National Survey Report
of PV power applications in Sweden
2008

IEA PVPS

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

International Energy Agency
CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task 1
Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications in Sweden
2008

Prepared by Adam Hultqvist
Ångström Solar Center,
Uppsala University
P.O. Box 534, SE-751 21 Uppsala, Sweden

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

May 2009

Contents

i Foreword 7

ii Introduction **7**

Summary in Swedish – Sammanfattning på svenska **9**

1. Executive summary **11**
1.1 Installed PV-power 11
1.2 Costs & prices 11
1.3 PV production 11
1.4 Budgets for PV 12

2. The implementation of PV systems **13**
2.1 Applications for photovoltaics 13
2.2 Total photovoltaic power installed 14
2.2.1 Methods and accuracy of data 14
2.3 PV implementation highlights 16
2.3.1 Investment subsidy for public buildings 16
2.3.2 Interesting projects, regions and stakeholders 18
2.4 Highlights of research and development 20
2.4.1 Industrial research 21
2.5 Public budgets for PV 22
2.5.1 PV research 22
2.5.2 Market stimulation 22
2.5.3 Demonstarion/field test programmes 22

3. Industry and growth **23**
3.1 Feedstock and wafers 23
3.2 PV cells and modules 23
3.2.1 Gällivare PhotoVoltaic AB 23
3.2.2 ArcticSolar AB 23
3.2.3 REC ScanModule AB 23
3.2.4 PV Enterprise Sweden AB 24
3.2.5 n67 Solar AB 24
3.2.6 General trends 24
3.3 Other components 25
3.4 System prices 25
3.5 Labor places 26
3.6 Business value 26

4. Framework for deployment 28
4.1 Support measures and new initiatives 28
4.2 Indirect policy issues 28
4.2.1 Grid-connection Legislation 28
4.2.2 Electricity certificates 28
4.2.3 Taxes 29
4.3 Standars and codes 29
4.3.1 Building permits 29
4.3.2 Public procurement act 29

5. Highlights and prospects 30
5.1 Highlights 30
5.2 Prospects 30

Annex 32

Country information 32

List of abbreviations

ABB Asea Brown Boveri
BIPV Building integrated PV
BOS balance-of-system
CD Compact Disc
CIGS $Cu(In,Ga)Se_2$
GPV Gällivare photovoltaic
IEA International Energy Agency
IEA-PVPS IEA Photovoltaic Power System Programme
MISTRA The Foundation for Strategic Environmental Research
NSR National Survey Report
OECD The Organisation for Economic Co-operation and Development
PV Photovoltaic
REC Renewable Energy Corporation
SEK Swedish Krona
SSF The Swedish Foundation for Startegic Research
VR The Swedsih Research Council

i Foreword

The Organisation for Economic Co-operation and Development (OECD) incorporates the self supporting International Energy Agency (IEA) since 1974. IEA as an organization with the help of the European Commission as a participant strives for sharing and cooperation between the 21 member countries in terms of energy policies.

Since 1993 there is a subgroup of the IEA named IEA Photovoltaic Power System Programme (IEA-PVPS) that specifically addresses energy transformed from sunlight into electricity. The main objective of the IEA-PVPS is to accumulate, share and exchange information about solar cell power systems among the participating countries through various projects.

The current members of IEA-PVPS are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DEN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia (MAL), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). Non country members are the European Photovoltaic Industry Association (EPIA) and the European Commission.

The IEA-PVPS work is directed by the Executive Committee where each participating country has one representative. General research projects within IEA-PVPS are named Tasks and are governed by an Operating Agent. The homepage for IEA-PVPS www.iea-pvps.org contains more information about the goals for current and the results from previous tasks.

ii Introduction

Statistics on Sweden's photovoltaic (PV) market, industry, applications and official PV policies for 2008 are contained in this National Survey Report (NSR). This NSR contributes to the international IEA report "Trends in Photovoltaic Applications", which is a compilation of the statistics from all of the participating countries. Since the entire world market is not contained within the member countries additional statistics are acquired or estimated for non member countries.

The target audiences of this NSR are national stake holders, companies, politicians, decision makers, research programs and the Swedish PV community in general. Besides giving information on the domestic market, industry, applications and policies the report includes statistics on the installed power and the module production in Sweden 2008.

Sammanfattning på svenska – Summary in Swedish

Installerad effekt

Subventionstödet som har funnits i Sverige mellan 2005 och 2008 har haft en kraftig betydelse för mängden av installerad solcellseffekt. Det har exempelvis installerats en effekt på 1700 kW topp, kW_t, under 2008 medan det endast installerades 300 kW_t under 2004. Installationstakten 2008 begränsades till en början av ett tak i subventionsprogrammet som lyftes i mars månad 2008. Utsikterna för 2009 ser sämre ut eftersom det inte finns något stödprogram för solceller i Sverige överhuvudtaget efter slutet på 2008. Förhoppningsvis kommer det nya subventionssystemet som näringsdepartementet har lagt som förslag inför Europakommissionen att accepteras och det kommer i så fall att starta tidigast i juni 2009. Det nya förslaget liknar det gamla, men har ändrats på ett antal punkter. I det nya förslaget är solcellsinstallationer på alla typer av fastigheter tillåtna, men stödet är sänkt något så att 60 % av installations och komponentkostnaderna är stödberättigade, samtidigt som det maximala stödbeloppet som kan betalas ut är 2 MSEK. Förslaget är tyvärr inte slutgiltigt och därmed tvingas de företag som installerar anläggningarna att vänta på fastslagna siffror innan de kan börja planera nya projekt. Hur stor skadan blir på grund av uteblivna installationer för de här företagen under ett halvår av global ekonomisk kris är svårt att säga i dagens läge. Det finns idag inga planer i Sverige på att stimulera ekonomin genom ökad statlig finansiering av solcellsrelaterad verksamhet.

Installationen av fristående solcellssystem fortsätter att vara ungefär 300 kW_t per år, främst på grund av en stabil marknad för den här typen av system. Det återstår att se om detta kommer att ändras 2009, eftersom allmänheten oftast är ovillig att spendera sina besparingar under finanskriser.

Priser

Världsmarknadspriset reglerar de svenska priserna för solceller. Som exempel föll de annars så stabila priserna på solceller för fristående system vid slutet på 2008 i samband med att priserna föll i övriga världen. De nätanslutna solcellssystemen har nästan enbart installerats genom stödprogrammet som i sig självt inte pressar priserna neråt. Indirekt sjunker ändå priserna eftersom installationskunskapen ökar med antalet installerade system.

Tillverkning

Det finns fem modultillverkare i Sverige och de expanderade alla sin produktion under 2008. En del utav dem är med i en större produktionskedja och har därför inga problem att få tag på celler, medan de andra företagen måste sluta uppgörelser med flertalet mindre celltillverkare för att täcka sina behov. Under 2008 var celltillgången momentant den begränsande faktorn för produktion för vissa företag. Det producerades 185 MW_p totalt sett under 2008 en ökning på 164 % från de 70 MW_p som producerades under 2007.

Eftersom den svenska solcellsmarknaden är så liten exporteras nästan alla moduler, därmed blir modultillverkarna väldigt beroende av läget både på den europeiska och på den internationella solcellsmarknaden.

Allmänna medel till solcellsverksamhet

Historiskt sett har Sveriges solcellsbudget fokuserats på demonstrationsprojekt, utveckling och forskning, detta förändrades när stödprogrammet infördes 2005. Ett exempel på det är att det under 2008 gavs 64 MSEK i stöd till installationer av nätanslutna solcellsanläggningar.

1. Executive summary

1.1 Installed PV power

The direct subsidy programme that lasted between the start of 2005 and the end of 2008 have had a vital impact on the installed PV power in Sweden. As an example of this 1700 kW peak, (kW_p) power was installed during 2008 compared to only 300 kW_p during 2004. The growth during 2008 was limited by a total cap for the subsidy programme that was lifted in March 2008. More severe is the prognosis for 2009 since there was no new subsidy policy starting at the end of 2008. There is currently a new proposed subsidy programme that is being reviewed by the European Comission that if it is accepted would give a 60 % direct subsidy to installations on any type of building. At the earliest this new scheme is active in June 2009 and until then the numbers are not finalized, leaving the domestic market without any ability to start or plan new projects for at least 6 months. The gap has most unfortunately coincided with the global financial crisis to make things even worse. Sweden has currently no plan to counter act this or to stimulate its finances through giving or lending money to PV related activity.

Installations of off-grid systems continue to be around 300 kW_p per year due to a stable market of PV systems for remote places both domestic and non-domestic. It remains to see if this trend continues through 2009 as the public generally feels more reluctant to spend their earnings during a financial crisis.

1.2 Costs and prices

World market prices drive the PV system costs in Sweden. A good example of this was the fall of the module prices at the end of 2008 where even the otherwise so rigid price level of the off-grid systems dropped in Sweden. Grid-connected systems have almost exclusively been installed through the subsidiary program, a program that does not promote cost reductions.

1.3 PV production

There are five Module producers in Sweden and they all expanded their production during 2008. Some of them are part of a vertically integrated production scheme and have no problems with acquiring cells, while the others have to make numerous agreements with smaller cell providers. The supply of cells was sometimes a limiting factor for the production during 2008. In total 185 MW_p was produced during 2008 a 164 % increase from the 70 MW_p 2007. Since the Swedish PV market is so small the module production companies export almost every module and are therefore strongly dependent on the status of the European market.

1.4 Budget for PV

Historically the Swedish PV budget has been focused on demonstration, development and research. However since the subsidy program started there has been a significant amount of funding for the new grid-connected installations. As an example 64 MSEK was paid for new PV systems through the subsidy during 2008.

2. The implementation of PV systems

A PV system cost is defined to include batteries, modules, inverters, control electronics and installation in this report. All systems larger than 40 W_p are a considered to be big enough to contribute to the Swedish market.

2.1 Applications for photovoltaics

There has been a remarkable growth of the Swedish PV market since the introduction of the 70 % investment subsidy. Previously there was a steady market that almost exclusively consisted of off-grid systems, during 2007 and 2008 however the grid-connected systems have surpassed the installed power of the off-grid systems.

Off-grid applications Before the subsidy started the smaller systems for off-grid applications dominated a small and relatively steady market. These systems have been popular in places where it is hard or impossible to connect to the grid such as in summer houses, boats and island settlements to generate electricity for lighting, radio, TV, water pumps, refrigerators, cooling fans, heating and other smaller equipments. These domestic off-grid systems are generally connected to batteries to extend their working hours.

90 % of the off-grid systems are domestic the other 10 % are non-domestic systems that support stand alone electronic units such as antennas, parking meters, road gates, navigational aids, metrological measurement equipment and various telecommunication devices.

Year	Sub market/application				Total [kW_p]
	Off-grid domestic [kW_p]	Off-grid non-domestic [kW_p]	Grid-connected distributed [kW_p]	Grid-connected centralized [kW_p]	
2008	252	23	1403	-	1678

Table 1: Total photovoltaic power installed during 2008

Grid-connected applications A few years ago there was hardly any grid-connected systems in Sweden to be found. At that time the grid-connected systems were almost exclusively installed as demonstration or research projects to increase the knowledge and the interest in PV for the public and the companies. Although those systems did receive smaller funding the picture changed dramatically with the introduction of the subsidy.

The subsidy did not only promote building of more grid-connected systems, but it also helped to diversify the people asking for funding from previously being electric companies, building companies, researchers and stakeholders to also include local associations, owners of sport arenas, the Swedish church, schools, universities and public organizations.

Figure 1: A grid-connected system installed at Fyrishovsbadet, Uppsala
(Courtesy Uwe Zimmermann)

2.2 Total photovoltaic power installed

2.2.1 Methods and accuracy of data

Most of the data was acquired through interviews with stakeholders, questionnaires to stakeholders and various types of reports. Fiscal year reports, stock market values, media and online price comparison tools have also been used to some extent. Generally there was no problem to obtain data from companies, but in certain cases the company refused or did not reply and the numbers had to be interpolated based on previous years. As a result the amount of installed and produced power might vary as much as ±15 %.

Since almost all of the grid-connected systems were installed through the subsidy scheme, they got listed in a public document. The document includes data on the systems such as approval date and peak power. As a continuation of one of the SolEl 03-07 research studies, all of the installed grid-connected systems are collected into an online database, where i.e. peak power and installation date is listed. Comparing the document with the database gives a good estimate on the installed grid-connected power in Sweden.

Off-grid markets There is no investment subsidy for the off-grid installations, this is reflected in the stable market for these types of systems. Both the domestic installations of 252 kW_p and the non-domestic installations of 23 kW_p during 2008 are close to the same amounts as previous years. It is harder to predict the installations for 2009, since there is currently a global recession, which makes the public more reluctant to spend their savings.

Grid-connected markets During 2008 the positive trend of a growing grid-connected market continued with an installation of 1404 kW_p, which is a 25 % increase from 2007, even though the subsidy cap was lifted as late as March 2008. Almost every project during 2008 was partially financed by the investment support scheme and only a few smaller installations were done solely by private or company funding.

The installations became more numerous and smaller in comparison to 2007, only a few of the systems were comparably large. This is likely due to the uncertainty before the cap was increased and to the limited time for finishing projects after the increase.

Figure 2: An example of both a large installation and a flat roof mounted PV system located at Andersbergs Centrum, Gävle (Courtesy Anders Holmsten)

2.3 PV implementation highlights, major projects, demonstration and field test programmes

Even though the 48 grid-connected systems installed in 2008 was not a big increase compared to 2007 and even though no new largest system in Sweden was installed during 2008, there were other noteworthy highlights occurring in 2008.

Year	Sub market/application				Total [kW_p]
	Off-grid domestic [kW_p]	Off-grid non-domestic [kW_p]	Grid-connected distributed [kW_p]	Grid-connected centralized [kW_p]	
1992	590	205	5	-	800
1993	760	265	15	-	1040
1994	1020	293	24	-	1337
1995	1285	304	31	-	1620
1996	1452	364	33	-	1849
1997	1640	394	93	-	2127
1998	1823	433	114	-	2370
1999	2012	448	124	-	2584
2000	2216	465	124	-	2805
2001	2376	507	149	-	3032
2002	2595	544	158	-	3297
2003	2814	573	194	-	3581
2004	3070	602	194	-	3866
2005	3350	633	254	-	4237
2006	3630	665	555	-	4850
2007	3878	688	1676	-	6242
2008	4130	701	3079	-	7910

Table 2: Cumulative installed power

2.3.1 Investment subsidy for public buildings

2008 was the last year of the subsidy scheme that granted a funding from the government on up to 70 % on the total project cost or a maximum of 5 MSEK per installation for grid-connected systems installed on special buildings or buildings exempt from taxation by the property taxation law (1979:1152). Hospitals, sport arenas, churches and museums are examples of this type of buildings. The subsidy was eligible for project costs consisting of payment to external project management, mounting and materials.

Since the cap at 150 MSEK was hit at the end of 2007 more funds were provided to lift the cap in March 2008 in order to keep the timeframe for the subsidy from May 2005 to the end of 2008. The problems arising from reaching the cap had small but noteworthy impacts on the market. When the cap was reached the amount of subsidized system applications slowed down to a halt. After the cap was increased new applications arrived, but for smaller systems. Systems that the companies thought they would be able

to finish before the end of 2008 when the subsidy seized. The total amount of installed grid-connected power during the subsidy was around 3.5 MW_p. The program has generally been viewed as a success, both regarding the growing Swedish PV market and regarding the new interest from companies, municipalities, the public and the government.

From the beginning of 2009 there is no subsidy program at all running in Sweden and only a few systems that were accepted towards the end of 2008 have been built in early 2009. There is another scheme that has been completed by the Swedish government and that is currently being reviewed by the European Commission. At the earliest this new subsidy program can start in June 2009. The new suggestion is very similar to the recent programme in being a direct investment capital that covers projecting, installations and materials. It will last between middle of 2008 and the end of 2011. The funding is reduced to 60 % and a maximum of 2 MSEK per system to reflect the growing PV market in Sweden at the end of the old program. However the numbers in the scheme is only temporary until the European Commission gives their agreement on the suggestion and therefore the official statement from the government to the companies is to not plan any future systems until the numbers are finalized. Unfortunately this leaves the installation and projecting companies without work for almost half a year and on top of that during a time with global economic recession.

Figure 3: A PV system installed at the high school Nils Ericsongymnasiet, Trollhättan, through the subsidy programme, used both for power generation and for shading. (Courtesy Switchpower**)**

The Swedish PV community is not pleased with this subsidy gap and is questioning why the new programme is of such a modest nature when numerous countries in the world have more aggressive approaches using feed in tariffs or similar subsidies.

Another key issue is the ability to sell overproduced electricity to the grid. In Sweden each power plant needs to pay a fee for the reading of the electricity meter and a base fee for using and delivering to the grid. In return, delivering renewable energy to the grid gives a small payback through the electricity certificate system. However this system is designed for larger power plants such as bigger wind power parks or smaller hydro power plants. For small installations such as a PV plant the cost of reading, connecting and delivering is bigger than the payback for the produced power. The government has acknowledged this problem and is at this point officially working on it.

2.3.2 Interesting projects, regions and stakeholders

Malmö Malmö is the biggest city in Sweden in terms of installed PV power, mainly due to their open mind about solar cells and renewable energies. Since a few years there is an organization named Solar City Malmö that was formed in cooperation between the local energy agency, Malmö City and the University of Lund. The objective of the organization is to increase the stakeholders', the local politicians', the companies' and the public's awareness and knowledge of PV and solar thermal systems. During 2008 several new smaller plants were built in Malmö and there are plans for building yet more systems in 2009. Sege park in Malmö is still the home of Swedens largest PV installation with its power of 166 kW_p.

Västra götalands län A collection of municipalities in southwestern Sweden are together called västra götalands län, within this region half of the municipalities have formed an organization called Soluppgång i väst together with Solar Energy Association of Sweden, Chalmers University of technology and SP Technical Research Institute of Sweden. Their main objective is to help the local municipalities, the public and the companies with the process of buying and installing PV and solar thermal systems.

Heby and Sala municipalities To a poll conducted by the local energy provider during 2008 the majority of the responses were positive towards installing PV systems to generate electricity in their municipality. It turned out that a part of the public living in these regions actually would like to own fractions of a big solar cell system and even buy the generated electricity for a higher price than the regular rate. In response to this an organization is being formed and new large PV systems are so far planned on a conceptual level.

Falun emergency station On the slanted rooftop of the emergency station in Falun one of Swedens largest installations was finished in March 2008. The system has a total power of 150 kW_p and was mainly funded through the subsidy program. According to the calculations the installation covers 20 % of the buildings energy demand throughout the year, the overproduced electricity during summer is distributed to the local grid

Figure 4: One of the systems in the Soluppgång i Väst region installed on the slanted roof of and as window shading for the city hall in Ulricehamn
(Courtesy Switchpower)

Helsingborg hospital Although the 80 kW_p installation on top of the hospital in Helsingborg is smaller than the originally planned 180 kW_p, the generated power is enough to provide the energy needed for 20 of the elevators inside the hospital during a year. Through this installation the hospital manager hopes to save both the environment by reducing carbon emissions and money on the electricity bill provided that the modules last for 25 years. An interesting aspect of hospitals is that they run every hour of the week and therefore constantly need electricity even during summer, where the long days in Sweden can be utilized to produce solar electricity to the fullest extent.

Akademiska hus Recently Akademiska hus, a governmental company that owns almost all university buildings in Sweden has become a key stakeholder. This is an effect of the interest to show the technology, to try it and of the subsidy program that made it affordable. During 2008 another three Akademiska hus installations were finished with a total power of 37 kW_p.

The Swedish Church During the subsidy program solar cell installations on church properties has been a part of the modernization of the church. This approach has led to numerous installations during the subsidized years and during 2008 another 71 kW_p was installed on seven different locations. Out of the seven only one was on an actual church, Bua kyrka outside Varberg built in the 1970s, which is the first time in Swedish PV history. Most churches in Sweden are old enough to be claimed to have cultural value by Swedish National Heritage Board and installing PV systems on them is considered to degrade their cultural value.

2.4 Highlights of R & D

Thin-film solar cells Fundamental research of $Cu(In,Ga)Se_2$ (CIGS) thin-film solar cells is carried out by the thin-film solar cell group at Uppsala University. This group is and has been closely related to the spin-off company Solibro AB.
Another CIGS project is running in collaboration between the Swedish CIGS company Midsummer AB and the department of microscopy and microanalysis at Chalmers University of Technology.

Dye-sensitized solar cells Center of Molecular Devices is a framework for the collaborated research on Dye-sensitized solar cells done at Uppsala University, The Royal University of Technology and the corporate research institute Swerea IVF. Understanding of fundamental processes, material properties, device testing and up scaling are all research topics within the centre.

Energy & Building Design Building integrated PV (BIPV) and integration of combined PV and solar thermal systems are research topics at the division of Energy & Building Design at the University of Lund.

Polymer and Organic Solar Cells The idea of having solar cells on electronic papers and packaging materials led to research on organic solar cells within the Center of Organic Electronics, a collaboration between Linköping University and Chalmers University of Technology.

Systems research PV systems are studied both at the division for Environmental Systems Analysis at Chalmers University of Technology and at Uppsala University. At Chalmers the research contains technological system innovations due to the Swedish subsidy program and at Uppsala it contains the prospects of distributing Swedish PV electricity.

SolEl 08-11 SolEl 08-11 commenced at the beginning of 2008 as a continuation of the successful SolEl 03-07 research and development program. The research program acts as a fund provider for projects within Sweden relating to BIPV, show case systems, PV education, collection and dissemination of information and system monitoring.

During 2008 a few projects started and one of them is to do follow up studies on the installed systems and gather the lessons learnt from operation and installation. Previously the problem has been that the built up knowledge from each system is confined to the people working on it. To counteract this, a knowledge database is being established to prevent unfortunate decisions during installation and operation.

Another study within the program addresses the issues with the current electricity certificate system, a payback method based on how much energy that has been produced from the system. The method has generated a pay back of billions of SEK for hydro and wind power in comparison to the thousands of SEK granted for the PV systems. Explanations for this unfortunate outcome and suggestions for a new method are addressed within the study.

A final research example is the follow up on the installation of new electronic electricity meters that has to be installed by law in every household in Sweden before the middle of 2008. Previously the metering has not been electronic and it has been impossible to do remote readouts and thus a person had to visit every house and do a manual readout yearly, which is not often enough for the power companies to allow for private electricity delivery to the grid. This has hindered the idea of a feed in tariff being applied in Sweden and as it turns out in the project will continue to be a problem since most of the new meters cannot record delivered electricity only consumed.

2.4.1 Industrial research

Absolicon During 2008 the rapidly growing Arontis Solar Concentrator AB changed name to Absilicon. Their key product is a system, X10, that combines solar cells receiving a low concentrated light with solar heating of water from cooling the solar cells. A vertically tracking trough with an applied mirror like film concentrates the light ten times. Solar cells are mounted on the focusing point and water is heated up through cooling the backsides of the solar cells. Absolicon received an extra 4 MSEK in funds for their projects during 2008, additionally another 3 MSEK was supplied for building up a laboratory for solar energy research in Härnösand, Sweden. Currently Absilicon has installed their systems in Sweden, Spain and Germany and has in the beginning of 2009 received a major order for a larger installation in Spain.

Midsummer AB This company just outside of Stockholm, Sweden, has taken an unconventional approach to making their $Cu(In,Ga)Se_2$ thin film solar cells. Instead of interconnecting solar cell stripes during the fabrication they produce solar cells the size of ordinary silicon wafer solar cells ready to be mounted into modules. The cells are grown by sputtering Cu, In and Ga on steel foils with post selenization. Combining this with mass production knowledge from the Compact Disc (CD), manufacturing industry they hope to produce solar cells for less than 1 USD/W_p during 2010. Their research funding is not yet completely official, but consists partially of the European Union and The Swedish Energy Agency.

Solibro Research AB Since Q-Cells bought Solibro AB, a spin-off company from the $Cu(In,Ga)Se_2$ research at Uppsala University, the actual module production has moved to Germany where there is currently one factory producing and another one being built.

However the process research has remained in Sweden under the name Solibro Research AB where new schemes for better solar cell modules are tested at the miniature production line before going live in the German factories. The company reached 30 employees during 2008 a large amount compared to 2007 and have now taken measures to expand their buildings to compensate this.

Sol voltaics AB Sol voltaics AB was formed 2007 as a spin-off company from the nanowire research at Nanometer Structure Consortium of Lund University. The idea is to fabricate low cost high efficiency multi junction solar cells for concentrator systems using nanowires. Additionally, nanowire technology is possible for a wider range of material combinations compared to the classical planar technique and it can also be applied to a silicon substrate. The basic idea has been shown to work on a small scale and the company is currently trying to rally enough funds for the production of a prototype.

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

2.5.1 Budgets for PV research

The Swedish Energy Agency distributes the Swedish Government's funds to all types of energy related research and is one of the major PV funders. Other major funding organizations for fundamental and industrial research that supports PV projects are The Swedsih Research Council (VR) and The Swedish Foundation for Startegic Research (SSF).

2.5.2 Budgets for market stimulation

During 2008 the municipalities and The National Board of Housing, Building and Planning distributed 64 MSEK of the public funds for market stimulation through the subsidy programme. Even though the subsidy cap was raised as late as March 2008 the distributed funding increased from 45 MSEK to 64 MSEK from 2007 to 2008.

2.5.3 Budgets for demonstration/field test programmes

There were no public budgets for demonstration/field test programmes during 2008, although the remaining 30 % for a few of the subsidy projects were financed through public demonstration budgets.

	R & D [MSEK]	Demo/field test [MSEK]	Market [MSEK]
National	29	-	64
Regional	-	-	-
Total	29	-	64

Table 3: Public budgets (in MSEK) for R & D, demonstration/field test programmes and market incentives

3 Industry and growth

3.1 Production of feedstocks and wafers

There was no production or plans of starting production of wafers or feed stock during 2008 in Sweden.

3.2 Production of photovoltaic cells and modules

Sweden has five companies that mount imported silicon solar cells into modules. Since the Swedish market is small compared to the capacity of the module production most of the modules are exported.

There was no commercial solar cell production in Sweden during 2008, however Midsummer AB are producing $Cu(In,Ga)Se_2$ solar cells for modules similar to silicon wafer solar cells on a research level and hope to enter the market in a near future.

3.2.1 Gällivare PhotoVoltaic AB

Gällivare Photovoltaic AB (GPV) is the oldest module producer in Sweden and until 2006 when REC Scanmodule expanded it also had the largest capacity. The current capacity is 45 MW_p/year an increase by 15 MW_p/year from 2008. The company imports their cells from within Europe at the moment, but plans to have their own cell production in the future. GPV export the majority of the produced modules, in contrast to this they are also a major module supplier on the small Swedish market.

3.2.2 Arctic Solar AB

The majority of the Arctic Solar AB shares are held by NAPS (of Finland) and Alfa Solar (of Germany) at equal parts. The company produces modules for its owners, but have however no secured supply of cells. Because of this Arcitc Solar bought cells from multiple cell producers within Europe during 2008.

3.2.3 REC ScanModule AB

Renewable Energy Corporation (REC), is a Norwegian company that is a major player in the PV market, since they have every part of the product chain. Their module fabrication sub company, REC ScanModule AB, is situated in Glava Sweden. During 2008 the new fully automated module production line, the first of its kind, was ramped up and at the end of the year 132 MW_p had been produced out of the maximum capacity of 154 MW_p. Solar cell supply is never an issue since the company is part of the REC production chain, enabling a stable growth, as an example the next expansion of the plant is scheduled for 2010.

3.2.4 PV Enterprise Sweden AB

PV Enterprise Sweden was the first module producer to enter the Swedish stock exchange. During 2008 the company had troubles getting hold of enough cells to keep up their production even though they covered all bases by having agreements with companies all over the world. In the beginning of 2009 the problem is no longer a shortage of cells but the global crisis where the both the module price and the demand has dropped.

3.2.5 n67 Solar AB

n67 solar is the youngest module producer in Sweden and is currently growing rapidly. As an example of this the capacity was increased from 5 MW_p/year at the start of 2008 to 11 MW_p/year at the end of 2008, which has further increased to 26 MW_p/year at the beginning of 2009. During 2008 the modules were exported to Germany, Italy, Spain, Belgium, The Netherlands and Luxemburg. The solar cells are exclusively provided by Q-Cells through a partnership agreement.

		Total production (MW_p)*			Maximum Capacity (MW_p)		
Manufacturer	Technology	Cell	Module	Conc.	Cell	Module	Conc.
GPV	mc-Si	-	24.2	-	-	30	-
ArcticSolar	Poly-Si	-	9.6	-	-	14	-
ScanModule	mc-Si	-	132	-	-	154	-
PV Enterprise	Poly/mc-Si	-	13	-	-	30	-
N67 Solar	Poly-Si	-	6-7	-	-	11	-
Total			185			239	

Table 4: Production and production capacity information for the year for each manufacturer

3.2.6 General trends

Most of the Swedish module producers are increasing their production despite the current low demand caused by the global economic crisis. As an example the module production was increased from 70 MW_p in 2007 to 185 MW_p in 2008, an astounding 164 % increase. The cells are generally supplied through agreements and a few companies are part of a major production chain. Almost all of the modules were exported to Europe during 2008 and the prices varied quite a lot in coherence with the European module prices. Since almost every module is exported the module companies have little or no influence on the Swedish PV market.

	Year						
Module prices	2002	2003	2004	2005	2006	2007	2008
Large orders	30	26	26	32	30	28,5	25.5
Single Modules	75	70	70	70	65	63	61

Table 5: Typical module prices (SEK/W_p, excl. VAT) for a number of years

3.3 Manufacturers and suppliers of other components

There were no system components such as switches, tracers, mounting or inverters manufactured in Sweden 2008. Parts were however provided from Asea Brown Boveri (ABB) to switches and inverters.

3.4 System prices

Grid-connected and off-grid system prices are driven by the subsidy program and the retail price respectively.

The retail price for off-grid modules is strongly dependent on the market prices in Europe and the balance-of-system (BOS) components. The off-grid price has been quite stable 2008, until the very end when it fell significantly in coherence with the price drop in Europe and the economic recession.

Grid-connected systems are almost exclusively installed through the subsidy program for installations on public buildings. Since each building potentially needs to be retrofitted to some degree, the actual module price becomes hidden in the total installation cost. It is therefore hard to get a good estimation on the price per installed Watt peak for the system.

Category/range	Typical application	SEK/W_p
Off-grid Up to 1 kW_p	Domestic or professional remote electrification	90
Off-grid (>1 kW_p)	-	n/a
Grid-connected (< 10 kW_p)	Typical roof mounted system	96
Grid-connected (> 10 kW_p)	The largest type of BIPV system in Sweden	67

Table 6: Turnkey prices of typical applications

YEAR	2002	2003	2004	2005	2006	2007	2008
Price [SEK/W_p]	100-130	90-110	90-110	90-110	90-110	85-110	55-130

Table 7: National trends in system prices (SEK/W_p) for off-grid applications (small systems)

3.5 Labor places

There is a steady increase in PV labor places since the production and company research has been growing due to the world market growth and since the number of installations has been increasing due to the subsidy program. In total there are an estimated 450 company related labor places in Sweden, the majority of those approximately 430 are in the module production industry, the rest are either at research or installation companies. Approximately another 50 are employed at public PV research facilities at universities. In some cases it is hard to define if a person is working with PV, sometimes only part of the work is PV related and sometimes the person is working in a retail store were PV systems is one of many products.

3.6 Business value

Almost 90 % of the Swedish PV turnover consists of module production. The solar cell production at GPV and Midsummer does not yet contribute since it is still on a planning and a research stage respectively. There are a few small installation and consulting companies started as a result of the subsidy program contributing to the turnover, but the installation is still relatively small compared to the module production. A rough and therefore uncertain estimate of the Swedish PV business value is found in table 8.

Sub market	Capacity installed in 2008 [kW_p]	Price [SEK/W_p]	Value [MSEK]
Off-grid domestic	252	90	23
Off-grid non-domestic	23	90	2
Grid-connected	1403	82	115
		Totals	140
Export of PV products			4718
Charge in stocks held			n/a
Import of PV products			3756
		Value of PV business	1102

Table 8: Value of PV business

	National / Regional (State) / Local
Enhanced feed in tariffs	-
Direct capital subsidies	National
Green electricity schemes	-
PV specific green electricity schemes	-
Renewable portfolio standards (RPS)	National
Investment funds for PV	-
Tax credits	-
Net metering	-
Net billing	-
Commercial bank activities	-
Electricity utility activities	-
Sustainable building requirements	-

Table 9: PV Support Measures

4 Framework for deployment (Non technical factors)

4.1 Support measures, new initiatives and market stimulation

The cap of the old subsidy scheme was lifted in early 2008 and was able to extend the scheme until the end of the year as planned. Unfortunately there was no subsidy program continuing at the start of 2009, even though the politicians have worked on a continuation of the scheme for some time. The situation becomes graver as it turns out that a new subsidy programme can start in June 2009 at the earliest. Even though the Swedish proposition was completed early 2009 it now needs to be approved by the European Commission which delays the programme start further. Until the numbers are finalized new installations cannot be planned, which leaves the installation companies without work for at least half a year.

Currently the Swedish government does not have any intentions to stimulate the economy by additional funding to PV research or the PV market.

4.2 Indirect policy issues

4.2.1 Grid-connection legislation

It is allowed to connect a smaller roof mounted system of a few kW_p to the Swedish electric grid. However, to legally distribute power on the electric grid the output of the power plant needs to be measured on an hourly basis. Only the local utility companies are allowed to do such a measurement and the lack of competitors allows the utility companies to charge large fees for this service. For a small roof mounted PV system of 3 kW_p the fee becomes approximately 1 SEK/kW_p.

The proposal to waive the hourly measurement for power plants with an output of less than 63 ampere is still being discussed.

Utility companies in Sweden started to offer billing based on a monthly consumption during 2008 for smaller users such as households. According to Swedish law all of the utility companies are obliged to supply this service from the middle of 2009. To know the monthly power consumption is valuable for dimensioning roof top PV systems to not overproduce in summer, since delivering electricity to the grid is an economic loss because of the fees.

4.2.2 Electricity certificates

To increase the renewable energy production in Sweden a market based incentive scheme, that is based on electricity certificates was introduced in 2003. An electricity certificate is awarded for each MWh of energy produced by a renewable energy power plant. All the Swedish electricity customers are obliged to buy a certain amount of electricity certificates per MWh, the amount increases for each year to promote production of renewable energy in the long run. The target is an increase in renewable energy production of 17 TWh for each year until 2016.

The reward from the certificates is close to 0.20 SEK/kWh, not enough by far to pay back the investment cost of a PV system within its lifetime. Electricity certificates are thus not attractive for PV, as is also seen in the statistics from 2008 where only a tiny part of the certificates were awarded to PV.

Combining the certificate system with the costs of the grid connection fees there was no economic gain for distributing power to the grid 2008 from a PV system.

4.2.3 Taxes

The energy tax included in the electricity price is 0,005 SEK/kWh for industry applications and between 0.18 and 0.27 SEK/kWh for other activities. On top of the regular tax, value added tax is applied. While the electricity taxes are high they are not as profit limiting as the certificate system and the installation cost for grid connected PV systems.

4.3 Standards and codes

Sweden does not have any standards and codes defined for solar cell systems. Installations need to follow more general electrical guidelines instead, such as the high current installations standard, ELSÄK-FS 2004:1 and the electrical installation standard, SS 436 40 00. Additionally Swedenergy has developed an instruction for connecting smaller systems to the grid. A collection of the important standards and guidelines for installation and maintenance of PV systems is found in the publication Installationsguide, Nätanslutna solcellsanläggningar released in 2007 by the SolEl 03-07 programme [1].

4.3.1 Building permits

Installations of PV systems on buildings or on free standing structures changes the visual appearance of the objects and must therefore acquire building permits. Achieving a permit can be controversial for buildings that have cultural, heritage or architectural value. As an example the first PV installation on a church came in 2008. The Swedish church has nothing against PV installations on churches, but most of the churches in Sweden have cultural value and are therefore not eligible for that reason. In this particular case the church was from the 1970’s and not yet considered to be old enough to have national heritage value.

4.3.2 Public procurement act

The public procurement act has forced stakeholders of proposed PV systems to use a public tender system to decide the system supplier. Unfortunately the PV system proposal needs to be very detailed and the stakeholder can not ask the provider for assistance because of the public tender, which makes it hard to create an attractive proposal in the first place.

5 Highlights and prospects

One of the most interesting events of 2008 was the lift of the subsidy cap that resulted in an increased growth of grid-connected power compared to 2007. Another key point is the termination of the subsidy programme as 2008 came to an end leaving a gap for at least half a year.

5.1 Highlights

After lifting the cap of the subsidy program early 2008 the PV installations continued to increase totaling 1.7 MW_p for the entire year compared to the 1.4 MW_p of installed power during 2007. The cumulative installed power had increased by 30 % at the end of 2008 compared to the previous year.
Swedish module production increased with a remarkable 164 % from 70 MW_p 2007 to 185 MW_p 2008. The main reason for this is a good supply of cells and up scaling of the existing plants.

5.2 Prospects

At the beginning of 2009 there was no active subsidy programme, the government has however finished a proposal that is currently being reviewed by the European Commission. Unfortunately this delays the start of a new subsidy program until the middle of 2009 at the earliest, leaving a subsidy gap for at least half a year. There is no telling of what will happen to the installation companies that started due to the old subsidy program, especially since the gap coincides with the global economy crisis. At the beginning of 2009 there were no initiatives to stimulate the Swedish market by giving money to PV research or the PV market.

While most of the Swedish module production has a good supply of cells through long term contracts and through a good market supply, they are facing a challenge to expand or to survive with less profit and a low demand due to the recent drop in module prices initiated by the global economic recession.

References

[1] Installationsguide, Nätanslutna Solcellsanläggningar. SolEl 03-07 Available at: http://www.elforsk.se/solel, 2007

Annex

Country information

i) The price for electricity including electricity certificates, electric energy price, energy taxes, distribution fees and value added tax was 1.7 SEK/kWh for a consumption of 5000 kWh, a household without electric heating and 1.4 SEK/kWh for a consumption of 20000 kWh, a household with electric heating.

Depending on the consumption the industry pays in between 0.6 and 1.2 SEK/kWh including energy taxes, electrical energy price, distribution fees and certificates, but excluding value added tax. In comparison with households the distribution fee and the energy taxes are substantially lower for the industry.

ii) Because of a cold climate, a high ratio of electric heating and an electricity intensive industry the consumption per person is as high as 16500 kWh in Sweden. An average flat consumes 2000 kWh/year while an electrically heated house consumes 20000 kWh/year.

iii) During 2008 household consumers of electricity were still paying for a predicted consumption based on previous years. A yearly reading correlated the predicted and the actual consumption for the year to improve the prediction for the upcoming one. A decision has been taken to have mandatory monthly readings starting from the middle of 2009 and thereby making the customers pay for the actual consumption during the previous month.

A break down of the electric bill includes the price of electricity, energy taxes, distribution fees, electricity certificate fees and value added tax applied to the energy tax. The industrial bill is typically modified for time of use.

iv) The median income for a Swedish household is 249000 SEK/year.

v) The average interest rate for households in 2008 increased from 5.2 % at the start of the year to 6.2 % in September. When the financial crisis appeared the interest rate was forced down to stimulate the market and finished at 4.1 % at the end of the year.

vi) Long distance grid transmission lines operates at 200 or 400 kV, the voltage is down converted to between 20 and 130 kV regionally and further down converted to 10 kV locally. The end user has 230 V nominal in the power outlet.

vii) The major distribution network is owned and managed by Svenska kraftnät, while the local and regional networks are owned by monopoly utility companies. To lower the electricity price the retailing market was opened 1996, allowing companies to compete for customers with low prices.

Opening the market has split it into retailing, transmission and generation sub markets. Larger companies such as Fortum AB, E.ON and Vattenfall AB are active in all of the three sub markets giving them an advantage against the competition. Nordic electric energy exchange, Nord Pool, containing German and Polish actors has also entered the Swedish energy market recently.

viii) The price of diesel increased from 13 SEK/l at the beginning of 2008 to 15 SEK/l in September the same year. After the start of the economic crisis the price dropped and finished at 11 SEK/l at the end of the year.

ix) Energy production per installed power unit is in the range of 600 to 800 kWh/kW, for a PV system in Sweden.