electricity supplier.

Vattenfall started to buy surplus electricity from small-scale private electricity producers in October 2011. The government-owned energy company pays the Nord Pool spot price minus 0.04 SEK per kWh for the surplus electricity as long as the private producer is a net consumer on a yearly basis and purchases the rest of the electricity from Vattenfall. The

client can belong to any grid area in Sweden as long as the client has a valid feed-in subscription with the grid company in question. The offer is also only valid if the main fuse is at 63 A or lower and if the production facility has a maximum power of 43.5 kW or lower.

E.ON olso offered the Nord Pool spot price minus 0.04 SEK per kWh. However, E.ON dos not require that the client belong to the grid or have E.ON as their electricity supplier.

4.4 Interest from municipalities and local governments

Several municipalities have started some smaller projects within PV, often in cooperation with local utility and construction companies. The largest project is probably the association Solar Region Skåne which started in 2007 as a collaboration between the municipality of Malmö, Energikontoret Skåne and Lund University. Solar Region Skåne is a network and knowledge center for solar energy activity in the Skåne province. The aim of the association is to in a neutral and objective way disseminate knowledge and information about solar technologies, thus increasing the interest and skills of various stakeholders in the solar industry and among the public.

4.5 Standards and codes

4.5.1 Grid connection rules

A PV production facility connected to an existing electrical installation must meet certain requirements to be safe and not affect other equipment in a detrimental way.
The requirements are stated by the ELSÄK-FS 2000:1 and ELSÄK-FS 2007:1 legislation. These refer to technical product standards in agree with European directives. A manufacturer of a product to contained in a power generation facility must also CE mark the product for it to be allowed to be used on the market. The National Electrical Safety Boards (Elsäkerhetsverket) regulations also set that a permanent installation of a production facility shall be performed by a qualified electrician.
Connecting a production facility to an existing electrical installation means that the production facility also is connected to the grid. In the electrical legislation, Ellag (1997:857), it is stated that the transfer of electricity must be of good quality. In order to determine what good quality is, European standards and industry practices are used. Regulations which further specify good quality for the transmission of electricity are currently under formulation by the Swedish Energy Agency (Energimyndigheten).

There are furthermore two important PV specific standards that apply for grid-connected PV system. Swedish Standard SS-EN 61727, Solar power plant - Connection to grid and Swedish Standard SS-EN 61173, Solar power plant - instructions to protect against overvoltage. There are also more general electrical guidelines such as the electrical installation standard SS 436 40 00, the connection of low voltage circuits to the grid standard SS 437 01 40 and the National Electrical Safety Board (Elsäkerhetsverket) directions on how electrical installations shall be executed, ELSÄK-FS 2004:1 that should be followed. A summary of all important standards and guidelines for PV system installation and maintenance has been released in a compilation by the SolEl-program.

4.5.2 Building permits

Installation of PV systems on roofs does normally not require building permits, but it can differ between different municipalities. However, if the installation change the external appearance of a building significantly a building permit is required. Some restrictions on roofing materials and roof angles may apply, particular in culture-sensitive environments and buildings.

4.5.3 Public procurement act

For a procurement of a PV system for a public building the stakeholder planning the system must use an open tender system according to the public procurement act. This unfortunately means that the stakeholder cannot ask a supplier for advice or assistance in the proposition making process. In addition, when it comes to public procurement procedures reference projects are often requested from the installers, which makes it harder for new actors to enter the market.

5 HIGHLIGHTS AND PROSPECTS

5.1 Highlights

The prices for turnkey PV-system decreased significantly during 2011 and at the end of the year the prices for complete systems where about half of what the prices were only two years ago. The price drop resulted in an increase in PV installations, 4.3 MW_p for 2011 as compared to 2.7 MW_p in 2010.

A major highlight in 2011 was that the utility companies started to take a larger interest in PV and there are now a number of different compensation schemes available for small scale producers that would like to sell their surplus electricity.

5.2 Prospects

The installation rate in 2012 is expected to increase slightly due to further reductions in system prices. The direct capital subsidy has been prolonged for one year and funds are available from this subsidy in 2012. However, a problem is that the budget for the direct capital subsidy is small and therefore both functions as a market stimulation and a capacity cap, since people that apply for the subsidy but don't get it often terminate their installation plans. How the Swedish PV market will develop after 2012 is hard to foresee. No plans for a prolongation of the direct capital subsidy for 2013 have yet been announced and the market development will depend on if a national net metering scheme will be implemented in the near future.

The year of 2011 saw a major drop in module production numbers in Sweden and the production companies struggled in a tough world marked. However, some of the production companies reported that they expect an increase in their production for 2012.

ANNEX A: COUNTRY INFORMATION

1) The retail electricity prices went down in Sweden under 2011. For a department the prices went down from ~2.2 in 2010 to ~1.75 SEK/kWh. For a house without electricity warming the prices went from ~2.0 to ~1.5 SEK/kWh and ~1.7 to ~1.25 SEK/kWh for a house with electricity warming. The industry paid in 2011 about 1 SEK/kWh.

2) The average Swedish household electricity consumption is 4.5 MWh per year.

4) The average salary per month was in 2010 28400 SEK before tax.

5) Typical mortgage interest rates for 3 month fixation loans started in 2011 at ~3.2 % and slowly increased under the year to ~4.6 % at the turn of the year.

6) Electricity is transported from the major power stations to the regional electricity grids (40-130 kV) via the national grid (220 kV and 400 kV). From the regional grids, electricity is transported via local grids (40 kV or less) to electricity consumers. The voltage in the wall sockets in Swedish homes is 230 V.

7) The backbone of the electrical grid, the national grid, is owned by the government and managed by Svenska Kraftnät, whereas power utility companies own the regional and local grids. The base price of the electricity is daily set by the Nordic electricity retailing market, Nord Pool. Electricity supplier companies then use this price as basis for their pricing in the competition for customers.

The Swedish market is dominated by three companies; Vattenfall AB, Fortum and E.ON that are all active in all of three sub markets; generation, retailing and transmission, and therefore have a big influence on the overall electricity market.

8) The average pump price of diesel at a manned station was ~14 SEK/l under 2011, including taxes.

9) A typical value of energy production per installed PV power unit in Sweden is 900 kWh/kW but differs for different systems and locations in the country.