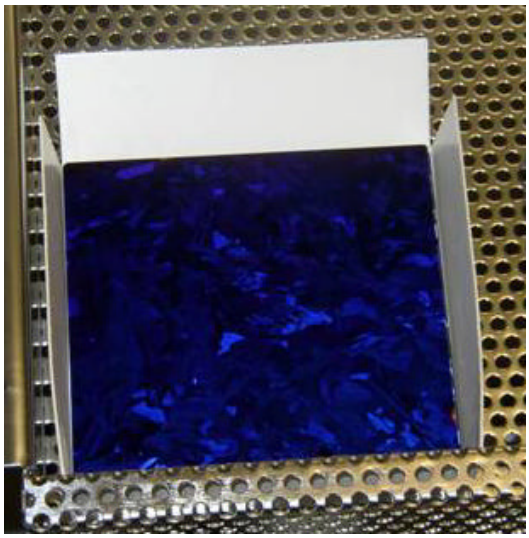
International Energy Agency

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 *Norway* *2002*



Solar cell produced at ScanCell's newly started production facilities at Narvik. At this plant photovoltaic cells will be produced for the world market.

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Table of Contents

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 twenty participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), The United Kingdom (GBR) and The United States of America (USA). The European Commission is also a member.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (tasks) is the responsibility of Operating Agents. Eight tasks have been established, and currently five are active. Information about these tasks can be found on the public website www.iea-pvps.org. A new task concerning urban-scale deployment of PV systems is being developed.

The objective of Task 1 is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems.

ii Introduction

The present " National Survey Report of PV Power Applications in Norway 2002" is an update of the previous "National Survey Report of PV Power Applications in Norway 1998", "-1999", "-2000" and "- 2001" within the frame of the same IEA task 1. The present report is based on data and information supplied by the local suppliers of PV modules and systems, the Norwegian Research Council, the Norwegian Association for Solar Energy, research institutions and professionals within the field.

iii Definitions, symbols and abbreviations

In this report, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 Wp 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°C, AM 1,5 solar spectrum – (also see 'Peak power').

Peak power: Amount of power produced by a PV module or array under STC, written as Wp.

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 Wp or more.

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 in households and villages that are not connected to the utility grid. Usually a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'.

Off-grid non-domestic PV power system: System used for a variety of 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 on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected domestic PV systems and other grid-connected PV systems on commercial buildings, motorway sound barriers. etc. These may be used for support of the utility distribution grid.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station.

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 systems 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, utilities etc.

NC: National Currency

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.

1 Executive summary

Installed PV power

The yearly Norwegian PV-market in 2002 was roughly of the same size as in 2001, 175 kW. Since there are still no public incentives focusing on PV deployment, the market is completely commercial. An increase in market growth rate can only be expected if prices come down significantly. A modest growth of PV into new market niches seems to be observable, since PV starts to become a standard solution in tourist cottages and more ambitious systems, offering near-grid comfort, are being installed in leisure cabins.

Costs & prices

The prices for PV-systems for the leisure market have been fairly stable in the last years (80 – 150 NOK/W), in spite of a decline in module cost. It is difficult to estimate systems cost for other market segments than the leisure market due to low volume.

PV production

Norway has a large manufacturing capacity for PV wafers. The capacity was 55 MW at the end of 2002, and capacity additions will come in 2003. The entire production was exported in the past, but from 2003 there will also be cell manufacture in Norway, at ScanCell.

The starting up of the ScanCell PV cell plant in December 2002 was one of the most significant events of the year, PV-wise. Only test production runs were carried out in 2002, and production will be increasing throughout 2003.

Renewable Energy Corporation AS has entered into a joint venture with ASiMI LLC (USA) for producing granular polysilicon feedstock in the US. Through this move REC has become the first PV company with own feedstock production.

The Norwegian ferroalloy producer Elkem is a world wide leading supplier of metallurgical grade silicon, and as such an important actor in the PV value chain. It is expected that Elkem will venture into commercial production of solar grade silicon within the next few years.

Budgets for PV.

There are no public funds in Norway, either for research or market introduction that are earmarked for PV. The total public research funding that went to PV in 2001 was USD 1 120 000. If industry contribution is added to this, the total amount spent on PV

research in 2002 was almost 2 million USD. For all practical purposes, there are no national funds available for demonstration and market introduction of PV.

The research effort in Norway has been significantly intensified and diversified, a trend that will be continued into 2003. This development gives promise of a continued rapid industrial development of PV in Norway.

Norsk sammendrag

Installert PV effekt

Det årlige norske markedet for solceller var stort sett like stort i 2002 som i 2001, 175 kW. Siden det ikke finnes noen offentlige finansieringsmekanismer for å stimulere til installering av solcellesystemer, er markedet fullstendig kommersielt. En økning i tilveksten av markedet kan kun forventes dersom prisene skulle falle vesentlig. Det kan imidlertid virke som om solceller har begynt å etablere seg i nye markedsnisjer, siden solceller begynner å bli en akseptert løsning på turisthytter og forholdsvis ambisiøse systemer, med tilnærmet nett-komfort, begynner å bli benyttet i hytter.

Kostnader og priser

Prisene for solcellesystemer til hyttemarkedet har vært forholdsvis stabile i de siste årene (80 – 150 NOK/W), på tross av at prisene på solcellepaneler har gått ned. Det er vanskelig å anslå priser for andre markedssegmenter på grunn av det lave volumet.

Solcelleproduksjon

Norge har en betydelig produksjonskapasitet for solcelle wafere. Kapasiteten av 55 MW per år ved slutten av 2002, og denne vil øke i løpet av 2003. Hele produksjonen har vært eksportert, men fra 2003 vil solcelleproduksjon i Norge også motta leveranser av norske wafere.

Starten av solcelleproduksjon ved det nystartede selskapet ScanCell AS i desember 2002 var en av de viktigste hendelsene på solcelleområdet i fjor. Det ble kun kjørt prøve-produksjon i 2002, men produksjonen vil øke gjennom hele 2003.

Renewable Energy Corporation AS (REC) vil gjennom et samarbeid med ASiMI LLC i USA starte opp produksjon av granulert polysilicon i USA. Gjennom dette samarbeidet blir REC det første solcelleselskapet med egen råvareproduksjon.

Det norske ferrolegeringsselskapet Elkem er en ledende leverandør av metallurgisk silisium til verdensmarkedet, og på den måten en viktig aktør i verdikjeden til solceller. Det forventes at Elkem vil starte opp kommersiell produksjon av dedikert solcellesilisium innen et par år.

Budsjett for solceller

Det finnes ikke noen offentlig finansiering, verken for forskning eller markedsintroduksjon, som er øremerket for solceller. Totalt gikk det ca. 1 120 000 USD til forskning påsolceller i Norge i 2001. Dersom man ogsåregner med industriens bidrag til forskningen, blir tallet ca. 2 000 000 USD. I praksis finnes det ikke noen offentlige midler tilgjengelige for demonstrasjon eller markedsintroduksjon av solceller.

Forskningsinnsatsen i Norge er blitt påfallende styrket og diversifisert i de senere år, og denne trenden vil fortsette i 2003. Denne utviklingen gir løfter om en fortsatt rask utvikling av norsk solcelleindustri.

2 The implementation of PV systems

2.1 Applications for photovoltaics

The main market for PV in Norway continues to be related to off-grid applications. This refers to both the leisure market (cabins, leisure boats) and the professional market (primarily lighthouses/lanterns along the coast and telecommunication systems) in this vast and sparsely populated country. Exceptions are demonstration projects for which grid-connection in some cases was performed.

Up to 1992 the leisure market, dominated by new installations in remote cabins in the forests and mountains of Norway, grew rapidly. After 1992 this market slowed down due to saturation. However, some cabins have been fitted with additional power to serve new demands like TV and refrigeration. Since the first installations are now more than 30 years old, it will probably make sense to start to replace systems, rather than repairing them.

The cabin market accounts for 80-90% of the Norwegian market, with 85 W being a representative typical system size. Applications for leisure boats have also grown over the past years. In Norway most of systems used on leisure boats exceed 40 W.

During the 20 past years size and comfort of the Norwegian cabins have increased significantly. Although modern cabins are often built in compact fields connected to the grid, thus offering the same comfort as permanent houses, surveys have uncovered that 70% of cabin owners value surroundings that are mainly unaffected by human activities. While new cabins therefore in many instances do not offer an opportunity for PV systems, this is not a universal trend. To the contrary, in the last few years we have seen the introduction of more ambitious systems in the leisure market for PV-systems. A few cabins have, on commercial terms, been equipped with comparably large PV systems, about 600 W. These systems have a 12 V installation for lighting and an inverter for supplying 230 VAC to conventional power outlets. They may also have a small generator for backup.

In the border between the leisure and professional market, installations at a couple of tourist cottages in the mountains were a notable feature in 2002. Also these installations provide 230 VAC and have a generator as backup. As a continuation of

this trend, one might hope that in the near future, the installation of PV systems will become fully integrated into the design and construction processes for cottages.

In the period after 1992, the slowdown in the market for cabins was partly compensated by the development of new markets. PV powered coastal lighthouses was a significant new market. Even north of 70°, lighthouses may be powered by PV, provided the battery bank has sufficient capacity. The programme was launched by the Coastal Guard in 1982 and was completed in 2000-2001. Approximately 2350 installations serving lighthouses and coastal lanterns have been achieved. The smallest are equipped with one single module of 60 W, the largest with arrays counting up to 66 modules. A large number of the systems are powered by 3 to 4 modules of 60 W. The average is 135 W per installation. The cumulative installed PV power is 310 kW.

Applications of stand-alone PV for telecommunication stations and hybrid utility systems (called here the professional market in opposition to the leisure market) have also grown during the past years. Utility companies have made some selective investments for providing electricity to remote dwellings. PV in combination with other energy sources has been demonstrated for permanent dwellings, and may offer a viable solution where the distance to existing electricity grid exceeds 10 km. An earlier demonstration project, where PV was combined with a LPG fired engine generator-set, has been followed up by a few other LPG or diesel powered systems. Although these systems include battery storage, they do not appear to have included PV installations. Actual turnover and installations vary from year to year, depending largely on project allocations. The market is estimated to 5-10 kW in average. In 2002 the actual figure was in the low range.

In marked contrast to many countries in Europe, Norway does not have any incentive schemes supporting installation of PV systems. Therefore there are very few grid-connected systems. The same may be said about building integrated approaches, although a few small systems have been installed on private initiative, and a 5 kW system is under planning in Kristiansand. The latter project is sponsored by the EU – financed project PV-Nord.

There are plans for equipping a private home in Bergen with 3,8 kW PV in 2003. This project is carried out on completely private initiative, without any public incentives, and also comprises solar heating and wood firing. The building is a single family house originally constructed in 1936. If realized, this project will be reported in the NSR for 2003.

2.2 Total photovoltaic power installed

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with an installed PV power of 40 W or more. A PV system consists of modules, charge controller and energy storage (batteries) or power electronics for grid-connection (inverters), and all installation and control components for modules, inverters and batteries.

The total cumulative installed PV power for each sub-market on the 31 December of each year from 1992 onwards is presented in Table 1.

Table 1 The cumulative installed PV power in 4 sub-markets.

Sub-market/ application	31 Dec. 1992 kW	31 Dec. 1993 kW	31 Dec. 1994 kW	31 Dec. 1995 kW	31 Dec. 1996 kW	31 Dec. 1997 kW	31 Dec. 1998 kW	31 Dec. 1999 kW	31 Dec. 2000 kW	31 Dec. 2001 kW	31 Dec 2002 kW
off-grid domestic	3 700	3 970	4 240	4 460	4680	4 900	5 100	5 400	5 650	5 810	5 966
off-grid non-domestic	100	130	160	190	220	250	300	320	330	335	350
grid-connected distributed							4	6	50	65	68
grid-connected centralized											
TOTAL	3 800	4 100	4 400	4 650	4 900	5 150	5 400	5 730	6 030	6 210	6 384

In addition to the figures presented above, NAPS Norway AS exported systems totalling about 100 kW in 2002. These systems were mainly intended for applications in the health, education and telecom sectors in developing countries. Some of the systems were procured in relation to disaster relief operations.

Also in addition to the figures in the table, it may be mentioned that the market for systems with less than 40 W installed power can be estimated to 6 kW in 2002.

2.3 Major projects, demonstration and field test programmes

In 2002 the EU sponsored project PV-Nord, aimed at demonstrating building integration of PV, was started with Norwegian participation. PV-Nord aims at collecting experiences related to building integration and operation of PV-systems. For more information, see www.pvnord.org.

Vest-agder county will host a demonstration project in Norway for PV-Nord, but this system will not be installed until 2003. The consulting company KanEnergi also participates in the project, being responsible for the workgroup on financing and

ownership. In addition to EU, Enova SF (www.enova.no) sponsors the Norwegian pariticipation.

In recent years there has been a few demonstration projects for building integrated PV (the technical university in Trondheim (16kW), BP in Stavanger (approximately 16 kW), and the low-energy dwelling at Hamar (2,2 kW). None of these were installed in 2002.

However, 2002 did witness the installation of a small building integrated system at Kvernhuset Junior High School in Fredrikstad (720 W). The system was not commissioned until January 2003.

Table 2: Summary of major projects, demonstration and field test programmes

Project Date plant start up	Technical data/Economic data	Objectives	Main accomplishments until the end of 2002/problems and lessons learned	Funding	Project management	Remarks
Kvernhuset Junior High School	*grid-connected power: 720 W multicrystalline silicon PV cells mounted in south façade.*	*The PV installation will function as part of the teaching facilities.*	*System installed*	-	-	
PV-Nord, Vest-agder county	*System not designed by end of 2002.*	*To demonstrate aesthetically satisfactory building integration of PV.*	*The building is designed and blasting for the foundations initiated. PV system is under design.*	*65% Vest-agder county,* *35% EU 5th FWP*	*Tet AS*	*The system will be installed during the summer of 2003.*

2.4 Highlights of R&D

Research activities on PV in Norway used to focus strongly on issues relating to silicon feedstock for crystalline cells. In recent years the research activity has expanded into new areas relating to other PV technologies and system integration issues. This trend will be continued into the coming years.

The Norwegian Research Council manages all public funding to R&D (no funding to Demo/Field Test or Market Support). Funding is provided along two different financing lines, one where industry is the principal beneficiary and one where research institutions have the lead role. Enova had some very limited co-funding for the research components of the project PV-Nord.

The research activity in both areas was significant in 2002. In the industry led programme, public support was approximately 550 000 USD, while the industry itself provided about 2 times that amount.

The programme led by research institutions received some 570 000 USD in funding in 2002. Also here the industry contributed funds (approximately 140 000 USD).

The research financing was reduced about 25% from 2001, but funding may be increased again in the years to come. A programme aimed at cost reduction of solar cells has recently been approved, and the allocation of public research funds will be about 600 000 USD per year for 5 years.

Most of the R&D activities take place at the Norwegian Technology University (NTNU) and SINTEF in Trondheim where 5 PhD-students will graduate in PV sciences under a long-term program. Research focuses on:
- silicon refining and purification
- silicon crystallization
- silicon characterization

NTNU works in close collaboration with other Norwegian research institutions, and with research organizations in other countries. During 2002 two researchers spent half a year each at the Fraunhofer Institute in Germany and at ECN in the Netherlands, respectively.

SINTEF is participating in EU funded programmes (CRAFT). The work focuses on cell quality and characterization of materials and solar cells.

The Institute for Energy Technology (IFE) employed 4 researchers during 2002. IFE's department for renewable energy is focussing on solar cell production technology and is working in close co-operation with the Norwegian industry. The research activity at IFE will be considerably strengthened from 2003.

At Agder College (HiA) two candidates are currently preparing PhDs in co-operation with the University of Oslo. Topics are:
- Decomposition of silane
- Silicon wafer characterization.

Both IFE and HiA are also working on issues related to system integration.

All these organizations are in close co-operation with the Norwegian industry, particularly Elkem ASA (solar grade silicon), ScanWafer ASA (multicrystalline silicon wafers), ScanCell AS (crystalline silicon solar cells) and Renewable Energy Corporation AS. With the private funding coming on top of the public funding, one assumes that in total near 2 million USD were spent in 2002 on PV R&D projects. This figure does not include funding from the EU. For the coming years, several of the Norwegian research institutions will be able to expand activities, partly due to the initiation of a Nordic collaborative research initiative.

On a sad note, the programme for technology introduction managed by Enova has been discontinued. There is now no bridge between research and commercialization of technologies. This can become a problem when new technologies and products expected from the recently up-geared and diversified research activities are to be tested for and introduced to the market.

2.5 Public budgets for R&D, demonstration and market stimulation

Table 3 Public budgets for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/ Field test	Market
National/federal	1 120 000	0	0
State/regional	not relevant		
Total	1 120 000	0	0

Note

Figures are given in USD.

3 Industry and growth

3.1 Production of photovoltaic cells and modules

Module: In 2002 there was no production of modules in Norway. There are no plans to produce any in the near future. However, Norwegian interests own module production facilities in Sweden (ScanModule).

Cells: ScanCell AS started test production of solar cells in December 2002. During December about 10 kW were produced. The capacity is expected to approach 7 MW per year in 2003, but the total output during that year will be much lower. Multicrystalline wafers are purchased from the Norwegian wafer supplier ScanWafer. Although not integrated into a

corporate group, both ScanWafer ASA and ScanCell AS have Renewable Energy Corporation AS (REC) as main shareholder. State of the art technology including silicon nitride antireflective coating are applied to the wafers to produce cells. Since no modules are produced in Norway, the total production will be exported.

Silicon wafers: Norway has become a significant producer and supplier of multicrystalline silicon wafers for the word solar cell industry through the company ScanWafer AS. The technology applied is directional solidification of high-purity silicon followed by slicing by means of multiwire sawing. The raw material is a mix of different sources of high-purity silicon all imported including cut-off from single crystals, ingots from aborted runs, top and tails from single crystals, second grade and intentionally produced “polysilicon” in “Siemens” reactors, etc… Established in 1994 the company started to produce in 1997 and since then has been continuously increasing its output as a combined result of internal improvement and capacity expansion. The nominal capacity (calculated on basis of wafers converted to 13,5% efficiency cells) corresponded at the end of 1999 to 6,3 MW, the end of 2000 to 8 MW and the end of 2001 to 50 MW. By end of 2002 the capacity was 55 MW. After the ongoing expansion of the capacity has been completed (new factory in Porsgrund) the capacity is expected to reach 80 MW by the end of 2003 and 140 MW by the end of 2004. The entire output was exported worldwide to cells and modules manufacturers, except a few wafers to ScanCell (see above).

Silicon feedstock: The Norwegian ferroalloy producer Elkem is a worldwide leading supplier of metallurgical grade silicon. Of the order of 10% of the output can be assumed to end up as solar cells. The company has since the late 1970ies spent great efforts in the development of solar grade silicon using metallurgical processes familiar to the company. In 2000 Elkem entered into an agreement with AstroPower (USA) with the objective to produce such solar grade silicon. It is expected that Elkem will start commercial production of solar grade silicon within the next few years.

Renewable Energy Corporation AS (REC) and ASiMI LLC (USA) have entered into a Joint Venture for producing granular polysilicon feedstock at ASiMI’s plant of Moses Lake in the USA. Through this move REC has become the first solar energy company with own feedstock production.

Silicon carbide: An important and strategic material for wafering silicon ingots is silicon carbide. There are 4 - 5 worldwide suppliers. Two of them, Saint-Gobain Ceramic Materials and Orkla Exolon, are producing in Norway (3 plants at 3 locations).

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

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MWp)	
		Cell	Module	Cell	Module
ScanCell	mc-Si	.01	0	7 (end 2003)	0

Table 4a: Typical module prices (NC) for a number of years

Year	1992	1993	……..	2002
Module price(s):	n.a.	n.a.	n.a.	n.a.

Table 4 is not relevant for Norway since modules are not produced in the country. The domestic retailers assembling systems for the professional and leisure markets purchase modules from the global market. Some suppliers have long-term retailing agreements with large international PV companies. BP Solar and Siemens (Shell) Solar are the two largest companies supplying modules and technology to the cabin market. NAPS, Total Energy and Photowatt have also minor market shares, focussing on professional and marine market niches.

Prices for imported modules were reported to be in the range 3,1 – 3,5 USD/W in 2002.

3.2 Manufacturers and suppliers of other components

There are no producers of other PV components (PV inverters, batteries, charge controllers, etc.) in Norway. The market for grid-connected systems is next to nil.

Table 5: Price of inverters for grid-connected PV applications.

Size of Inverter	<1 KVA	1-10 KVA	10-100 KVA	>100 KVA
Average Price per kVA (NC)	n.a.	n.a.	n.a.	n.a.

3.3 System prices

Prices for the leisure markets is based on a survey of the suppliers. Prices for professional systems are strongly dependent on the application, and a meaningful basis for comparison is therefore difficult to establish.

Table 6: Turnkey Prices of Typical Applications

Category/Size	Typical applications and brief details	Current prices per W in NC (NOK)
OFF-GRID Up to 1 kWp	Leisure cabin, typically 85 W module, battery, charge controller, loads and cabling. Leisure boat, typically 50 W module and charge controller. Telecom repeater (professional)	80 – 150 55 – 85 typ. 100
OFF-GRID >1 kWp	Approximately 2 – 3 kW for tourist cottages. Telecom Hybrid system commissioned by utility company, 5,5 kW electricity, 12 kW heat.	no price (no systems sold in 2002)
GRID-CONNECTED Up to 10 kWp	(no systems sold in 2002)	
GRID-CONNECTED >10 kWp	(no systems sold in 2002)	

Prices appear to be relatively stable. The quality of non-PV components, and hence prices, vary within wide margins. Some suppliers even offer different levels of systems based on the same PV-power. An 85W system may therefore vary in price by a factor of 2.

Table 6a: National trends in system prices (current NOK) for remote cabins, which is the major domestic application.

YEAR	2000	2001	2002
Price /Wp:	**60 – 100**	**80 – 150**	**80 - 150**

3.4 Labour places

An estimation of labour places is given in the following (where these are mainly involved with PV):
a) Research and development (not including companies): **20 man-years**
b) Manufacturing of PV system components, including company R&D: **240 man-years**
c) All other, including within distributors, electricity companies, installation companies, consultants etc.: **15 man-years**

Most of the labour places under b) have been created since 1998-99. Approximately half of them were created during 2001. This figure represents an average for the whole year. At the end of 2001 one estimated the current figure to be **275 labour places**. With start up of a cell production plant in 2002 and a wafer plant in 2003 the increase of labour places is expected to continue with additional 100-120 for the next two years.

3.5 Business value

It is estimated that the value of the PV business in 2002 was 400 million NOK, or about 60 million USD. The business value has been calculated based on an average system price times total volume of PV systems. To this has been added turnover of ScanWafer and NAPS Norway. ScanCell did not have sales in 2002, but will have so for 2003.

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

There are no new initiatives stimulating deployment of PV systems.

4.2 Indirect policy issues

There are so far no policy measures targeting use PV energy in Norway. There is no market introduction programme and the few demonstration projects have been motivated by educational or private interest (research and high school sector, industry and utilities). There are policy measures for promoting renewable energy in general, but PV applications normally have difficulty in competing with other solutions for the applications targeted.

Norwegian authorities earlier adopted a “wait-and-see” stance as regards green certificates for electricity from renewable sources. However, the power shortage in the winter of 2002 – 2003 may accelerate the process of introducing green certificates. Green certificates are already generated in Norway for the European market.

Norway is a country with a relatively modest solar resource (about 1000 kWh per square meter and year), large seasonal variations and a high interest rate in an international perspective. Due to these factors, PV applications are only competitive in situations where small amounts of electricity has a high value. In addition Norway has huge energy resources i.e. hydropower, oil and gas (offshore), and the traditional forestry activity is a favourable

factor for the development of biomass applications. The windy climate along the southern, western and north-western coast is favourable for deployment of windmills.

The newly established public company Enova took over the responsibility for promoting energy efficiency and renewable energy from the Directorate for Water Resources and Energy in 2002. Enova has to fulfil specific targets and has concluded that it can provide a subsidy on the level of 0,30 NOK/kWh to projects aimed at furthering the objectives of Enova. Generally, this subsidy level will not be sufficient for triggering PV projects.

Only the large number of remote places where grid connection is a high cost alternative in terms of installation and maintenance cost, as well as the perspective of “green certificates” are slightly motivating the utility companies to consider PV applications. for instance as integrated in hybrid systems (diesel, wind, others). However, in utility applications a back-up is usually mandatory, and a gen-set with battery bank and inverter, i.e. a PV hybrid system minus the PV, is usually the least cost alternative.

4.3 Standards and codes

Norway normally follows EC norms and standards. There are no specific PV standards.

5 Highlights and prospects

Although occurring in the closing of the past year, the starting up of the ScanCell PV cell plant in December 2002, was one of the most significant events of the year. From now on Norway will be a significant supplier also of PV cells. The continued rapid development of ScanWafer is also a notable feature.

Another interesting development is the incipient demand for PV cottage systems providing almost the same level of comfort as grid connection. This development can provide important awareness raising concerning the high quality of service that PV systems can provide.

Although not part of the PV market in Norway, the sustained effort and considerable success of system exporters (NAPS Norway) and PV service providers in an international setting (Solenergy), deserves to be especially mentioned.

Finally, the significantly intensified and diversified research effort that is coming into a new gear gives promise of a continued rapid industrial development of PV in Norway.

Annex A Method and accuracy of data

All information has been collected using direct interview. It is expected that data regarding research funding is accurate to within ±5%, and value of business within ±15%.

The figures on the market may be expected to have an accuracy of ±10%.