IEA INTERNATIONAL ENERGY AGENCY

Forskningsrådet

IEA-PVPS

National Survey Report of PV Power Applications in Norway

2016

PVPS

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 2016. 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 2016 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2016, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

The market for PV in Norway is split between of grid-connected systems and PV to off-grid applications . The main driver for the grid-connected segment is high environmental goals set by property developers who want energy efficient buildings or operations to reduce the amount of energy from the grid. The off-grid market is expanded from small systems with 12 V DC battery only to larger hybrid systems with larger battery-capacities, diesel or petrol back-up generators and electrical conversion to 230 V AC.

1.2 Total photovoltaic power installed

Totally 11,4 MWp was installed in 2016, which is 366% more than the volume installed in 2015. This strong growth happens despite low prices for retail electricity combined with weak and fragmented support-schemes for PV. However, some of the capacity realized in 2016 was probably planned for the previous year when the market development suffered from uncertainties related to the legal framework for prosumers ('Plusskundeordningen') and their right to receive the production-premium Renewable Energy Certificates, RECS ('Elsertifikater'). This uncertainty was removed in January 2016 when the right to receive RECS for solar power prosumers was confirmed.

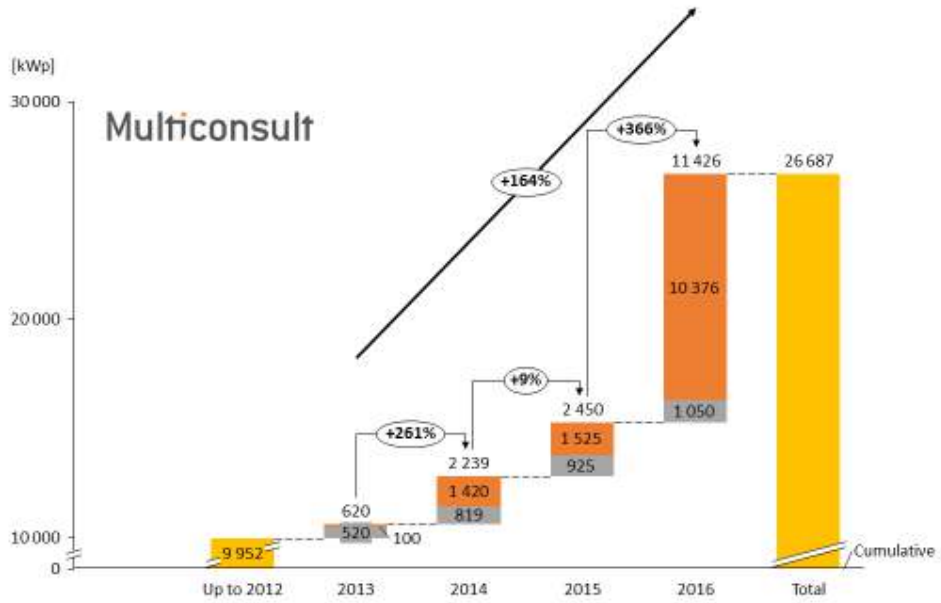

Table 1: PV power installed during calendar year 2016

AC			MW installed in 2016 (mandatory)	MW installed in 2016 (optional but HIGHLY NEEDED)	AC or DC
Grid-connected	BAPV	Residential	10,4	3,0	DC
		Commercial		7,4*	DC
		Industrial		0,0*	DC
	BIPV (if a specific legislation exists)	Residential	NA		
		Commercial			
		Industrial			
	Ground-mounted	cSi and TF	NA		
		CPV			
Off-grid		Residential	1,0	1,0	
		Other	0,05	0,05	
		Hybrid systems			
		Total	11,4		DC

*A significant share of the commercial installations is on roofs of large industrial buildings

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?	Multiconsult
Link to official statistics (if this exists)	https://www.ssb.no/energi-og-industri/statistikker/elektrisitet/aar https://www.nve.no/energiforsyning-og-konsesjon/energiforsyningsdata/
	The main sources of the market data are the suppliers of PV-systems and equipment

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

GW for capacities and TWh for energy	2016 numbers	2015 numbers
Total power generation capacities (all technologies)	33,808	33,837
Total power generation capacities (renewables including hydropower)	32,700	32,239

Total electricity demand (= consumption)	132	129
New power generation capacities installed during the year (all technologies)	0,433	0,141
New power generation capacities installed during the year (renewables including hydropower)	0,433	0,141
Total PV electricity production in GWh	21	12
Total PV electricity production as a % of total electricity consumption	0,016	0,009

Table 4: Other informations

	2016 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	NA
Capacity of decommissioned PV systems during the year in MW	NA
Total capacity connected to the low voltage distribution grid in MW	13,6
Total capacity connected to the medium voltage distribution grid in MW	0
Total capacity connected to the high voltage transmission grid in MW	0

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

Cumulative installed PV power in 4 sub-markets	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Stand-alone domestic	6,4	6,8	7,2	7,5	7,8	8,1	8,4	8,8	9,3	9,8	10,5	11,3	12,1
Stand-alone non-domestic	0,4	0,4	0,4	0,4	0,4	0,5	0,5	0,5	0,5	0,5	0,6	0,7	0,9
Grid-connected distributed	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,2	0,3	1,7	3,2	13,6
Grid-connected centralized	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total [MW]	6,9	7,3	7,7	8,0	8,3	8,7	9,1	9,5	10,0	10,6	12,8	15,3	26,7

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Not Available.

Table 6: Typical module prices for a number of years

Year	1992					2015	2016
Standard module crystalline silicon price(s): Typical							NA
Lowest prices							NA
Highest prices							NA

2.2 System prices

System prices collected from system suppliers serving the Norwegian market. The system prices show large variations, and the referred are average prices excluding VAT. VAT of 25% is added to sales-cost to be paid by the end-user.

Table 7: **Turnkey Prices of Typical Applications – local currency (NOK)**

Category/Size	Typical applications and brief details	Current prices per W
OFF-GRID Up to 1 kW		30-150
OFF-GRID >1 kW		45-150
Grid-connected Rooftop up to 10 kW (residential)		15
Grid-connected Rooftop from 10 to 250 kW (commercial)		14
Grid-connected Rooftop above 250kW (industrial)		12
Grid-connected Ground-mounted above 1 MW		NA
Other category (hybrid diesel-PV, hybrid with battery…)		

Off-grid systems offered as complete packages for mountain-cabins normally include batteries, charging controls, modules and mounting-equipment, and may in addition include cables, connectors, lighting-equipment and so forth. There is a growing market for larger capacities, with hybrid solutions, which may include transformation to 230 V and other components such as micro wind-turbines and diesel-generators. Large price-variance from small 'do-it-yourself' packages with PV-module, regulator, battery, cabling to larger 'power-systems' including 230V-inverter and gen-set.

Table 8: National trends in system prices (current) for different applications – local currency

Price/Wp	1992		2011	2012	2013	2014	2015	2016
Residential PV systems < 10 KW			40-60	20-30	21	20	18	15
Commercial and industrial				15-20	15	16	15	14
Ground-mounted *					12	13	13	12

* There's no ground-mounted installations, so these prices reflects the level for large (>250 kW) industrial flat-roof installations.

Increasing competition drives the prices downwards for all applications. Small residential systems show variations between 21 and 9 NOK/W. Commercial and industrial roof-mounted systems show variation between 17 and 11 NOK/W. In 2016 some large industrial systems exceeded 1MW. The prices obtained for these are not statistical relevant, but such large systems will likely cost around 10 NOK/W.

2.3 Cost breakdown of PV installations

Cost breakdown data is not available.

2.3.1 Residential PV System < 10 kW

Table 9: Cost breakdown for a residential PV system – local currency

Cost category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module			
Inverter			
Other (racking, wiring…)			
Soft costs			
Installation			
Customer Acquisition			
Profit			
Other (permitting, contracting, financing…)			
Subtotal Hardware			
Subtotal Soft costs			
Total			

2.3.2 Utility-scale PV systems > 5 MW

Table 10: Cost breakdown for an utility-scale PV system – local currency

Cost Category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module			
Inverter			
Other (racking, wiring, etc.)			
Soft cost			
Installation Labor			
Customer acquisition			
Profit			
Other (contracting, permitting, financing etc.)			
Subtotal Hardware			
Subtotal - Soft cost			
Total Installed Cost			

2.4 Financial Parameters and specific financing programs

Table 11: PV financing scheme

Average rate of loans – residential installations	2-3% *
Average rate of loans – commercial installations	2-4% *
Average cost of capital – industrial and ground-mounted installations	4-5% **

*There is no specific PV financing schemes, and most installations are likely financed by normal real estate bank loans. The interest rate for these loans vary with the size of the loan, the equity-share etc.

** post tax

2.5 Specific investments programs

Some companies are offering leasing-contracts to both domestic and commercial customers. The companies take care of all planning, financing and installation, and the customer are typical paying a fixed price per kWh for the PV-electricity over 20-25 years. The companies offering the leasing typical cooperates with installers and finance-institutions.

Third Party Ownership (no investment)	Yes (leasing)
Renting	
Leasing	Yes
Financing through utilities	Yes
Investment in PV plants against free electricity	
Crowdfunding (investment in PV plants)	
Other (please specify)	

2.6 Additional Country information

Table 12: Country information

Retail Electricity Prices for an household (range) NOK/kWh (incl.VAT)	0,385 excl. taxes and distribution cost 0,50 – 1,00 including taxes and distribution	
Retail Electricity Prices for a commercial company (range) NOK/kWh	0,26-0,36**	
Retail Electricity Prices for an industrial company (range) NOK/kWh	0,30 -0,31	
Population January 1st 2017	5 258 317	
Country size (km^2)	323 772	
Average PV yield (according to the current PV development in the country) in kWh/kWp	800	
Name and market share of major electric utilities.	Grid owners: Hafslund, Agder Energi, Skagerak, BKK, Lyse, Eidsiva, Trønder Energi, Fortum, NTE, Troms Kraft, Glitre, Fredrikstad Energi etc. Power Producers: Statkraft, E-Co, Hydro, Lyse Produksjon, NTE, Trønderenergi, Glitre,	

*The electricity price consists of three parts: electricity, grid, and taxes with large seasonal variation as well as significant variation from year to year as shown via this link: https://www.ssb.no/energi-og-industri/artikler-og-publikasjoner/stromprisene-oker-for-husholdningene

**Electricity contract price excluding taxes and distribution cost(Ref: https://www.ssb.no/statistikkbanken/selectvarval/Define.asp?subjectcode=&ProductId=&MainTable=KraftSluttbrukB&nvl=&PLanguage=0&nyTmpVar=true&CMSSubjectArea=energi-og-industri&KortNavnWeb=elkraftpris&StatVariant)

3 POLICY FRAMEWORK

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

3.1 Direct support policies for PV installations

3.1.1 New, existing or phased out measures in 2016

3.1.1.1 Description of support measures excluding BIPV, and rural electrification

With nearly all power-production from hydropower, Norway has not defined any national goals when it comes to implementation of PV technology.

Enova SF, a public agency owned by the Ministry of Petroleum and Energy, was established in 2001 as an instrument to improve energy system efficiency and increase renewable energy production. Enova offers support schemes in the areas in which the greatest effect in the form of saved, converted, or generated clean energy can be achieved.

In 2015 Enova introduced a new right-based support for a range of energy efficient technologies for households including PV. PV is supported with 35% of the investment within an upper support-limit of 10 000 NOK, plus 1250 NOK per kWp for systems up to maximum 15 kWp. Only private households are eligible for this support. Depending on the system-size and price, the support will typically be in the range 10% to 30%.

For commercial buildings, Enova has several support programs which may include support also for PV. The most relevant program supports New Innovative Technologies, systems and new type of combinations not demonstrated in the Norwegian market before, and is focusing on BIPV-solutions.

For the commercial building segment, some of the projects that Enova supported under the demonstration support program in 2016 was so-called “plus energy buildings” or “Near-Zero or Zero Emission Buildings” in which the use of PV was a central part of the concept among several other energy-efficiency measures.

New renewable power generation capacity from wind and hydropower will receive support from the Nordic el-certificate market. This bilateral agreement and common market for Renewable Electricity Certificates (RECS) between Norway and Sweden was established in 2012, but it is not designed to take PV-systems into account. The RECS-market has a minimum entrance fee of minimum NOK 15 000,- (~1850 €) which is an effective barrier for small PV-systems. RECS are traded with floating prices and is at the moment worth 0,13 NOK/kWh (~1,4 €c/kWh). During 2015 the market development suffered from uncertainties related to the legal framework for prosumers (‘Plusskundeordningen’) and their right to receive the production-premium Renewable Energy Certificates, RECS (‘Elsertifikater’).

The regulator, the Norwegian Water Resources and Energy Directorate (Norges vassdrags- og energidirektorat, NVE) framed a proposal which would only issue RECS for the amount of electricity actually fed to the grid, and not for the amount of PV-production that is self-consumed behind the energy meter. In November 2015, the Parliament instructed NVE to write a new proposal ensuring that PV-plants can recieve el-certificates for the total production. Because of this, the market for PV on large commercial and industrial buildings halted during 2015, but showed strong growth in 2016, probably partly influenced by delayed realization of plants planned in 2015.

For households in Oslo the climate-fund of the municipality of Oslo extended a limited demonstration-project with 40% investments support for PV. The budget for this project was increased by 2 mill.NOK to 8 mill.NOK totally in 2016.

3.1.1.2 BIPV development measures

Environmental qualities or aspects seem to become an increasingly important market parameter for stakeholders in the Norwegian building and construction sector. Enova has a strong focus on energy efficient buildings. BIPV and innovative energy solutions can be included in projects that can obtain support for a portion (normally in the range 20-50%) of the extra cost for energy qualities beyond the required building standard. More information about Enova and the annual report for 2016 can be found here: https://www.enova.no/om-enova/kampanjer/arsrapport-2016/

3.1.1.3 Rural electrification measures

NA

3.1.1.4 Support for electricity storage and demand response measures

As for BIPV, Enova supports ambitious building-projects that are testing new and innovative energy solutions such as batteries and DSM-solutions. Projects can obtain support for a portion (normally in the range 20-50%) of the extra cost for energy qualities beyond the required building standard.

Table 13: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2016 - residential	On-going measures Commercial + industrial	Measures that commenced during 2016 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2016 – ground mounted
Feed-in tariffs						
Feed-in premium (above market price)						
Capital subsidies	Enova-subsidies in the range 10-30% of a PV-investment.		Enova-subsidies of BIPV and innovative energy solutions in the range of 20-50% of additional cost.			
Green certificates	(RECS) High entrance fee		RECS High entrance fee		RECS High entrance	

	a barrier for PV. So far, no PV-plant in this category is registered for RECS.		a barrier for PV. So far, only a few PV-plants are registered for RECS.		fee a barrier for PV. So far, no ground-mounted PV-plant is built.	
Renewable portfolio standards (RPS) with/without PV requirements						
Income tax credits						
Self-consumption						
Net-metering						
Net-billing						
Collective self-consumption and virtual net-metering						
Commercial bank activities e.g. green mortgages promoting PV						
Activities of electricity utility businesses						
Sustainable building requirements						
BIPV incentives						
Other (specify)						

3.2 Self-consumption measures

Self-consumption is allowed for residential plants under the 'Plus-customer scheme' (Plusskundeordningen) provided that the customer is a net consumer of electricity on a yearly basis. During 2016 the Plus- customer scheme was voluntary for the utilities, but from January 1st 2017 this became a compulsory scheme for the grid operators / utilities.

Under this scheme the utilities handles the transactions related to the power fed to the grid from distributed micro-generators such as PV-systems. PV-electricity fed to the grid is compensated by the current hourly spot-price in the power-market Nordpool (http://nordpoolspot.com/).

The Nordic electricity market has split power and grid cost and taxes are added for end-use. Electricity fed in to the grid is hence given an energy sur-charge based on marginal losses in the grid. This charge could be even positive or negative (+/- 0,5 €c/kWh). Normally this means additional compensation for distributed PV because distributed production reduces the marginal losses related to power transmission and distribution.

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Avoided cost of electricity from the grid (including grid-cost and taxes).
	3	Charges to finance Transmission & Distribution grids	Tariff for marginal losses (cost or income)
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Yes, normally the hourly spot-price
	5	Maximum timeframe for compensation of fluxes	
	6	Geographical compensation	
Other characteristics	7	Regulatory scheme duration	
	8	Third party ownership accepted	Yes
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Minimum NOK 15 000 registration fee for RECS
	10	Regulations on enablers of self-consumption (storage, DSM…)	
	11	PV system size limitations	Maximum 100 kW injected into the grid from 'Plus-customers'. (i.e. production – consumption < 100 kW)
	12	Electricity system limitations	
	13	Additional features	

3.3 Collective self-consumption, community solar and similar measures

Condominiums can install jointly-owned PV-systems and each of the apartments / households can be 'Plus-customers' under the revised Plus-customer scheme. This will be implemented in the new automatic reporting system for power-consumption (Elhub). (https://www.nve.no/nytt-fra-nve/nyheter-elmarkedstilsyn/enklere-a-produsere-strom-selv/)

3.4 Tenders, auctions & similar schemes

NA

3.5 Financing and cost of support measures

Enova is financed via funds allocated from the Energy Fund. These funds must be used in as cost effective way as possible in order to achieve the goals that the authority sets.

The Energy Fund is financed via a small additional charge to electricity bills of 0,01 NOK/kWh. In addition, the Energy Fund has been allocated the proceeds from "The “Green Fund for Climate, Renewable Energy and Energy Efficiency Measures”. Enova invested 2,3 Billion NOK in 2016.

Elcertificates

From January 1st 2012 Norway and Sweden have had a common market for elcertificates. An elcertificate is an electronic document granted to producers of new renewable electricity for each MWh they produce. Hence this gives a surplus income on top of the spot-price per kWh produced by renewable energies. The support-scheme is financed by the consumers. Most consumers with some defined exceptions are obliged to buy a specific amount of elcertificates each year. Within year 2020, the target for this support scheme is to increase renewable energy production in Norway and Sweden with 28,4 TWh.

3.6 Indirect policy issues

All households will get new smart (two-ways) energy meters installed within 2019. The new meters will register the consumption on an hourly basis and communicate metering data automatically to the system operator. The customer will get access to clear information of power consumption and prices and the meters can also enable additional functionality and services. Differentiated power distribution tariffs are used for commercial large customers, and they are under preparation also for households, but not implemented fully yet.

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

The Research Council of Norway (RCN) is the main agency for public funding of research in Norway. Within the energy field it funds industry oriented research, basic research, and socio-economic research.

The total RCN funds for solar related R&D projects, mostly in PV, were approximately 107 MNOK (13 MUSD) for 2016. Most of the R&D projects are focused on the silicon chain from feedstock to solar cells research, but also related to fundamental material research and production processes.

The Norwegian Research Centre for Solar Cell Technology has completed its last full year of operation (www.solarunited.no) before the transition to a new center takes place in the first half of 2017. Leading national research groups and industrial partners in PV technology participate in the center. The research activities have been within silicon production, mono- and multi-crystalline silicon, next-generation modeling tools for crystallizing silicon, solar cell and solar panel technology, new materials for next-generation solar cells, and new characterization methods. In addition the center has a value-chain project that applies the results of the other activities in production of working solar cell prototypes. The total center budget is ~350 MNOK (42 MUSD) over its duration (2009–2017).

RCN approved the application for a new solar cell technology FME-center from 2017. The new center will have its focus on up-stream activities (silicon feedstock, ingots and wafers), but it will also include research that is relevant for use of PV systems with Norwegian building codes in northern European climate conditions.

There are six main R&D groups in the university and research institute sector of Norway:

- Institute for Energy Technology (IFE): Focuses on polysilicon production, silicon solar cell design, production, characterization, and investigations of the effect of material quality upon solar cell performance. A solar cell laboratory at IFE contains a dedicated line for producing silicon-based solar cells. Additionally, there are a characterization laboratory and a polysilicon production lab, featuring three different reactor types.

- University of Oslo (UiO), Faculty of Mathematics and Natural Sciences: The Centre for Materials Science and Nanotechology (SMN) is coordinating the activities within materials science, micro- and nanotechnology.

- Norwegian University of Science and Technology (NTNU) Trondheim: Focuses on production and characterization of solar grade silicon. Some activities on PV systems took place in the FME-center ZEB (Zero Emission Buildings), which ended in 2016. Further work in the new Zero Emission Neighbourhoods (ZEN) FME-center.

- SINTEF Trondheim and Oslo: Focus on silicon feedstock, refining, crystallisation, sawing and material characterisation.

- Norwegian University of Life Sciences (NMBU): Focus on fundamental studies of materials for PV applications and assessment of PV performance in high-latitude environments.

- Agder University (UiA): Research on silicon feedstock with Elkem Solar. Renewable Energy demonstration facility with PV-systems, solar heat collectors, heat pump, heat storage and electrolyser for research on hybrid systems.

- The Northern Research Institute (Norut) in Narvik also has a research group that is active in silicon solar cell research and testing of PV systems under arctic conditions.

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

The support for demonstration is a rough estimate based on the information given by Enova. This includes both specific PV-support for private households and support for commercial systems supportet as part of support within one of the support programs for buildings which includes a range of technologies.

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

	R & D	Demo/Field test
National/federal	107	3*
State/regional		2
Total		

* Stipulated the PV-share of Enova support to innovative building projects.

5 INDUSTRY

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

The Norwegian PV industry is divided between "upstream" materials suppliers and companies involved in the development of solar power projects. The industry supplies purified silicon, silicon blocks, and wafers in the international markets. Solar power project development is to a large extent oriented towards emerging economies.

REC Silicon is noted on the Oslo stock exchange, but the company's production of high purity silicon takes place in the United States.

Elkem Solar operates a production plant for solar grade silicon (ESS) in Kristiansand in southern Norway. This plant uses a proprietary metallurgical process that consumes much less energy than other processes for purification of silicon. The production capacity is approximately 6500 tons of solar grade silicon per year. In addition, Elkem Solar produces multicrystalline silicon blocks at Herøya in eastern Norway for its subsidiary REC Solar. (REC Solar has a yearly solar panel production capacity of 1300 MW at its integrated wafer, cell, and solar panel manufacturing plant in Singapore.)

NorSun manufactures high performance monocrystalline silicon ingots and wafers at its plant in Årdal in western Norway. Annual ingot production capacity is equivalent to 350 MW of solar panel capacity. The major part of this ingot production is converted to wafers utilizing diamond wire sawing at the Årdal plant.

Norwegian Crystals produces monocrystalline silicon blocks in Glomfjord in northern Norway. The capacity of the factory is equivalent to 200 MW per year. The company also supplies wafers to its customers.

The Quartz Corp refines quartz at Drag in northern Norway. Parts of this production are special quartz products that are adapted for use in crucibles for melting of silicon.

Scatec Solar is a provider of utility scale solar (PV) power plants and an independent solar power producer (IPP). The company develops, builds, owns, and operates solar power plants. The present portfolio of power plants has a capacity of 322 MW and is located in the Czech Republic, South Africa, Rwanda, Honduras, and Jordan. The company has a project backlog of 1143 MW that includes new projects in Malaysia, Brazil, and Mozambique.

Table 15: 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)
Elkem Solar	Silicon feedstock	6500 tonnes		
	mc-Si ingots	3500 tonnes		
Norwegian Crystals	sc-Si ingots.	200 MW		
Norsun	sc-Si ingots	1000 tonnes		
	sc-Si wafers	280 MW		

Describe briefly the overseas activities of any key companies also operating in other countries.

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.

There is no cell or module production in Norway.

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 2016

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					
1		a		b	
2		c	d	e	f
3 etc					
Total					
Thin film manufacturers					
1		x	*x*	y	*y*
2					
Cells for concentration					
1		g		h	
TOTALS		**a+c+x+g**	**d+x**	**b+e+y+h**	**f+y**

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. Please briefly comment on the nature of this industry in your country, paying particular attention to recent trends and industry outlook, under the headings of:

- PV inverters (for grid-connection and stand-alone systems) and their typical prices
- Storage batteries
- Battery charge controllers
- DC switchgear
- Supporting structures

Eltek is a world leader in high-efficiency power electronics and energy conversion. - See more at: http://www.eltek.com/detail.epl?cat=23290#sthash.I2qknDhu.dpuf

Siemens Norge, ABB, PBES and several other companies are suppliers of battery-systems and related equipment.

Hydro Aluminum is a global producer of aluminum material and products, for example aluminum-profiles widely used in the solar industry.

6 PV IN THE ECONOMY

6.1 Labour places

Table 17: Estimated PV-related labour places in 2016

Research and development (not including companies)	170
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	
Distributors of PV products	
System and installation companies	830
Electricity utility businesses and government	
Other	
Total	1000

6.2 Business value

Table 18: Value of PV business

A rough estimate of the value of the PV-business given below, which is based on the market volume and price information provided. The industry has not been willing to share information of the value of their exported products, hence the value of export is not available.

Sub-market	**Capacity installed *in 2016* (MW)**	**Price per W** *(from table 7)*	**Value**	**Totals**
Off-grid domestic	*1*	*40*	*40 000 000*	
Off-grid non-domestic	**0,05**	*100*	*5 000 000*	
Grid-connected distributed	**3**	*15*	*45 000 000*	
Grid-connected centralized	**7,4**	*14*	*103 600 000*	
				193 600 000
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

Short description of the electricity industry landscape Norwegian Water Resources and Energy Directorate (NVE) is responsible for managing domestic energy resources, and is also the national regulatory authority for the electricity sector.	The Norwegian power sector is characterised by a large number of stakeholders within different areas of activity. The sector is organised around generation, grid and trading of power. Public bodies are considerable owners in the sector; for example, about 90 per cent of Norwegian hydropower production is owned by public entities

7.2 Interest from electricity utility businesses

The utilities showed increasing interest in PV for the domestic market during 2016, first of all by partnership in various research projects related to smart-grid.

Enova and NVE have initiated a pilot-program 'Smart meters – smart consumers' for testing demand side response related to smart-meters. 7 utilities run separate pilot-projects focusing on communication and information with customers, some also including automatic control of applications such as heating systems, hot water boilers etc. Also the influence of PV-systems and Electric vehicles can be included in the projects.

Enova supports the program with 60 mill.NOK and involves approximately 25 000 households. Data from the projects will be analysed and evaluated to quantify the demand side response of different communication platforms and energy efficient technologies within different consumer-segments. The program runs through year 2021. The utilities participating are Eidsiva Marked, Fjordkraft, Fredrikstad Energi, Glitre Energi, Lyse Energisalg, NTE Marked and Ringriks-Kraft Strøm and their partners. More details about the projects: https://www.enova.no/privat/smarte-strommalere-ams/enova-og-ams/

More information related to smart grid can be found on Norwegian Smart Grid Centre (NSGC, http://smartgrids.no/)

Some utilities launched marketing programs for PV towards the residential market.

7.3 Interest from municipalities and local governments

Oslo is member of C40 (http://www.c40.org/) and has already in place sound solutions and a strong political focus. Oslo's strategy promotion of electrical vehicles, public transport, and combination of waste material-recycling and waste-to-energy solutions have created significant interest internationally. The municipality of Oslo implemented a demonstration-project for PV with 40% subsidy of the system cost was extended with 2 mill.NOK in 2016.

Oslo has been awarded **the European Green Capital Award for 2019** by the EU Commision. The jury was particularly impressed by the holistic approach demonstrated by Oslo covering topics ranging from biodiversity, public transport, social integration and citizen health accompanied by the theme 'City for everyone, putting people first'. More information: http://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2014/04/EGCA-2019_EGL_2018_Winners_Announcement_02062017.pdf

8 HIGHLIGHTS AND PROSPECTS

The Norwegian Government has adopted a “technology neutral” strategy for increased production of renewable energy. There are no particular targets for solar power deployment.

‘Energy21’ is the Norwegian national strategy for research, development, demonstration and commercialisation of new energy technology. It is the Ministry of Petroleum and Energy’s permanent strategic body for research, development and demonstration in the energy sector.

The political strategies for future energy policies formulated in the Energi21-document includes solar power as one of six key areas. Each of these areas is characterised by significant potential, major challenges and tremendous opportunity. These are areas in which Norway enjoys competitive advantages in future energy markets, thanks to its natural energy resources, substantial technology and competency base, and widespread industrial experience. Among the strategy’s six priority focus areas, the Energi21 board recommends devoting special attention to Hydropower and Flexible energy systems. These two areas represent the very foundation of Norway’s energy system and are vitally important for current as well as future value creation.

In addition to these two strategic core technology-areas, Solar power together with Energy efficiency, offshore wind power and Carbon capture and storage are recommended for strategic focus going forward. The Energi21-documents can be downloaded here: http://www.energi21.no/prognett-energi21/Documents/1253955410595

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