IEA INTERNATIONAL ENERGY AGENCY

Swedish Energy Agency

National Survey Report of PV Power Applications in SWEDEN

2013

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

PVPS

Prepared by

Johan Lindahl, Uppsala University

TABLE OF CONTENTS

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 24 participating countries are Australia (AUS), Austria (AUT), Belgium (BEL), 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), Thailand (THA), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission (EC), the European Photovoltaic Industry Association (EPIA), the US Solar Electric Power Association (SEPA), the US Solar Energy Industries Association (SEIA) and the Copper Alliance 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 promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. 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 country National Survey Report for the year 2013. 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 INSTALLATION DATA

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, PV installations are included in the 2013 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2013, although commissioning may have taken place at a later date.

1.1 Applications for Photovoltaics

Historically, the Swedish PV market has almost only consisted of a small but stable off-grid market where systems for holiday cottages, marine applications and caravans have constituted the majority. This domestic off-grid market is still stable and is growing slightly. Since 2007 more grid-connected capacity than off-grid capacity has been installed annually and Sweden now has four times 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 relatively small systems can be seen as centralized systems.

1.2 Total photovoltaic power installed

The growth of PV in Sweden continued to increase in 2013. In total, 19.1 MW_p were installed, which is more than twice as much as the 8.3 MW_p that were installed in 2012. Grid-connected system accounted for most of the installed capacity and the largest increase, from 7.5 MW_p in 2012 to 17.9 MW_p in 2013. The off-grid market also grew slightly from 0.8 MW_p in 2012 to 1.1 MW_p in 2013. The cumulative PV capacity in Sweden was 43.2 MW_p at the end of 2013. This capacity produces an estimated 39 GWh per year, which currently represents about 0.03 % of Sweden's total electricity consumption.

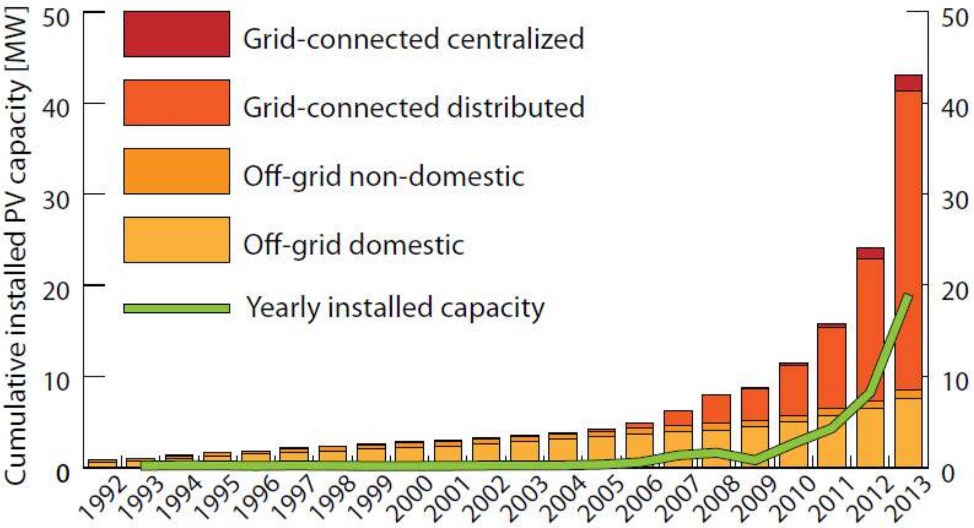

Figure 1: The cumulative installed PV power in Sweden in 4 sub-markets and the yearly installed capacity.

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 installers and retailers of PV systems but the quality and exactness of the data from different companies varies. Most companies provided very accurate data while a few only provided estimations. Furthermore, some unrecorded installations have probably been carried out that fall outside this report. The accuracy of the data for annual installed power is therefore estimated by the author to be within ± 10 %.

The numbers for the cumulative installed capacity in Sweden are more uncertain. There are in the current situation, no practical way to estimate how many systems that have been decommissioned. The Swedish PV market still is very young and a majority of the systems have been installed during the last 5 years. Since a PV system typically has a lifetime of at least 25 years, the number of decommissioned systems is probably very low. However, to be absolutely correct, the numbers for the cumulative installed PV capacity should be seen as the total 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 2013.

AC			**MW_p installed in 2013**	**MW_p installed in 2013**	**AC or DC**
Grid-connected	BAPV	Residential	17.92 MW_p	6.59 MW_p	DC
		Commercial		10.67 MW_p	DC
		Industrial		0.66 MW_p *	DC
	BIPV (if a specific legislation exists)	Residential	included in BAPV	N/A	-
		Commercial		N/A	-
		Industrial		N/A	-
	Ground-mounted	cSi and TF	Included in BAPV	N/A	-
		CPV		N/A	-
Off-grid		Residential	1.16 MW_p	N/A	DC
		Other		N/A	DC
		Hybrid systems		N/A	DC
		Total	**19.08 MW_p**		DC

* Centralized PV – PV system that work as central power stations.

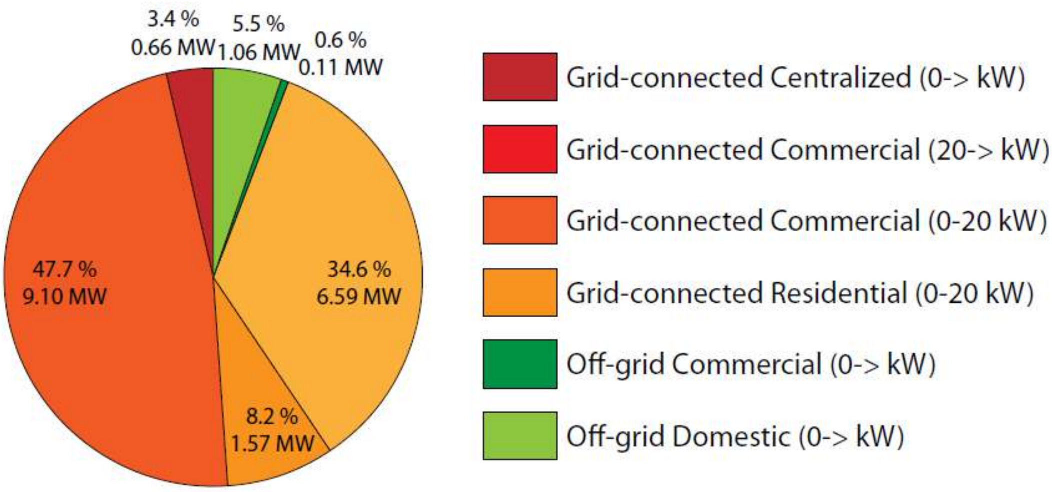

Figure 2: The Swedish PV market in 2013 divided into market segments

Table 2: Data collection process.

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	Data is reported in DC
Is the collection process done by an official body or a private company/Association?	It is done by the author on behalf of the Swedish Energy Agency
Link to official statistics (if this exists)	This report
	The accuracy is estimated by the author to be within ± 10 %

Table 3: PV power and the broader national energy market[1].

	2013 numbers	2012 numbers
Total power generation capacities	38.273 GW	37.353 GW
Total renewable power generation capacities	24.107 GW	23.354 GW
Total electricity demand	139.5 TWh	142.9 TWh
New power generation capacities installed during the year	1.034 GW	1.072 GW
New renewable power generation capacities installed during the year	0.753 GW*	1.047 GW*
Total PV electricity production in GWh-TWh	~38 GWh	~21 GWh
Total PV electricity production as a % of total electricity consumption	0.03 %	0.01 %

*Net increase of renewable power generation capacities.

The Electricity production in Sweden is dominated by hydropower, 40.6 % of total electricity generation in Sweden in 2013, and nuclear power, 42.5 %. Wind turbines have been built at an accelerated rate in recent years and electricity from wind power accounted for 6.6 % of the total electricity generation in Sweden in 2013. The rest is CHP, of which bio fuels accounted for about 6.5 %. The total electricity generation in Sweden was 149.5 TWh in 2013[1].

[1] Elåret 2013, Svensk Energi.

Table 4: Other information.

	2013 Numbers
Number of PV systems in operation in your country	Unknown
Capacity of decommissioned PV systems during the year in MW	Unknown
Total capacity connected to the low voltage distribution grid in MW	Unknown
Total capacity connected to the medium voltage distribution grid in MW	Unknown
Total capacity connected to the high voltage transmission grid in MW	None

Table 5: The cumulative installed PV power in 4 sub-markets (MW_p).

Year	Off-grid domestic	Off-grid non-domestic	Grid-connected distributed	Grid-connected centralized	Total
1992	0.59	0.21	0.01	0	0.80
1993	0.76	0.27	0.02	0	1.04
1994	1.02	0.29	0.02	0	1.34
1995	1.29	0.30	0.03	0	1.62
1996	1.45	0.36	0.03	0	1.85
1997	1.64	0.39	0.09	0	2.13
1998	1.82	0.43	0.11	0	2.37
1999	2.01	0.45	0.12	0	2.58
2000	2.22	0.47	0.12	0	2.81
2001	2.38	0.51	0.15	0	3.03
2002	2.60	0.54	0.16	0	3.30
2003	2.81	0.57	0.19	0	3.58
2004	3.07	0.60	0.19	0	3.87
2005	3.35	0.63	0.25	0	4.24
2006	3.63	0.67	0.56	0	4.85
2007	3.88	0.69	1.68	0	6.24
2008	4.13	0.70	3.08	0	7.91
2009	4.45	0.72	3.54	0.06	8.76
2010	4.95	0.80	5.41	0.29	11.45
2011	5.66	0.82	8.93	0.40	15.80
2012	6.47	0.83	15.65	1.14	24.08
2013	7.52	0.93	32.92	1.79	43.16

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Sweden is a net exporter of PV modules. However, the majority of the production is exported and a majority of the installations are done with imported modules, mainly from China and Germany. Module prices in Sweden are therefore heavily dependent on the international module market and actions, such as the European Commission's anti-dumping duties on Chinese PV imports, also affect the module prices in Sweden. Sweden has seen a very fast price decline on PV modules the last years due to a growing domestic market, which has allowed retailers to import larger quantities, and due to the overall price decline of modules on the international market.

Table 6: Typical module prices for a number of years (excluding VAT)(SEK/W).

Year	2004	2005	2006	2007	2008	1009	2010	2011	2012	2013
Standard module prices:	70	70	65	63	61	50	27	19	18	10
Best price	-	-	-	-	-	-	-	-	-	-
PV module price for concentration	-	-	-	-	-	-	-	-	-	-

2.2 System prices

The prices for grid-connected systems in Sweden are depending on two factors, the global market for modules and balance-of-system components and the size of the Swedish market. In 2013 the demand 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 continued to decrease in 2013. The turnkey prices presented in table 7 and figure 3 are an average of what different installers considered to be their typical price at the end of 2013, and do not represent the overall pricing during 2013.

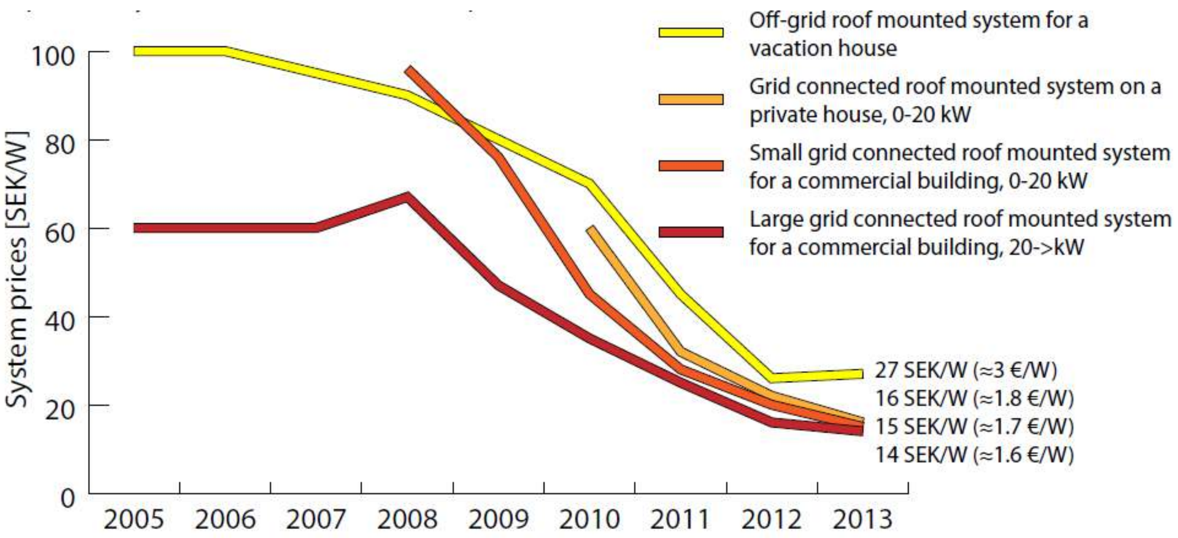

Figure 3: Typical prices for turnkey photovoltaic systems (excluding VAT) reported by Swedish installation companies.

Table 7: Turnkey Prices of Typical Applications (excluding VAT).

Category/Size	Typical applications and brief details	Current prices per W_p
OFF-GRID Up to 1 kW_p	A stand-alone PV system is a system that is installed to generate electricity to a device or a household that is not connected to the power grid. Typically modules or systems for small cottages, caravans or boats.	27 SEK/W_p
OFF-GRID >1 kW_p	A stand-alone PV system is a system that is installed to generate electricity to a device or a household that is not connected to the public grid. Typically systems in combination with batteries for small cottages and vacation houses.	22 SEK/W_p
Grid-connected Rooftop up to 10 kW_p (residential)	Systems installed to produce electricity to grid-connected households. Typically roof mounted systems on villas and single-family homes.	16 SEK/W_p
Grid-connected Rooftop from 10 to 250 kW_p (commercial)	Systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, agriculture barns, grocery stores etc.	15 SEK/W_p
Grid-connected Rooftop above 250 kW_p (industrial)	Systems installed to produce electricity to grid-connected industrial buildings.	14 SEK/W_p
Grid-connected Ground-mounted above 1 MW_p	Power-generating PV systems that work as central power station. The electricity generated in this type of facility is not tied to a particular customer and the purpose is to produce electricity for sale. No such system with a capacity over 1 MW_p was installed in Sweden in 2013.	N/A
Other category existing in your country (hybrid diesel-PV, hybrid with battery…)		N/A

Table 8: National trends in system prices for different applications (SEK/W, excluding VAT).

	2006	2007	2008	2009	2010	2011	2012	2013
Off-grid, 0-1 kW_p	100	95	90	80	70	45	26	27
Residential PV systems < 10 kW_p	-	-	-	-	60	32	22	16
Commercial and industrial	60	60	67	47	35	25	16	14
Ground-mounted	-	-	-	-	-	-	-	13

2.3 Financial Parameters and programs

The Swedish PV market is still quite small and therefore there is currently no standard way on calculating the return on a PV investment.

Table 9: PV financing scheme.

Average Cost of capital for a PV system	N/A

2.3.1.1 PV financed by cooperatives

One interesting PV financing scheme that exists in Sweden is PV cooperatives. The high upfront cost of a PV system can be difficult to finance for a private person, and one way to get around this is to get together and form a cooperative.

In 2009 the first FiT agreement in Sweden was established between the local power utility company Sala-Heby Energi AB and a small PV cooperative, Solel i Sala & Heby ekonomiska förening. The power utility company has agreed to buy all the electricity that the PV cooperative produces to a price of 3.21 SEK/kWh, compared to the average system spot price of 0.341 SEK/kWh in 2013. In 2013 the PV cooperative had in total six systems with a total production capacity of 599 kW_p. Each of the 225 members in the PV cooperative has bought at least one share for a price of 5 000 SEK. The initial profits for the PV cooperative will be spent on increasing the production capacity but after five years from the start a part of the profit will be distributed to members according to number of shares. The PV cooperative is slowly expanding with more members from all over the country.

Two more PV cooperative was started in 2013, Åsbro Solel and Solel i Lindesberg ekonomisk förening. Åsbro Solel now has 20 members and is planning to build their first system in the 2014 with support from Askersund Municipality. Solel i Lindesberg ekonomisk förening has 80 members and plan to build their first system in March 2015. In both of the PV cooperatives the shares cost 5000 SEK each.

2.4 Additional Country information

Sweden is a country in northern Europe. With an area of 449,964 km², Sweden is the fifth largest country in Europe and has a population of about 9.6 million people. The population density of Sweden is therefore low with about 21 inhabitants per km², but with a much higher density in the southern half of the country. About 85 percent of the population lives in urban areas, and that proportion is expected to increase.

2.4.1.1 Electricity prices

In Sweden the physical electricity trading takes place on the Nordic electricity retailing market, Nord Pool Spot market. Historically, electricity prices in Sweden have primarily been dependent on the rainfall and snow melting. The availability of cheap hydro power in the north determines how much more expensive production that is needed to meet demand. Continued global economic recession, stable production of nuclear power and the lack of longer periods of intense cold resulted in small differences in the monthly average electricity prices in 2013. The average price on the entire Nord Pool Spot market was 0.329 SEK/kWh in 2013, which is an increase of 20 % from 2012 but more than 20 percent lower than in 2011. The highest price in 2013 was 0.910 SEK/kWh and the lowest 0.012 SEK/kWh[2].

The Swedish electricity market is from the first of November 2011 divided into four bidding areas by decision of the Swedish National Grid (Svenska Kraftnät). The reason is that northern Sweden has a surplus of electricity production compared with the 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

[2] Elåret 2013, Svensk Energi.

grid. The idea of the four bidding areas are to make it clear where in Sweden the national grid 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 Nord Pool spot prices in 2013 for the different areas was 0.338 SEK/kWh in area 1 (Luleå), 0.338 SEK/kWh in area 2 (Sundsvall), 0.341 SEK/kWh in area 3 (Stockholm) and 0.345 SEK/kWh in area 4 (Malmö)[3]. The very small difference between the areas does not influence the distribution of PV systems over the country in the same extent as the global solar radiation does.

The consumer price of electricity varies between different categories of clients, between urban and rural areas and depends on the variable distribution costs, differences in taxation, subsidies, government regulation and electricity market structure. Household electricity costs consist of several components. The base is the Nord Pool Spot price of electricity. On top of that, energy tax, the cost of green electricity certificate, the variable grid charge, the fixed grid charges, VAT and sometimes an electricity surcharge and fixed trading fee is added. Figure 4 illustrates this and shows the evolution of the lowest variable electricity price deals offered by different utilities for a base case, which is a typical house with district heating in the Stockholm bidding area that has a consumption of 10 000 kWh/year and has Vattenfall as the grid owner. The figure also shows the variable part of the electricity prices, which is what can be saved if the client replaces purchased electricity with self-generated PV electricity.

About 50 % of the households in Sweden have fixed long-term prices and therefore pay a little bit more than the lowest variable deals.

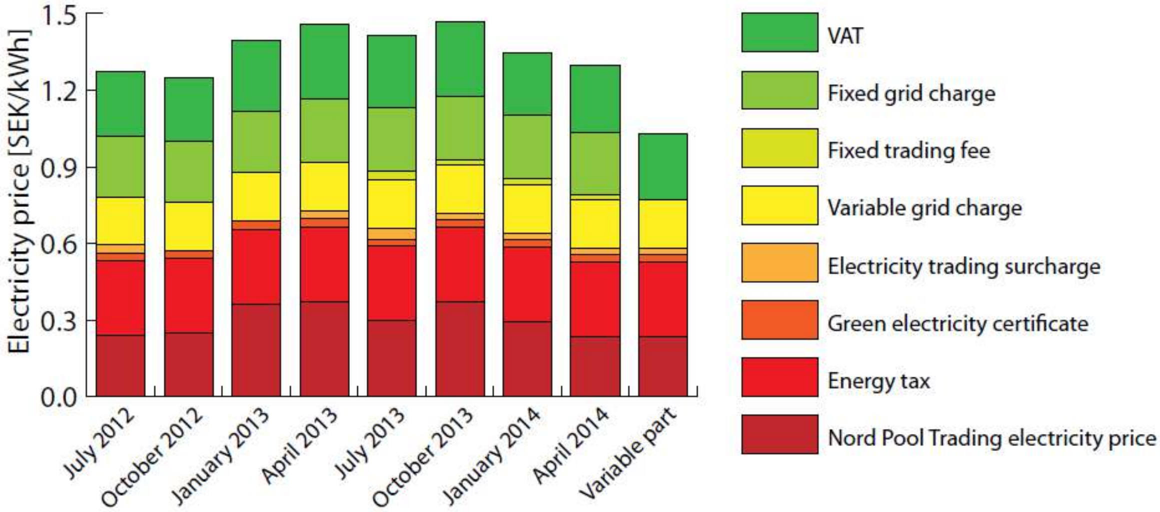

Figure 4: Evolution of the lowest variable electricity price offers for a typical house with district heating in Stockholm that has an annual electricity consumption of 10 000 kWh/year, a 16 ampere fuse and Vattenfall as the grid owner[4].

[3] Elåret 2013, Svensk Energi.

[4] http://www.elprisguiden.se/

2.4.1.2 Global solar radiation

The total amount of solar radiation that hits a horizontal surface is called the global radiation. The global solar radiation thus consists of the direct radiation from the sun and the diffuse radiation from the rest of the sky and the ground. The solar radiation in Sweden is lower than in countries farther to the south since the maximum insolation angle is only 58 degrees in the far south. In the long-term variation of global radiation in Sweden a slight upward trend of +0.3 % per year has been noted and the average solar radiation has increased with about 8 % from the mid-1980s until now, from about 900 kWh/m^2 in 1985 to about 1000 kWh/m^2 in 2013. 2013 was a very sunny year in Sweden. The Swedish Meteorological and Hydrological Institute (SMHI) measures the global solar radiation at 17 locations in Sweden, and on six of these stations new solar global radiation records were set in 2013[5].

Table 10: Country information.

Retail Electricity Prices for a household	1.2-1.8 SEK/ kW_p (including grid charges and taxes)			
Retail Electricity Prices for a commercial company	1.0-1.5 SEK/ kW_p (including grid charges and taxes)			
Retail Electricity Prices for an industrial company	0.55-1.0 SEK/ kW_p (including grid charges and taxes)			
Population at the end of 2013	9 644 864			
Country size (km^2)	449.964 km^2			
Average PV yield	800 – 1 100 kWh/ kW_p			
Name and market share of major electric utilities		Electricity production[6]	Share of grid subscribers[7]	Number of retail customers[8]
	Vattenfall	45 %	35 %	18 %
	E.ON	17 %	19 %	13 %
	Fortum	16 %	17 %	12 %

[5] Statistics from The Swedish Meteorological and Hydrological Institute homepage.

[6] Elåret 2013, Svensk Energi.

[7] Statistics from The Swedish Energy Markets Inspectorates homepage.

[8] Data from Energimarknaden, a part of Svenska Nyhetsbrev.

2.5 Levelized cost of electricity

Including the Swedish VAT of 25 % in the system price led to an investment cost of about 20 SEK/W for a typical residential installation at the end of 2013. In a reference case, where an investment cost of 20 SEK/W, a real interest rate after tax of 2 % and commonly used assumptions about the solar system's performance was assumed, Stridh et al[9] estimated the production cost, or the levelized cost of electricity (LCOE), to be 1.22 SEK/kWh without any subsidies for a residential PV system. Including the Swedish direct capital investment subsidy of 35 % of the investment cost, the LCOE was lowered to 0.85 SEK/kWh. These values, of course, depend on the assumptions made and should not be seen as exact values but rather indications on the LCOE of PV.

For larger commercial systems the investment costs are typically lower but a higher interest rate might need to be assumed as demands on return of investment probably are higher.

The variable part of the electricity price, excluding the fixed subscription costs, of the lowest variable offers from the utilities ranged between 1.00 and 1.10 SEK/kWh for a house in the Stockholm bidding area with a consumption of 10 000 kWh/year in 2013. With the assumed parameters used by Stridh et al[9] one can conclude that the production cost of PV electricity, by the end of 2013, was in the same order as the variable part of the cost of purchased electricity for a household.

[9] B. Stridh, S. Yard, D. Larsson, B. Karlsson, Production Cost of PV Electricity in Sweden, 28th European Photovoltaic Solar Energy Conference and Exhibition, ISBN: 3-936338-33-7.

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

3.1 Direct support policies

Table 11: PV support measures summary table.

	On-going measures	**Measures that commenced during 2013**
Feed-in tariffs		
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		
Prosumers' incentives (self-consumption, net-metering, net-billing…)	Offered by some utilities	
Commercial bank activities e.g. green mortgages promoting PV		
Activities of electricity utility businesses	Yes	
Sustainable building requirements		

3.1.1 Direct Support measures existing in 2013

3.1.1.1 The national direct capital subsidy for PV program

A direct capital subsidy for installation of grid connected PV systems open for all has been active in Sweden since 2009[10]. This subsidy was planned to end by the 31st of December 2011 but was first prolonged for 2012 and in December 2012 the government announced that it will be extended until 2016 with a budget of 210 million SEK for the years 2013-2016. Since the start in 2009 the program had at the end of 2013 assigned 385.6 million SEK and disbursed 265.9 million SEK in total[11].

In 2011 the subsidy covered 60 % (55 % for big companies) of the installation cost of PV systems, including both material and labor costs. For 2012 this was lowered to 45 % to follow the decreasing system prices in Sweden and was further lowered in the new 2013-2016 ordinance to 35 %. In the 2013-2016 ordinance, funds can only be applied for if the system costs are less than 37 000 SEK excluding VAT/kW$_p$. Solar power/heat hybrid systems are allowed to cost up to SEK 90 000 plus VAT/kW$_p$. If the total system costs exceed 1.2 million SEK, capital support is only granted for the part of the system costs that is less than this value.

[10] Förordning (2009:689) om statligt stöd till solceller. Ministry of Enterprise, Energy and Communications.

[11] Support for installation of solar cells - Monthly Report December 2013, The Swedish Energy Agency.

In 2012 there was some uncertainty about the future of the Swedish PV market since no one knew if there would be a subsidy in place for 2013. The announcement from the government for a prolongation to 2016 at the end of 2012 was therefore welcome. One upside of the new ordinance is that it now will extend over several years, which will enable installation companies to plan further ahead than they could when the subsidy was prolonged for one year at the time. A downside of the subsidy is that there are much more applications than funding. The waiting time for the investment subsidy decision is thereby in general 1-2 years in average, but varies between the 21 county administrations (Länsstyrelser). The effect of the long waiting times and the fact that there are more applications than the current budget leads to that the program not solely stimulates, but also constitutes an upper cap of the Swedish PV market.

3.1.1.2 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 electricity certificate system is estimated to have generated 13 TWh of renewable electricity between 2002 and 2011 in Sweden. The basic principle of the system is that producers of renewable electricity receive one certificate 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. Ultimately it is the electricity customers that pay for the expansion of renewable electricity production as the cost of the certificates is a part of the final electricity price. 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 2013, the quota obligation for electricity supplier companies was 13.5 %[12].

As from January 2012, Sweden and Norway have a joint certificate market. The objective of the certificate system is to increase the production of electricity from renewable sources by 26.4 TWh between 2012 and 2020 in Sweden and Norway combined. The common market makes it possible to deal with both Swedish and Norwegian electricity certificates for meeting quotas. Although the market is shared, respective national legislation is governing the electricity certificate system in each country.

In 2013, production facilities equivalent to 3.0 TWh was introduced in the green electricity certificate system, 2.5 TWh in Sweden and 0.5 TWh in Norway. The average price for a certificate was 197 SEK/MWh in 2013, which resulted in an average additional price of 0.027 SEK/kWh for electricity bought from the grid[12].

The electricity certificates can in the present shape give some economical contribution to existing solar installations. However, only 3705 certificates out of the total 15.3 million certificates issued in 2013 was issued to PV[13]. These certificates corresponds to 3705 MWh of PV electricity production, which can be compared to an estimated production of 34.7 MW_p * 900 $kWh/kW_p \approx$ 31 200 MWh from all grid-connected PV systems in Sweden. Thus, only about one-eighth of the entire PV production received a green electricity certificate in 2013. This indicates that the certificate system of today does not provide a significant support for PV installations in Sweden.

The main reasons why it has been difficult for PV to take advantage of the green electricity certificate system is that 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 will not receive a certificate, if not the extra cost for an internal meter and an extra yearly measurement fee is paid. For residential PV systems the extra cost for the meter and

[12] En svensk-norsk elcertifikatmarknad – Årsrapport för 2012. ET2013:15. The Swedish Energy Agency.

[13] Statistics of certificates from Cesar, the Swedish National Grid system for account management of certificates and guarantees of origin.

the yearly measurement fee is higher than the income from the extra certificates from the electricity used in the building. Therefore, residential PV systems owner does not get certificates for all of their electricity production.

3.1.1.3 Guarantees of origin

Guarantees of origin (GO's) are electronic documents that guarantee the origin of the electricity and are intended to provide energy customers the ability to choose electricity suppliers from an environmental aspect. The law on guarantees of origin was introduced in December 2010 and affects electricity producers and suppliers. Electricity producers receive a guarantee from the state for each MWh of electricity produced, which can then be sold on the open market. The guarantee of origin shows the type of energy that the electricity comes from. Guarantees of origin are issued for all types of power generation. Applying for guarantees of origin is still voluntary.

2337 GO's from PV were issued in 2013[14]. The value of GO's from PV is yet indeterminate since there currently is no real market in Sweden for trading PV GO's, as it is for e.g. GO's from wind power. Some utility companies have attempted to get the trade going by, e.g. buying PV electricity to higher prices than the spot price and offer their customer a certain percentage of PV electricity in their delivered electricity mix. But the volumes are still too small for a working GO's from PV trading market in Sweden. One can argue that value of PV GO's is what some utility companies are paying above the Nord Pool spot price for the surplus electricity produced by small-scale PV systems (see section 7.2). From this point of view, the value of PV GO's varied between 0 and 1 SEK/kWh in Sweden in 2013.

3.1.2 Prosumers' development measures

Self-consumption of PV electricity is allowed in Sweden, but no national net-metering or feed-in tariff system exists. However, several utilities offer various agreements, including net-metering, for the surplus electricity of a micro-producer (see 7.2). In the wake of the government's proposal for a tax credit for self-generated renewable electricity (see 3.1.9) a debate started in the spring of 2014 about what tax rules that apply to micro-producers. It was for a while unclear what regulations to follow, but in June 2014 the Swedish Tax Agency (Skatteverket) came out with a percept and clarified the following[15].

3.1.2.1 Income tax

Owning a PV system is not regarded as a business from a legal point of view. The revenues will be taxed as capital income (Chapter 42. 30§ Income Tax Act) from a private residence. In many cases there will be no income tax because of the standard deduction of 40 000 SEK, which can be subtracted from the total income of each residence.

3.1.2.2 Energy tax

The assessment that owning a PV system not is regarded as a business activity is also relevant concerning the energy tax. Electricity from a PV system is excluded from energy tax and the producer of PV electricity does not have to pay the energy tax neither for the self-consumed nor for the delivered electricity. This applies provided that:

- The producer does not have other electricity production facilities that together have an installed capacity of 100 kW_p or more.
- The producer does not professionally deliver any other electricity to other consumers.

---

[14] Statistics of guarantees of origin from Cesar, the Swedish National Grid system for account management of certificates and guarantees of origin.

[15] The Swedish Tax Agenct's percept "Beskattningskonsekvenser för den som har en solcellsanläggning på sin villa eller fritidshus som är privatbostad". Serial number 131 325316-14/111. 2014-06-05.

- The compensation for the surplus electricity does not exceed 30 000 SEK in a calendar year.

3.1.2.3 Registration for VAT

Even if owning a PV system not is regarded legally as a business activity, a special assessment must be made as to the obligation to register for and pay VAT.

The judgment C-219/12, Fuchs, in the European Court concluded that the sale of electricity from a PV system located on, or adjacent to, a private residence is an economic activity when the electricity produced continuously is supplied into the grid for remuneration. The PV system is therefore obliged to register for, and pay VAT, regardless of the amount of electricity that is sold.

3.1.2.4 Deduction of the VAT for the PV system

Sweden has a non-deductible VAT for permanent residence (Chapter 8. 9§ VAT Act). The possibility to deduct the input VAT for a PV system therefore depends on whether all produced electricity is sold, or if a portion of the generated electricity is consumed directly for housing and only the surplus electricity is sold to an electricity supplier.

If only the surplus electricity is sold to an electricity supplier and the PV system also serves the private facility, then deduction of the VAT for the PV system is not allowed.

If all generated electricity delivered to the power grid PV system is used exclusively in economic activity, then deduction of the VAT for the PV system is allowed.

3.1.3 BIPV development measures

There were no measures for BIPV development in 2013 in Sweden.

3.1.4 Rural electrification measures

Sweden has a well-developed power grid and practically all permanent housing is connected to the grid. However, there are some recreational cottages in the remote country side that lack electricity and the market for off-grid PV for these houses is relative large in Sweden. However, this market is economically competitive and does not need any subsidies. So, currently there exist no PV specific measures for electrification of rural areas.

3.1.5 Other measures including decentralized storage and demand response measures

There are currently no national measures for decentralized storage or demand response in Sweden. However, development of smart grids is ongoing.

The biggest smart grid project is on the Swedish island Gotland called Smart Grid Gotland. This is a development project that will show how it is possible to modernize an existing power gird to be able connect larger amounts of renewable energy, while maintaining or improving power quality. The project also aims to give the customers the opportunity to actively participate in the energy market through demand response. One sub project is a market test, where electricity prices are based on the current wind power generation. Electricity consumers in the market test will receive price signals that indicate when electricity prices are low or high, and through a smart energy box installed at their house, the consumers will be able to regulate the consumption of electricity.

3.1.6 Support measures phased out in 2013

No PV support measures were phased out in Sweden in 2013.

3.1.7 New support measures implemented in 2013

No new PV support measures were implemented in Sweden in 2013.

3.1.8 Financing and cost of support measures

The 265.9 million SEK disbursed through the direct capital subsidy for installation of grid connected PV systems is financed by government money, which is distributed by the 21 county administrations.

The tradable green electricity certificate system is financed by electricity consumers and led to an increase of the average price of 0.027 SEK/kWh in 2013. Electricity-intensive industries have certificate costs only for the electricity that is not used in the manufacturing process. The 15.3 million certificates issued in 2013 had a total worth of about 3 billion SEK. The value of the certificates issued for PV was about 730 000 SEK.

3.1.9 Measures currently discussed but not implemented yet

The issue concerning the value and rules of surplus electricity from micro-producers currently does not have a national solution in Sweden. There is strong support among stakeholders for net-metering in Sweden, but the introduction of a national scheme in Sweden has been and is a long and complicated affair. The first investigation was initiated by the government in 2007, "*Bättre kontakt via nätet – om anslutning av förnybar elproduktion"*, and was finished in February 2008. This investigation proposed, among other things, exemptions from hourly metering for small electricity producers and the opportunity to use net metering or net billing[16].

In 2010 the Swedish Energy Markets Inspectorate, EI, (Energimarknadsinspektionen) presented the report "*Nettodebitering – Förslag till nya regler för användare med egen elproduktion"*. EI's view was that it is not appropriate to put an obligation on electricity suppliers to set off withdrawn and delivered electricity, but rather leave it open to them to voluntarily offer net-metering agreements. However, they concluded that net-metering was not consistent with the current tax legislation since the energy tax and VAT on electricity is based on the customer's total demand for electricity, and not on a net of withdrawn and delivered electricity. In order to allow full net-metering, EI suggested that the government gave the Swedish Tax Board (Skatteverket) the assignment to investigate the possibility of changing the tax rules so that net-metering would be allowed to include energy taxes and VAT[17].

The government then gave the Ministry of Finance the task of developing a legislative proposal for the introduction of a net-metering system and give recommendation on who should be subjected to energy tax on electricity. The investigation, "*Beskattning av mikroproducerad el m.m*" was presented in June 2013 and considered that net-metering was not consistent with EU directives on VAT. Many found this conclusion strange since a few EU member states do practice or have practiced net-metering. However, the investigation instead suggested that a micro producer should get a tax credit for the excess electricity that approximates the amount that the producer would have earned in a net-metering system[18].

The suggestion resulted in a new law proposal that the government submitted to the Judicial Preview Council (Lagrådet) in March 2014. In this law proposal both private persons and companies are entitled a tax credit of 0.6 SEK/kWh as long as:

- The renewable electricity is fed into the same point as the micro-producer takes out electricity.
- The fuse at the connection point does not exceed 100 A.

---

[16] Bättre kontakt via nätet – om anslutning av förnybar elproduktion. Swedish Government Official Reports. SOU 2008:13. ISBN 978-91-38-22914-9. ISSN 0375-250X.

[17] Nettodebitering – Förslag till nya regler för användare med egen elproduktion. Swedish Energy Markets Inspectorate. EIR 2010:23.

[18] Beskattning av mikroproducerad el m.m. Swedish Government Official Reports. SOU 2013:46. ISBN 978-91-38-23964-3. ISSN 0375-250X.

- The number of kWh's fed into the grid during a calendar year do not exceed the amount of purchased kWh's.
- The electricity feed into the grid does not exceed 30,000 kWh per person or per connection.

The legislative proposals were proposed to come into force by the first of July 2014[19].

However, in June 2014 the Swedish Energy Minister stated that the tax credit proposal will be delayed, probably to the first of January 2015, since it is not consistent with the new EU Commission rules on state aid. The problem seems to lie in the inclusion of already existing micro-producers in the tax credit scheme, as it does not meet the "incentive effect" under Article 8 in the General Block Exemption Regulation of the European Commission. In short, tax credits paid to PV systems already installed will not be effective to promote new PV installations.

It is still unsure if this tax credit will be implemented in January 2015 since there is a governmental election in September 2014 and all the opposition parties have declared that they want to introduce net-billing instead. If this complies with the law is still unsure. What is clear is that the issue concerning the surplus electricity from micro-producers has not received a national solution despite nearly eight years of investigation.

3.2 Indirect policy issues

3.2.1 National policies affecting the use of PV Power Systems

3.2.1.1 ROT tax deduction

The ROT-program is an incentive program for the construction industry in Sweden in the form of tax credits. ROT is a collective term for measures to renovate and upgrade existing buildings, mainly residential properties. Repair and maintenance as well as conversions and extensions are counted as ROT work and are therefore tax deductible, provided that such work is carried out in close connection with a residence that the client owns and in which he or she lives, or if it is a second home, like a recreational summer house.

The ROT-tax deduction can be exploited for labor cost of maximum 50 000 for the installation of a PV system if the house is older than five years and if the client has not received the direct capital subsidy for PV. Installation or replacement of solar panels is entitled ROT, while services of solar panels are not. The ROT can typically contribute to between 1000-4000 SEK/kW$_p$ for a grid connected roof mounted system on a private house.

3.2.1.2 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. The total property tax on electricity generation plants in 2012 is estimated at around 4 billion SEK (equivalent to about 0.055 SEK/kWh on average for hydropower, 0.004 SEK/kWh for wind and 0.003 SEK/kWh for nuclear power). In addition, utilities pay the state income tax (28 % corporate tax on profit before tax) as all other companies do.

The taxes associated with electricity consumption are mainly the energy tax on electricity and the related VAT, but there are also charges to fund agencies. The industry paid 0.005 SEK/kWh in energy tax during 2013 and the rate for residential customers was 0.293 SEK/kWh (excluding VAT), with the exception of some municipalities in northern Sweden where the energy tax was 0.194 SEK/kWh (excluding VAT). Additionally, VAT (25 %) is applied on top of the energy tax.

---

[19] The Swedish governments law proposal "Skattereduktion för mikroproduktion av förnybar el". January 31, 2014.

Altogether, roughly 45 % of the total consumer electricity price was taxes, VAT's and certificates in 2012. Revenues from energy and carbon taxes were about 70 billion SEK in 2012, corresponding to just above 4 % of the government's revenues.

3.2.1.3 Deduction for interest expenses

If one borrows money to buy a PV system one can utilize the general interest rate deduction of 30% of loan rates. If the deficit of capital exceeds 100 000 SEK, the tax credit is 21% for the excess amount.

3.2.2 International policies affecting the use of PV Power Systems

3.2.2.1 Emission trading

The EU system for emission trading began 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 next trading period ran from 2008-2012, the same as the Kyoto Protocol commitment period. The current trading period started in 2013 and will 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 and smaller combustion plants connected to district heating with a total capacity greater than 20 MW_p are included in the system. There are about 760 of these plants in Sweden[20].

In January 2013, the price was just over 6 euros/tonne and then it decreased to less than 3 euros/tonne in mid-April. There after it started to rise and ended up at 5 euros/tonne at the end of December. The recession is a major contributing factor to the low prices. An applicable rule of thumb is that a price of 10 euros/tonne results in a spot price of almost 0.08 SEK/kWh at the Nord Pool spot market.

3.2.3 The introduction of any favourable environmental regulations

No new environmental regulations that strongly affect PV were implemented in Sweden in 2013.

3.2.4 Policies relating to externalities of conventional energy

3.2.4.1 Increased property tax

Power generation facilities in Sweden are charged with a general industrial property tax. In 2013 the assess value for hydropower was increased, raising the tax to a level of about 0.089 SEK/kWh. By this increase the tax revenues from property tax on hydropower increased from about 4 billion SEK per year to 6 billion SEK per year. Furthermore, the assess value for nuclear power and CHP was increased by about 100 % and 75 %, respectively[21].

---

[20] From the Swedish Environmental Protection Agency homepage about emission trading.

[21] Elåret 2013, Svensk Energi.

3.2.4.2 Changes in nuclear funding

A series of changes in financial legislation has been proposed by the Swedish Radiation Safety Authority (Strålsäkerhetsmyndigheten) which aims at making the financing system for nuclear waste products more robust and predictable. If the changes are implemented, a fee of about 0.022 SEK/kWh will probably be enough to cover the cost of demolishing the nuclear power plants and dispose the spent nuclear waste[21].

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

The Swedish solar cell related research consists largely of fundamental research in new types of solar cells and photovoltaic materials. Several of the research groups in this category are at the forefront and are highly regarded internationally. Before 2013, no research on the world-dominant silicon technology has been conducted, but now Karlstad University has initiated activities within this topic. Furthermore, there are some smaller groups that focus on PV systems and PV in the energy system oriented research.

4.1.1 Commercial R&D

4.1.1.1 SolEl programmet

The SolEl-program 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 been an important platform for dialogue between the building and property sector, the government, industry, utilities and solar energy companies.

During 2013 a new phase of the program started. A first call for projects was announced and the new projects will start during 2014. The program is focused on PV in the future smart grids, sustainable cities and building related PV-questions.

4.1.1.2 SP Technical Research Institute of Sweden

SP Technical Research Institute of Sweden is an international research institute, which conducts various PV research activities. In 2013, SP was involved in, among other things, a study on PV systems in the agriculture, comparative testing of small grid-connected solar electric systems and certification of PV system installers. SP is also active in IEA-PVPS task 13 “performance and reliability of photovoltaic systems”. Late 2013 SP together with Glava energy center, Chalmers, SERC and ten other partners started the project ”Testbed for new solar energy solutions” which aims at developing the innovation infrastructure for products, services and processes in the solar field.

4.1.2 Academic research

4.1.2.1 Center for Molecular Devices

The research constellation, Center for Molecular Devices (CMD), is one of the world leading scientific centers for research and development of dye-sensitized and nanostructured solar cells. CMD is a collaboration between Uppsala University, the Royal Institute of Technology (KTH) in Stockholm and the industrial research institute Swerea IVF in Mölndal. About 35 people worked within the CMD collaboration in 2013. The center activities include fundamental research in physical chemistry for understanding of components, interfaces and devices, synthetic chemistry for design and preparation of the different components, as well as engineering research for up-scaling and process development. Immaterial property rights generated by the center are handled in the company Dyenamo AB. The breakthrough of CMD in 2010 by replacing the iodide redox couple with a 1-electron transfer redox system such as Co-complexes has created a very intense research direction worldwide during the last year. New possibilities for solid-state solar cells using organic hole conductors instead of liquid redox electrolytes and replacing dyes with inorganic perovskite layers have also been intensively investigated in the CMD during the last year. In 2013, 14 % conversion efficiency was achieved for a solar cell with the promising perovskite material.

4.1.2.2 Chalmers

At Chalmers University of Technology Foundation research in many different PV associated areas is carried out, such as design of polymers, organic and hybrid solar cells, plasmons for enhanced light absorption in solar cells, electrolytes and quantum dots for dye-sensitized solar cells, 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, during 2012 a new collaborative project was initiated, called Photon fusion and photon fission, which is aiming at add-on technology for existing PV technology involving both physical science research and life cycle analysis.

4.1.2.3 Högskolan Dalarna

The Solar Energy Research Center (SERC) at Dalarna University carries out research on PV and PV hybrid systems. The group is doing both simulations and practical testing of systems and has several demonstration systems along with a lab where off-grid, grid connected and micro grid systems can be tested In 2013 the existing equipment has been further developed and the group has worked with companies to test components. The group is also involved in international PV projects financed by the EU Commission and Swedish International Development Cooperation Agency (SIDA). Part of the work is done in multidisciplinary projects where also social, cultural and economic aspects of PV are studied.

4.1.2.4 Karlstad University

The Materials Physics group at Karlstad University has been running research projects on polymer-based photovoltaics since 2002. The active layer in this type of solution-processed solar cell is a thin film consisting of an electron-donating conjugated polymer and an electron-accepting fullerene-type molecule. The research work is focused on morphological studies of this active layer and its influence on the device performance of bulk-heterojunction solar cells. For the morphology studies microscopy, depth profiling and various synchrotron-based photoelectron spectroscopy techniques are used. New research directions are related to materials' photo degradation in air.

Karlstad University also has a silicon solar cell research group. The group was recently started, and the initial time was spent on setting up laboratory equipment for the characterization of solar cells and solar cell materials. The present research focuses on crystalline silicon, especially ingot cast silicon, which is the worlds most used material for solar cells. Apart from material research, further activities are planned in the field of improved and specialized solar modules together with the local industry and European partners. In 2013 the group used their resolution light beam induced current (LBIC) topography together with a dislocation density mapping technique to measure the recombination strength of dislocation clusters, which are among the most important defects within this material. This was successfully correlated to the amount of precipitated impurities in the material measured by synchrotron nanoprobe X-ray fluorescence topograms.

4.1.2.5 Linköping University

Semi-transparent solar cells can be used for building stacked tandem solar cells with different band gaps. Balancing photocurrent between these is of importance, in order to add photo voltages in an optimal way. The Biomolecular and Organic Electronics group at Linköping University have introduced dielectric light scattering into semitransparent solar cells, in order to return transmitted photons back to the active layer, as well as to balance the photon flux between a front and a back cell, in order to generate the same photocurrent in both.

Processing of solar cell material has under the last years improved, and group are now starting to use a prototype printing machine for printing polymer solar cell modules at rapid rates.

4.1.2.6 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. The group participated in the international work within IEA SHC Task 41; "Solar energy and architecture" that was finalized in 2012. The task included 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. A new IEA SHC project, Task 51 Solar energy in urban planning, was officially started in May 2013, with Swedish leadership by Maria Wall from the group.

At the departments of Chemistry and Physics research on light induced processes in novel types of solar cell materials and solar cells, dye-sensitized solar cells, plastic solar cells and solar cells based on semiconductor nanowires are conducted. A new research area, which started in 2013, is organic perovskites, which is a promising solar cell material. The aim of the group's research is to understand light induced processes like energy transport, charge generation, charge separation and transport, as well as how these processes are related to material properties and morphology. The group now also has plans for making complete working solar cells of the perovskite material.

4.1.2.7 Mälardalens University

Mälardalens University is conducting research in projects regarding development of the energy system with a high fraction of solar electricity for energy efficient buildings. The projects are about PV plus district heating and PV plus heat pumps, which enable buildings to be an active component in the future energy system, and increase the consumer influence on the Nordic Energy market.

4.1.2.8 Umeå University

The Organic Photonics & Electronics Group at Umeå University develops photonic and electronic devices based on novel organic compounds. In 2013, the group has performed a number of studies on organic solar cells, using novel device configurations and in-house synthesized materials, and will publish their first results in 2014.

4.1.2.9 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 research on thin film solar cells are being conducted. There are two established technologies for fabrication of absorber layers for thin film solar cells in the group. The first is co-evaporation or sputtering of $Cu(In,Ga)Se_2$, CIGS, thin films and the second is a two-step process, consisting of sputtering and selenization/sulphurization where the final outcome is a thin film of $Cu_2ZnSn(S,Se)_4$, CZTS. As the name suggests these thin films are used as light absorbing layers in thin film solar cells. In order to obtain high quality thin film solar cells, optical and electrical properties of all layers in the solar cell need to be co-optimized. Best efficiencies for CIGS are 19.5 % for a solar cell and 16.8 % for a mini module. The best results for the newcomer CZTSSe is around 8 % efficiency after three years of research. In addition to research on the solar cells and modules also system aspects are studied, such as field testing. Climatic data and module power output data are collected for the most common solar cell technologies at a test site on the roof of the Ångström Laboratory are are used as basis for evaluation of e.g. energy yield.

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 system perspective. Major research topics related to PV are solar energy potential in the built environment, variability assessment of solar irradiance, integration of distributed PV into the power system and self-consumption of on-site PV generation in 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).

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

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, and the Swedish Research Council (Vetenskapsrådet). Other organizations that can dispense governmental money to PV related research are The Swedish Governmental Agency for Innovation Systems (VINNOVA) and The Swedish Foundation for Strategic Research (SSF).

The Energy Development Committee (Energiutvecklingsnämnden) decided in June 2012 to start the research program "El och bränsle från solen". The program has a budget of 123 million spread over four years. The program started in January 2013 and will run until December 2016, and has been established to gather research financed by the Swedish Energy Agency (Energimyndigheten) in the areas of PV, solar thermal and solar fuels. The program's vision is to provide technologies that enable an increased use of solar energy in both the Swedish and the global energy system and thereby contributing to a sustainable energy system. The program includes projects of various kinds, from research and development projects carried out by various research institutions to experimental development and demonstration in companies.

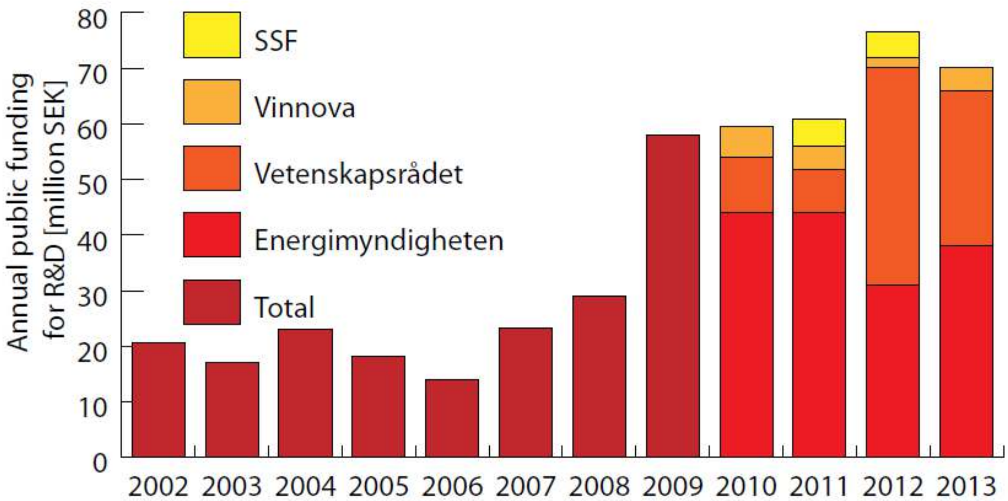

Figure 5: Annual public funding for PV related R&D in Sweden.

Table 12: Public budgets for R&D, demonstration/field test programmes in 2013.

	R & D	Demo/Field test
National/federal	70.1 million SEK	Included in the R & D number
State/regional	N/A	N/A
Total	**70.1 million SEK**	

4.2.1 Demonstration and field test sites

4.2.1.1 Kullen

On a hill close to Katrineholm lies the company Egen Els production and demonstration facility Kullen. The hill is littered with several small PV systems and wind turbines and works both as a power plant that sells electricity and as a place where people can come and have a look at different kinds of small-scale renewable electricity systems, suitable for private persons. Several guided tours and information days are arranged each year for the interested public. The park also offers individuals and companies that do not own land or a suitable property a place where they can set up their own PV systems or rent space on existing ones, and thereby contribute to renewable electricity production. The park is growing each year and had a capacity of 330 kW_p, of which 301 kW_p is PV, at the end of 2013.

4.2.1.2 Glava Energy Center

South east of Arvika in Värmland lies Glava Energy Center, which is a test center for renewable energy solutions. Glava Energy Center has three PV parks, one off-grid and two grid-connected. The off-grid park consists of five separate systems of various sizes totaling 2.3 kW_p. The first grid-connected park consists of four systems, totaling 134.6 kW_p. The second park consist of two systems, totaling 73.6 kW_p, one of which is fully owned by Fortum and one owned by Glava Energy Center. Fortum and Bixia buy all the electricity that the two grid-connected parks produce. In 2013 a test bed was developed in cooperation with SP Technical Research Institute of Sweden, and with support from Vinnova. The main purpose of this test bed is to test various concepts of modules, mounting stands and inverters in the Nordic climate.

All interested parties that wish to use the park for different tests are welcome to do this if they either become a member of the center or contribute with equipment, which can be used by the center. Currently Glava Energy Center has about 30 members. Glava Energy Center is besides from the members funded through the Interreg/EU, Region Värmland and some municipalities.

5 INDUSTRY

5.1 Production of feedstocks, ingots and wafers

Sweden did not produce any feedstock or wafers in 2013 and there are currently no plans for this kind of production in the future.

Table 13: Production information for the year for silicon feedstock, ingot and wafer producers.

Manufacturers (or total national production)	Process & technology	Total Production	Product destination (if known)	Price (if known)
N/A	Silicon feedstock	tonnes	N/A	N/A
N/A	sc-Si ingots.	tonnes	N/A	N/A
N/A	mc-Si ingots	tonnes	N/A	N/A
N/A	sc-Si wafers	MW	N/A	N/A
N/A	mc-Si wafers	MW	N/A	N/A

5.2 Production of photovoltaic cells and modules

The overall module production in Sweden in 2013 was 34.0 MW_p, exclusively produced by SweModule AB. In the beginning of 2011 there were five module producers in Sweden that fabricated modules from imported silicon solar cells. The acceleration of PV module price reductions on the world market in 2011 and 2012 partly came from a huge imbalance between the demand and the much higher production capacity in the world at that time. The Swedish module manufacturers struggled along with the rest of the module production industry and at the end of 2012 only SweModule AB of the Swedish companies remained in business.

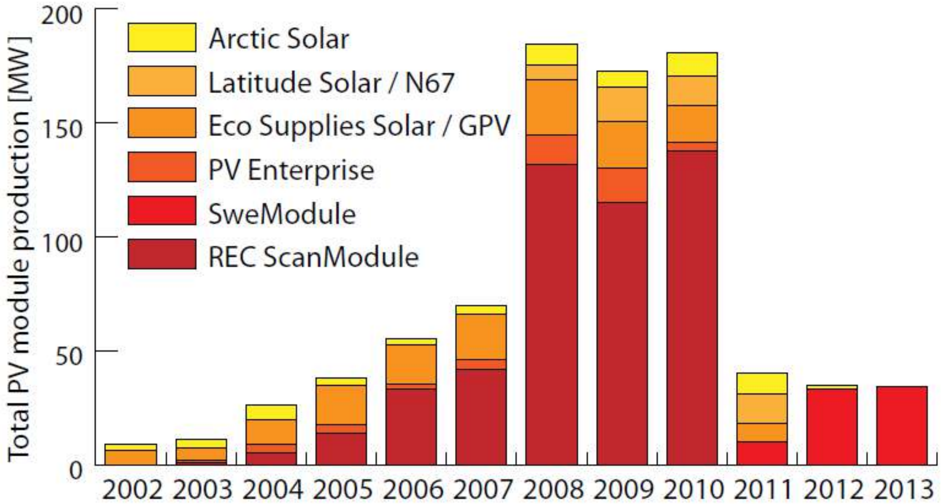

Figure 6: PV module production in Sweden over the years.

Table 14: Production and production capacity information for 2013.

Cell/Module manufacturer	Technology	Total Production (MW)		Maximum production capacity (MW_p /yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
SweModule	Mono/Poly-Si	-	34	-	100
Thin film manufacturers					
N/A		-	-	-	-
Cells for concentration					
N/A		-	-	-	-
TOTALS		**0**	**34**	**0**	**100**

5.2.1.1 SweModule AB

SweModule AB was the only active module producer in Sweden in 2013. The company was formed in 2011, after the closure of the REC ScanModule AB factory, and took over most of ScanModule's facilities and equipment in Glava. SweModule AB produces multi crystalline silicon modules with solar cells from the company's owner Norwegian Innotech Solar. The company produced 34 MW_p of modules in 2013, of which about 0.5 MW_p was sold on the Swedish market. The primary markets for the company in 2013 were Germany, Italy and France.

5.2.1.2 Jowa Energy Vision

Jowa Energy Vision bought in 2012 the production equipment from the former Swedish producer Artic Solar AB and are constructing new factory in Allingsås. The plan is to produce modules for building integrated systems with focus on roof application, but the company will also be able to accommodate orders from architects with special requests. The production is planned to start in 2014 and the targeted market for the modules is the Swedish market and the rest of the Nordic countries.

5.3 Manufacturers and suppliers of other components

5.3.1.1 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 systems with unit sizes of 1 MW_p. In Sweden ABB manufactures breakers, contactors, electricity meters, enclosures, miniature circuit breakers, pilot devices, power supply relays, residual current devices, surge suppressors, switch disconnectors, and terminal blocks, which all can be used in photovoltaic systems.

5.3.1.2 MAPAB

MAPAB (Mullsjö Aluminiumprodukter AB) manufactures aluminium structures for the assembly of PV modules. The company provides solutions for mounting on roofs, facades or the ground. Previously, most of the production was exported to the European market, but in 2012 MAPAB started to deliver more of their products to the growing Swedish market and in 2013 95 % of their products were sold in Sweden.

5.3.1.3 Midsummer AB

Midsummer's business model is to make equipment which produces 6 inch wafer-like CIGS thin film solar cells deposited on stainless steel substrates using a proprietary all sputtering process. With the rapid price decline of PV products, Midsummer has developed a niche with flexible modules that weigh about 25 % of a corresponding crystalline Silicon module. Their production tool, called DUO, has previously been sold to China and in 2013 the company received an order from Poland for a 5 MW production line. Midsummer has also developed a generic research tool called UNO that they aim to sell to universities and institutes interested in depositing a large number of thin films in an unbroken vacuum chain. The UNO R&D tool can be supplied with both CIGS and CZTS processes, but is not limited to PV only. In parallel to these activities there has been continuous research and improvements in the lab and the company set a record efficiency for a square centimetre cell of 15.8 % in 2013.

5.3.1.4 SolarWave AB

The main business of SolarWave AB is to provide solar driven water purification systems and desalination systems. The target market is mainly developing countries in Africa and the company has subsidiaries in Uganda, Tanzania and Nigeria where the company's stand-alone system is sold by authorized distributors. The company has sold around 50 systems from the start, of which 15-20 systems were sold in 2013.

5.3.1.5 Swedish Electroforming Technology AB

Sweltech is a machine manufacturing company that in 2013 continued to develop their machine and a process for electro deposition of the grid for silicon solar cells. Contact with a big European solar cell manufacturing company is established the company hopes to sell their first process tool in 2014.

5.4 Installers and retailers of PV modules and systems

The list below contains all of the companies (that were known to the author at the time of the writing) that either sold and/or installed PV modules and/or systems in Sweden in 2013 and that have contributed with data and information to this report. For this report only one company has refused to contribute with data and is thereby not included in this list. There is a broad range of reported capacity between the different companies, from only a few kW_p as solar cells for charging of electronics to several hundreds of kW_p for grid connected large PV systems. If the reader knows of any other active company, please contact the author at: johan.lindahl@angstrom.uu.se

Absolicon Solar Concentrator AB	AddCleantech Solar Systems AB	Air By Solar Sweden AB
Alfa SolVind i Skåne AB	Attemptare AB	Awimex International AB
B&D Båttillbehör AB	Bauhaus & Co KB	Belo Elektriska AB
Billesol AB	Celltech AB	Clas Olsson
Co2Pro AB	Comne Work AB	Dala Värmesystem AB
Delta Energy Systems AB	Deson AB	Direct Energy Sweden AB
Ecoklimat Norden AB	Ecologisk Kraft Eskilstuna AB	Effecta AB
Egen El AB	Egiva AB	Ekologisk Energi Vollsjö
El & EnergiCenter	El B-man	Electronic Technic LS AB
Electrotec Energy	Elfa AB	Elkatalogen i Norden AB
Elmco AB	Energi-Center Nordic AB	EnergiEngagemang Sverige AB
Energiförbättring i väst AB	Energihuset i Vimmerby AB	ETV Energy Group
European Sun Products	EWF ECO AB	Fasadglas Bäcklin AB
Futura Energi	Gaia Solar A/S	Gari EcoPower AB
GermanSolar Sverige AB	GFSol AB	Glacell AB
Glen Dimplex Nordic AB	Global Sun Engineering Sweden AB	Gridcon AB
Hallands Energiutveckling AB	Helio Solutions AB	Herrljunga Elektriska AB
HESAB	Hjertmans båttillbehör	Innosund AB
JN Solar AB	Järbo Elcenter AB	KAMA Fritid AB
Kjell & Co Elektronik AB	Kraftpojkarna AB	Kretsloppsenergi kummelnäs AB
Lego Elektronik AB	Lightenergy AB	Miljö & Energi Ansvar AB
Modern Energi Sverige AB	Naps Solel AB	Naps Sweden AB
Norden Solar	Nordic Solar Sweden AB	Nordic Sunpower
Nordisk System Teknik AB	Nuenergi AB	Nyedal Solenergi
Orust Engineering	Per Martin Hellström AB	Perpetuum Automobile
Plug in Electric Europe AB	Polygress Solution AB	Prolekta Gotland AB
Rexel Sverige AB	Sapa Building System AB	Sol & Energiteknik SE AB
Sol Eye	Solar Supply Sweden AB	Solarenergy Scandinavia AB
Solarit AB	Solarlab Sweden	SolarOne
Solect Power AB	SolEL Dalby	Solelia Greentech AB
Solenergi & Teknik i Åmål AB	Solenergi i Undrom	Solfångaren i Viby
Solitek	Solkraft TE	Solortus AB
Sundaya Nordic AB	Sunwind Exergon AB	Svesol värmesystem AB
Teknikhamstern	Ten Star Solar AB	Upplands Energi AB
UPS-teknik i väst AB	Vancos Munka Ljungby AB	Warm-Ec Skandinavia AB
Veosol Teknik AB	Westpro Scandinavia	Viessmann Värmeteknik AB
Windforce Airbuzz Holding AB	Windon AB	Volta Solar
Åkerby Solenergi	24 Volt	

5.5 R&D companies and companies with R&D divisions in Sweden

5.5.1.1 Absolicon Solar Collector AB

Former Absolicon Solar Concentrator AB underwent a reconstruction in 2013 and changed its name in this process to Absolicon Solar Collector AB. Absolicon has been producing and installing its combined low-concentrating solar tracking PV and solar thermal power generation system, which consists of a cylinder-parabolic reflector that concentrates the light of the sun ten times onto the receiver, where the solar cells are mounted. The system yields about five times as much heat power as electrical power. In the wake of the bankruptcy and the reconstruction, the company devoted the work in 2013 solely to product development and research projects. The company has plans for construction of two fully automatic factories, one with location in Härnösand in Sweden and one in US.

5.5.1.2 Dyenamo AB

Dyenamo is the commercial platform of the Center for Molecular Devices and offers various services concerning dye-sensitized solar cells, like patent evaluations and device characterization and analysis. The company also provides materials for dye-sensitized solar cells such as organic dyes and cobalt-complexes for electrolytes.

5.5.1.3 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 develop and construct inverters for both grid connected and off-grid systems, which are then manufactured in China.

5.5.1.4 Exeger Sweden AB

Dye-Sensitized solar cells have the potential to achieve a low cost per W, but have so far lacked conversion efficiency on an industrial scale. Exeger Sweden AB, which was known under the former name of NLAB solar in 2012, has addressed this problem and has been working on a transparent dye-sensitized solar cell suitable for mass production. In 2012 the company invented a new kind of nontransparent solar cell, similar to the DSC, but based on new materials. The new materials are cheaper than those used in the DSC and the company claims that there is a potential to reach higher efficiencies with these compared to the DSC. In 2012 NLAB managed to raise 135 million SEK in financing for the new cell and will continue to develop it alongside with the transparent DSC. In the end of 2013 Exeger received the machines and equipment for their planned DSC pilot line, with a capacity of 20 MW, and increased their workforce from 10 to 25 persons. The first part of 2014 will be devoted to install all the equipment and the company plans to have the first prototypes ready in the second half of 2014.

5.5.1.5 Ferroamp Elektronik AB

Ferroamp was founded in 2010 and is currently developing a product that they call an “energy hub”. The product is a two way inverter with three ports, one that can be connected to a PV system, one to the grid and one to a battery. This enables the electricity from the PV system to be temporarily stored in the battery before it enters the grid. The production is planned to be in Sweden and the company intend to start selling their product in 2014.

5.5.1.6 Global Sun Engineering Sweden AB

Global Sun Engineering is developing a technique for low concentrating combined PV and solar thermal power generation. Their product uses several flat mirrors forming a facet disc that focuses 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. The small Luleå based company continued under 2013 to develop their product.

5.5.1.7 Optistring Technologies AB

Optistring Technologies AB is developing a power inverter system for grid connected PV systems which includes electronics on each module. The system can thereby optimize the power output from each module and makes the entire system independent of external site conditions such as for instance different mounting angles or partial shading. The company was founded in 2011 and is a spin-off company from KTH.

5.5.1.8 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 energy 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. About 50 solar panels where produced in 2013, mostly the combined PV and thermal type. The company went through a restructuring in 2013, but things are now looking better for the company since new owners from Holland and Belgium have stepped in. Solarus now plans to move to new facilities in Gävle.

5.5.1.9 Solibro Research AB

The CIGS thin film solar cell company Solibro started as a spin-off company from Uppsala University and there is still a close collaboration between the company and the university. Solibro was in September 2012 acquired by Hanergy, a Chinese group focused on power production (hydro-, wind as well as solar power) and sales of PV systems based on thin film modules produced within the group. Since September 2013 Solibro Research AB is owned by Hanergy Solar Group Ltd, a company listed on the Hongkong stock exchange. Still the Solibro Research task is to further develop the Solibro technology. During 2013 the company achieved a new world record for thin film module efficiency with 18.7 % and holds the present thin film small area solar cell world record of 21 %.

5.5.1.10 Sol Voltaics AB

The nanotechnology company Sol Voltaics AB is producing a nanowire PV material which is designed to be used by existing solar cell producers, both thin film and silicon, 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 called Aerotaxy. Nanowire solar cells may have the potential to reach a high efficiency due to advanced materials and nanophotonics compared to regular planar solar cells and to be cheap since they use less material then other technologies.

6 PV IN THE ECONOMY

This chapter aims to provide information on the benefits of PV for the economy.

6.1 Labour places

The number of labour places in the Swedish PV module production industry has in recent years gone down dramatically due to the bankruptcy of several companies. However, the number of people involved in selling and installation of PV systems increases as the market grows. The growing Swedish PV market also leads to an increased involvement from the utilities.

In many companies and research institutes several people only work partly with PV related duties. The number of PV related jobs in this report is an assembly of all the reporting stakeholders' estimations over how many full-time jobs in total the PV market cause. The figures are therefore not exact and should be seen as rough estimations.

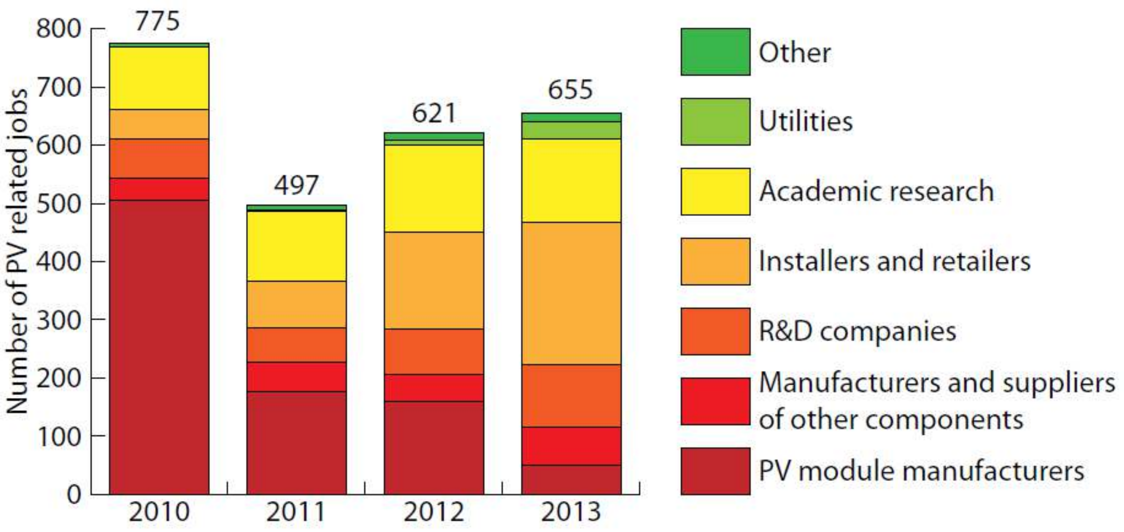

Figure 7: Evolution of the number of PV related labour places in Sweden.

Table 15: Estimated PV-related labour places in 2013.

Research and development (not including companies)	144
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	223
Distributors of PV products	244
System and installation companies	
Electricity utility businesses and government	30
Other	14
Total	**655**

6.2 Business value

In table 16 some very rough numbers of the value of the Swedish PV business can be found. In Sweden about 0.5 MW_p of the domestic module production was installed in the country, which means that roughly 33 MW_p was exported and 18 MW_p was imported.

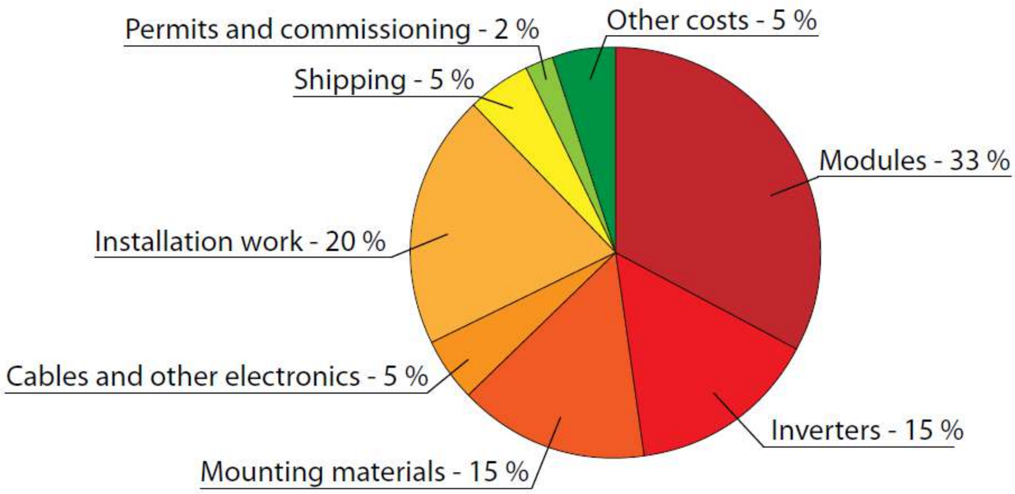

Figure 8: Sectioning of system costs in 2012 for a typical turnkey grid connected roof-mounted system on a commercial building (> 10 kW_p) based on data from four installers. Note that the segmentation of system costs can vary greatly between different companies.

Table 16: Value of PV business.

Sub-market	Capacity installed in 2013	Price per W	Value	Totals
Off-grid domestic	1.06 MW_p	22 SEK/W	23.3 million SEK	
Off-grid non-domestic	0.11 MW_p	22 SEK/W	2.2 million SEK	
Grid-connected distributed	17.26 MW_p	15 SEK/W	258.9 million SEK	
Grid-connected centralized	0.66 MW_p	14 SEK/W	9.2 million SEK	
Value of PV market				~ 294 million SEK
Export of PV products	~ 33 MW_p of modules exported * 7 SEK/W			~ 231 million SEK
Import of PV products	Included in the Value of PV market			N/A
Change in stocks held	Unknown			N/A
Value of PV business				**~ 525 million SEK**

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

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 Sweden is 230 V.

The backbone of the electrical grid, the national grid, is owned by the government and managed by the Swedish National Grid (Svenska Kraftnät), whereas power utility companies own the regional and local grids. The Energy Markets Inspectorate (Energimarknadsinspektionen) is the regulatory authority over the electricity market. Since the grid is a monopoly, there is only one network owner in each area that is licensed.

The base price of the electricity is daily set by the Nordic electricity retailing market, Nord Pool. Electricity trading companies then use this price as basis for their pricing in the competition for customers. The Swedish electricity market was deregulated in 1996, and three years later the requirement for hourly metering was abolished, which resulted in that the customers could change their electricity supplier more easily.

There are about 120 electricity trading companies and 160 grid owners. However, 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, transmission and retailing, and therefore have a big influence on the overall electricity market.

7.2 Interest in PV from electricity utility businesses

Several utility companies started in 2012 to market small turnkey PV systems suited for roofs of residential houses. Systems sizes vary between the companies, but are all between 1.5 kW_p to 15 kW_p. The utility companies that the author is aware of that at the offer these kinds of turkey PV systems are: Bixia, Din El, Elverket Vallentuna AB, E.ON, Eskilstuna Energi & Miljö, Fortum, Kraftringen, Lunds Energi, MälarEnergi, Nossebro Energi, Skånska Energi, Telge Energi, Vattenfall and Öresundskraft. These utility companies all have in common that they collaborate with local Swedish installation companies that provide the actual system and execute the installation.

Several utility companies started in 2011 to introduce compensation schemes for buying surplus electricity produced by small-scale PV systems. This trend continues and more and more utility companies now have various offers for micro-producers of electricity. Below is a list of a number of these compensation schemes for micro-producers. The requirement to be defined as a micro-producer is that the system and the fuse do not exceed 43.5 kW_p and 63 A respectively. A micro-producer that is a net consumer of electricity during a year doesn't have to pay for the grid tariff or the cost of meter installation. There are about 120 electricity trading companies and about 160 grid owners in Sweden, so the list is probably not complete, but gives examples of the various offers that a micro-producer can find. If the reader is aware of other utility companies that offer compensation for surplus electricity production from micro-producers, feel free to contact the author at johan.lindahl@angstrom.uu.se.

Utility Company	Compensation	Requirement to belong to specific grid	system requirements	Requirement to be a net consumer on yearly basis	Require the customer to be an electricity retail customer
Skellefteå Kraft	1.35 SEK/kWh	No	Micro-producer	Yes	Yes
Telge Energi	1.30 SEK/kWh	No	Micro-producer	No	Yes
Din El	Net metering on yearly basis	No	Up to 10 kW_p	No	Yes
Umeå Energi	Net metering on yearly basis	No	Micro-producer	Yes	Yes
Kungälv Energi	Net metering on yearly basis	Yes	Micro-producer	Yes	No
Elverket Vallentuna	Net metering on yearly basis	No	Micro-producer	Yes	Yes
Mölndal Energi	Net metering on monthly basis	Yes	Micro-producer	Yes	No
Tekniska verken	Net metering on monthly basis	Yes	Micro-producer	Yes	No
MälarEnergi	Net metering on monthly basis	Yes	Micro-producer	Yes	Yes
	Nord Pool spot price	No	Micro-producer	Yes	Yes
Eskilstuna Energi	1.00 SEK/kWh	Yes	Micro-producer	No	No
Kraftringen	1.00 SEK/kWh	Yes	Up to 10 kW_p	Yes	Yes
Dalarnas nätbolag	1.00 SEK/kWh	Yes	Micro-producer	Yes	No
Egen El	1.00 SEK/kWh	No	Micro-producer	Yes	Yes
Falkenberg Energi	1.00 SEK/kWh	No	Micro-producer	Yes	Yes
Skånska energi marknad	1.00 SEK/kWh	Yes	Micro-producer	Yes	Yes
Upplands Energi	1.00 SEK/kWh	Yes	Micro-producer	Yes	No
Öresundskraft	1.00 SEK/kWh	Yes	Micro-producer	Yes	Yes
Affärsverken	0.90 SEK/kWh	Yes	Micro-producer	Yes	Yes
	Nord Pool spot price + 0.05 SEK	No	Micro-producer	Yes	Yes
Sala-Heby Energi	0.60 SEK/kWh	No	Micro-producer	No	Yes
Sundsvall elnät	0.43 SEK/kWh	Yes	Micro-producer	Yes	No
Bixia	Nord Pool spot price	No	No upper limit	No	No
GodEl	Nord Pool spot price	No	Micro-producer	Yes	Yes
Fortum Markets	Nord Pool spot price	No	Micro-producer	Yes	Yes
Bergs Tingslags Elektriska	Nord Pool spot price - 0.01 SEK	Yes	Micro-producer	Yes	Yes
Storuman Energi	Nord Pool spot price – 0.02 SEK*	No	No upper limit	No	Yes
Nossebro Energi	Nord Pool spot price - 0.03 SEK	No	Micro-producer	No	Yes
E.ON	Nord Pool spot price - 0.04 SEK	No	Micro-producer	No	No
Gotlands Elförsäljning	1.25 SEK/kWh**	Yes	Micro-producer	Yes	Yes
	Nord Pool spot price - 0.04 SEK	No	Micro-producer	Yes	Yes
Vattenfall	Nord Pool spot price - 0.04 SEK	No	Micro-producer	No	Yes

*The revenues are deposited into an account with 3.5 % interest rate on.

**For customers that bough the system from Gotlands Energi AB.

7.3 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 centre for solar energy activity in the Skåne province. The aim of the association is, in a neutral and objective way, to disseminate knowledge and information about solar technologies, thus increasing the interest and skills of various stakeholders in the solar industry and among the public.

7.3.1.1 Sun maps

To help potential stakeholders in PV to easier assess the potential for their particular roof, several of Sweden's largest cities have initiated ”sun maps”. These sun maps illustrates in color scale the incoming solar radiation on all of the roofs in the city, taking into account the tilt of the roof and shadowing effects of nearby buildings or building elements. The cities that have launched or is about to launch a sun map is Stockholm, Göteborg, Lund, Örebro, Eskilstuna and Uppsala.

8 STANDARDS AND CODES

8.1 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. Some of the regulations and standards related small-scale PV systems in Sweden are:

- The National Electrical Safety Boards (Elsäkerhetsverket) regulations of certain electrical equipment.
- The National Electrical Safety Boards regulations on electromagnetic compatibility (EMC).
- The National Electrical Safety Boards regulations require that a permanent installation of a production facility shall be performed by a qualified electrician.
- A manufacturer of a product that will be used in a power generation facility must CE mark the product for it to be allowed to be used on the market.
- Section 712 of the Swedish Standard SS 436 40 00, power systems with photovoltaic solar cells.
- Swedish Standards SS 437 01 40, The connection of low voltage circuits to the grid standard.
- Swedish Standard SS-EN 50438, Requirements for connection of small generators in parallel operation with the general grid.
- Swedish Standard SS-EN 61727, Solar power plant - Power supply.
- Swedish Standard SS-EN 61173, Solar power plant - Instructions for protection against over voltage.
- Product standards EN (IEC) 61215 - Photovoltaics - Design and approval of PV modules of crystalline silicon
- EN (IEC) 61646 - Photovoltaics - Design and approval of photovoltaic thin film technology
- CE marking and EMC Directive (89/336/EEC) for inverters.

More information can be found at www.elsakerhetsverket.se and www.solelprogrammet.se/.

8.1.1.1 Cost of metering equipment and installation

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. 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_p is defined as a micro-producer, and will no longer need to pay for the grid tariff or the cost of meter installation as long as the producer during one calendar year draws more electricity from the national grid than the producer feeds in.

8.2 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.

8.3 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.

9 HIGHLIGHTS AND PROSPECTS

The prices for turnkey PV-system continued to decrease in 2013. In 2010 the price of a typical PV system of 5 kW_p for a villa was about 375 000 SEK, including VAT. With the rapid price reductions in recent years, the price was approximately 100 000 SEK, including VAT, at the end of 2013, and there are indications that the prize decline trend will continue in 2014. The price drop helped to increase PV installations in Sweden. 19.1 MW_p was installed in 2013, which is more than twice as much as the 8.3 MW_p that was installed in 2011.

The installation rate in 2013 is expected to increase, but to what extent is unsure. There is a growing interest for PV in Sweden and general public is very positive towards the technology. In a survey done in the beginning of 2014 almost one out of five of the Swedish homeowners said that they are considering investing in the production of their own electricity in the next five years in the form of PV or a small wind turbine. However, the uncertainties and debate about what tax rules that apply to micro-producers that were going on before the summer, the fact that there is almost no money left in the direct capital subsidy program and that probably no national program will be introduced in 2014 to solve the issue with the micro-producer surplus electricity will probably have negative effects on the Swedish residential market segment.

Definitions, Symbols and Abbreviations

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^{o}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_p 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_p 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_p of installed PV power.

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

PV support measures:

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 that may be higher or lower 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

Compensation schemes (self-consumption, net-metering, net-billing…)	These schemes allow consumers to reduce their electricity bill thanks to PV production valuation. The schemes must be detailed in order to better understand if we are facing self-consumption schemes (electricity consumed in real-time is not accounted and not invoiced) or net-billing schemes (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). The compensation for both the electricity self-consumed and injected into the grid should be detailed. Net-metering schemes are specific since they allows PV customers to incur a zero charge when their electricity consumption is exactly balanced by their PV generation, while being charged the applicable retail tariff when their consumption exceeds generation and receiving some remuneration for excess electricity exported to the grid
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

IEA INTERNATIONAL ENERGY AGENCY