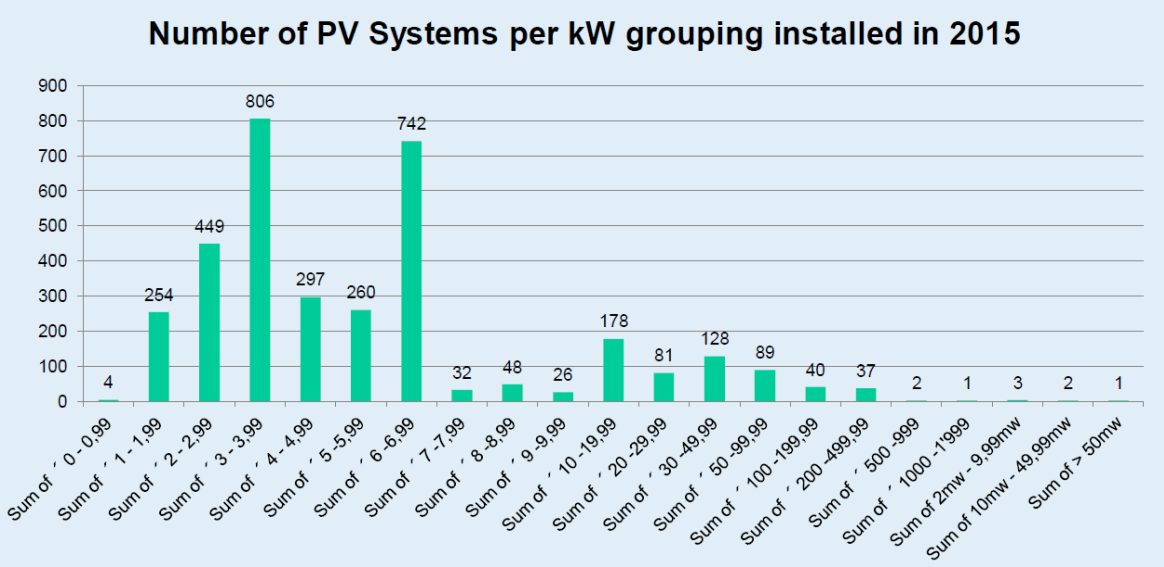
IEA INTERNATIONAL ENERGY AGENCY

National Survey Report of PV Power Applications in Denmark

2015



PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

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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 member countries

The IEA Photovoltaic Power Systems Technology Collaboration 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 participating countries and organisations can be found on the www.iea-pvps.org website.

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 2015. 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.

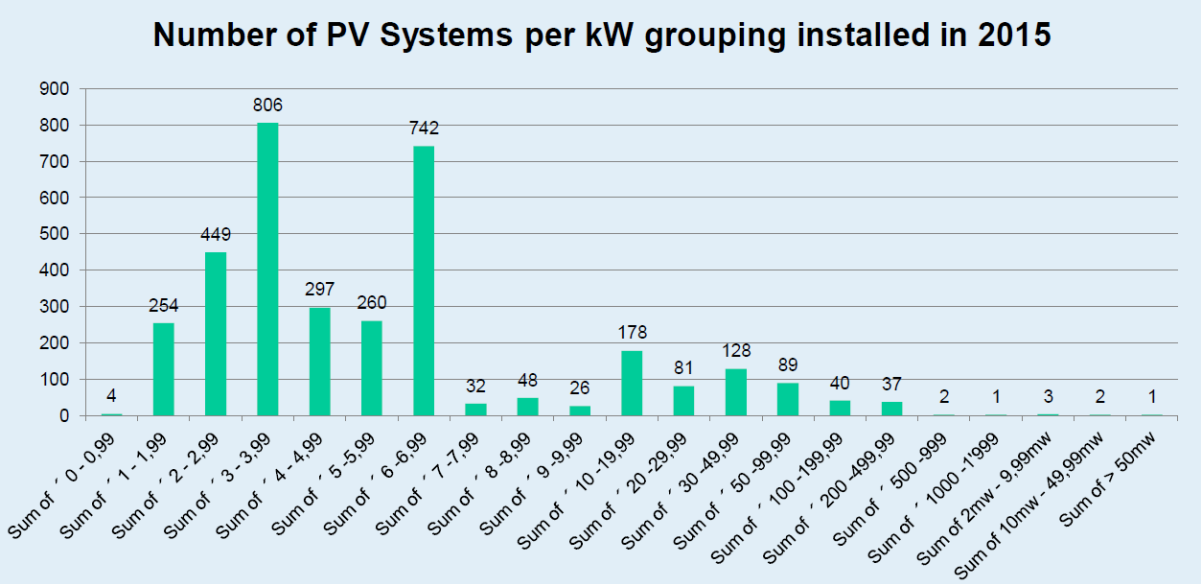
For the purposes of this report, **PV installations are included in the 2015 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2015, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

The main PV market in Denmark is BAPV and BIPV. Effective since late 2011 the Danish state owned TSO Energinet.dk (www.energinet.dk) registers all grid-connected PV systems, as it is mandatory for the installer responsible for the grid hook-up to report a number of technical details of each PV system including the time of grid hook-up or start of operation. The basic data in this database (in Danish) is as of early 2014 freely available at the above website.

Using this database as source it can be stated with a quite high degree of accuracy, that in 2012, the Danish PV boom year, 70.221 PV systems corresponding to 406,661 MW were put in operation. The similar figures for 2013 are 29.370 PV systems corresponding to 155,439 MW, and for 2014 only about 1.860 PV systems corresponding to 42,019 MW. In 2015 about 3.500 PV systems were installed corresponding to about 181 MW.

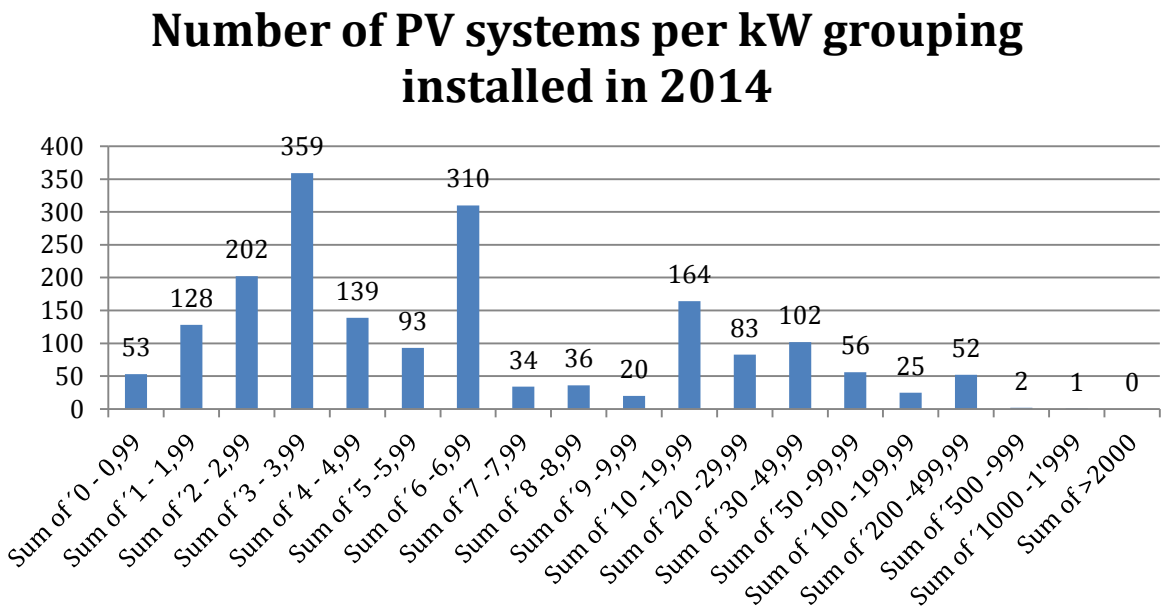
In order to try to analyze the market development the data for 2012 to 2015 have been sorted in number of PV systems per size, e.g. 0-1 kW, 1-2 kW, 2-3 kW etc. and in number of PV systems connected to the grid per month. The results are shown in the following 4 charts[1].

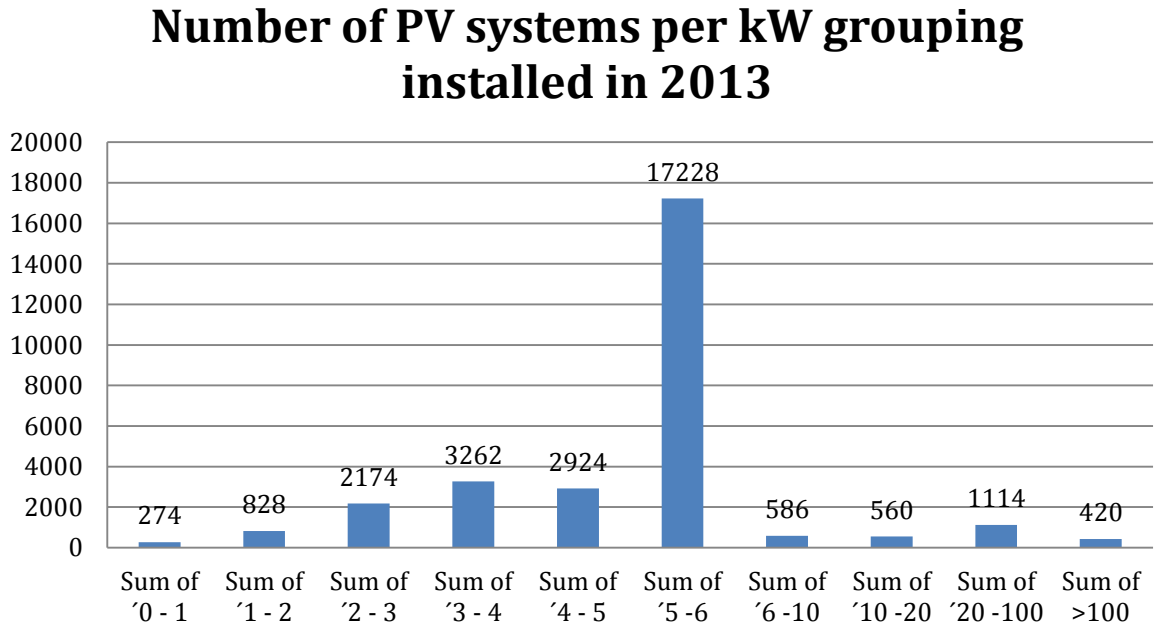


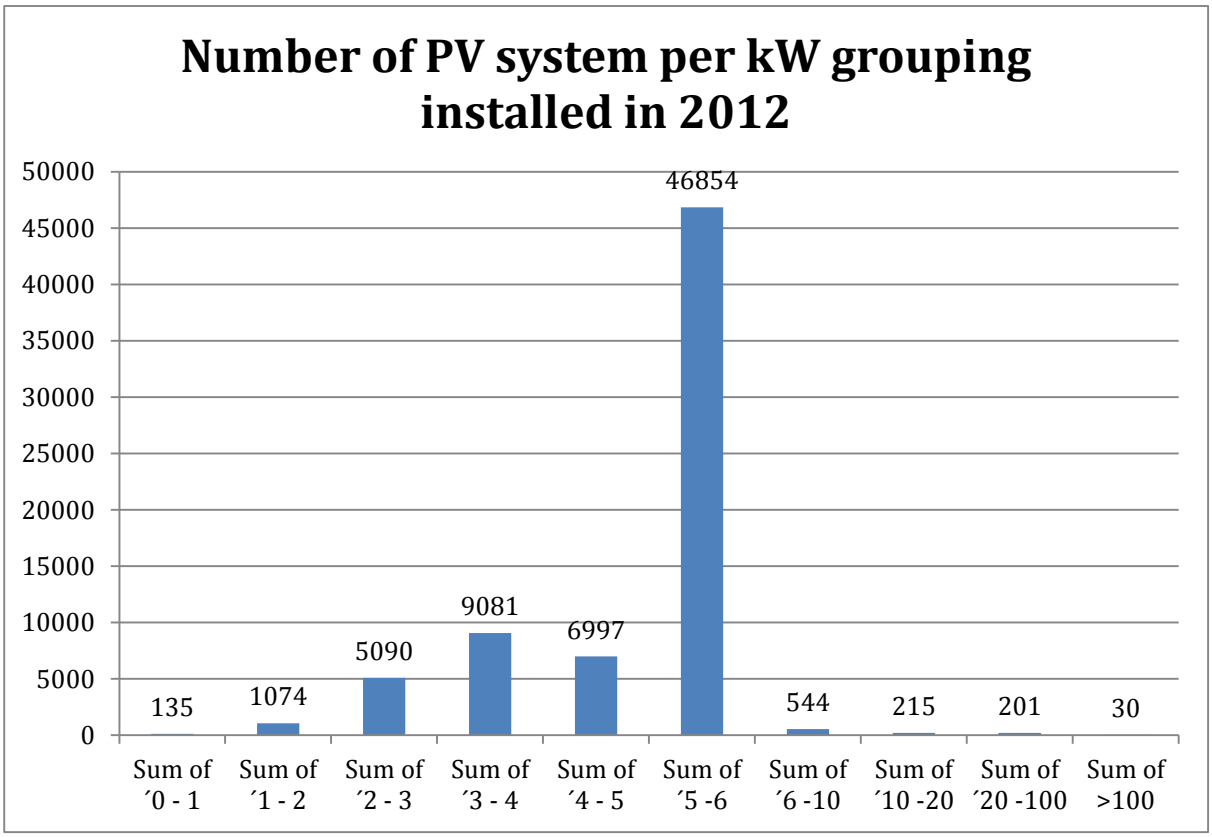
It should be noted, that in December 2015 five large scale PV farms ranging from 9 to 70 MW were registered in the above database in terms of about 340 sub-units of 400 kW driven by the FIT regulations of 2015. This is the first time Denmark experienced large scale PV farms. The above graph is the result of sorting the above database content of 400 kW installations as to

[1] The previous Danish National Survey Reports also included graphs showing the distribution of PV systems per month of registration; these graphs have been discontinued as they are regarded to be of little value.

postal code; it is assumed, that only one large scale PV farm is found per postal code, but of course there may be some uncertainty in this approach.







Looking at only four years interpretation of trends will be quite uncertain, but the writer believes the following observations to be pertinent:

- The Danish PV market has been disrupted in 2013 and 2014 as indicated above by the uncertainties of the actual feed-in-tariffs due to the dispute between Denmark and the European Commission (EC) on the current Public Obligation Service (PSO) system, which is base for most Danish support to electricity producing renewable energy technologies. This problem reached an interim solution early 2015, but needs to find a more permanent solution before end of 2016.
- The number of PV systems grouped by system size are grouped according to the PV panel maximum output (DC). The systems at 6-7 kW and below are typically BAPV installations on residential housing (roof-tops) with a concentration of systems at 6-7kW, and includes for 2012 almost 70.000 systems and for 2103 almost 27.000 systems. For 2014 and 2015 this trend has almost disappeared to be replaced by small (3 kW) systems indicating an increased focus on self-consumption for residential roof-tops. Self-consumption appears also to have driven the PV systems from >7 to 100 kW typically being BAPV and BIPV installations on commercial buildings; systems >100 kW are mostly BAPV installations again on large commercial buildings and as mentioned above in 2015 five large scale PV farms (ground mounted) ranging from 9 to 70 MW were registered all in the month of December and all in terms of about 340 sub-units of 400 kW driven by the 2015 FIT regulations.
- The dramatic reduction in number of systems from 2013 to 2014, in particular concerning residential roof-tops, and the emergence in 2015 of large scale PV farms are a clear consequence of a very political influenced market – both by domestic policies and the above mentioned dispute with the EC.
- The overall result of the rather panicky series of political changes in the support scheme for PV as mentioned above appears to be an increasing focus on PV system designed for a high degree of self-consumption both for the residential and the commercial market

sectors. For the residential sector a self-consumption ratio of 20-30 % appears possible, for the commercial sector a ratio of up to 40 % seems realistic. There is an increased interest in "behind-the-meter" storage to increase the self consumption rate. The increasing focus on self-consumption, and thus loss of revenue for the government (green taxes) and loss of revenue for the DSO's have lead to considerations of both a tax on the self-consumed electricity and a fee for the grid access of PV system owners, but no final decisions on these issues have been taken.

- It should be noted, that early in 2016 a dramatic increase in the number of applications for large scale PV farms were registered; some sources reported of up to 4,5 GW. The applications targeted the 17 year old FIT system for PV providing DKK 0,60 for the first 10 years and DKK 0,40 the following 10 years (€c 8,05, respectively €c 0,54). The PV technology had obviously reached a degree of maturity making the 17 year old FIT attractive to developers. The end result was a very fast political reaction cancelling the old FIT scheme on May 3 inside a few hours. So once again the PV development caught the Danish political/administrative system by surprise again resulting in panic reaction.

1.2 Total photovoltaic power installed

Table 1: PV power installed during calendar year 2015

AC			**MW installed in 2015 (mandatory)**	**MW installed in 2015 (optional but HIGHLY NEEDED)**	**AC or DC**
Grid-connected	BAPV	Residential	50		
		Commercial			DC
		Industrial			
	Ground-mounted	cSi and TF	131		DC
		CPV			
Off-grid		Residential	0,1		DC
		Other	0,2		DC
		Hybrid systems			
		Total	181,3		DC

Table 2: Data collection process:

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	
Is the collection process done by an official body or a private company/Association?	The state owned TSO
Link to official statistics (if this exists)	www.energinet.dk
	All grid connected PV systems must be registered at the TSO; off-grid is authors estimate

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

MW-GW for capacities and GWh-TWh for energy	2015 numbers	2014 numbers
Total power generation capacities (all technologies)	11 GW (est.)	11 GW
Total power generation capacities (renewables including hydropower)	6,5 GW (est.)	6 GW
Total electricity demand (= consumption)	31 TWh (est.)	32,8 TWh
New power generation capacities installed during the year (all technologies)	- 0,5 GW (est.)	- 0,4 GW
New power generation capacities installed during the year (renewables including hydropower)	0,5 GW (est.)	0, 5 GW
Total PV electricity production in GWh-TWh	788 GWh	613 GWh
Total PV electricity production as a % of total electricity consumption	2,5	1,8

NB: Significant international export/import of power over the year

Table 4: Other informations

	2015 Numbers (est.)
Number of PV systems in operation in your country (a split per market segment is interesting)	**105.000**
Capacity of decommissioned PV systems during the year in MW	**< 0,1**
Total capacity connected to the low voltage distribution grid in MW	**600**
Total capacity connected to the medium voltage distribution grid in MW	**75**
Total capacity connected to the high voltage transmission grid in MW	**130**

Table 5: The cumulative installed PV power in 4 sub-markets (MW $_{DC}$).

Sub-market	Stand-alone domestic	Stand-alone non-domestic	Grid-connected distributed	Grid-connected centralized	Total
2005	0,1	0,2	2,4	0	2,6
2006	0,1	0,2	2,6	0	2,9
2007	0,1	0,3	2,7	0	3,1
2008	0,1	0,3	2,8	0	3,2
2009	0,2	0,4	4	0	4,6
2010	0,2	0,5	6,4	0	7,1
2011	0,3	0,5	15,9	0	16,7
2012	0,5	0,5	406,7	0	407,8
2013	0,6	0,9	556,8	5	563,3
2014	0,7	1,1	595,8	8	605,6
2015	0,8	1,4	645,8	131	786,6

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Table 6: Typical module prices for a number of years (DKK/W)

Year	2009	2010	2011	2012	2013	2014	2015
Standard module crystalline silicon price(s): Typical	15-25	10-15	8-12	6-10	5-10	4-9	3-7

2.2 System prices

Table 7: **Turnkey Prices of Typical Applications (DKK/W)**

Category/Size	Typical applications and brief details	Current prices per W
OFF-GRID Up to 1 kW	Telemetry, navigational aids, information displays, etc.	15-30
OFF-GRID >1 kW	Professional remote, telecommunication, etc.	20-45
Grid-connected Rooftop up to 10 kW (residential)	Residential roof-tops	10-18
Grid-connected Rooftop from 10 to 250 kW (commercial)	BAPV/BIPV	9-16
Grid-connected Rooftop above 250kW (industrial)	BAPV/BIPV	8-13
Grid-connected Ground-mounted above 1 MW	Only 8 plants (price commercial secret – estimates)	5-9
Other category (hybrid diesel-PV, hybrid with battery…)	None	

Table 8: National trends in system prices (current) for different applications (DKK/W)

Price/Wp	2008	2009	2010	2011	2012	2013	2014	2015
Residential PV systems < 10 KW	35-45	25-40	20-30	18-25	15-25	12-20	11-19	10-18

2.3 Cost breakdown of PV installations

It appears not possible to obtain this information for obvious commercial reasons. Even the members of the Danish PV Association (DSF) are reluctant to provide this degree of detail.

2.3.1 Residential PV System < 10 kW

Table 9: Cost breakdown for a residential PV system (DKK/W)

No reliable data.

2.3.2 Utility-scale PV systems > 1 MW

Table 10: Cost breakdown for an utility-scale PV system (DKK/W)

No reliable data.

2.4 Financial Parameters and specific financing programs

Table 11: PV financing scheme

Average rate of loans – residential installations	1-3 (mortgage)
Average rate of loans – commercial installations	2-5
Average cost of capital – industrial and ground-mounted installations	No data

2.5 Specific investments programs

There are no specific acquisition or leasing programmes.

2.6 Additional Country information

able 12: Country information

Retail Electricity Prices for an household (range)	DKK 2,25 – 2,45 /kWh
Retail Electricity Prices for a commercial company (range)	DKK 1,65 – 1,85/kWh
Retail Electricity Prices for an industrial company (range)	DKK 0,75 – 1,20/kWh
Population at the end of 2014 (or latest known)	5,6 mio
Country size (km^2)	44.000
Average PV yield (according to the current PV development in the country) in kWh/kWp *)	~900 kWh/kW (max. 950)
Name and market share of major electric utilities.	http://www.danishenergyassociation.com/

*) most systems are South oriented. However, with the increased focus on self consumption more East-West oriented systems are coming up reducing the average PV yield; statistics not yet available.

3 POLICY FRAMEWORK

Renewable energy is not only a future option, but very much a present and considerable element in the Danish energy supply: by end of 2015 more than 44 % of the national electricity consumption was generated by renewable energy sources including incineration of waste. Ongoing research, development and demonstration of new energy solutions including renewable energy sources have high priority in the government's energy plan, the main objectives being the development of a future environmental benign energy system completely free of fossil fuels; however, same government has removed the operational targets in the energy plan.

Denmark has no unified national PV programme, but a number of projects supported mainly by the Danish Energy Authority's EUDP programme and via the Public Service Obligation (PSO) of Danish transmission system operator, Energinet.dk, a fully government owned body, e.g. the ForskEL programme mainly D&D promoting green electricity. A couple of public funds also support PV related projects, mainly supporting market entrance.

Since the boom year of 2012 the regulatory framework for PV in Denmark has been characterized by a series of quick and ad hoc political decisions and regulations as the political/administrative system tried to keep the deployment of PV in check, but the fast technical and economic development repeatedly kept surprising the decision makers leading to haphazard interventions and a growing market uncertainty.

PV electricity is officially recognized as less costly than electricity from off-shore wind and increasingly more and more competitive with other sources. In an answer to the parliaments Energy Commission the minister responsible for energy early May 2016 said, that PV electricity received in real terms public support of DKK 0,13-0,14/kWh; this is the same as for on-shore wind electricity. Off-shore wind produced electricity can receive public support of DKK 0,22 -0,40/kWh indicating the level of competitiveness of PV.

However, the above mentioned track record of haphazard interventions appears to have left PV giving "a bad taste" for decisions makers.

A new national PV Strategy was developed during 2015 and published in February 2016; the impact of this PV Strategy is not yet clear.

3.1 Direct support policies for PV installations

3.1.1 New, existing or phased out measures in 2015

3.1.1.1 Description of support measures excluding BIPV, and rural electrification

The standard support measures during 2015 included a FIT of DKK 0,60/kWh for 10 years followed by DKK 0,40/kWh for the next 10 years. (This scheme was suspended in May 2016 in another "panic" reaction). Besides the standard support measure capped lots of PV for different applications have been offered during 2015 with a higher FIT of approx. DKK 1/kWh; the actual FITs are reduced from offer to offer. The success of these offers has been very limited leading to a build-up of unused offers. The main reason for the lack of success is the complex administrative procedures linked to the offers.

3.1.1.2 BIPV development measures

There are presently no direct support measures for BIPV. However, the building codes promote the use of BIPV in new buildings and at major refurbishments.

3.1.1.3 Rural electrification measures

N.a.

3.1.1.4 Support for electricity storage and demand response measures

There are presently no support measures for electricity storage and DSM, but R&D projects in these areas are ongoing.

Table 13: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2015 - residential	On-going measures Commercial + industrial	Measures that commenced during 2015 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2015 – ground mounted
Feed-in tariffs	Yes	No	Yes	No	Yes	No
Feed-in premium (above market price)	Yes for capped lots	Yes for capped lots	No	No	Yes interim scheme	No
Capital subsidies	No	No	No	No	No	No
Green certificates	No	No	No	No	No	No
Renewable portfolio standards (RPS) with/without PV requirements	No	No	No	No	No	No
Income tax credits	No	No	No	No	No	No
Self-consumption	Yes	No	No	No	No	No
Net-metering	(Yes)	No	No	No	No	No
Net-billing	No	No	No	No	No	No
Commercial bank activities e.g. green mortgages promoting PV	No	No	No	No	No	No
Activities of electricity utility businesses	Yes	No	No	No	No	No
Sustainable building requirements	Yes	No	No	No	No	No
BIPV incentives	No	No	No	No	No	No

3.2 Self-consumption measures

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Retail price of electricity

	3	Charges to finance Transmission & Distribution grids	Not yet, but under way
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Standard FIT
	5	Maximum timeframe for compensation of fluxes	1 hour
	6	Geographical compensation	None
Other characteristics	7	Regulatory scheme duration	None
	8	Third party ownership accepted	No
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Not yet, but under way
	10	Regulations on enablers of self-consumption (storage, DSM…)	None
	11	PV system size limitations	No
	12	Electricity system limitations	No
	13	Additional features	-

3.3 Tenders, auctions & similar schemes

At the end of 2015 it was discussed politically to launch a pilot tender scheme of 20 MW for relative large scale ground based PV systems up to 2,3 MW, the intention being to clear up the "real cost of PV electricity". Early 2016 the tender scheme was implemented and it was opened for bids from Germany in order to comply with the EU state support regulations. Later Germany has opened its tender scheme for Danish bids.

The pilot tender scheme is so far a one off.

3.4 Direct Support measures

3.5 Financing and cost of support measures

Financing of support to renewable energy R&D&D and deployment has for several decades been carried out as a Public Service Obligation (PSO) levy on all electricity sold. This way the funding has been independent of the state budget. In 2014 the EC pointed out, that the Danish PSO scheme was in conflict with the EU state support regulations as only Danish entities could benefit, and it was agreed between the EC and the Danish government, that a solution should be found before end of 2016. By mid 2016 the government has proposed to give up the PSO scheme and use the state budget instead, but this proposal is still in the political process.

3.6 Indirect policy issues

There is an ongoing and increasing conflict between climate and energy policy and the resulting loss of revenue for the government due to both conservation and green generation. DSO's face a similar conflict providing grid access to customers buying less and less electricity.

Discussions at the political level continues, but no clear cut solutions can be seen.

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

During 2015 R&D efforts in the fields of organic dye sentizised 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 2015 involving industry including a screen printing company. 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, however no firm data on this is available. Also the Technical University (DTU) carries out basic R&D in mono-X Si cells.

R&D of a novel approach to manufacturing of solar grade silicon has been initiated.

A small R&D&D programme targeting BIPV was agreed by end of 2012 with a first call-for-proposals in the first half of 2013. Additional calls went out in early 2014 and again in early 2015. This programme is now discontinued, but projects are still running and new BIPV products and solutions are emerging.

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

Table 14: Public budgets for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/Field test
National/federal	Approx. DKK 30 mio	Approx. DKK 25 mio
State/regional	-	-

5 INDUSTRY

5.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

There is no commercial crystalline silicon manufacturing industry in Denmark.

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. Several investors have announced commercial interest in PV farms in and outside Denmark, but no details are available.

5.2 Production of photovoltaic cells and modules (including TF and CPV)

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 9 below.

Table 16: Production and production capacity information for 2014

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
Thin film manufacturers none					
Cells for concentration none					
TOTALS		**-**	**2**	**-**	**2,5**

NB. No information on company Racell.

Gaia Solar produces 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.

Modules are exported, although in limited numbers – mostly custom designed modules.

Company Racell develops and has limited production of large-scale (7-8 m^2) PV-T modules.

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.

5.3 Manufacturers and suppliers of other components

Balance of system component manufacture and supply is an important part of the PV system value chain. For 2015 the situation in Denmark is briefly described below.

The company Danfoss produces modular inverter systems, but no detailed information is publicly available on technology, performance, volume and prices. Danfoss has entered into formal collaboration with the German based inverter manufacturer SMA and sales and services of Danfoss PV inverter products are carried out by SMA .

The company Grundfos produces its special variable frequency inverter system for its RE powered range of water pumping systems. However, no detailed information is publicly available on technology, performance, volume and prices except for general information on the company website.

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 reported to be looking into development and manufacturing of support structures and trackers.

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

6 PV IN THE ECONOMY

6.1 Labour places

a) Public research and development (not including private companies): 30

b) Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D:
200

c) All other, including within electricity companies, installation companies etc.: 300

Information on labour places is based on the author's best estimate - no official statistics available. Table 17 on labour places cannot be completed due to lack of data.

Table 17: Estimated PV-related labour places in 2014

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	

6.2 Business value

Total business value for 2015 is estimated by the author, no solid data available, to about half a billion DKK, but this is only the authors own estimate.

Table 18 on business value cannot be completed due to lack of reliable data.

Table 18: Value of PV business

Sub-market	**Capacity installed *in 2014* (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				*e*
Change in stocks held				*f*
Import of PV products				*g*
Value of PV business				***a+b+c+d+e+f-g***

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

The transmission systems for power and gas are operated by the state owned TSO, Energinet.dk, see http://www.energinet.dk/EN/Sider/default.aspx .

The DSO's are mostly owned by the consumers as cooperatives, but a few commercial DSO's can also be found. The DSO's are organized in an association, see http://www.danishenergyassociation.com/.

The government regulator controls the pricing of electricity and the margins and accumulated wealth of the DSO's. The DSO's are by law obliged to contribute to energy conservation and has at present a target of 3 % energy conservation per year; if the target is not met the DSO's are fined. The DSO's have full (commercial) freedom how to implement the conservation targets.

7.2 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 EU EcoGrid project encompassing many smart grid activities including up to 7 MW of PV providing a local PV penetration of around 17 % in the grid of the island of Bornholm. Energinet.dk has published reports on PV in the Grid System and PV & Batteries, both with forecast up to 2040. The main message is, that from the point of view of a

TSO there should be no major problem in accommodating 6-8 GW of PV in the Danish grid system. A further message is, that PV and wind complement each other.

The distribution utilities, notably EnergiMidt, have also promoted the use of PV and has included the technology in its business portfolio, 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 access to 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 are now in the process of changing to a fee-for-service scheme as the Danish regulator has found this free service in principle illegal; Dansk Energi is now reported to be working on recommendations to its members on such a fee and issued a first proposal early 2015; this proposal was however quickly withdrawn following a lot of criticism from a wide range of stakeholders and a revised proposal is expected in 2016.

7.3 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. PV on municipal buildings are faced with significant 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 any result.

The deployment of PV in a municipal context has been capped at an additional 20 MW up to 2020, if the involved municipalities want to benefit from the special regulations and higher FIT in force for municipal PV systems. If not municipalities are forced to created one administrative operational unit per PV system making municipal PV systems an administrative nightmare, and many municipalities have had to cancel otherwise planed PV installations on schools, kindergartens and administrative facilities.

8 HIGHLIGHTS AND PROSPECTS

The former net-metering scheme was getting more and more attractive driving the market for PV systems qualifying for the scheme; explosive growth in roof-tops during 2012 was seen. The long term market impact of the revised net-metering scheme and its associated transitory measures are not known yet. However, although the market is reported to suffer severely from the uncertainties and lack of European Commission notification (approval) following the net-metering changes effected November 20 2012 up to June 2013, in practice the market almost froze at about 43 MW in 2014 with an increase up to 181 MW in 2015 of which about 125 MW was utility scale ground based PV farms.

Following the settlement of the aforementioned dispute between Denmark and the EC on the PSO scheme the Danish Energy Agency early 2015 opened up for additional FIT at the level of DKK 1,03/kWh for a total window of 60 MW distributed on 4 main areas of applications and

with a rather complicated range of constraints. As mentioned previously this new approach has been found overly complicated by many potential end users, and very few applications have been received and approved leading to a build-up of unused lots.

Early 2016 the PV development reached a point, where the 17 year old standard FIT of DKK 0,60/kWh for 10 years and DKK 0,40/kWh the nest 10 years became attractive for developers, and applications for up to 4,5 GW was received. This lead to a panic reaction from the side of the government, which inside a few hours cancelled the standard FIT scheme again creating serious uncertainty in the PV market.

A revised national PV Strategy was published primo 2009, and a revision has in spring 2015 been decided by the Danish Energy Agency to proper reflect the very fast technical and economic development of PV. Furthermore the Danish minister of Climate. Energy and Buildings announced in the parliament during spring 2015, that "PV electricity now was cheaper than electricity from off-shore wind". . In an answer to the parliaments Energy Commission the minister responsible for energy early May 2016 said, that PV electricity received in real terms public support of DKK 0,13-0,14/kWh; this is the same as for on-shore wind electricity. Off-shore wind produced electricity can receive public support of DKK 0,22 -0,40/kWh indicating the level of competitiveness of PV.

However, the above mentioned track record of haphazard interventions appears to have left PV giving "a bad taste" for decisions makers despite growing competitiveness.

However, a new more long term political energy plan is under preparation, and hopefully this new plan will recognize the potential of PV also for Denmark.

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