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 Denmark 2011

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June 2012

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i. Foreword

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

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

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

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

ii. Introduction

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

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

iii. 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 PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically

perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

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

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

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

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

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

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

Currency: The currency unit used throughout this report is DKK (Danish Crown)

PV support measures:

Enhanced feed-in tariff	an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh somewhat higher than the retail electricity rates being paid by the customer
Capital subsidies	direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost
Green electricity schemes	allows customers to purchase green electricity based on renewable energy from the electricity utility business, usually at a premium price
PV-specific green electricity schemes	allows customers to purchase green electricity based on PV electricity from the electricity utility business, usually at a premium price
Renewable portfolio standards (RPS)	a mandated requirement that the electricity utility business (often the electricity retailer) source a portion of their electricity supplies from renewable energies

PV requirement in RPS	a mandated requirement that a portion of the RPS be met by PV electricity supplies (often called a set-aside)
Investment funds for PV	share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends
Income tax credits	allows some or all expenses associated with PV installation to be deducted from taxable income streams
Net metering	allows PV customers to incur a zero charge when their electricity consumption is balanced by their PV generation, to be charged the applicable retail tariff when electricity is imported from the grid and to receive some remuneration for PV electricity exported to the grid
Net billing	the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity account is reconciled over a billing cycle
Commercial bank activities	includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems
Activities of electricity utility businesses	includes 'green power' schemes allowing customers to purchase green electricity, operation of large-scale (utility-scale) PV plants, various PV ownership and financing options with select customers and PV electricity power purchase models
Sustainable building requirements	includes requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy foot print or may be specifically mandated as an inclusion in the building development

1. EXECUTIVE SUMMARY

1.1 Installed PV power

By the end of year 2011 Denmark (including Greenland) had about 17 MW installed, an increase of more than 9 MW compared to 2010. Grid-connected distributed systems constitute at about 90 % the majority of PV systems. Denmark has no general incentive for reducing the investment cost of PV systems, but has a net-metering scheme for private households and institutions set by law. Due to increasing taxes on electricity the net-metering scheme is getting more and more attractive, which is driving the market illustrated by a market increase 2010 to 2011 of 140 %. That this trend continues indicates preliminary data for 1. Quarter 2012 showing an additional 12 MW installed. Many new commercial actors are found.

1.2 Costs & prices

The installations completed in 2011 demonstrate turn-key system prices for medium to large scale "roof-tops" of around 17-18 DKK/W. The price of PV modules dropped during 2011, but not as dramatic as in 2010. The individual PV systems implemented during 2011 exhibit turn-key system prices in the range of 18 to 30 DKK/W primarily depending on degree of building integration.

1.3 PV production

The module production company Gaia Solar for 2011 reports a volume of about 2 MW, at a manufacturing capacity of 2,5 MW/Y. The main export markets for Gaia Solar are Germany and Sweden. Another module manufacturer Dansk Solenergi has an estimated production volume of 1,5 MW during 2011 at a 2 MW manufacturing facility. The Danish holding company Phototonic Energy owns PV manufacturing facilities in China (Jumao Photonics) and PV developers in Germany. During 2011 the inverter developer and manufacturer Danfoss Solar Inverters reported increasing commercial activities reaching more than 1 GW of capacity produced. Danfoss Solar Inverters has entered Smart Grid activities and projects demonstrating inverters with dispatchable VA and VAR and with fault-ride-through capability. There is no production of PV batteries in Denmark.

The building industry is showing growing interest in developing PV-building integrated components and systems in particular in connection with highly industrialized building processes; tightening of the energy footprint in the building codes stimulate this trend.

The national PV industry association, Dansk Solcelleforening (www.dansksolcelleforening.dk) established in 2008 consolidated itself during 2011 and has strengthened its position as unified voice for the Danish PV sector.

1.4 Budgets for PV

In 2010 the government confirmed its commitment to support renewable in its annual "Statement of Energy", followed early 2011 by a new energy strategy "Energy Strategy 2050" reaching up to 2050 and targeting independence of fossil fuels. Public funding for R&D into energy is on track being doubled from about 0,5 billion DKK in 2007 to 1 billion by 2010 continuing during 2011 and is expected to continue on this level. Over a 3-5 year period more than 150 million DKK will be allocated to R&D in renewables. A new energy plan was proposed by the government in 2011, but did not gain the broad political support usually sought in Denmark. After elections early 2012 the new government has managed to obtain broad political acceptance of a slightly modified energy plan. In 2011 the Public Service Obligation (PSO) of the Danish transmission system operator Energinet.dk, the so called ForskEL and ForskVE programmes, funded about 17 million DKK for applied research and

demonstration projects in PV's, and the other public programme EUDP funded about 19 million DKK for PV R&D&D activities. There was no call-for-proposals under the ForskVE programme during 2011 due to the above mentioned unclear political situation as to the energy plan. PV market actors also receive support from other public sources targeting market introduction of "new green technologies".

2. THE IMPLEMENTATION OF PV SYSTEMS

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

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

2.1 Applications for photovoltaics

The national electric grid covers practically all of Denmark and leaves little room for stand-alone applications besides the traditional low-power niche applications such as signalling, week-end cottages, garden lights, telemetry & telecommunication and urban furniture such as parking meters and information displays. In Greenland stand-alone PV's play a major role as power source for remote signalling and for the telecommunication network extending more than 2 000 km on the western coast line.

Grid connected PV applications are seen as the largest potential in Denmark, in particular building applied or integrated applications on single family houses, apartment buildings, commercial and office buildings. The public interest for building integrated PVs is increasing, and most efforts are focused on developing and demonstrating PVs in the context of existing buildings. The main PV application during 2011 (see also Figure 1) has been PV roof-tops on residential houses, a market driven by the net-metering scheme, and with electricity retail prices around DKK 2,10 (€c 30) a typical pay-back time of around 10 years was seen in 2011.

The EU directive[1] on energy consumption in buildings was in 2005 minted into a revised national building code – moved into force early 2006 – which specifically mentions PV and allocates PV electricity a factor 2,5 in the calculation of the "energy foot print" of a building. However, due to the inertia in the construction sector only in 2009 is was possible to detect some real impact on PV deployment, as developers, builders and architects openly admitted the inclusion of BIPV in projects due to the building codes. This trend was markedly strengthened during 2011 Ongoing political discussions both on the EU level and nationally indicate an upcoming further tightening of the building codes, which may further promote BIPV, and the future energy requirements in the building codes are now known up to 2020 with many new buildings in compliance with these future codes.

2.2 Total photovoltaic power installed

The PV power installed in 4 sub-markets during 2011 is shown in Table 1.

[1] EU directive: Directive 2002/91/EC of 16.12.02

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

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	Total
PV power installed in 2011 (MW)	0,1	0,13	9,5	0	9,7
Amount of CPV in the above (MW)		0	0	0	
Amount of PV in hybrid systems (MW)	0				

Figure 1: PV capacity installed during 2011 distributed on system sizes

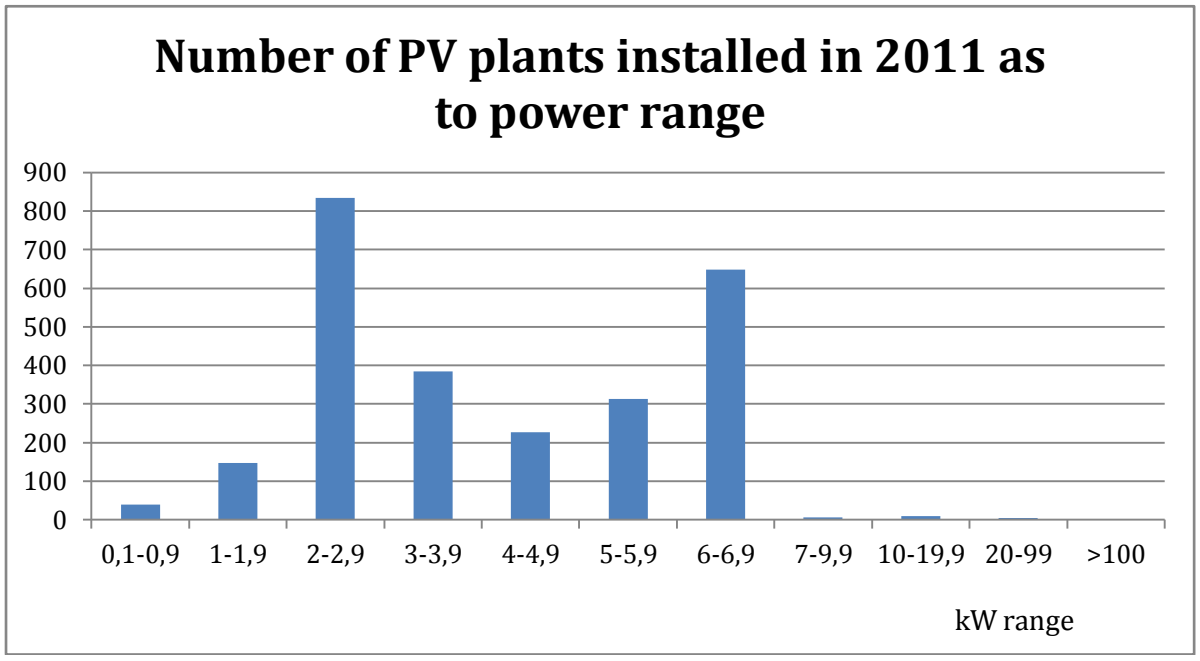

Table 2a: PV power and the broader national energy market.

Total national (or regional) PV capacity (from Table 2) as a % of total national (or regional) electricity generation capacity	New (2011) PV capacity (from Table 1) as a % of new electricity generation capacity	Total PV electricity production as a % of total electricity consumption
n.a.	n.a.	n.a.

A summary of the cumulative installed PV Power, from 1996-2011, broken down into four sub-markets is shown in Table 3.

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

	Cumulative installed capacity as at 31 December															
Sub-market	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Stand-alone domestic	20	25	35	40	50	50	50	55	65	70	80	100	125	165	220	300
Stand-alone non-domestic	120	125	140	150	155	160	165	170	190	225	255	285	315	375	470	505
Grid-connected distributed	105	272	330	890	1255	1290	1375	1675	2035	2355	2565	2690	2825	4025	6375	15875
Grid-connected centralized	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL (MW)	245	422	505	1070	1460	1500	1600	1900	2290	2650	2900	3075	3265	4565	7065	16680

The main Danish PV market sector, grid-connected distributed, exhibited quite some progress mainly due to a combination of dropping prices and increasing retail price of electricity (the net metering scheme), the effect of the building codes as mentioned previously and a few medium-scale projects, e.g. the PhotoSkive project targeting 1 MW on municipal buildings but now reaching 1,5 MW and the Bornholm project (BIPV) targeting 5 MW. The only general incentive for PV in Denmark remains the net-metering scheme targeting private household and institutions with some limiting conditions; however, as mentioned the net-metering scheme is getting more attractive as electricity retail prices increase mainly due to taxation.

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

During 2011 no national PV promotional activities were found; as mentioned previously the ForskVE program was unable to launch a call-for-proposals due to lack of political commitment. The PhotoSkive project targeting 1 MW BIPV on municipal buildings supported by the ForskVE programme received a one year extension to implement a new target of 1,5 MW. Also the PVIB project targeting up to 5 MW of PV's on the island of Bornholm received support from this program, but support allocated previously, not in 2011. The PVIB project is closely linked to the EcoGrid project, which is an EU supported Smart Grid "real-life" laboratory (www.ecogrid.dk).

The PV related impact of the more stringent building codes could clearly be found, as several new buildings implemented BIPV or BAPV with a direct reference to same building codes.

The off-grid professional and private market sectors developed almost as in the previous years although accelerated somewhat due to lower PV technology costs.

For a more historical overview or context, please refer to the Danish National Survey Reports covering 2008 and previous years (www.iea-pvps.org).

2.4 Highlights of R&D

During 2011 R&D efforts in the fields of organic dye sentizied PV cells (PEC), polymer cells and "PV cells-architecture-lights" continued with steady progress primarily for the polymer cells, and efforts to commercialize the R&D results in the field of polymer cells initiated in 2010 were quite successful continued in 2011 involving the screen printing company Mekoprint. R&D efforts into nano-structured PV cells were continued as well.

Basic research into PV cells based on mono-X Si is ongoing at the University of Aarhus in a partnership with industry.

One company (Sunsil) is developing an innovative PV module with an integrated, distributed optimizer/inverter structure allowing each group of 6 cells to operate individually and in an optimized mode this way minimizing effects of shadows and cell mismatches. Sunsil originally expected a market introduction during 2011, but has now postponed this to ultimo 2012.

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

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

	R & D	Demo/Field test	Market incentives
National/federal	25	25	-
State/regional	-	-	-

Funding is mainly from the PSO ForskEl, ForskVE and the EUDP programmes and there is no funding dedicated only to PV – only RE in general. The figures in table 3 are thus indicative. Funding for more basic research is in principle also available for PV's, but few if any projects benefitted from this during 2011. A major demonstration project, Photo-Skive, targeting 1 MW of BIPV on the buildings of the Skive municipality has received 22 million DKK in support from the ForskVE programme and has during 2011 reached a total of about 1 MW; the project has been extended with 1 year and it is expected that the project during 2012 will reach a total of 1,5 MW. The PVIB project targeting 5 MW corresponding to a PV penetration of 10 % in the grid system of Bornholm has received support from the ForskVE programme at about 20 million DKK, and is expected to reach about 3 MW with the current funding level. The third phase of the project is expected – given additional funding – to add the remaining 2 MW, partly in terms of a large scale ground mounted PV plant, the first in the country.

3. INDUSTRY AND GROWTH

3.1 Production of feedstocks, ingots and wafers

Table 5: 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)
	Silicon feedstock	tonnes		
	sc-Si ingots.	tonnes		
	mc-Si ingots	tonnes		
	sc-Si wafers	MW		
	mc-Si wafers	MW		

No information available on the above. The company Topsil produces manufacturing equipment for float zone Si ingots. The company Photonic Energy owns large scale PV manufacturing facilities in China, but no details are available.

3.2 Production of photovoltaic cells and modules

Module manufacturing is defined as the industry where the process of the production of PV modules (the encapsulation) is done. A company may also be involved in the production of ingots, wafers or the processing of cells, in addition to fabricating the modules with frames, junction boxes etc. The manufacturing of modules may only be counted to a country if the encapsulation takes place in that country.

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

Table 6: Production and production capacity information for 2011

Cell/Module manufacturer (or total national production)	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Gaia Solar	mc-Si, sc-Si	-	2	-	2,5
Dansk Solenergi	mc-Si, sc-Si	-	10	-	30
Thin film manufacturers					
Cells for concentration					
TOTALS		**-**	12	**-**	33

Gaia Solar and Dansk Solenergi produce modules (laminates) based on imported cells. Modules are of the standard glas-EVA-Tedlar design. Product range is 50-250 Wp with 75-200 W modules being most typical. Normal warranty: 5 years. The companies are open to custom design modules. Certification to IEC 61215.

Typical PV module cost range between DKK 8 – 12/W. Most modules are exported, although the fast growing home market is of increasing importance.

Some companies have announced plans to establish more large scale PV module production, and a few other companies have shown interest in manufacturing window-integrated PVs, but so far the throughput is estimated as commercially negligible.

The company Photonics Energy acts as a holding company inter alia with PV manufacturing facilities in China (Jumao); no details of manufacturing capacities and technologies are available.

3.3 Module prices

Table 7: Typical module prices for a number of years

Year	2005	2006	2007	2008	2009	2010	2011
Standard module price(s): Typical	30-50	40-60	30-50	25-45	15-25	10-15	8-12
Best price	-	-	-	-	-	-	-

The trend towards lower module prices found since 2008 has continued so far up to end of 2011.

3.4 Manufacturers and suppliers of other components

Balance of system component manufacture and supply is an important part of the PV system value chain. For 2011 the situation in Denmark is briefly described below.

The company Danfoss Solar Inverters has reported multi million € commercial orders for its recently developed modular inverter system. For 2011 a production volume of > 1 GW has been reported, but no detailed information is publicly available on technology, performance, volume and prices.

The company Grundfos produces its special variable frequency inverter system for its water pumping systems. However, no detailed information is publicly available on technology, performance, volume and prices.

No battery producers in Denmark with PV related products.

Three companies produce (on a small scale) charge controllers and PV related electronics for stand-alone PV systems.

One company (Linak) is looking into development and manufacturing of support structures and trackers.

The company Velux Industries has developed and marketed a roof-integration package. However, no detailed information is publicly available on technology, performance, volume and prices.

3.5 System prices

Table 8: Turnkey Prices of Typical Applications

Category/Size	Typical applications and brief details	Current prices per W
OFF-GRID Up to 1 kW	Telemetry, navigational aids, emergency phones, road signs, displays, parking tickets, etc.	20-35
OFF-GRID >1 kW	Professional remote, telecommunication, etc.	35-60
GRID-CONNECTED Specific case	2-6 kW roof-top systems	18-25
GRID-CONNECTED up to 10 kW	PV systems on buildings	18-30*)
GRID-CONNECTED >10 kW	PV systems on buildings	10-40*)
GRID – CONNECTED (utility-scale plant, if relevant)	-	-

*) some BIPV systems are quite costly

Table 7a: National trends in system prices (current) for roof-tops

YEAR	2004	2005	2006	2007	2008	2009	2010	2011
Price /W:	33-36#)	33-36#)	35-45#)	33-40	35-45	25-40	20-30	18-25

#) only for systems on long term contract, e.g. SOL 1000. Other individual systems exhibit higher prices with a marked variation.

3.6 Labour places

a) Research and development (not including companies): 30
b) Manufacturing of PV system components, including company R&D: 700
c) All other, including within electricity companies, installation companies etc. 150

Information on labour places is based on the author's best estimate – no official statistics available. Table 8 on Labour Places cannot be completed due to lack of data.

Table 9: Estimated PV-related labour places in 2011

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

3.7 Business value

Total business value for 2011 is estimated (author's estimate – no way of getting solid data) to in total about 5 billion DKK .

Table 9 on Business Value cannot be completed due to lack of data.

Table 10: Value of PV business

Sub-market	**Capacity installed *in 2011* (MW)**	**Price per W** *(from table 7)*	**Value**	**Totals**
Off-grid domestic	*X*	*Y*	*a = X x Y x 1 000 000*	
Off-grid non-domestic			*b*	
Grid-connected distributed			*c*	
Grid-connected centralized			*d*	
				a+b+c+d
Export of PV products *(including information from Tables 4 & 5)*				*e*
Change in stocks held *(including information from Tables 4 & 5)*				*f*
Import of PV products *(including information from Tables 4 & 5)*				*g*
Value of PV business				***a+b+c+d+e+f-g***

4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

Table 11: PV support measures

	On-going measures	Measures that commenced during 2011
Enhanced feed-in tariffs (gross / net?)	-	-
Capital subsidies for equipment or total cost	-	-
Green electricity schemes	-	-
PV-specific green electricity schemes	-	-
Renewable portfolio standards (RPS)	-	-
PV requirement in RPS	-	-
Investment funds for PV	-	-
Income tax credits	-	-
Net metering	Net metering	-
Net billing	-	-
Commercial bank activities e.g. green mortgages promoting PV	-	Some banks have established PV loans
Activities of electricity utility businesses	ForskVE programme for demonstration of PV	*)
Sustainable building requirements	Building codes	Building codes with planned future tightening, known up to 2020

*) No call-for-proposals during 2011 due to lack of political commitment.

4.1 Indirect policy issues

The European Commission has early 2007 established binding targets for RE implementation in the EU as such. This has been followed by binding targets for the member countries, but no technology specific targets have yet been set.

The Danish government has as previously mentioned – also early 2007 – set binding RE targets for the country for 2025 and later for up to 2050. However, few technology specific targets have been set and none for PV. The new energy plan accepted by parliament early 2012 does not set any targets for PV.

The extent to which these overall RE targets may stimulate the deployment of PV's in Denmark is very uncertain.

The EU Directive on energy in buildings has lead to obligatory building codes in the EU member states including Denmark. The revised Danish building codes were introduced in 2006, and were expected to promote PV's as PV's enter favourably into the calculation of a buildings energy "foot print". The building sector has proven to be quite "conservative", but in 2010 and in particular during 2011 architects, builders and developers reported increasing application of PV's due to the building codes with planned and known tightening up to 2020, i.e. new buildings are implemented in compliance with building codes only coming into force by 2015 and 2020.

4.2 Interest from electricity utility businesses

The Danish TSO Energinet.dk has for several years expressed interest in PV as a potential contributor to the electricity supply and in support of the electric grid. This interest has also been minted out via support channelled through the various relevant PSO support programmes. One example is the previously mentioned EU EcoGrid project encompassing many smart grid activities including 5 MW of PV.

The distribution utilities, notably EnergiMidt, have also promoted the use of PV, and in particular since 2009 several distribution utilities have included PV technology in their portfolio of products. EnergiMidt made for a couple of years use of a capital incentive to customers inside its service area, but is now marketing PV technology without any special support. Most distribution utilities simply regard PV as a relevant standard product and some offer finance packets and payment via the electricity bill.

Through its national federation Dansk Energi the Danish utilities in 2010 announced, that they will not charge PV system owners for the use of the grid (related to the use of the net-metering scheme), and several distribution utilities will not charge for the metering system needed to benefit from the net-metering scheme. However, these free services of the utilities can be expected to change to a fee-for-service scheme when the PV penetration reaches a certain so far unknown point.

4.3 Interest from municipalities and local governments

Municipalities and regions in Denmark have demonstrated a fast growing interest in PV technology. The main driver here is the climate plans and targets formulated by most municipalities, e.g. to aim for a CO_2 neutral community by a certain year. Municipalities then follow up with lighthouse demonstration of the PV technology by installing PV on the many municipal buildings such as schools, hospitals, kindergartens, homes for the elderly, etc. Many municipalities combine the PV demonstration systems with information campaigns

both targeting the citizens using the municipal buildings and the general public. The current net-metering scheme also includes PV on municipal buildings with some constraints as to ownership, size and application. These constraints are seen as serious barriers for PV deployment by several municipalities, and proposals to lift same barriers have been submitted to the government – so far without result.

The deployment of PV in a municipal context is expected to increase considerably in the coming years.

4.4 Standards and codes

Certification scheme for PV components and systems are established but in practice dormant; however revival of the scheme is expected to be imminent. Certification of installers is established and ongoing stimulated by EU requirements.

The aforementioned EU Directive on energy consumption in buildings has lead to national building codes in favour of BIPV. The revised Danish building codes has move into force early 2006 and includes a factor of 2,5 for BIPV when calculating the energy "foot print" of a building, see also section 4.2.

Grid codes are under revision in preparation of a high penetration of decentralized grid connected generators including PV. These grid codes are expected to reflect the existing German grid codes for the low respectively medium voltage networks, and are part of a holistic approach towards a smart grid system with 50% RE in the electricity supply by 2030 and 100% by 2050.

5 HIGHLIGHTS AND PROSPECTS

The existing net-metering scheme (bound by law) is getting more and more attractive driving the market for PV systems qualifying for the scheme. Sharply decreasing price of PV technology combined with increasing tariffs for electricity (mostly due to increasing taxes; by end of 2011 the tariff (retail price) including taxes was about 2,10 DKK/kWh) have since 2009 driven an accelerating annual market growth albeit from a very low starting point, and this trend is expected to continue. In 2011 the annual growth rate of the market was about 140%.

The revised national PV Strategy was published primo 2009, and a revision is soon needed to proper reflect the above development.

ANNEX A: COUNTRY INFORMATION

The following brief description of the Danish scene in which PV activities take place is based on the author's estimates and opinion.

The national electric grid covers practically all of Denmark and leaves little room for stand-alone applications besides the traditional low-power niche applications such as signalling, week-end cottages, garden lights, telemetry & telecommunication and urban furniture such as parking meters and information displays. In Greenland stand-alone PV's play a major role as power source for the telecommunication network extending more than 2 000 km along the west coast as well as for powering navigational aids.

Grid connected PV applications are seen as the largest potential in Denmark, in particular building integrated applications on single family houses, apartment buildings, municipal building, commercial and office buildings.

For private households and municipalities the retail price of electricity is constituted by a number of elements including various taxes and on top of everything 25 % VAT; by end of 2011 the average retail price of electricity for private households was around 2,10 DKK/KWh with certain variations across the country.

Commercial entities are sub-divided into several categories and can according to category avoid elements of the taxation of electricity.

Average household electricity consumption is estimated to 4 400 kWH/year, and for private households electricity is typically metered at a constant flat rate. Net-metering (allowing the meter to run "backwards") is permanently set by law for PV systems up to 6 kW and under certain conditions to prevent misuse. For municipal institutions 6 kW for each 100 m^2 of building area qualify for the net-metering scheme.

For single family houses PV roof-top systems are seen as an integrated part of the house with regard to taxing, insurance, mortgage etc. Typical mortgage interest is in the range of 2-5 % depending on type of loan.