平成12年度

ニューサンシャイン計画

太陽光発電システム実用化技術開発

国際協力事業

IEA太陽光発電システム研究協力プログラム実施協定

タスクⅠ

平成13年３月

新エネルギー・産業技術総合開発機構
太陽技術開発室

平成１２年度

ニューサンシャイン計画

太陽光発電システム実用化技術開発

国際協力事業

ＩＥＡ太陽光発電システム研究協力プログラム実施協定

タスクⅠ

平成１３年３月

新エネルギー・産業技術総合開発機構

太　陽　技　術　開　発　室

目　次

第１章　太陽光発電システム実用化技術開発概要

太陽光発電システム実用化技術開発
国際協力事業
「国際エネルギー機関／太陽光発電システム研究協力プログラム(ＩＥＡ／ＰＶＰＳ)」
「International Energy Agency/Co-Operative program on Photovoltaic Power Systems」

第１章　概要

１．１　事業目的

太陽光発電技術の実用化促進を目的として、国際エネルギー機関（ＩＥＡ:International Energy Agency)における「太陽光発電システム研究協力プログラム実施協定（ＰＶＰＳ:Implementing Agreement for a co-operative programme on Photovoltaic Power Systems)」の日本側実施機関として、執行委員会及びタスク専門家会議等に出席し、我が国における研究開発成果に関する情報提供等を行うとともに、収集した情報の国内外への普及を図る。

１．２　事業内容

ＩＥＡ太陽光発電システム研究協力プログラム（ＰＶＰＳ）に参加し、研究開発・実証・分析・情報交換・導入促進等の協力を行う。

執行委員会及び継続中のタスクⅠⅡⅢⅤⅦの他、平成９年度にタスクⅥサブタスク50として正式発足し、平成１１年度にタスクⅧに移行したタスク「砂漠等未利用地を利用した大規模太陽光発電に関する可能性調査研究」の運営機関国(ＯＡ)として活動を行う。なお本タスクはＩＥＡ気候技術推進計画(ＣＴＩ)の活動の一環としてＰＶＰＳに提案されたものであり、ＣＴＩとの連携を保ちながら活動が行われている。また平成１１年度に発足したタスクⅨ「開発途上国との協調による太陽光発電技術の普及」にも参加する。現在日本はタスクⅤ及びタスクⅧのＯＡを担当している。

１．３　事業の経緯

我が国は平成５年４月にＩＥＡ太陽光発電システム研究協力プログラム実施協定に調印した。新エネルギー・産業技術総合開発機構は外務省から本協定の日本側契約締結機関に指定されている。本実施協定は平成９年１１月に所定の５年間の実施機関を満了したが、ＩＥＡ/エネルギー研究技術委員会(ＣＥＲＴ:Committee on Energy Research and Technology)/再生可能エネルギーワーキングパーティ(ＲＥＷＰ:Renewable Energy Working Party)により平成１４年まで５年間の延長が認められた。

１．４　ＩＥＡ太陽光発電システム研究協力プログラムの概要

本プログラムは、参加各国の政府あるいは政府が指名した機関の代表１名ずつから構成される執行委員会(Ex.Co:Executive Committee)により運営・管理される。また、各タスクは運営機関(OA:Operating Agent)により運営される。協定実施期間延長後のタスクの構成は以下の通り。

タスクⅠ：太陽光発電システムに関する情報交換と普及

「Exchange and dissemination of information on photovoltaic power systems」

運営機関国　　オーストラリア　G.Watt

タスク専門家　神門正雄総括主任研究員（ＮＥＤＯ太陽技術開発室）

タスクⅡ：太陽光発電システム及びサブシステムの運転性能と設計

「Operational Performance,Maintenance and Sizing of Photovoltaic Power Systems and Subsystems」

運営機関国　　ドイツ　R.Dahl

タスク専門家　作田　宏一主任研究官（電子技術総合研究所）

タスクⅢ：独立型及び離島用太陽光発電システムの応用

「Use of Photovoltaic Systems in Stand-Alone and Island Applications」

運営機関国　　フランス　P.Jacquin

タスク専門家　湯本　登（（有）ﾜｲ･ｴﾇ･ｲﾝﾀｰﾅｼｮﾅﾙ）

タスクⅤ：建物設置等の分散型太陽光発電システムの系統連系

「Grid Interconnection of Building Integrated and Other Dispersed Photovoltaic Power Systems」

運営機関国　　日本　　米田　文重 部長（ＮＥＤＯ導入促進部）

タスクⅦ：建築物一体型太陽光発電システム

「Photovoltaic power systems in the built environment」

運営機関国　　オランダ　T.Schoen

タスク専門家　西川省吾 主任研究員（関電工）

タスクⅧ：砂漠等未利用地域を利用した大規模太陽光発電に関する可能性調査研究

「Study on Very Large Scale Photovoltaic Power Generation systems」

運営機関国　　日本　　神門正雄総括主研（ＮＥＤＯ太陽技術開発室）

黒川浩助教授（東京農工大学）

タスクⅨ：発展途上国との協調による太陽光発電技術の普及

「Deployment of Photovoltaic Technologies:Co-Operation with Developing Countries」

運営機関国　　イギリス　B.McNelis

タスク専門家　谷　隆之（日本エネルギー経済研究所）

第２章　ＩＥＡ太陽光発電システム研究協力プログラム実施協定タスク１

第２章　ＩＥＡ太陽光発電システム研究協力プログラム実施協定タスク１

２．１　タスク１の概要

１）目的

参加国の電力応用について、太陽光発電システムの技術的、経済的、環境的諸事項に関する情報を交換し、対外的に普及させると同時に、各タスクを横串にして全体の調整を行う。

（主な活動内容）

●ＮＳＲ(National Survey Report)の収集　－　参加国２０カ国

●ＩＳＲ(International　Survey Report)の発行　－　年１回

●Newsletterの発行　－　年２回

●各国コミュニケーション・ストラテジーの策定

●PVPS Web-siteの検討・改善およびタスク１のホームページ作成

●その他の特別活動

２）参加国

ＩＥＡ／ＰＶＰＳ実施協定への全参加国の２０ヶ国および１機関

オーストラリア、オーストリア、カナダ、デンマーク、ＥＵ、フィンランド
フランス、ドイツ、イスラエル、イタリア、日本、韓国、メキシコ,オランダ、
ノルウエー、ポルトガル、スペイン、スウェーデン、スイス、英国、米国

３）活動期間

１９９３年4月１６日～
（ＩＥＡ／ＰＶＰＳ協定実施の期間内は実施）

４）専門家会議

第１６回専門家会議	２０００年　３月１５日～１７日	イタリア（ナポリ）
第１７回専門家会議	２０００年１０月　９日～１１日	ドイツ（ミュンヘン）
付加価値ワークショップ	２０００年　５月　５日	英国（グラスゴー）

（今後の予定）

第１８回専門家会議	２００１年　３月２１日～２３日	（デンマーク）
第１９回専門家会議	２００１年１０月　４日～　６日	米国（サクラメント）

２．２　活動進捗状況と今後の計画

１）ＩＳＲ(International Survey Report)の作成・発行

○ＩＳＲ-2000年版(92-99)

・５月末までに日本のＰＶの普及施策、ＰＶ導入量、生産量等に関するＮＳＲ(National Survey Report)作成・提出。

・各国ＮＳＲを元に、ﾃｸﾆｶﾙﾗｲﾀｰ(Mr. John Knight of Halcrow Gilbert(GBR)がＩＳＲ作成

・上記ＩＳＲを各国タスク１専門家及び執行委員が監修。製本完成（９月末）

○ＩＳＲ-2001年版(92-00)
課題：各国のＮＳＲ作成の期限遵守

2）ニュースレターの作成・発行
○ニュースレター＃１２　２０００年　２月に発行
○ニュースレター＃１３　２０００年　９月に発行
○ニュースレター＃１４　２００１年　２月に発行予定

課題：各国の　Target　Audience　を明確にする

3）Ｗｅｂ　Ｓｉｔｅの改良
○ｗｗｗ．ｉｅａ-ｐｖｐｓ．ｏｒｇ

4）Market Implementation
○ドイツ、スウェーデン、デンマーク、ノルウェー、日本をリーダー国にまとめる。
（今後の予定）
ExCoへの計画提示（２００１年４月）、ExCo承認および出版（２００１年１０月）

２．３　付加価値ワークショップ
日時：２０００年５月５日（ＥＵＰＳＥＣと並列開催）
場所：英国　グラスゴー　IEE Scottish Engineering Lecture Theater
参加：１４ヶ国から５３名が参加
今後の取り組み・課題
(1)日本がリーダーとなり、Special Activityとしてまとめる。
ワーキンググループ：日本、英国、スイス、オランダ
(2)総合レポート作成、総合レポートはInternational Reportとする。豪州 Dr. Muriel Wattが札幌、グラスゴーでのプレゼン資料、討議内容をもとに総合レポートの原稿を作成。2001年１月中に最終ドラフト。編集、印刷（1000部）は英国Halcrow社にて行い、２月中に各国向け配布する。

２．４　Q&A集の作成
フランスよりPVに関するQ&A集を作成する提案がなされ、各国の意見を基に集大成し、レポートとして発行する。

第3章　第１８回ＩＥＡ／ＰＶＰＳタスクＩ専門家会議

18th IEA-PVPS, Task 1 Meeting on 21th- 23th March 2001 in Aarhus, Denmark

Dear Colleagues,

In the following you will find some practical information about the forthcoming IEA, Task 1 meeting in Aarhus.

Location of meeting:

The meeting will be held in the

Hotel Marselis
Strandvejen 25
DK-8000 Aarhus
Denmark
Phone: +45 86 14 44 11
Fax: +45 86 11 70 46
www.marselis.dk

The Hotel Marselis is located at the beach 3 km south of the City center on the edge of the Marselisborg Forest and with a beautiful view of the Bay of Aarhus.

Accomodation

We have pre-booked a block of rooms at the Hotel Marselis – the venue of the meeting, giving us an option from Tuesday the 20th through Friday the 23th March on 20 rooms. This option is valid until March 10, but we believe it is advisable to make **reservation as soon as possible**; the registration form is attached to this message. *Please submit the completed hotel registration form by fax directly to the Hotel Marselis with a copy to us and to Greg Watt.*

The price for a single-room is DKK 906 / night (about US $ 113).
The price for a double-room is DKK 1076 / night (about US $ 135).

Reaching Aarhus & Hotel Marselis

Aarhus is the second largest city in Denmark and is situated on the East coast of Jutland. It can be reached conveniently by air in two ways:

Option 1
via Copenhagen International Airport and continuing by domestic flight to Aarhus Airport; there are about 12 daily flights.

From Aarhus Airport to the City center there is a bus service. It takes about ¾ of an hour and cost about 55 DKK. The bus city terminal is at the main railway station, where taxis are available. Distance to the Hotel Marselis is about 3 km corresponding to about 60 DKK.

Another possibility is when ordering the domestic flight to/from Aarhus to ask your travel agent to book a so-called limousine service (can only be done together with the airline ticket). The limousine will take you – and up to a maximum of two other guests – directly to their destination in Aarhus and you will be picked up the same way when leaving. Cost of the limousine service is about DKK 460 (total: both arriving and departing). On arrival look for the sign saying „Limousine Meeting Point" just outside the arrival hall and contact one of the drivers waiting there. When leaving contact the hotel reception well in advance of departure.

Option 2
Via Billund International Airport with daily connections to many European hubs such as Amsterdam, Munich, Bruxelles etc. There is a bus service from Billund Airport to Aarhus City center, taking about 1½ hours and costing about DKK 125. Contact the busdriver en route for instructions on how to get a taxi in Aarhus; cost of taxi is about DKK 70. A taxi directly to the Hotel Marselis from Billund Airport will be rather costly at DKK 600-700; please check with the driver in advance.

Technical Visit

The technical visit is scheduled for Friday the 23th October. We are planning a combination of a visit to an off-shore wind farm and a visit to the Sol-300 project taking most of Friday. We plan to leave the hotel by bus at 8.30 in the morning and be back again at 17.00 (5 pm) in the afternoon. We will show you the 6 MW off-shore wind farm at the Tunø Knob (weather allowing we will actually sail out to and enter the wind turbines) and will continue to the distribution utility EnCon, managing the Sol-300 project (300 roof tops / 750 kWp). After lunch and some introductory remarks at EnCon we will visit a residential area with about 100 roof-tops including meeting some of the house owners in their homes.

Please indicate on the hotel registration form, whether you intend to participate in the technical tour or not. This will allow us to adjust the practical arrangement to the actual number of participants.

Weather

The Danish weather in March is a bit unpredictable and can swiftly change between pleasant sunny spring conditions and quite cold and windy conditions with showers. Please bring some „all-round outdoor clothes".

We hope this information will help you to arrange your travel to Aarhus.

If you have any questions about the travel and the stay in Aarhus / Denmark don't hesitate to contact us. Regarding the agenda for the meeting Greg Watt will provide the necessary details in mid February.

Please don't forget to reserve your hotel in time.

We look forward to see you in Aarhus.

Best regards

Peter Ahm (on behalf of the Danish Task 1 Team)
PA Energy A/S

International Energy Agency - Implementing Agreement on Photovoltaic Power Systems: Task 1 - Exchange and Dissemination of Information

18TH TASK 1 PARTICIPANTS' MEETING, 20-23 MARCH 2001 – DRAFT MEETING SCHEDULE / AGENDA

Hotel Marselis, Strandvejen 25, Aarhus, Denmark

Dates & Times	Activities & Key Parties	Outcomes

Tuesday 20 March 2001
15:30 – 17:30 Initial meeting of '*Costing …*' working group – Hotel Marselis
19:00 – For those interested, meet in lobby of Hotel Marselis
19:00 – 21:00 Informal meeting over dinner to confirm arrangements, discuss matters of interest & set the scene for 18th Task 1 meeting

Wednesday 21 March 2001 – Hotel Marselis

9:00 – 10:30	Item 1: Introduction & welcome by hosts	
	Item 2: Introduction of meeting participants, new members & apologies	
	Item 3: Adoption of Agenda for 18th meeting	
	Item 4: Matters arising from Minutes of 17th meeting	
	Item 5: Matters arising from ExCo meeting in Sorrento, Italy (October 2000)	Information for Task 1 participants.
10:30 – 11:00	*Break*	
11:00 – 12:30	Item 6: International Survey Report: ❑ Introduction of new technical writer – Dr Alan Taylor, Halcrow ❑ Reiteration of changes to be incorporated in ISR6 as discussed in Munich (see attachment 1 to this agenda, and Munich minutes) ❑ Schedule for production for 2001 ❑ Choice of photos (please bring to meeting) for ISR6	Task 1 endorsement of format, content and schedule for ISR6.
12:30 – 14:00	*Lunch*	
14:00 – 15:30	Item 7: National Survey Reports: ❑ Progress against revised guidelines (previously circulated) ❑ Publication of selected NSR information on the public website	Identification of any information gathering problems. Agreement on NSR information to be incorporated on the website.

	Item 8: *PVPower* newsletter: ❑ Progress on matters raised during Munich meeting (Paul Cowley) ❑ Feedback on past issues; plans for future contents (Paul Cowley) ❑ Newsletter 'policy' note (Greg Watt)	Endorsement of format and content of subsequent issues of *PVPower*.
15:30 – 16:00	*Break*	
16:00 – 18:00	Item 9: Country 'reports' (short informal presentation) by willing participants, and discussion. Other Task reports	Information for Task 1 participants.

Thursday 22 March 2001 – Hotel Marselis

9:00 – 10:30	Item 10: Discussion about potential new work ❑ Feedback from ExCo members following Task 1 OA's approach? ❑ Task 1 ideas Item 11: Special information activities (1) – *Frequently asked questions* ❑ Any final matters before posting on the public website	Agreement on topics to develop further. Agreement on *FAQs* to post on website, and where to locate them.
10:30 – 11:00	*Break*	
11:00 – 12:30	Item 12: Special Information Activities (2) – *Added values …….* ❑ Seeking feedback from the target audience for the report ❑ Discussion of options for widening dissemination of results in each country Item 13: Special Information Activities (3) – *Costing ……..* ❑ Proposed activity plan from working group, as a result of Tuesday's discussions	Agreement to seek feedback from target audiences on the *Added values …* information. Identification of ideas on how to make further use of the *Added values …* information. Agreement on the plans for carrying out the *Costing …* activity.
12:30 – 14:00	*Lunch*	
14:00 – 15:30	Item 14: Communication & public PVPS website ❑ Task 1 website & internal communication ❑ Inter-task communication ❑ National communication strategies ❑ Progress with 'points raised' in Munich re public website ❑ Other public website issues (see attachment 2 to this agenda)	Identification of any communication issues to be resolved (within Task 1 or by the ExCo). Identification of outstanding website issues to be resolved (including matters for the ExCo). Agreement on how to manage and where to locate new material to be provided for the website.

15:30 – 16:00	*Break*	
16:00 – 17:30	Item 14 continued Item 15: Other business Item 16: Next meetings - main issues, location & timing.	

Friday 23 March 2001

Technical visits
8:30 Depart from Hotel Marselis by bus
Visit the 6 MW wind farm at the Tunø Knob.
Lunch at distribution utility EnCon.
Introductory remarks about the Sol-300 project (300 roof tops/750 kWp).
Visit residential area with 100 PV roof tops, and meet home-owners.
17:00 Arrive back at Hotel Marselis by bus.

Attachment 1: Format & content for International Survey Report 6 – total length ~20 pages

Table of Contents	
Foreword	Short introduction of approximately two paragraphs in length.
Executive Summary	Not required
Chapter 1 **Introduction**	This should be kept as short as possible but should include a global overview. Includes Definitions, Symbols and Abbreviations.
Chapter 2 **Implementation of photovoltaic systems**	**Section 2.1 Applications for photovoltaics** **Section 2.2 Total photovoltaic power installed** **Section 2.3 Major projects, demonstrations and field test programmes** **Section 2.4 Budgets for market stimulation, demonstration and R&D**
Chapter 3 **Industry and growth**	**Section 3.1 Photovoltaic cell and module production** **PV technology note** - center-spread, double page feature **Section 3.2 Balance of system component manufacturers and suppliers.** **Section 3.3 System prices**
Chapter 4 **Framework for deployment**	**Section 4.1 New initiatives in photovoltaic power systems** **Section 4.2 Indirect policy issues and their effect on the photovoltaic market** **Section 4.3 Standards and codes**

Chapter 5 **Summary of trends**	1 page maximum
Annex A **IEA-PVPS Task I**	Give names, affiliations and countries of the National Experts, other Task Participants and Technical Writer. Give details of the public website (inside back cover).
Annex B **Exchange rates**	Give Country; ISO Country Code; Currency and ISO Code; Exchange Rate relative to USD – sourced in total from the IEA (inside back cover).

Attachment 2: Other website issues for discussion

Are we meeting the needs of the professional audience (eg utility staff - technical & marketing; bureaucrats - renewables policy & programmes; and renewables industry people)?
Any unresolved problems eg downloads, internal links?
How do we deal with 'presentation' material eg graphs, photos? Are there any good website models we could copy?
Should we develop new sections for statistics, analyses and conclusions from PVPS (for example, country annual reports, material from NSRs, key results from all tasks etc)?
Should we have a current news section and, if so, how would we manage this?
Regarding links – how far should we go? For example, Greenpeace? And what do we do about commercial organizations that are somehow contributing to the participation of the particular participating organization?
Should we feature authors (eg ExCo members with regard to the annual reports) in the keywords?
What style should we present – *friendly* using 'we', 'our' etc as is done currently or *formal* using 'IEA-PVPS'?
Should we refer to *products* or is there a better terminology?
Should there be references to every *PVPower* article or should this be more selective?
Which conferences should be included?
What is our vision for the future of the website?

平成１３年３月２６日

海　外　出　張　報　告　書

(IEA PVPS 第１８回 Task1 Expert Meeting)

１．出張者

ＮＥＤＯ太陽技術開発室　　総括主研　神門　正雄
　　　　　　　　　　　　　主査　　　脇　　栄一

２．出張目的

IEA PVPS 第 18 回 Task1 専門家会議に参加し、PV システムに関する各国の動向調査および情報交換を行った。

３．日時

2001 年 3 月 20 日（火）～3 月 25 日（日）

４．会議場所

デンマーク　オーフス　Hotel Marselis 会議室

５．参加国および参加者

オーストラリア	: Mr. Greg Watt (Australian PVPS Consortium Secretariat)　OA
カナダ	: Mr. Ray Thomas (Newsun Technology Ltd.)
デンマーク	: Mr. Peter Ahm
	Mr. Flemming Kristensen(EnCon)
	Mr. Henrik Bindner (RISO)
	Mr. Soren Poulsen(Danish Technological Institute)
	Mr. Arne Faaborg Poulsen(Elsam)
フランス	: Mr. Andre Claverie (ADEM)
ドイツ	: Mr. Hans Peter Sprau (WP)
イスラエル	: Ms. Yona Siderer (TEL-AVIV University)
日本	: 神門正雄（NEDO　太陽技術開発室　総括主研）
	脇　栄一（NEDO　太陽技術開発室　主査）
	一木　修（(株) 資源総合システム　代表取締役社長）
	山本修二（PVTEC　技術部　課長）
韓国	: Mr. Kyung-Hoon Yoon(Korea Institute of Energy Research)
オランダ	: Mr. Michiel van Schalkwijk(NOVEM)

Ms. Irene De Jong (Utrecht University Utrecht Energy Center)
ノルウェー　：Mr. Bruno Ceccaroli (Solar Silicon AS)
スウェーデン　：Mr. Olle Luundberg (Upsala University)
スイス　：Mr. Pius Heusser (Nova Energie GmbH)
英国　：Mr. Paul Cowley (IT Power Ltd.)
Mr. Alan Taylor (Halcrow)
米国　：Mr. Charles W. Linderman (Alliance of Energy Suppliers)

以上 14 カ国 23 人。今回欠席はオーストリア、EU、フィンランド、イタリア、メキシコ、ポルトガル、スペイン

6．専門家会議

日時　：3 月 21 日（水）9：00～18：00 及び 3 月 22 日（木）9：00～17：30

6．1　歓迎挨拶

OA の Mr. G. Watt より開会の挨拶があり、続いてホスト国のデンマークを代表して Mr.Peter Ahm より歓迎の挨拶およびデンマークにおける Renewable エネルギーの現状について説明があった。

1）デンマークは経済成長に調和した自然エネルギーの拡大を計っている
2）京都プロトコルに沿った CO_2 の削減計画を推進中（1988-2005 で 20%削減）
3）各種自然エネルギー（風力、太陽光など）をバランスよく発展させている（12-14%）

また、太陽光発電について下記のプロジェクトを推進中である。

1996 年～1997 年　Solar City Project
1998 年～2001 年　SOL　300 Project
2000 年～2002 年　SOL 1000 Project

6．2　出席者紹介

続いて出席者全員の自己紹介があり、今回初めて参加するデンマークのメンバー、英国、オランダおよび一木氏の紹介がなされた。

6．3　AGENDA の確認

Costing を第 1 日の午前に討議するなど若干の変更を行い承認された。

6．4　第 17 会議議事録の承認

第 17 回専門家会議（2000 年 10 月　ミュンヘン）の議事録について再確認および承認が行われた。

６．５　16 回 ExCo 会議議事録確認

第１６回 ExCo 会議（2000 年 10 月　ソレント）の状況について OA より説明および内容の確認があった。

６．６　ISR（International Survey Report）の検討

ISR について再検討が行われ、下記の事項が確認された。

１）フォーマットの変更：Table 2.3 に EU のデータを入れる

２）Table 3.1 の Crystalline module については特に変更しない

３）IEA 非加盟国のデータを今後加える

４）次回 ISR より写真を多く挿入する（例えば Added Value Report の表紙写真）

５）17th European Photovoltaic Solar Energy Conference and Exhibition(22-26 October 2001)および Upex 01(Photovoltaic Experience Conference, September 30 – October 5,2001)の両コンファレンス用に ISR の増刷を行う

６．７　NSR（National Survey Report）の検討

NSR について検討が行われ、下記の事項が確認された。

１）各国の NSR 提出期限は規定通り 5 月 31 日とすることが再確認された。

２）NSR Table 1 の各国の Executive Summary を PVPS の Website に掲載する

６．８　PVPower Newsletter の検討

Newsletter について検討が行われ、下記の事項が確認された。

１）Format に関しては特に変更しないことが Task1 全員で了承された。
（今後は“DRAFT POLICY FOR PVPOWER NEWSLETTER”に基づいて行う）

２）#15 の記事について、日本、Task5、Task7、Task9 のニュースを記載する

３）印刷の時期はミュンヘンの Conference 以前とする

４）その他の記事について希望があれば 7 月中旬までに Mr. P. Cowley (IT Power)に連絡する

６．９　各国 PV 状況報告・他タスク状況報告

他 Task 状況について Task５の状況説明が Mr. Arne Faaborg Poulsen（デンマーク）より行われた。続いて各国の PV 状況説明が行われ、中でも特に日本と米国について注目が集まった。

日本の状況について NEDO の神門総括主研より下記の説明があった。

１）日本の長期新エネルギー供給計画は次のように変更された。

エネルギー	今までの目標	新しい目標
PV	5000MW	4820MW
WIND	300MW	3000MW

□日本は PV システムの設置数量を増大するために、尚一層のコストダウンを行う

□助成金プログラムに多すぎるほどの応募があった

□低コスト PV セル製造技術の確立を行う

□拡大のための共通技術および次世代技術の確立

またこの他、日本の 2001 年の PV 予算についての説明もなされた。

2）米国カリフォルニア州における電力不足問題について

Mr. C. Linderman より、米国カリフォルニア州で起こっている電力供給不足問題の概要説明があった。深刻な電力不足は結果的に PV への関心と注文を大幅に増加する結果となり、州全体の PV 関係のディーラーおよびメーカーの売上は 10~100% 増になった。また DWP（Department of Water and Power）プログラムによりロスアンジェルスで製造する PV メーカーには＄5/watt（その他地域では＄3）が助成されるため、最近ロスアンジェルスへ工場進出した Siemens Solar への引き合いは 1 日 20 件から 6 倍の 120 件に増加し、BP Solar ではカリフォルニア州のピーク電力 45,000MW に対し、対応できるのは現在 220MW のみである。この思わぬ事態によって結果的に PV が電力の安定供給という面で見直されることになった。

6．10　Potential New Work に関する討議

FAO（国連食料農業機関）から PV 普及計画に関する協力依頼があり、ExCo の要請で Task1 がサポートすることになった。これは SARD（Sustainable Agriculture and Rural Development）に基づく計画で、発展途上国の農業発展のために必要なプログラムを積極的に推進する計画で、Task1 として下記の事項についてどんな国際的活動を行うか検討することになった。

1）技術的な課題、資金的な問題、市場戦略の検討

2）Grid-connected（系統連系）、Off-grid（非系統連系）両面の検討

3）OECD 加盟各国、発展途上国との取り組み

6．11　特別活動 FAQ（Frequently asked questions）

Mr. A. Claverie の作成した FAQ について意見聴衆が行われ、全体的な賛同があった。確認事項は下記の通り。

1）内容に関してさらに改善を行うため、最終コメントを 3 月末までに提出する

2）日本は完成版入手後日本語訳版（イラストを多く加える）を作成し国内関係者に配布する

3）完成後英語版を Website に掲載する

6．12　特別活動（Added Values）

Halcrow 社の Mr. A. Taylor より Added Value Report の最終校正版が提示され、全員に回覧された。表紙写真やデザイン等について全員の賛同があった。3 月中に印刷・配布を行う。今後の課題として下記事項が確認された。

1）各関係者へのガイドライン（非技術的・プロジェクト中心）とするための方法を

検討する

2）ExCo メンバーへの配布は次回 ExCo 会議（2001 年 4 月サクラメント）にて日本が直接 2 部づつ手渡す

６．１３　特別活動（Costing）

OA より Costing ワーキンググループ会議の状況および確認事項の説明があった。今後はデンマークを中心に作業を進め、OA が次回 ExCo 会議で趣旨説明を行い、ExCo の賛同を得る予定である。

６．１４　特別活動（Workshop）

17th European Photovoltaic Solar Energy Conference and Exhibition（2001 年 10 月 22－26 日）に合わせワークショップを開催することが提案され、下記の事項が確認された。

1）招待者は主に Utility グループおよび PV に関する推進者とする

2）Added Value および Costing についてプレゼンテーションを行い、Added Value に関しては Mr. P. Heusser（スイス） Mr. P. Cowley（英国） Mr.M.V.Schalkwijk（オランダ）のいずれか 1 人が行う

3）ワークショップの開催については OA より次回 ExCo で趣旨説明を行い、ExCo の賛同を得る

６．１５　コミュニケーション及び PVPS ホームページについて

□Task1 の Website について Mr. P. Heusser より説明があり、下記の点が確認された。

1）Task1 関連の写真をもっと多く掲載する

2）新しいパスワードを後日 Task 1 メンバーに連絡する

□Intertask コミュニケーションについては今後も改善を行う

□各国の統計、情報を Website に掲載する

□Ms. De Jong より PVPS の Website 運営状況について説明があった。

結論は下記の通り

1）ホームページ訪問の数は次第に増加している

2）成果物、PV、Task に関するページが最も人気

3）67%の訪問者は IEAPVPS メンバー国の住民。内 36%が欧州

4）上記訪問者は他の関連 Website から PVPS の存在を知った。

5）3.9%のみがサーチエンジンで直接アクセス

6）殆どの訪問者が下記のコンピューターを所有

Windows、MSIE、1024×768 または 800×600、16Bit または 32Bit

また、Menue に関し下記のように順番を変更することになった。

1）Introduction

2）Programme(& activities & network)

3）Products

4）Statistics (tables, graphs)
5）(PVPS) country summary
6）Newsletter
7）FAQS
8）PV basics
9）Events
10) Links
11) Search

6．16　その他関連事項

□PVPS の Annual Report について Task 1 の Subtask 4（Executive Conference）を削除する。

□PV に関する市場展開促進戦略プログラムについて
(Short note on a market acceleration for photovoltaic / Eric Lysen and Stephan Nowak, Chair of the IEA-PVPS Programme)

6．17　今後の会議予定

第 19 回会議予定：10 月 8～10 日	ノルウェー	Bod□
第 20 回会議予定：3 月 13～15 日	米国	ハワイ島またはロングビーチ

7．テクニカル・ツアー

日時　：3 月 22 日（金）

7．1　5MW 風力発電システム（Tuno　Knob）

設置状況は下記の通り
1）1995 年、世界最初の Off-shore Windfirm を建設
3）デモンストレーション用、環境的観点での実験調査が目的
4）2 列、合計 10 基、南北方向、Jutland へ 6km、Tuno へ 3km
5）Jutland への系統連系　10kv の海底ケーブル

仕様

1）タービン	：	10　Vestas　V39　500kw
2）総出力	：	5MW
3）ハブ高	：	39m
4）ロータースピード	：	33rpm
5）開始風速	：	4m
6）停止風速	：	25m
7）定格風速	：	14m

8）タービン重量　　　　：　57トン

9）年間発電出力　　　　：　15mil. KWh　（4000軒住宅相当
CO_2　12,500t 削減）

7．2　エネルギー会社 EnCon の概要

EnCon は 1999 年 1 月 1 日に電力会社 HOH と VOH の合併によって設立され、25,000 の家庭およびビジネスセクターへ電力供給を行っている。子会社に下記の 3 社がある；

EnCon Marked　：デンマーク国内および外国との電力売買を担当

A/S、EnCon Net　：電力ネットワークの拡張（地中ケーブルおよび鉄塔）、変電所の設置、送電、メンテナンスを担当

EnCon Enterprise A/S：エネルギー供給に関する個人および企業向けのコンサルタントとサービス業務を担当

7．3　SOL-300 Project（300 roof tops/750 kWp）

SUNCITY Project (30 軒の住宅屋根に PV 設置 1996-1999)の経験に基づき、1998 年にデンマークで最大のソーラーパワープロジェクト SOL-300（2001 年まで継続）が発足した。Jutland および Funen 地区の個人住宅 300 軒の屋根に 0.6～6kWp の PV システムを設置し、全体では 750kWp

7．4　100PV roof tops

SOL-300 以前に実行された個人住宅 100 軒分の Roof top PV システム。デンマークで最初の PV システムを屋根に設置した家庭を訪問。

International Energy Agency - Implementing Agreement on Photovoltaic Power Systems

Task 1 - Exchange and Dissemination of Information

SUMMARY

18TH TASK PARTICIPANTS' MEETING
Aarhus, Denmark, 20-23 March 2001

Item 1: Introduction & welcome by hosts

Greg Watt welcomed meeting participants and thanked the Danish members for their excellent meeting arrangements. Peter Ahm welcomed Task 1 to Aarhus, described the energy situation in Denmark, and outlined arrangements for the following days.

Item 2: Introduction of meeting participants & apologies

Meeting participants were Greg Watt (Australia), Raye Thomas (Canada), André Claverie (France), Peter Ahm, Flemming Kristensen, Søren Poulsen, Henrik Bindner & Arne Povlsen (Denmark), Peter Sprau (Germany), Kyung-Hoon Yoon (Korea), Yona Siderer (Israel), Masao Kando, Eiichi Waki, Shuji Yamamoto & Osamu Ikki (Japan), Michiel van Schalkwijk (The Netherlands), Olle Lundberg (Sweden), Pius Hüsser (Switzerland), Paul Cowley (United Kingdom), Bruno Ceccaroli (Norway), Charles Linderman (USA), Alan Taylor (Halcrow Gilbert) and Irene De Jong (webmaster). New, changed or visiting participants (underlined) were welcomed. Lars Stolt (Sweden) participated in the "Costing .." meeting held the previous day (Tuesday).

Apologies were received from Salvatore Guastella and Anna De Lillo (Italy).

Updated contact details can be found on the Task 1 website.

Item 3: Adoption of Agenda for 18th meeting

The following changes to the draft agenda as circulated were noted:
- Item 13 "Costing ..." was brought forward to the first day;
- Discussion about a workshop in Munich was included in the morning of day two.

The amended final agenda is shown at attachment 1 to these minutes.

Item 4: Matters arising from Minutes of 17th meeting

Greg Watt noted that all the action items arising from the 17th meeting would be discussed under subsequent agenda items.

Task 1 participants are to refer to attachment 2 of this document for an updated summary of new actions requiring attention.

Item 5: Matters arising from ExCo meeting in Sorrento, Italy (October 2000)

Greg Watt, noting that the minutes had been circulated, summarized the main issues for Task 1as follows:

- The Annual Report is to have better quality control in future;

- Lack of expert participation remains an issue to varying degrees in all tasks;
- The task website guidelines proposed by Task 1 were endorsed;
- Distribution numbers for the ISR are the responsibility of Task 1;
- The document production plan for "Added values .." was approved;
- The new work on "Costing .." was supported in principle;
- There was interest in expanding the performance indicators for each task to give a better insight into task progress;
- Halcrow was awarded the contract for ISRs 6 & 7;
- Improvements in intertask communication (eg through development of the website and invitation of national experts to task meetings) were acknowledged;
- National communication strategies, particularly involving the ExCo member and Task 1 participant, are regarded as useful management tools;
- The ExCo website group has been re-established;
- The REWP "Renewable Energy Market Initiative" remains a focus for the ExCo. Pius Hüsser presented work recently prepared by Erik Lysen and Stefan Nowak for this initiative, *Short note on a market acceleration strategy for photovoltaics* (copy circulated)

Item 6: International Survey Report

Dr Alan Taylor of Halcrow was introduced to the meeting as the new technical writer for ISR6.

The following changes for ISR6 were endorsed:
- Layout is to be improved with the report length increasing to 20 pages;
- Table 2.1 is to again report both off-grid domestic and non-domestic;
- EU data (annual budgets) are to be included in Table 2.3;
- Some reporting of labour places should occur;
- Section 3.1 is to include a graphic example of module price trends;
- Section 3.3 is to include a graphic example(s) of system price trends for a specific application(s);
- Background colour eg Table 4.1 is to be lightened to facilitate better photocopying;
- Non-IEA country information will be actively sought for ISR6;
- Exchange rate information (annex B) will be sourced from the IEA;
- The 'light bulbs' are to be removed from the page corners;
- Tables are to be numbered as per the reporting guidelines.

The 2001 schedule for ISR6 was endorsed as follows:
End May – All National Survey Reports to be emailed to Technical Writer;
Early July – 1st draft of the ISR emailed to Task 1 participants by Technical Writer;
Early August – 2nd draft of the ISR emailed to Task 1 participants by Technical Writer. Task 1 participants are expected to discuss the draft with their ExCo member at this stage.
Mid August – Final draft of the ISR sent to graphic designer by Technical Writer;
End August – Technical Writer provides 'wet proofs' for final checking by selected Task 1 participants;
Early September – Technical Writer initiates printing;
Mid September – Technical Writer organizes bulk distribution of reports by courier.

The issue of printing extra copies of the 2001 ISR for distribution at both the UPEx conference in Sacramento at the beginning of October and the European PVSEC in Munich in late October was discussed. The ExCo is to be asked to consider additional funding for this.

Item 7: Special information activities (1) – Costing ....

Outcomes of the meeting of the working group (Denmark, Sweden, Norway, Canada, Germany and Japan) held on Tuesday 20 March 2001 were reported to the meeting. This work will build on earlier research carried out in Denmark, will focus on grid-connected applications and will provide useful support of PV marketing through publication of an IEA-PVPS report and software.

Most of the details agreed to by the working group are contained in attachment 3 of this document. It was also noted that:
- there should be some collaboration with both Task 5 (Activity 54.2 – Financial Aspects) and Task 7 (Activity 3.3 – Economics of BIPV);
- The activity may lead into work on off-grid costings in the future;
- There should be general discussion about electricity prices eg highlighting the Californian situation;
- There should be some reference to application of carbon credits.

Item 8: National Survey Reports

No 'new' problems were reported regarding information gathering, although it was acknowledged that this is becoming an increasingly difficult task for some countries. Task 1 participants were reminded of the amended items in the latest guidelines:
- labour places data are again to be reported;
- countries having a significant PV programme (eg on-grid distributed) or a well documented market segment (eg off-grid domestic and/or non-domestic) plus access to the required data (eg as presented for residential systems by both Germany and Japan during the meeting) should include data on system prices for a number of years;
- module prices should be reported for a number of years;
- off-grid domestic and non-domestic are again to be reported separately if possible;
- exchange rates are no longer required to be provided.

The year 2000 NSRs are to be completed by the end of May 2001. The reports will be circulated to Task 1 participants in June 2001.

It was agreed that, in response to feedback from the target audiences requesting 'earlier' release of information, the executive summaries and cumulative installed capacities by application will now be included on the public website under the 'PVPS Country Summaries'.

Item 9: *PVPower* newsletter

Paul Cowley reported on how the matters raised during the Munich meeting had been addressed, in particular:
- Longer articles now contain sub-headings;
- 'New on the net' is now more focused, and has been renamed 'Internet resources';

Issue No. 14 has been drafted but is behind schedule for printing and distribution. The Netherlands no longer funds this activity and printing was delayed until an agreement was put in place for the Common Fund to pay for this activity. The ExCo will be asked to consider whether (1) another country may be willing to support this activity or (2) a competitive tender for the printing and mailing should be offered.

The proposed contents for Issue No.15 were discussed, including various Task 5, Task 7 and Task 9 reports that are due for publication, PV for Small Island Developing States, PV refrigeration, PV on churches, PV and the US situation re electricity prices etc. This issue should be produced in time to be available for the October conferences.

The newsletter policy document was endorsed and will be added to the *Handbook of policies and procedures*. A number of issues of *PVPower* are available on the website.

Task 1 members are expected to continually review and update the *PVPower* target audience within their country, and their requirements from the newsletter.

Item 10: Country reports etc

Each participant at the meeting provided a short, informal presentation of current issues influencing implementation of PV in their country. Charles Linderman provided an interesting overview of the electricity supply crisis in California. It was suggested that in future it would be of value to circulate key points from all these presentations during the meeting.

The visiting Danish PVPS Task 5 Expert described progress in this task.

Item 11: Discussion about potential new work

It was noted that there had been no response from ExCo members to the request for input on this topic.

Consequently, the meeting considered issues raised by the REWP "Renewable Energy Market Initiative", recommendations in the report *Solar photovoltaics for sustainable agriculture and rural development* by the UN Food and Agriculture Organization and suggestions for further work arising from the 'Added values of photovoltaic power systems' activity. The summary of these discussions, within the framework of the issues raised by the REWP, is presented in attachment 4.

A number of priority activities (for which Task 1 could develop workshops, surveys, reports etc) that appear relevant to each of the above have been identified, including:

- "Innovative financing and marketing strategies" – can apply to grid-connected and off-grid; will involve collaboration with other tasks (particularly 7, 8 & 9); will consolidate the outcomes, for the appropriate target audiences, of the variety of approaches that have been developed world-wide; could be part of (or stimulate) a wider 'renewables' activity; will have national benefits through identifying and assessing available promotion mechanisms (eg for the Israeli interest in identifying international funding opportunities for domestic PV).
- "Implementation issues" – aimed at overcoming those non-technical impediments to PV deployment (legislative, planning, institutional etc) by identifying and documenting 'best practices' in the participating countries, and qualifying the benefits that have resulted.

The critical factor is having a country prepared to lead and/or host activities that have been identified, or having some other means to resource these activities. This matter will be raised at the ExCo meeting.

Item 12: Workshop for European PVSEC, October 2001

It was proposed that a PVPS workshop on electricity utility issues and applications be held in conjunction with the European PVSEC, with the aim of attracting electricity utility players to the conference. A Task 1 working group (Switzerland and the US) will develop the scope for this activity, with the aim of closely involving European utility industry associations. The ExCo will be requested to endorse in principle the planned workshop, and provide some guidance as to funding etc.

Item 13: Special information activities (2) – Answers to frequently asked questions

The draft report (*Answers to frequently asked questions about solar photovoltaic electricity: an international perspective* Internal report IEA-PVPS T1-03:2001) has been prepared by André Claverie, and was endorsed by the meeting.

The final document is to be circulated to Task 1 participants to use as they please, and the complete set of questions and answers will be loaded on to the public website in April 2001 under 'Frequently Asked Questions' for all PVPS members to use as a resource when asked questions etc.

Item 14: Special information activities (3) – Added values .....

The public PVPS report for this activity (*Added values of photovoltaic power systems* Report IEA-PVPS T1-09:2001) has been written, endorsed by Task 1 and approved by the ExCo. Printed copies of the public report will be available in April, and the report will also be able to be downloaded from the public website. Feedback about the usefulness of this material is to be reported in time for the September 2001 Task 1 Status Report. Switzerland, the Netherlands and the UK plan to submit a paper on this activity for the European PVSEC to be held in October 2001.

Item 15: Communication & public PVPS website

Following a request for guidance on the matter, Task 1 recommends that the ExCo endorse the use of the following terminology consistently across PVPS:
- grid-connected
- off-grid or stand-alone.

It was discussed that, in its current format, the PVPS annual report attempts to achieve different outcomes for different target audiences. It was agreed that the ExCo would be requested to consider whether it may be more effective to produce two more clearly targeted documents:
- an inexpensive report covering the tasks, participants, meetings, technical visits etc aimed at PVPS members, national funding bodies and the IEA hierarchy, and,
- a glossy document containing the national reports, photographs, feature articles about PVPS achievements etc aimed at the wider professional and public audiences.

Greg Watt noted that progress toward enhancing inter-task communication was mostly good, with minutes etc now being regularly circulated, and national task participants being invited to meetings in their countries.

Greg Watt noted that less than half the participating countries have prepared a written national communication strategy, but that this should be regarded as an ExCo management process.

The webmaster, Irene De Jong, gave a detailed presentation on the format, content and 'performance' of the website, which was followed by a detailed and productive discussion regarding its further development. The summary of these discussions (prepared by Irene with input from Greg) is presented in attachment 5.

Item 16: Other business

It was agreed that, as Task 1 does not play a role in defining the scope, inviting participants or even disseminating information for the Executive Conference, the ExCo should be requested to remove the reporting of "subtask 4.0" from Task 1 annual reporting.

Task 1 participants discussed new names for the task, but an obvious replacement was not forthcoming (although some of the acronyms were interesting!).

Yona Siderer presented to the meeting details about the European organization OPET, which may provide useful synergies regarding technical collaboration. It was suggested that the information be provided to an ExCo member for presentation to the ExCo meeting, as development of these sort of collaborative ventures are ExCo rather than task responsibilities.

Item 17: Next meetings

The 19th Task 1 Participants' meeting will be held at a hotel with a large BIPV system on the Big Island, Hawaii, 8-10 October 2001.

The 20th Task 1 Participants' meeting will be held in Bodø, Norway, 13-15 March 2002, with a technical visit to the SCANWAFER production facility.

Attachment 1: Final meeting schedule / agenda - 18th Task 1 participants' meeting, 20-23 March

Hotel Marselis, Strandvejen 25, Aarhus, Denmark

Dates & Times	Activities & Key Parties	Outcomes

Tuesday 20 March 2001
15:30 – 17:30 Initial meeting of '*Costing …*' working group – Hotel Marselis
19:00 – For those interested, meet in lobby of Hotel Marselis
19:00 – 21:00 Informal meeting over dinner to confirm arrangements, discuss matters of interest & set the scene for 18th Task 1 meeting

Wednesday 21 March 2001 – Hotel Marselis

9:00 – 10:30	Item 1: Introduction & welcome by hosts	
	Item 2: Introduction of meeting participants, new members & apologies	
	Item 3: Adoption of Agenda for 18th meeting	
	Item 4: Matters arising from Minutes of 17th meeting	
	Item 5: Matters arising from ExCo meeting in Sorrento, Italy (October 2000)	Information for Task 1 participants.
10:30 – 11:00	*Break*	
11:00 – 12:30	Item 6: International Survey Report: ❑ Introduction of new technical writer – Dr Alan Taylor, Halcrow ❑ Reiteration of changes to be incorporated in ISR6 as discussed in Munich (see attachment 1 to this agenda, and Munich minutes) ❑ Schedule for production for 2001 ❑ Choice of photos (please bring to meeting) for ISR6 Item 7: Special Information Activities (1) – *Costing ……..* ❑ Proposed activity plan from working group, as a result of Tuesday's discussions	Task 1 endorsement of format, content and schedule for ISR6. Agreement on the plans for carrying out the *Costing* ... activity.
12:30 – 14:00	*Lunch*	
14:00 – 15:30	Item 8: National Survey Reports: ❑ Progress against revised guidelines (previously circulated) ❑ Publication of selected NSR information on the public website	Identification of any information gathering problems. Agreement on NSR information to be incorporated on the website.

	Item 9: *PVPower* newsletter: ❑ Progress on matters raised during Munich meeting (Paul Cowley) ❑ Feedback on past issues; plans for future contents (Paul Cowley) ❑ Newsletter 'policy' note (Greg Watt)	Endorsement of format and content of subsequent issues of *PVPower*.
15:30 – 16:00	*Break*	
16:00 – 18:00	Item 10: Country 'reports' (short informal presentation) by willing participants, and discussion. Other Task reports	Information for Task 1 participants.

Hosted dinner

Thursday 22 March 2001 – Hotel Marselis

9:00 – 10:30	Item 11: Discussion about potential new work ❑ Feedback from ExCo members following Task 1 OA's approach? ❑ Task 1 ideas Item 12: Workshop for European PVSEC, October 2001	Agreement on topics to develop further. Proposal for ExCo
10:30 – 11:00	*Break*	
11:00 – 12:30	Item 13: Special information activities (1) – *Frequently asked questions* Any final matters before posting on the public website Item 14: Special Information Activities (2) – *Added values ....* ❑ Seeking feedback from the target audience for the report ❑ Discussion of options for widening dissemination of results in each country	Agreement on *FAQs* to post on website, and where to locate them. Agreement to seek feedback from target audiences on the *Added values …* information. Identification of ideas on how to make further use of the *Added values …* information.
12:30 – 14:00	*Lunch*	
14:00 – 15:30	Item 15: Communication & public PVPS website ❑ Task 1 website & internal communication ❑ Inter-task communication ❑ National communication strategies ❑ Progress with 'points raised' in Munich re public website Other public website issues (see attachment 2 to this agenda)	Identification of any communication issues to be resolved (within Task 1 or by the ExCo). Identification of outstanding website issues to be resolved (including matters for the ExCo). Agreement on how to manage and where to locate new material provided for website.
15:30 – 16:00	*Break*	

– 30 –

16:00 – 17:30	Item 15 continued Item 16: Other business Item 17: Next meetings - main issues, location & timing.	

Friday 23 March 2001

Technical visits
8:15 Depart from Hotel Marselis by bus
Visit the 6 MW wind farm at the Tunø Knob.
Lunch at distribution utility EnCon.
Introductory remarks about the Sol-300 project (300 roof tops/750 kWp).
Visit residential area with 100 PV roof tops, and meet home-owners.
17:00 Arrive back at Hotel Marselis by bus.

Agenda attachment 1: Format & content for International Survey Report 6 – total length ~20 pages

Table of Contents	
Foreword	Short introduction of approximately two paragraphs in length.
Executive Summary	Not required
Chapter 1 **Introduction**	This should be kept as short as possible but should include a global overview. Includes Definitions, Symbols and Abbreviations.
Chapter 2 **Implementation of photovoltaic systems**	**Section 2.1 Applications for photovoltaics** **Section 2.2 Total photovoltaic power installed** **Section 2.3 Major projects, demonstrations and field test programmes** **Section 2.4 Budgets for market stimulation, demonstration and R&D**
Chapter 3 **Industry and growth**	**Section 3.1 Photovoltaic cell and module production** **PV technology note** - center-spread, double page feature **Section 3.2 Balance of system component manufacturers and suppliers.** **Section 3.3 System prices**
Chapter 4 **Framework for deployment**	**Section 4.1 New initiatives in photovoltaic power systems** **Section 4.2 Indirect policy issues and their effect on the photovoltaic market** **Section 4.3 Standards and codes**

Chapter 5 **Summary of trends**	1 page maximum
Annex A **IEA-PVPS Task I**	Give names, affiliations and countries of the National Experts, other Task Participants and Technical Writer. Give details of the public website (inside back cover).
Annex B **Exchange rates**	Give Country; ISO Country Code; Currency and ISO Code; Exchange Rate relative to USD – sourced in total from the IEA (inside back cover).

Agenda attachment 2: **Other website issues for discussion**

Are we meeting the needs of the professional audience (eg utility staff - technical & marketing; bureaucrats - renewables policy & programmes; and renewables industry people)?
Any unresolved problems eg downloads, internal links?
How do we deal with 'presentation' material eg graphs, photos? Are there any good website models we could copy?
Should we develop new sections for statistics, analyses and conclusions from PVPS (for example, country annual reports, material from NSRs, key results from all tasks etc)?
Should we have a current news section and, if so, how would we manage this?
Regarding links – how far should we go? For example, Greenpeace? And what do we do about commercial organizations that are somehow contributing to the participation of the particular participating organization?
Should we feature authors (eg ExCo members with regard to the annual reports) in the keywords?
What style should we present – *friendly* using 'we', 'our' etc as is done currently or *formal* using 'IEA-PVPS'?
Should we refer to *products* or is there a better terminology?
Should there be references to every *PVPower* article or should this be more selective?
Which conferences should be included?
What is our vision for the future of the website?

Attachment 2: SUMMARY OF KEY TASK 1 ACTIONS

ACTION	RESPONSIBLE PARTY	TIMING
1. Follow-up on EU data for ISR	Greg Watt	By end May 2001
2. Follow-up on non-IEA country data for ISR	Paul Cowley	By end May 2001
3. Provide photos to Alan Taylor for ISR	All Task 1	By mid 2001
4. Ask ExCo to fund printing extra copies of ISR for distribution at conferences	Greg Watt	April 2001 ExCo meeting
5. Circulate existing costing report and software to all Task 1 participants	Greg Watt	April 2001
6. Send *Financing* paper and working group email addresses to Henrik Bindner	Greg Watt	April 2001
7. Seek ExCo endorsement of plans for "Costing .." activity	Greg Watt	April 2001 ExCo meeting
8. Email NSRs to Alan Taylor	All Task 1	By 31 May 2001
9. Ask ExCo to discuss the future of printing and mailing of *PVPower*	Greg Watt	April 2001 ExCo meeting
10. Prepare printed one page summary (or similar) of 'country presentation'	All Task 1	October 2001 Task 1 meeting
11. Ask ExCo to consider how to resource further Task 1 special information activities	Greg Watt	April 2001 ExCo meeting
12. Develop a PVPS workshop on electricity industry issues and applications for EPVSEC	Pius Hüsser, Charles Linderman, Greg Watt	April 2001 ExCo meeting (initial milestone)
13. Circulate final FAQs	André Claverie, Greg Watt	Done
14. Develop an "Added values .." paper for EPVSEC	Pius Hüsser, Paul Cowley, Michiel van Schalkwijk	Abstract by end April 2001
15. Advise Greg Watt regarding feedback about usefulness of "Added values .." report	All Task 1	September 2001
16. Ask ExCo to endorse the consistent use of applications terminology across the whole of PVPS	Greg Watt	April 2001 ExCo meeting
17. Ask ExCo to consider producing more clearly targeted Annual Reports	Greg Watt	April 2001 ExCo meeting
18. Ask ExCo to remove reporting of Executive Conference from Task 1 responsibilities	Greg Watt	April 2001 ExCo meeting
19. Clarify the policy for task websites	Greg Watt	April 2001 Operating Agents meeting
20. Encourage other tasks to provide more information for the public website	Greg Watt	April 2001 Operating Agents meeting
21. Initiate discussion on whether the Task 2 website could be located within the public website	Greg Watt	April 2001 Operating Agents meeting
22. Ask ExCo to consider a "News" section on the website	Greg Watt	April 2001 ExCo meeting
23. Ask ExCo to decide the policy for commercial links from the website	Greg Watt	April 2001 ExCo meeting

Attachment 3: Production plan – Costing of energy from photovoltaic power systems

1. Title (final)

Costing of energy from photovoltaic power systems

2. Report number

(Probably) Report IEA-PVPS T1-11:2002

3. Author or editor

Denmark is the lead country for this activity, with RISØ managing the research. The actual technical writer has yet to be decided

4. Purpose of document

To provide a consistent methodology and accepted assumptions both for calculating the basic cost of PV generated energy in whatever country, and for comparing these costs between various countries;
To raise awareness of the concepts being discussed and other qualitative issues that should be considered whenever economic analyses of PV are to be used as the basis for policy, planning etc, and to make recommendations as to how these should be addressed.

5. Subtask connection (if any)

Special information activity

6. Abstract

To be developed

7. Table of contents or major chapter headings (indicative)

The work will be organized into four discrete sections:

- Discussion of issues relating to costing eg rationale, limitations, cost v. price, projections, financial v. engineering approaches, direct/indirect costs etc.
- Description of the costing elements relevant to PV, including documentation of references used.
- Development of the generic costing model, with flexibility to incorporate other more sophisticated sub-models eg for net energy production.
- Examples of use of the model through case studies of a number of PV applications compared with other energy supply options, from a number of countries (and including LCA where possible)

8. Intended audience

Bureaucrats, utility planners and renewable energy programme developers in all countries.

9. Category: Published Report or Internal Working Document

Published report and software model.

10. Responsibilities of specific Task participants for its preparation

Within Task 1, Denmark will have overall responsibility for the management of this activity, with Sweden, Norway, Germany, Japan and Canada providing 'working group' support. The lead country is responsible for ensuring that adequate resources are available to carry out the work required and produce the proposed deliverables. The lead country can engage other Task 1 countries as required.

11. Person responsible for printing

Production, printing and mailing of the report will be the responsibility of Denmark.

12. Details regarding how hard copies of the document can be obtained/purchased

Task 1 participants should be approached regarding free bulk copies. The written report will also be able to be downloaded from the public PVPS website, together with an Excel spreadsheet of the model.

13. Expected number of copies to be published and proposed allocation

It is anticipated that 1000 copies of the written report will be published and disseminated free of charge, including (as per the Handbook of Policies and Procedures):

- 2 copies to each ExCo member
- 2 copies to the Executive Secretary
- 1 copy to each Operating Agent
- 1 copy to the IEA Secretariat.

Additional copies may be ordered at a cost to be decided.

14. Production schedule with expected dates:

14.1 drafts of costing issues and costing elements completed – September 2001
14.2 model development completed – October/November 2001
14.3 case studies commence following feedback at the 'Utilities' workshop planned for the European PVSEC – October 2001
14.4 approval, publication and distribution of results – probably around May 2002.

15. Dissemination and publicity plans

Task 1 participants will be responsible for providing printed copies of the report to the target audience in their respective countries. The report will be listed and also able to be downloaded as a .pdf document from the public PVPS website. The model will be downloadable as an Excel spreadsheet. An article about the activity will be placed in the September 2001 issue of *PVPower* (No. 15).

16. Plans to assess impact of product

An ongoing component of Task 1 work is to gather feedback from target audiences on the usefulness of material that is produced by the IEA-PVPS Programme. Results for this activity will be reported in subsequent Task 1 Status Reports.

Attachment 4: Framework for discussions about potential new work

REWP issue	Would this be an appropriate Task 1 activity?	Is it relevant to other PVPS tasks?	Relevant for off-grid products?	Relevant for BIPV?
Is a take-off market or application anticipated? (ie a break-through)	No	No		
Identification of current niche markets for the technology	Not really – only providing information eg case studies in *PVPower*	Probably Task 3	Yes, eg telecoms, SHS	Yes
Can the likely main pathways to price reduction be identified? (should be cost reduction)	Not really – maybe more general economic issues	Already the focus of much current component R&D	Yes	Yes
5-10 year projected investment/capacity in countries/regions	No – maybe some analysis of scenarios v. trends; maybe an interesting workshop topic	Not really		
Prices of competing technologies, energy sources	Not really – maybe just provide costing tools	Links to other IAs through ExCo	Yes	Only if added values are not considered!
Identifying countries with political will and significant potential markets for PV	Refer to ISR	Task 9 for off-grid; Task 8	Yes	Yes
Are short-term expansions of the PV markets likely? (eg are new applications likely to emerge)	Not really – should spread reliable information on markets and technology only	Task 7	Not really	Yes
Will longer-term PV system improvements be significant? (eg through R&D)	No	No		
Can legislative changes be addressed to accelerate implementation? (eg import duties etc)	Yes – see below	Maybe Task 9	Yes	Yes
Can non-recurring costs be tackled? (eg cost of planning approvals, interconnection etc)	Yes – propose "Implementation issues" for local govt., planners etc (non-technical people who can	Tasks 5 & 7	Yes	Yes

	hinder or drive projects / programmes)			
What investment strategies might be useful for PV? (eg different financing arrangements)	Yes – propose "Innovative financing & marketing strategies"	Tasks 7, 8 & 9, BUT also for all renewables; also links to FAO recommendations	Yes	Yes
What sort of international co-operation could be promoted?	Yes – identifying and preparing support material; but should be ExCo driven; also links to FAO recommendations; can link into the above	Tasks 8 & 9	Yes	Yes
Are other benefits likely to flow from the increased implementation of PV? (eg health & social improvements etc)	Yes – case studies and can link into "Innovative …. strategies" above	Maybe	Yes	Yes (& including energy efficiency)
Identify initial priorities that could be tackled (eg targeted projects)	No	ExCo decision	Yes	Yes

Attachment 5: Summary of website discussions

General

1. The main objective of the website was endorsed - to inform about the outcomes of the IEA-PVPS programme. The opening page will be amended to better reflect this.
2. The main target audience of the IEA-PVPS website was endorsed - professionals working in the field of solar photovoltaic electricity (government, utilities and industry).
3. Considering the main objective and target audience Task 1 has selected the following keywords for search engines: PV markets, PV statistics, PV market reports, PV world market, PV industry (previously: photovoltaics, solar electricity, solar photovoltaic electricity, IEA-PVPS, solar energy, renewable energy).
4. Regarding the language of the site, it was agreed that a balance between formal and informal should be employed. Use both the third person (IEA-PVPS) and the first person (we), depending on the information presented, e.g. when the programme is presented, "we" seems more appropriate, whereas when technical issues are discussed "IEA-PVPS" should be used. However, it was noted that generally on the web the language is less formal.
5. The Task 1 participants did not raise any unresolved problems regarding the website.
6. Regarding quality control it was decided that 3 or 4 Task 1 participants will review the website once per year. This will be added to the agenda of the March Task 1 meetings as an ongoing item.
7. The OA of Task 1 will discuss Task specific websites in the coming OA meeting, as these can create some confusion (see also 'Photon' last issue). The OA of Task 1 will propose that the Task websites will only be for a limited audience; access should be encouraged through the main IEA-PVPS website (as per the 'policy' endorsed at the previous ExCo meeting).
8. Database based website: in an earlier Task 1 meeting it was suggested to convert the current website to a database based website. Advantages: faster, better search engine possible. Disadvantages: fixed layout for each page, which will make it less attractive. As the current website is already managed by means of a database, the Task 1 participants did not feel the need to request conversion to a database based website.
9. A button will be added enabling visitors to subscribe to a "new to the website" message; they will be informed by broadcast email about new publications added to the website or any other essential changes.

Sections

PV section: As this section is less important for the target audience, it was decided to move it down the menu, and to rename it "Basics of PV". Task 1 members do not have specific comments on the contents, but were encouraged to provide any corrections etc directly to the webmaster.
FAQs, (Frequently Asked Questions) [NEW]: André Claverie will finalize the FAQs and send them to Irene de Jong to implement it as a separate section on the website. FAQs in other languages - if and when available - will also be added.
Programme: Whenever it seems appropriate the webmaster or the OA of Task 1 will propose changes to the IEA-PVPS chairman.
Tasks: As visitors not acquainted with the PVPS language do not know what "Tasks" are it was decided to rename this section "Activities". Moreover, the section will now be part of new menu item to reinforce the main objective of the website being to promote the outcomes of the programme.
Products: the appropriate "name" for the outcomes of the PVPS programme was discussed. Should they be referred to as "products" or rather as "publications"? It was decided to select

"products" as the keyword in the menu but to refer to it in the baseline as "publications and other products".
The opening page of this section should be made more appealing for visitors. Images will be added next to the list of ISRs (eg graphs), and next to Task 5 reports (eg an inverter).
For each product more information, such as the abstract, images, etc., should be made available. The OA of Task 1 will discuss this issue at the coming OA meeting. Further, the OA will discuss how the database of Task 2 can be made accessible through the web, e.g. make it an online application.
Statistics [NEW] (Statistics, tables and graphs): It was decided to add a new section "Statistics" with the complete ISR report, as well as tables and graphs from all tasks that can be downloaded (high resolution). This section will be implemented as soon as practicable (ie when there are current, published results).
PVPS country summaries [NEW]: It was also decided to add a new section called "PVPS country summaries" containing the national reports as published in the Annual Report as well as parts of the national survey reports. This section will be implemented as soon as the AR becomes available, and extended when the national survey reports become available.
Newsletter: It was decided that all articles published in *PVPower* should be added to the website. Whether references to websites of organizations mentioned in *PVPower* should be included is up to the ExCo (see section Links).
Events: It was decided to add all PV events to this section, as well as renewable energy events provided that they refer to PV.
Links: The main question was should commercial organizations be included – where do we draw the line? Within Task 1 the opinions regarding the question about which organizations should be listed differed (from a. IEA-PVPS should not promote commercial organizations, even though they are involved in the IEA-PVPS programme, to b. adding links to many organizations will provide visitors with more valuable information as well as strengthening the participation of these (commercial) organizations in the different tasks). Some examples of the current situation:

- Novem is listed, as it is perceived as a governmental organization and directly involved in the PVPS programme. Thus also in articles (*PVPower*) where Novem is mentioned an active link to the website is added.
- IT Power and Ecofys are not listed, as they are perceived as commercial consultants. However, they are both actively involved in the IEA-PVPS programme
- Shell Renewables is not mentioned, as it is a PV manufacturer. However, Shell Renewables is explicitly mentioned in the Press Release of Task 7 (which is also included on the website).

It was decided that the ExCo should make a decision about this 'policy' issue, and three options are presented in the Task 1 Status Report.
Search: The keyword list, which is used to search the website itself, was checked by Watt and Claverie, and will be adapted in due time. Moreover, "search by entering your own keywords" will be removed, whereas "search by means of a predefined keyword list" will be extended enabling visitors to select two keywords.
News [possible]: In an earlier Task 1 meeting there was a request for a News section, as this could provide a very useful resource for the target audiences. The main questions are how to provide the news and how to manage the section, as it should be updated regularly and must only contain credible information. As such a section would demand considerable resources, it was decided to ask the ExCo to consider the matter.

Menu
The changes discussed result in the following menu for the IEA-PVPS website:

Introduction
Programme, activities and contacts (which will include the current sections programme, tasks and network)

Products (Publications and other products)
Statistics (Statistics, tables and graphs)
PVPS country summaries
Newsletter
Links
FAQs
Basics of PV
Events
Search

International Energy Agency
Implementing Agreement for Co-operation on
Technologies and Programmes for Demand Side Management

IEA DSM Task VII

International Collaboration on Market Transformation

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Introduction

Under the International Energy Agency's Demand Side Management Implementing Agreement a revolutionary new Task has started which aims to transform the way energy efficiency is promoted and achieved in the marketplace. Known as 'Annex VII International Collaboration on Market Transformation' (or '**MT7**' for short), the task is currently pursuing exciting new work on branding and marketing energy efficiency and creating radical new approaches to the way that we currently transform market places.

Interest in the MT7 approach is growing at a rapid rate as new countries join this collaborative framework. A truly international feel has started to develop in the task – vital to the global marketplace that we all live and operate in. Joining costs have been kept deliberately low in order to encourage countries to join and to shape the task and subtasks in line with areas of interest to each country. The ability to join some subtasks and not others means that any contribution of expert time and cost sharing can be targeted effectively to activities that will yield the best actions and results for participating countries.

The Aims and Objectives of MT7

The need to meet Kyoto targets and to reduce greenhouse gas emissions through greater energy efficiency provides the driving force behind the new Market Transformation Task. Utilising the forces of the market and transforming those markets to better respond to energy efficient products helps to contribute to a more sustainable path whilst still maintaining a future vision of economic prosperity.

Specific objectives of this Task are to:

- Increase the market share of today's energy-saving products and practices.
- Accelerate the use of the most efficient new technologies in order to reduce the use of energy and other primary resources, thereby reducing the emission of greenhouse gases and other potentially harmful pollutants.

One important aspect is the deeper involvement of retailers and marketing – both in the accelerated acceptance of energy efficient products, and intensified targeting of the most appropriate methodology that will lead to an increase in sales.

Scope

The Market Transformation Task has three main areas of work as follows:

1. Market Transformation integrated Policy and Programmes development - developing a co-ordinated international approach to Market Transformation
2. Market Transformation Marketing - developing marketing based actions to deliver Market Transformation
3. Promoting Advanced Products Approach - using procurement, requirements , specifications and other tools in a targeted way to deliver Market Transformation.

Benefits of joining MT7

MT7 is producing groundbreaking new thinking and methods in international market transformation work. The 'mini monitor' market research study is delivering a common marketing communication platform that will be used as a valuable currency for discussions with multinational manufacturers and retailers of energy efficient products. This creates a solid base of marketing knowledge, tied into consumer aspirations and values, that will be used by multinationals to create unprecedented demands for ever more efficient products. Once branded at this level, energy efficiency ceases to be simply another add on feature, but instead describes a way of life, an attitude, a core value of who you are and what you aspire to be. This may be the first time that market research and branding have been so effectively used to sell the concept of energy efficiency as a marketable attribute in a global marketplace. Coupled with the innovative international market transformation forum, this delivers a powerful message to companies involved in retailing and manufacturing energy consuming goods, and opens a dialogue with these groups relating to the next generation of super efficient products. By creating the demand, we are challenging the suppliers, using their skills, research and expertise, to deliver a unique transformation of the international marketplace. The most effective, least expensive method of market transformation.

Work to Date

Most work to date within Task VII on Market Transformation has concentrated on developing the programme of work and co-ordinating participating country interests in order to deliver effective action projects. Six experts meetings have been held over the last year resulting in several subtask proposals and a refined programme of work. The original 6 interested countries have now been joined by Korea, taking the total number of countries involved in the Task to seven. The greater involvement of marketing experts within the task is resulting in some exciting prospects for increasing the role of marketing within the set of tools required for effective Market Transformation. Three of the five subtasks are underway with commencement of the additional two subtasks on market research and the Market Transformation Forum expected shortly.

The Projects

A brief synopsis of important areas of work is outlined below:

Subtask A: Defining the Market Transformation programme.

This part of the programme is concerned with the development of an internationally co-ordinated Market Transformation model that would help to inform policy, engage with the marketplace and deliver actions. The aim is to develop a robust and transparent approach to Market Transformation activities, and to provide the first international co-ordination on a policy approach to Market Transformation. An initiative led by the UK and the Netherlands hopes to align individual Market Transformation approaches in each country and collaborate on a unified Market Transformation approach to be used as a model for other interested countries.

Subtask B: International Market Research on Energy Efficiency – Market Transformation through Branding Energy Efficiency as A Positive Lifestyle Choice.

Energy efficiency is low or non-existent in the consumer's **hierarchy of needs** when deciding between competing consumer products. The work undertaken by Annex VII suggests that energy efficiency is not dominant in purchasing decisions because few consumers, if any, have ever been professionally exposed to marketing and branding of energy efficiency as a positive consumer choice.

A common market research study will allow MT7 to identify the differences of value patterns in participating countries and will develop a common means of communication. The research will provide invaluable information needed for talking to the market actors about 'selling' energy efficiency as a concept. MT7 aims to produce a definitive set of international target audience values and aspirations regarding energy efficiency branding. This information will be of benefit to energy efficiency promoters as well as valuable to the multinational producers and marketers of energy efficient products.

Subtask C: Market Transformation Workshop and Forum

The Synergy Workshop

A series of revolutionary brainstorming sessions on Market Transformation will be held in each participating country aimed at informing and invigorating the debate about the promotion of energy efficiency. The results of these facilitated meetings will be brought together in a one-day synergy symposium planned in 2001. This is intended as a showcase for best practice and lessons learned in Market Transformation and provides an opportunity for targeting a way forward for the future of Market Transformation activities – an answer to the challenging questions facing the energy efficiency community in today's marketplace.

MT7 High level International Forum

The first of its kind ever held for energy efficiency, the Forum will involve major industry players, marketing specialists and government policy makers in a two day discussion highlighting the critical success factors required for a step change in energy efficiency promotion and popular culture. This Forum is aimed at the highest level, involving the top influential marketers and politicians in a unique meeting that will highlight the importance of a radical new approach in energy efficiency policy, marketing and delivery. Chaired by a prominent personality this Forum promises to engage industry, the media and the public on a scale not yet achieved in energy efficiency circles.

Subtask D- Website and Communication
A series of brief Market Transformation case studies has been placed on the IEA DSM site. These incorporate a short outline of the project and link to the case-study website. Additional work has been undertaken setting up a Task information sharing system and email group.

Subtask E : Promoting Advanced Products
Importantly in this subtask work continues on the copier of the future competition with a winner announced in the last round. The high profile award ceremony, attended by the president of the winning company and the IEA, resulted in press coverage which dubbed the IEA DSM award the 'Nobel Prize' for energy efficiency. Further work continues on the LED procurement project following a seminar in Amsterdam. A subtask proposal plan has been finalised and work is underway in assessing new projects under this subtask.

MT7 Achievements and Future Plans
Overall, the Task is producing an active, ongoing exchange of information amongst participating countries on the successes and lessons learned from implementing both innovative and familiar market-oriented energy efficiency programs.

Annex VII Market Transformation has to date produced...
- A co-ordinated international approach to Market Transformation
- Greater involvement of marketing experts in the Task
- A refined Task work plan and several subtask proposals
- The presentation of the IEA DSM award of excellence for an advanced photocopier procured in subtask E – this award has been dubbed the 'Nobel prize' for energy efficiency
- Participation of new countries to the Task (notably Korea)
- A Task website and group information sharing activity including provision of country specific Market Transformation case studies
- A Paper presented to the IEA and World Energy Council congress in Ankara.
- Six experts meetings
- Shared knowledge of international approaches to market transformation.
- Access to, and contacts with, a wide variety of participating countries from which to draw project partners.

In the year 2001, MT7 will achieve...
- A revolutionised approach to marketing energy efficiency based on new research and action projects.
- A One off Forum yielding the latest market transformation approaches and sharing international perspectives.
- A co-ordinated and co-operative international approach to market transformation that yields effective market changing results.
- Regular briefings on current practices and latest knowledge of Market Transformation practice.
- Additional participating countries joining Annex VII
- A possible new project looking at Market Transformation of standby power in various devices
- A wider involvement of industry in the task including multinational chains of manufacturers and retailers

In the broadest sense the proposed Task is expected to facilitate a new approach to market transformation in order to bring about the changes that are required in international markets so that new energy efficient technologies penetrate the market and start to achieve their true potential. If successful, the proposed new Task will contribute significantly to the accelerated take up of energy efficient technologies in the marketplace, and therefore will assist in the conservation of energy reserves and a reduction in the emissions of greenhouse gases and associated pollution.

Countries Taking Part in the Annex

- Denmark
- Finland
- Korea
- Netherlands
- Norway
- Sweden
- United Kingdom

Interested and may join in 2001

- USA
- Australia
- Spain

Resources

At the present time the minimum joining fee is US$10,000, covering the costs of information sharing, communication and co-ordination, experts meetings and workshops etc; with additional subtasks costing extra as set out in the Task work plan. If a country wishes to join all subtasks and be involved in all MT7 activity this will cost US$10,000 to join + US$9,000 for the market research + US$4,000 for the MT7 Forum + US$3,000 for promotion of advanced products. The total amount would therefore be US$26,000. Some countries have been able to take part in all activity by finding different sponsoring bodies to fund different parts of the Task work plan.

There are currently 4-6 experts meeting held over the course of each year requiring one day of experts' time and a further commitment of 30 days of expert's time each year to fully contribute to the programme.

Activity Time Schedule

Task VII came into force in January 2000 and shall remain active until January 2002 unless an extension to the Task Activities is required

Subtask	1999	2000	2001
Subtask A: Defining the Market Transformation Programme and detailed project planning			
Subtask B: Market Transformation Market Research			
Subtask C: Market Transformation Workshop and Forum			
Subtask D: Market Transformation Website and Email list server			
Subtask E: Promoting Advanced Products			
Subtask F: Standby Power (to be confirmed)			
Subtasks G – […X,Y,Z]: Additional Subtasks (to be confirmed)			

If you would like more information or wish to join MT7 please contact Verney Ryan via email on ryanv@bre.co.uk or telephone ++44 (0) 1923 664318

EXPERT GROUP STUDY
ON
RECOMMENDED PRACTICES
FOR PHOTOVOLTAIC SYSTEMS
TESTING AND EVALUATION

1. ESTIMATION OF COST OF ENERGY FROM PHOTOVOLTAIC SYSTEMS

DRAFT 20 November 1997

Submitted to the Executive Committee
of the International Energy Agency Programme
for
Research and Development
on Photovoltaic Systems

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Contents

Foreword

The evaluation of a photovoltaic (PV) system encompasses many factors ranging from: energy production, quality of power, reliability, durability and safety, through to cost effectiveness or economics, impact on the environment and electromagnetic interference. The development of internationally agreed evaluation procedures for each of these areas is needed to aid the development of the industry while strengthening confidence and preventing chaos in the market. It is the purpose of the IEA expert groups to meet periodically to propose recommendations for PV systems testing and evaluation.

This document deals with Cost of Energy of PV systems, and is partly directly based on the corresponding IEA expert group recommended practices for estimation of cost of energy from wind turbines as reported in /1/.

The expert committee will seek to gain approval of the procedures in each member country through the IEA agreements. The recommendations shall be regularly reviewed and areas in need of further investigation shall be identified.

Introduction

The cost of energy from PV systems (and any other power generating systems) may be estimated in a variety of ways. A macro economic approach will require methods different from those needed for a private financial analysis, and the different methods will probably generate cost of energy figures not suitable for comparisons. Furthermore, even analyses intended for the same purpose may have different ways for estimating the cost of energy, and thus care should be taken whenever comparing energy cost figures to ensure that the analyses methods have been the same. This document describes a standard method for estimating the cost of energy from PV systems. The recommendations are for making *project specific* estimates for existing PV systems or for PV feasibility studies.

1. Scope and field of application

This document describes the recommended procedure for estimating the cost of energy from a PV system. The procedures and practices presented are generally applicable to PV systems of all sizes, as well as to groups of PV systems. Primarily, this document considers PV systems consisting of an array of PV modules, an inverter and a support structure, and intended for operation connected to a common electric grid. Methods for assessment of other types of PV systems, e.g. such as stand-alone PV systems with battery storage, are under consideration.

The recommended procedure may be applied to both existing and planned PV projects. The derived cost of energy figure is only as valid as the assumptions made, and will relate only to the specific PV system at the specific location. The method presented cannot replace a financial investment analysis, though it may be used to support it.

This document recommends a standard method for estimating the cost of energy from PV systems. The cost of energy is expressed as the *levelised production cost* (*LPC*) which is the cost of production of one kWh levelised over the PV system's entire lifetime. The derived cost of energy figure is most suitable for making cost comparison between PV and other sources of energy having similar functional and operational characteristics. Cost comparison with any other energy technologies may be appropriate for a market assessment and as an indication of the economic feasibility of installing the assessed PV system. The application of the *LPC* is further illustrated in examples 1 to 4.

Example 1:
A choice between two or more PVs for installation at a specific site is to be made. Basing the choice solely on cost efficiency, the PV with the lowest *LPC* should be selected.

Example 2:
A choice is to be made between a PV, a wind turbine and a wave power system. Basing the choice on cost efficiency, the system with the lowest *LPC* should be selected.

Example 3:
A specific PV is to be installed at one of several possible sites. Basing the choice on cost efficiency, the site yielding the lowest *LPC* should be selected.

Example 4:
The economic feasibility of installing PVs in an electric power supply system is to be estimated. An initial indication is provided by comparing the *LPC* of the PVs with the short run marginal cost (*SRMC*, i.e. operation cost) of the existing system. A *LPC* of the PVs lower than the *SRMC* for the existing system indicates economic soundness for small PV penetration levels. Higher PV penetration levels may modify the power system operation, and in such cases the cost of PV calculation should be supported by total power system modelling for deriving all costs and benefits. It is also noted that if expanding a power supply

system with PVs, it can be shown statistically that the loss of load probability is reduced. Hence, a PV system has a capacity value equivalent to the capacity of a conventional plant that would have to be installed to attain the same level of power supply reliability.

It is stressed that cost comparisons are meaningful only if the cost of energy figures are estimated on the same basis and with the appropriate level of accuracy. Furthermore, cost calculations of energy technologies are not a substitute for full system analyses deriving the total system cost of energy for adopting different energy generating technologies.

2. Definitions

For the purpose of this document, the following definitions apply:

2.1 Photovoltaic system (PV system)

A photovoltaic system converts photovoltaic energy (solar radiation) into electrical energy suitable for grid connection or stand-alone supply of electric loads.

NOTE: In this document a photovoltaic system is also denoted a PV system or simply a PV.

NOTE: In this document only grid connected systems are considered.

2.2 Photovoltaic module (PV module)

A PV module is the smallest usable building element in a PV array converting photovoltaic energy (solar radiation) into electrical energy.

2.3 Photovoltaic array (PV array)

A PV array consists of the appropriate number of PV modules configured according to need. An array may be divided into sub-arrays.

2.4 Inverter

An inverter converting the DC power from the PV array to grid quality AC power. Sub-arrays may have individual inverters.

3. Symbols and units

LPC	currency/kWh	Levelised production cost
TC	currency	Discounted present value of total cost of energy production
I	currency	Investment including possible interest during construction
OM_t	currency	Operation and maintenance cost during year t
SC_t	currency	Social cost during year t
RC_t	currency	Retrofit cost during year t
SV	currency	Salvage value after n years
LPC	currency/kWh	Levelised production cost
ANE_t	kWh	Net energy output during year t
AUE_t	kWh	Utilised energy during year t
$K_{per,t}$		Performance factor (rain, dirt, etc)
$K_{site,t}$		Site factor (shadow from obstacles, air clearness)
$K_{ava,t}$		Technical availability factor (failure, service)
$K_{los,t}$		Electric transmission losses factor
$K_{util,t}$		Utilisation factor
E_{pot}	kWh	Annual potential energy output
r		Discount rate
n	year	Economic lifetime
t		Year index
a		Annuity factor
TOM	currency	Total levelised annual "down-line cost"
$p(G_a)$	W	Power curve of the PV system
$f(G_a)$		Solar radiation probability distribution at the PV modules surface
P_{arr}	W	Output power from the array of PV modules connected to the inverter
η_{inv}		Inverter efficiency
η_{arr}		Array efficiency
η_{nom}		Nominal array efficiency
κ	%/K	Temperature efficiency coefficient of the array
T_{arr}	K	Array temperature
A	m^2	PV array surface area
G_a	W/m^2	Total solar radiation at the PV array surface
k_{ori}		Orientation factor
T_{amb}	K	Annual average ambient day-time temperature
G_p	W/m^2	Solar radiation perpendicular to the PV module surface
a_{arr}	$K/W/m^2$	Temperature scale factor
α_{ori}	radian	Orientation of PV array photosensitive surface
θ_{tilt}	radian	Tilt angle of PV array surface
β_{long}	radian	Latitude position of PV system

4. Abbreviations

PV	Photovoltaic (system)
PCC	Point of Common Coupling
LV	Low Voltage
MV	Medium Voltage
HV	High Voltage

5. Cost components and energy production

The cost components are assumed to be the investment cost (including possible interest during construction), operation and maintenance cost, repair or retrofit cost, salvage value and social cost. Apart from the social costs, only the costs relating to the PV system up to the point of interconnection with the public transmission or distribution network are considered. In some cases it may be necessary to reinforce the public transmission or distribution system (or to include special control devices, etc.) due to the introduction of PV. In such cases, depending on the scope of the analysis, these extra costs (or a part thereof) may be included in the analysis.

The PV output considered could be a) the annual net energy (ANE_t) as *available* at the PV terminals, or b) the annual energy as *utilised* in the connected power system i.e. the annual utilised energy (AUE_t). The relation between the annual utilised energy and the annual net energy can be described by:

$$AUE_t = ANE_t \cdot K_{los,t} \cdot K_{util,t}$$

Here, $K_{los,t}$ is a factor relating to the electric losses which occur between the PV terminals and the electric grid where the energy is utilised, and $K_{util,t}$ is a factor which depends on how the transmitted PV energy is utilised in the power system, see also figure 1.

Depending on the scope and field of application, both the annual net energy output and the annual utilised energy output are recognised as adequate energy measures, and the assessor must judge which to use in each case.

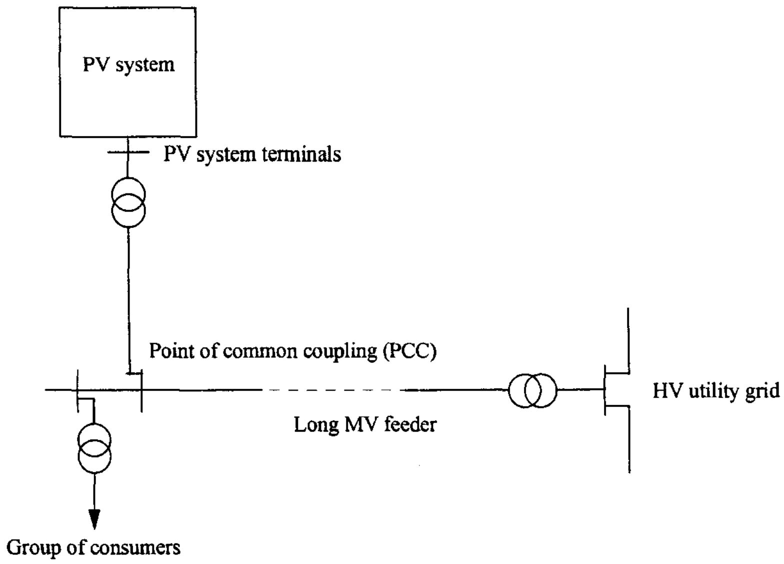


Figure 1 Example of an electrical system where the energy losses in the long medium voltage feeder are reduced due to the PV energy output so that the utilised PV energy becomes higher than the transmitted net energy and hence $K_{util,t} > 1$.

6. Cost calculation methodology

6.1 General approach

The measure of the estimated cost of energy adopted in this document is *the levelised production cost*. The levelised cost method is thoroughly described and discussed in /2/. The method will only be described briefly in the following text.

The levelised production cost (*LPC*) is the cost of one production unit (kWh) averaged over the PV system's entire expected lifetime. The total utilised energy output and the total costs over the lifetime of the PV system are both discounted to the start of operation by means of the chosen discount rate, and the *LPC* is derived as the ratio of the discounted total cost and utilised energy output.

It is assumed that all costs are given in a fixed currency for a specified year. The currency and cost level year should be decided and clearly declared by the assessor when reporting the estimated cost of energy. In the calculations all costs are discounted to the present value, i.e. the first date of commercial operation of the PV system. The discounted present value of the total cost (*TC*) is given as:

$$TC = I + \sum_{t=1}^{n}(OM_t + SC_t + RC_t)\cdot(1+r)^{-t} - SV\cdot(1+r)^{-n}$$

Here is I the investment cost, n the lifetime, OM_t the operation and maintenance cost in year t, SC_t the social costs in year t, RC_t the retrofit cost in year t, r the discount rate and SV the salvage value. These economic parameters are further explained in section 7.1.

The levelised production cost (*LPC*) is given as the ratio of the total discounted cost and the total discounted utilised energy, i.e.:

$$LPC = \frac{TC}{\sum_{t=1}^{n} AUE_t \cdot (1+r)^{-t}}$$

The annual utilised energy, AUE_t, should be specified for each year by adjusting the annual potential energy output, E_{pot}, with a number of correction factors:

$$AUE_t = ANE_t \cdot K_{los,t} \cdot K_{util,t} = E_{pot} \cdot K_{per,t} \cdot K_{site,t} \cdot K_{ava,t} \cdot K_{los,t} \cdot K_{util,t}$$

Here is ANE_t the net energy output during year t, E_{pot} the annual potential energy output, $K_{per,t}$ the performance factor (rain, dirt etc.), $K_{site,t}$ the site factor (shadow from obstacles), $K_{ava,t}$ the technical availability factor, $K_{los,t}$ the electric transmission losses factor and $K_{util,t}$ the utilisation factor. The parameters are further explained in section 7.2.

6.2 Simplified approach

In many cases it may be appropriate to assume the annual utilised energy to be constant from year to year (i.e. $AUE_t = AUE$ for $t=1$ to n). In such cases, the LPC can be calculated as:

$$LPC = \frac{I}{a \cdot AUE} + \frac{TOM}{AUE}$$

Here a is the annuity factor defined as:

$$a = \frac{1-(1+r)^{-n}}{r}$$

Hence, I/a is the capital to be paid annually during the assumed period in order to cover both the depreciation and the assumed interest. TOM is the total levelised annual "down-line costs", i.e. all costs other than the initial investment. TOM may for simplicity be estimated as a certain percentage of the investment. The exact definition of TOM is:

$$TOM = a^{-1} \cdot \sum_{t=1}^{n} (OM_t + SC_t + RC_t)(1+r)^{-t} - SV(1+r)^{-n}$$

7. Estimation and specification of input parameters

In this section the input parameters are specified further and guidance is given for their estimation. In many cases one or more of the input parameters will be known explicitly, and of course, the known figures should be used whenever possible.

7.1 Economic parameters

This document considers the cost of energy from PVs excluding all possible taxes and subsidies.

7.1.1 Investment

The investment should include all the costs of constructing the PV system. Although only the total investment is included in the formula for calculating the levelised production cost, the analysis report should include a breakdown of the investment as indicated in table 1. In some cases, e.g. for very large PV systems, the construction time may be of substantial length, and the interest on the investment, during the time from when the payment is made until the start of commercial operation, should be calculated and included in the total investment:

$$I = \sum_{i=1}^{j} I_i \cdot (1+r)^{t_i}$$

Here, j is the number of investment payments, r is the discount rate, and I_i is the investment part paid t_i years before the start of commercial operation of the PV installation. It is important to notice that bank interest for financing the investment is not considered, since in this document the *project* is being assessed, not how it will be financed.

7.1.2 Operation & maintenance

The O&M costs will depend on the PV system size and type, as well as the site conditions and the connected system. Accordingly, this document recommends project specific estimates of the O&M costs to be specified for each year of the scheme's lifetime. Although only the total annual O&M cost for each year is included in the formula for calculating the levelised production cost, the analysis report should include a break-down as indicated in table 2.

Table 1 List and specification of investment cost components for grid connected PV systems. The cost components may be further divided into parts and labour costs.

- PV array ex factory cost.
- Inverter ex. factory cost.
- Support structures ex. factory cost.
- Special certification or other external test procedure costs if procured.
- Transportation costs including loading and unloading and other costs associated with transporting the PV from the manufacturer to the site.
- Site preparation costs, e.g. civil works for preparing access road(s) and other works depending on the specific landscape and ground conditions.
- Foundation costs, i.e. civil works for preparing the PV system foundation.
- Erection costs, i.e. costs for erecting the PV system at the foundation.
- Grid connection and reinforcement costs, i.e. costs associated with the electrical works for connecting the PV system to the grid, as well as possible grid reinforcement costs,
- External monitoring and control system costs. Such external systems are typically associated with large PV farms monitored and operated from a remote utility central.
- Consultancy services and other costs for design and supervision of the installation works.
- Land costs, i.e. the cost of buying or renting land for the PV power installation. The costs should be discounted to the first date of commercial operation using the discount rate as specified in section 4.1.7. In cases where the land is also used for farming or other activities, the land investment cost should be reduced by the discounted income of these activities.

Table 2 List of operation and maintenance cost components for grid connected PV systems. The cost components may be further divided into parts and labour costs.

- Normal liability and property insurance costs covering sudden PV system damage and operational losses due to such damage.
- Special insurance for an annual energy output guarantee.
- Service costs may include the manpower costs of the scheduled services. Service costs during the first years are sometimes included in the PV system ex. factory price.
- Consumable spare parts for wear and tear.
- Repair costs, i.e. (minor) repairs outside the scheduled service and not covered by any insurance or guarantee surveillance. See also retrofit cost in section 7.1.4.
- Management costs, i.e. costs connected to the construction and operation management of the PV system.

7.1.3 Social costs

The social (or external) costs of energy production are those being borne by third parties and are not reflected in the market price of energy. Social costs may be associated with environmental damage, nuisance to people, etc. Consensus on specific methods for estimation of social costs has yet to be established. However, it is accepted that social costs exist and that these should be included when calculating the cost of energy production. It is also widely accepted that social costs of PV production are small or negligible, especially when compared to those associated with energy generation from non-renewable sources.

7.1.4 Retrofit cost

The need and costs for replacements or major repairs during the adopted lifetime (see section 7.1.6) should be evaluated. These are dependent on numerous factors, and it is recommended that project specific estimates are made of the timing and cost of possible major repairs or retrofits.

In the calculation example in Annex C the retrofit cost is not specified directly, but instead indirectly by specification of the lifetime of each of the investment components, and then calculated as the difference between the sum of investments and the discounted sum of investments.

7.1.5 Salvage value

The salvage value is defined as the difference between the scrap value and the decommissioning cost of the entire scheme at the end of the lifetime adopted for the economic analysis. If the adopted economic lifetime n is less than the assumed technical lifetime of the PV, the salvage value should be a positive value reflecting the capital value of the total PV power installation after n year of operation. Note that even if the adopted economic lifetime (see section 7.1.6) is set equal to the assumed technical lifetime of the PV system, the salvage value of the total scheme may not be zero as land, electrical cables, etc. may still have a significant capital value.

7.1.6 Economic lifetime

The actual technical lifetime of a PV system depends on numerous factors, and it may in fact be very difficult to predict. Modern electricity producing PV systems are commonly designed to have a life of 20 to 30 years, and normally a 20 to 30-year economic life can also be assumed. The economic life should not be set to a value that exceeds the technical life of the PV system. It should be noted that the economic life as described in this document is a parameter that can be decided by the analyst. It should not be confused with other parameters such as a possible loan payback period.

7.1.7 Discount rate

The discount rate r given in real terms is defined as the rate at which the nominal rate i exceeds the inflation rate v, i.e.:

$$1+r=\frac{1+i}{1+v}$$

The choice of the numerical value for the discount rate is up to the assessor. It may be chosen to reflect the cost of financing the project, the possible earned return of an alternative investment or the opportunity cost of capital, the project risks, or any policy objective or constraint. The following points should be noted:

- The levelised production cost of energy will be higher for a higher discount rate and lower for a lower discount rate.
- If the energy is sold at the calculated levelised production cost, the project costs and income will balance each other and the internal rate of return will be equal to the assumed discount rate.
- An increased discount rate will reduce the economic attractiveness of projects with high investments and low running costs compared to less capital-intensive projects.

International studies of electricity generation costs often adopt 5 to 7 % as the annual discount rate in real terms, whereas private investors investigating commercial projects may adopt higher values. In general, it is recommended that an analysis is carried out to determine the cost of energy sensitivity to the discount rate.

7.2 PV system output

The following discussion on estimating the annual utilised energy highlights the most important factors to be considered and reported. It is not meant to give strict directions and thus the appropriate calculation methods may vary considerably from system to system. This document recommends that the assessor applies the best available information for estimation of the annual utilised PV system output. Measured values give actual achieved operational statistics and production costs per kWh. Single "spot" measurements (e.g. one year of production figures) should however be used with care for calculation of the levelised production cost, as they can be significantly biased compared to the levelised lifetime figures.

The subsequent sections 7.2.1 to 7.2.8 consider single PV systems only. The utilised energy output of a PV plant consisting of more PV systems can be estimated either by treating the plant as a single large PV system, or it can be found by summing the individual utilised energy output estimates of all the PV systems in the PV plant.

7.2.1 Potential energy output

The annual potential energy output, E_{pot}, of a PV experiencing specific meteorological conditions is given as:

$$E_{pot} = 8766 \cdot \int_0^{\infty} p(G_a) \cdot f(G_a) dG_a$$

Here, 8766 is the average number of hours in a year, $p(G_a)$ is the power curve of the PV system, and $f(G_a)$ is the solar radiation probability distribution at the PV array surface.

The solar radiation distribution should ideally be based on many years of on-site solar radiation measurements, but in practice it will often be necessary to extrapolate long term data from nearby high quality measurement stations. In the calculation example in Annex C, the solar radiation distribution is specified as a discrete distribution for bin midpoints of $G_a = 50, 100, 150 \ldots 1200$ W/m^2.

The power curve $p(G_a)$ of the PV system must be specified. Ideally the power curve should be based on high quality measurements, or it may be calculated. In the calculation example in Annex C, the power curve is determined from calculations and specified for $G_a = 50, 100, 150 \ldots 1200$ W/m^2, i.e. for each bin midpoint of the discrete solar radiation distribution. The calculation procedure is illustrated by Figure 2, and further described in the following text.

From Figure 2 it is firstly seen that the output power is given by the below equation:

$$p(G_a) = P_{arr} \cdot \eta_{inv}$$

Here, P_{arr} is the output power from the array of PV modules connected to the inverter, and η_{inv} is the inverter efficiency.

The inverter efficiency is commonly depending on the input power, hence:

$$\eta_{inv} = f(P_{arr})$$

It is recommended that η_{inv} is specified applying verified manufacturer data. In the calculation example in Annex C, η_{inv} is specified for 25, 50, 75 and 100 % of the inverter's rated power, whereas the other points are found by linear interpolation.

The power P_{arr} from the PV array is given by:

$$P_{arr} = \eta_{arr} \cdot P_{in}$$

Here, η_{arr} is the array efficiency, and P_{in} is the photovoltaic input power given by:

$$P_{in} = A \cdot G_a$$

Here, A is the PV array surface area (m^2), and G_a is the total solar radiation at the PV array surface (W/m^2).

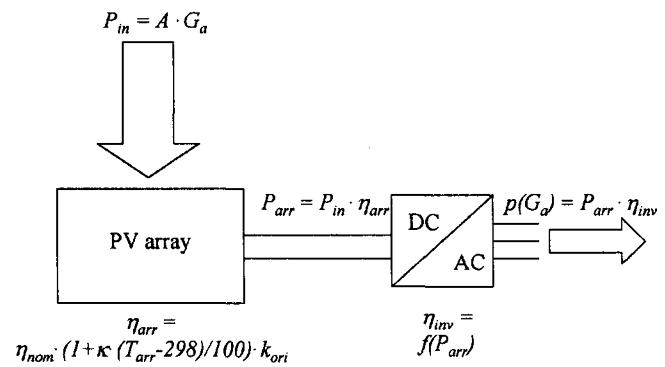


Figure 2 Illustration of PV system with indication of efficiency factors and input and output power.

The array efficiency depends partly on the modules and partly on their orientation, so in total the site specific array efficiency can be determined according to the following relation:

$$\eta_{arr} = \eta_{nom} \cdot (1 + \frac{\kappa}{100}(T_{arr} - 298)) \cdot k_{ori}$$

Here, η_{nom} is the nominal efficiency of the array, κ is the temperature efficiency coefficient of the array (%/K), T_{arr} is the array temperature (K) and k_{ori} is an orientation factor.

The nominal efficiency η_{nom} of the PV array is array specific. It shall be given for an array temperature of 298 K (25 degrees C) and a solar radiation of 1000 W/m^2 perpendicular to the array surface.

The temperature efficiency coefficient κ of the PV array is array specific. It is commonly (always) negative so that the array efficiency is reduced for temperatures over its nominal temperature (298 K) and vice versa. In case the coefficient is not available for the specific array in question, a temperature efficiency coefficient $\kappa = -0.5$ %/K may be applied.

In case the PV array is installed without any particular temperature control devices (such as cooling of the PV array with water) and in an open area, an approximate estimate of the array temperature can be found by applying:

$$T_{arr} = a_{arr} \cdot \frac{G_a}{k_{ori}} + T_{amb}$$

Here, T_{amb} (K) is the annual average ambient daytime temperature and a_{arr} ($K/W/m^2$) is a temperature scale factor found. In case the temperature scale factor is not available for the specific array in question, a temperature scale factor $a_{arr} = 0.02$ $K/W/m^2$ may be applied.

The orientation factor k_{ori} is defined as the ratio between G_a and G_p, where G_p is the solar radiation perpendicular to the array surface area.

For PV arrays with a fixed orientation and tilt angle, an approximate estimate of the orientation factor may be found by applying the below equations:

$$k_{ori} = \left|\cos(0.48 \cdot \alpha_{ori} \cdot \beta_{lat}) \cdot \cos(\theta_{tilt} - \beta_{lat})\right|$$

Here:

- α_{ori} is the orientation angle, i.e. the angle between the south direction and the normal of the array surface for locations north of equator, and between the north direction and the normal of the array surface for locations south of equator,
- β_{lat} is the latitude position of the PV system, and

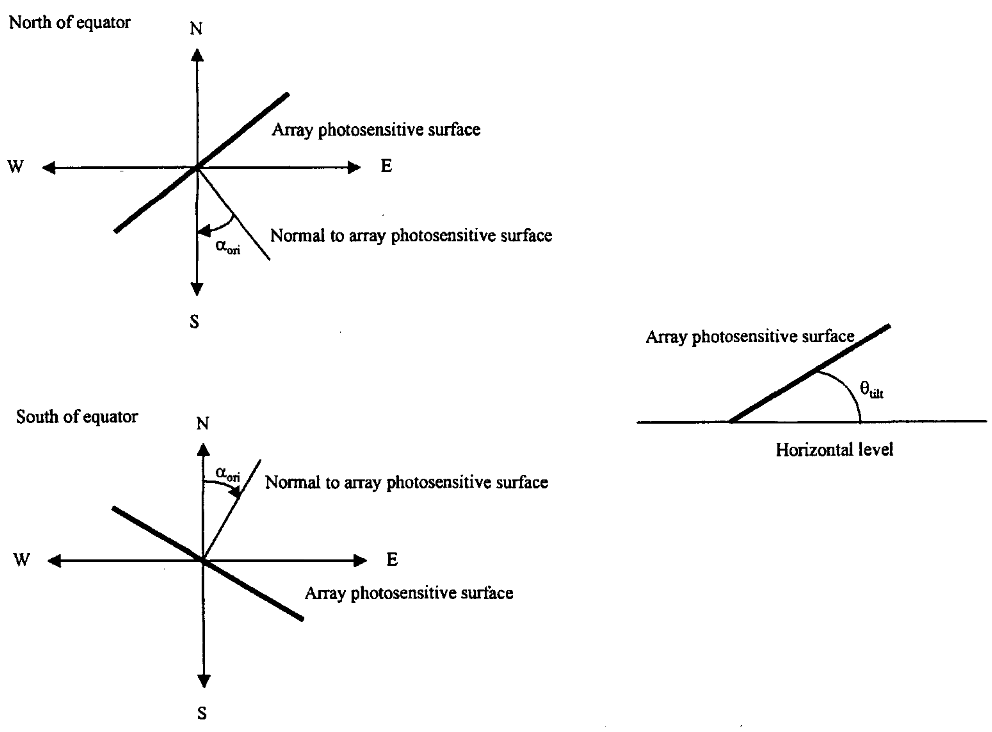


Figure 3 Illustration of PV system orientation and tilt angle.

- θ_{tilt} is the tilt angle of the array from the horizontal level.

α_{ori}, β_{lat} and θ_{tilt} are all in radians. The orientation and tilt angle is further illustrated in Figure 3.

The above formula for the orientation factor has been deducted by comparing measurements with calculated data for different α_{ori} and θ_{tilt} angles of PV arrays in Denmark. It fits well for the Danish latitude of 55 degrees and radiation conditions, but may not be very accurate for other latitudes, or areas with other irradiation conditions, e.g. having a different amount of diffuse radiation. Hence, the formula for the orientation factor must be used with care.

7.2.2 Performance factor

The performance of a PV system may be reduced dramatically due to dirt, rain or ice on the photosensitive surface, as well as due to wear and tear of the photosensitive surface coating. If the site conditions are likely to give such problems, then cleaning and maintenance of the photosensitive surface coating must be included in the O&M costs or a reduction in the annual energy output relative to the potential output must be assumed. This reduction in the annual energy output $\Delta E_{per,t}$ can be expressed by the performance factor $K_{per,t}$ defined as the ratio of the reduced annual energy output and the annual potential output:

$$K_{per,t} = 1 - \frac{\Delta E_{per,t}}{E_{pot}}$$

The performance factor may change over time due to wear, and changing seasonal climatic conditions.

7.2.3 Site factor

The solar radiation distribution assumed for calculating the potential energy output should be the solar radiation distribution at the surface of the PV. In some cases however, the site surroundings may change over time due to tree planting, construction of new houses, as well as activities modifying the air clearness thus influencing the solar radiation distribution and the energy output from the PV. In such cases, it may be adequate to apply a site factor to take account of the reduction in annual energy output $\Delta E_{site,t}$ due to the changed surroundings. The annual reduction may be expressed by means of the site factor $K_{site,t}$:

$$K_{site,t} = 1 - \frac{\Delta E_{site,t}}{E_{pot} \cdot K_{per,t}}$$

7.2.4 Technical availability factor

The technical availability $C_{ava,t}$ of a PV system is defined as the fraction of the year the PV is ready for operation:

$$C_{ava,t} = \frac{8766 - T_{out,t}}{8766}$$

Here, 8766 is the number of hours in an average year, and $T_{out,t}$ is the total annual scheduled and forced outage time of the PV system. The resulting technical availability $C_{ava,t}$ depend in general both on the PV installation and on the connected system, e.g. a grid connected PV will shut down in the event of an external grid failure. In such cases, it is often adequate to specify the technical availability of the PV and the connected system separately, and to estimate the resulting technical availability, $C_{ava,t}$, as the product of these two availability factors. It is noted that for large modern power systems, the grid availability may be very close to 1, whereas for smaller rural grids, the availability will typically be lower. The technical availability factor $K_{ava,t}$ assumed by this document is defined by the energy loss $\Delta E_{ava,t}$ due to the PV system availability:

$$K_{ava,t} = 1 - \frac{\Delta E_{ava,t}}{E_{pot} \cdot K_{per,t} \cdot K_{site,t}}$$

$K_{ava,t}$ may be different from $C_{ava,t}$, e.g. if the PV system servicing is scheduled during periods with less solar radiation, $K_{ava,t}$ will probably be higher than $C_{ava,t}$.

7.2.5 Net energy output

The annual net energy output (ANE_t) is the annual energy output at the PV terminals:

$$ANE_t = E_{pot} \cdot K_{per,t} \cdot K_{site,t} \cdot K_{ava,t}$$

7.2.6 Electric transmission losses factor

The annual electrical transmission loss $\Delta E_{los,t}$ is the difference between the PV net energy output (which can be measured at the PV system terminals) and the energy fed into the point of common coupling (PCC). The annual electrical transmission losses may be expressed by the factor $K_{los,t}$:

$$K_{los,t} = 1 - \frac{\Delta E_{los,t}}{ANE_t}$$

An estimate of the annual electric transmission losses may be based on the annual net PV power distribution and specifications of the transmission system up to the PCC. It is important to know the actual net PV power distribution as the transmission losses will be a function of the square of the net PV output power.

7.2.7 Utilisation factor

In most cases, the energy ($ANE_t \cdot K_{los,t}$) supplied to the PCC will be numerically very close to the annual utilised energy output (AUE_t) from the PV system. However, in certain cases (see example 5 and 6) there may be a substantial difference, and the utilisation factor is defined to take account for such cases:

$$K_{util,t} = 1 - \frac{\Delta E_{util,t}}{ANE_t \cdot K_{los,t}}$$

Example 5:
In a power system with high PV penetration, the power production may potentially be higher than the electric load during periods with high solar radiation and low electricity consumption. Thus, the power production must be reduced or the load must be increased during such periods. In either way, the consequence may be that some of the PV energy output may not be utilised in the power system, and the utilised energy output AUE_t becomes lower than the product of ANE_t and $K_{los,t}$.

Example 6:
In a power system where the PV system is connected to the grid at a point close to a large group of consumers and far from any other power plant, the grid losses in the grid between the power plant and the consumers in question is reduced,

and the utilised energy from the PV system AUE_t will be higher than the product of ANE_t and $K_{los,t}$. See also figure 1 for illustration.

7.2.8 Utilised energy

The annual utilised energy AUE_t is the PV output utilised in the connected system. The AUE_t may be estimated for each year of the PV's lifetime by assuming the potential output E_{pot} and the year specific factors $K_{per,t}$, $K_{site,t}$, $K_{ava,t}$, $K_{los,t}$ and $K_{util,t}$.

$$AUE_t = E_{pot} \cdot K_{per,t} \cdot K_{site,t} \cdot K_{ava,t} \cdot K_{los,t} \cdot K_{util,t}$$

8. Uncertainties

8.1 Nomenclature and general considerations

It is recommended that the *LPC* estimate is accompanied by an uncertainty analysis which follows the guidelines of /3/. This document provides an outline explanation to the guide. It is stressed that the simplifications proposed may not be valid in specific cases and should be carefully evaluated by the user.

When quoting an uncertainty, it is vital to state the associated confidence interval and confidence level. The confidence level defines the probability that the (actual) value lies within a given range, i.e. the confidence interval. An adequate way of stating an uncertainty would thus be to quote e.g. that one is 95 % certain that the actual cost of energy lays within the interval 1.0 ±0.1 USD/kWh. Here 95 % would be the confidence level and the confidence interval would be from 0.9 to 1.1 USD/kWh.

8.2 Uncertainties on input parameters

Any input parameter may have two types of attached uncertainty:

- Category A: uncertainty which is estimated on the basis of measurements; it is typically due to random error in observation of the parameter considered.
- Category B: uncertainty estimated on basis of the knowledge other than from measurements.

Category A uncertainty can be derived from the probability distribution of the observations, i.e. the classical method of probability. Furthermore, the (true) value of a parameter with only category A uncertainty will be equal to the mean value of N observations when $N \rightarrow \infty$, thus category A uncertainty may be reduced to any small value simply by making more observations. Category B uncertainties are determined by means other than measurements. It could be an uncertainty related to instrument

Table 3 Nomenclature and basic mathematical rules for stochastic variables used in this document for calculation of the levelised production cost uncertainty.

Nomenclature	
X	stochastic variable
$f(x)$	probability distribution of X
$E(X) = \int X \cdot f(x)dx = \mu$	expectation value of X
$V(X) = \int (X - E(X))^2 \cdot f(x)dx = \sigma^2$	variance of X
$STD(X) = \sqrt{V(X)} = \sigma$	standard deviation of X
Basic rules	
$E(X_1+X_2) = \mu_1 + \mu_2$	$E(X+c) = E(X)+c$
$E(X \cdot c) = E(X) \cdot c$	$V(X+c) = V(X)$
$V(X \cdot c) = V(X) \cdot c^2$	c is a constant
If X_1 and X_2 are independent $\Rightarrow$	$V(X_1 + X_2) = \sigma_1^2 + \sigma_2^2$

calibration or the way the instrument is used, and the magnitude of the uncertainty is evaluated by employing the experience of the analyst, i.e. statements regarding category B uncertainties will include judgement and/or belief. Category B uncertainties, unlike these from category A, cannot be reduced to a small value by making more observations. Qualified estimates of category B uncertainties may however still be obtained by utilising historical data for the project in question and experience from other similar projects.

Category B uncertainties are likely to dominate the input parameters considered in this document, and thus, for simplicity, category A uncertainties are assumed negligible.

In this document all uncertainties, category A or B, are considered independent.

In general, the uncertainty of an input parameter may be represented by any probability distribution judged appropriate for the specific parameter and type of analysis. In this document however, only Gaussian probability functions are assumed. A consequence of this suggestion is that it is adequate simply to specify the expectation value and variance for each input parameter in question.

Annex B identifies the input parameters considered, and gives sample suggestions for their 95 % confidence interval. The economic lifetime and the discount rate are not included in the table as these are regarded as decision parameters not connected with uncertainty. It should be stressed however, that both the lifetime and the discount rate have significant impact on the derived *LPC*. Hence, their impact should be determined in a sensitivity analysis by calculating the *LPC* for a number of chosen values, e.g. assuming a lifetime of 15, 20 and 25 years and a discount rate of 5, 10 and 15 %.

8.3 Calculation of resulting uncertainty

The best estimate (expectation value) of the *LPC* may be calculated by applying the best estimates of the input parameters.

The sensitivity α_l is defined as the partial derivative of the *LPC* with respect to the specific parameter X_l:

$$\alpha_l = \Delta LPC / \Delta X_l$$

By varying one parameter at a time graphs can be drawn as shown in figure 3. Here the slopes define the sensitivities.

For small perturbations, the formula for calculating the *LPC* may be approximated by a linear function:

$$LPC = E(LPC) + \sum_{l=1}^{k} \alpha_l \cdot \Delta X_l$$

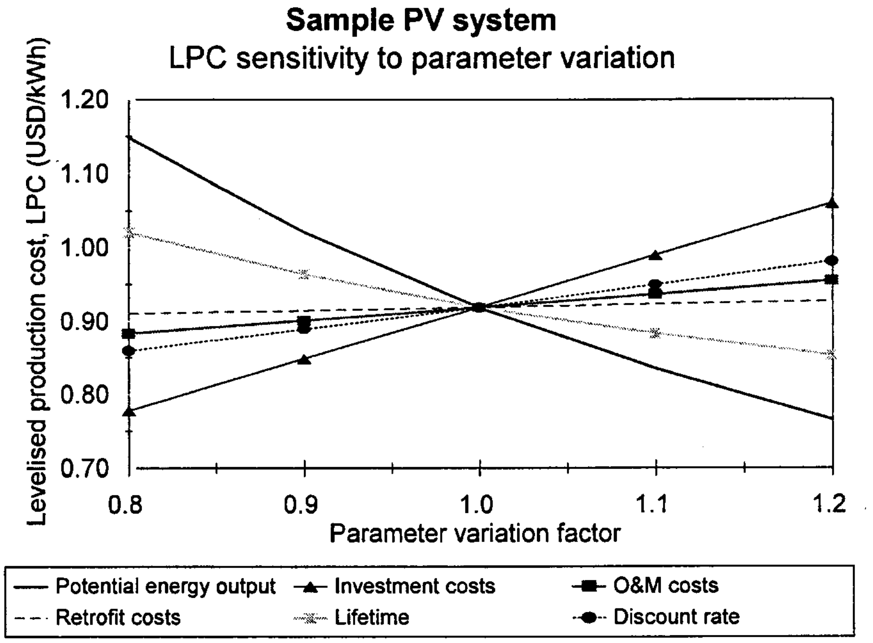


Figure 4 Estimated levelised production cost of energy from a PV system as a function of selected input parameters. The figure is for illustration purposes only.

Here, *E(LPC)* is the expectation value of the *LPC*, and ΔX_l is the perturbations on the expectation values of the input parameters. Following the definitions of section 5.1, and assuming the input parameters to be independent of each other, the standard uncertainty of the *LPC* may be deducted:

$$V(LPC) = V(E(LPC) + \sum_{l=1}^{k} \alpha_l \cdot V(\Delta X_l)) = \sum_{l=1}^{k} \alpha_l^2 \cdot V(X_l)$$

Hence, the overall uncertainty *U* specifying the confidence interval, *(LPC-U,LPC+U)*, of the *LPC* can be calculated applying:

$$U = c \cdot \sqrt{V(LPC)} = c \cdot STD(LPC)$$

Here, *c* is a factor that can be chosen to give a confidence interval corresponding to a desired confidence level. If the *LPC* has a Gaussian distribution, *c=2* gives a confidence level of 95 %.

In the calculation example in Annex C, the overall uncertainty *U* is calculated applying estimates of the normalised uncertainty u_l for each of the input parameters:

$$u_l = \frac{U_l}{E(X_l)} \cdot 100 = c \cdot \frac{STD(X_l)}{E(X_l)} \cdot 100 = c \cdot \frac{\sqrt{V(X_l)}}{E(X_l)} \cdot 100$$

Applying this, the standard uncertainty *V(LPC)* can be rewritten to yield:

$$V(LPC) = \sum_{l=1}^{k} \alpha_l^2 \cdot \left(u_l \cdot \frac{E(X_l)}{c \cdot 100} \right)^2$$

Further, in the calculation example in Annex C, the sensitivity is determined by applying $\Delta X_l = k \cdot E(X_l)$, so that the standard uncertainty, $V(LPC)$, can be rewritten:

$$V(LPC) = \sum_{l=1}^{k} \left(\frac{\Delta LPC_l}{k \cdot E(X_l)} \right)^2 \cdot \left(u_l \cdot \frac{E(X_l)}{c \cdot 100} \right)^2 = \sum_{l=1}^{k} \left(\frac{\Delta LPC_l}{k} \right)^2 \cdot \left(\frac{u_l}{c \cdot 100} \right)^2$$

Hence, the overall uncertainty U in the calculation example in Annex C is given by:

$$U = c \cdot \sqrt{\sum_{l=1}^{k} \left(\frac{\Delta LPC_l}{k} \right)^2 \cdot \left(\frac{u_l}{c \cdot 100} \right)^2} = \sqrt{\sum_{l=1}^{k} \left(\frac{\Delta LPC_l}{k} \right)^2 \cdot \left(\frac{u_l}{100} \right)^2}$$

As can be seen from the above equation, this way of calculating the overall uncertainty gives a confidence level for the overall uncertainty U of the LPC equal to the confidence level for the uncertainty of the input parameters.

9. Information to be reported

A report stating an estimate for the cost of energy for a specific PV project shall include, but not be limited to, the items listed below:

- Bibliographic data
- PV specification
- Energy system specification
- Site specification
- Economic data
- Energy calculation
- Specification of uncertainties
- Sensitivity analysis

A sample report format for selected parts of a full report is included in appendix C.

Acknowledgements

The present edition of this document has been developed in consultation with participants from the signatory countries to the IEA Photovoltaic Power Systems (PVPS) Implementing Agreement, active in Task 1: Exchange and Dissemination of Information on PV Power Systems.

References

/1/ IEA (1994) *2. Estimation of cost of energy from wind energy conversion systems.* Expert group study on recommended practices for wind turbine testing and evaluation. Editors: J.O.Tande and R.Hunter.

/2/ Nuclear Energy Agency (1983). *The cost of generating electricity in nuclear and coal fired power stations.*

/3/ *Guide to the Expression of Uncertainty in Measurements.* First edition 1993. ISBN 92-67-10188-9.

A Summary of input parameters

Input parameter	Range & Comment
Total initial capital investment, I	PV and system specific.
O&M cost, OM_t	PV and system specific; average annual O&M costs of ??? % of the ex. factory PV investment is often assumed for proven grid connected PV systems.
Social cost, SC_t	PV and system specific; commonly accepted as being negligible for PVs.
Retrofit cost, RC_t	PV and system specific; a retrofit after ??? years costing approx. ??? % of the ex. factory PV investment is often assumed for proven grid connected PV systems.
Salvage value, SV	PV and system specific; depends also on the adopted economic lifetime.
Economic lifetime, n	Decision parameter; should be equal to or shorter than the technical lifetime, 20 to 30 (???) year is commonly assumed for proven grid connected PVs.
Discount rate, r	Decision parameter, 5-7 % is commonly assumed in international studies of electricity generation costs.
Power curve, $p(G_a)$	PV system specific, should be calculated for actual site conditions.
Solar radiation distribution, $f(G_a)$	Site specific, should preferably be based on long term, high quality measurements at the site.
Performance factor, $K_{per,t}$	PV and site specific; the factor may range from 0.7 to ~1.0 depending on dirt, rain and ice conditions and on PV maintenance, ~1.0 is typical.
Site factor, $K_{site,t}$	Site specific; ~1.0 is typical.
Technical availability factor, $K_{ava,t}$	PV and system specific; 0.9 to ~1.0 is a typical range for proven grid connected PV systems.
Annual net energy, ANE_t	$ANE_t = E_{pot} \cdot K_{per,t} \cdot K_{site,t} \cdot K_{ava,t}$
Electric transmission losses factor, $K_{los,t}$	Depending on site transmission system and power production distribution; 0.9 to ~1.0 is a typical range for proven grid connected PVs.
Utilisation factor, $K_{util,t}$	Depending on system configuration, load and power production distribution. Values ~1.0 are typical for electrical power systems with low penetration of PV. Values much below 1.0 may be experienced if the installed PV capacity is higher than the minimum consumer load. Values up to 1.1 may be experienced in case the PV system is installed close to consumer loads (and far away from other power plants) so that electric transmission losses are saved.
Annual utilised energy, AUE_t	$AUE_t = E_{pot} \cdot K_{per,t} \cdot K_{site,t} \cdot K_{ava,t} \cdot K_{los,t} \cdot K_{util,t}$

B Summary of uncertainty parameters

Parameter	Sample normalised uncertainty *	Comment
Total investment, I	5	Assuming short-term (less than 2 years) forecast for specified proven technology at specific site.
O&M cost, OM_t	5-10	Assuming the forecast is for specified proven technology at a specific site; uncertainty depends on forecast length.
Social cost, SC_t	??	The uncertainty may be neglected as the social cost of PV is commonly assumed to be very low.
Retrofit cost, RC_t	??	Uncertainty may be neglected as having very little impact on the *LPC*.
Salvage value, SV	??	Uncertainty may be neglected as having very little impact on the *LPC*.
Potential energy output, E_{pot}	10-15	Depending on the quality of the power curve, and the quality and amount of historical solar radiation data.
Performance factor, $K_{per,t}$	5	Estimated uncertainty on the forecasted performance factor assuming no extreme operation conditions.
Site factor, $K_{site,t}$	4-6	Estimated as 1/3 of assumed total variability range of the site factor.
Technical availability factor, $K_{ava,t}$	1-2	Assuming proven technology; uncertainty depends on forecast length.
Electric transmission losses factor, $K_{los,t}$	3	Estimated as 1/3 of typical range of transmission efficiency, actual uncertainty depends strongly on method used for estimating the parameter.
Utilisation factor, $K_{util,t}$	3	Estimated as 1/3 of typical range of utilisation factor, actual uncertainty depends strongly on method used for estimating the parameter.

* The normalised uncertainty values are samples assuming a confidence level of 95 %. The given numbers should not be regarded as a substitute for the recommended project specific analysis.

C Calculation and reporting format example

This example has been prepared by using a spreadsheet that uses the formulae specified in this document for calculating the levelised cost of energy figure and uncertainty. The example also includes calculation of the profit and internal rate of return. The profit is the difference between revenue and cost for the given lifetime and discount rate, whereas the internal rate of return is the discount rate that would give zero profit. The revenue can for instance be the kWh sales price.

ESTIMATION OF COST OF ENERGY FROM PHOTOVOLTAIC SYSTEMS

Excel 97 for Windows spread sheet code by John O. Tande, Risø Nat. Lab., Denmark. Code ver. 04. 20 November 1997

SUMMARY DATA

Date and time	12/Mar/01	14:43		
System	Sample PV system			
Cost level		1996	Currency	USD
PV system inverter capacity (kW)		100	PV system potential energy output (MWh/year)	91.85
PV system array area (m2)		1300	PV system potential efficiency (%)	9.77
Annual avg. total solar radiation (W/m2)		82.5	PV system potential capacity factor (%)	10.48
Performance factor		0.90	PV system utilized energy output (MWh/year)	60.27
Site factor		0.90	PV system efficiency (%)	6.41
Technical availability factor		0.90	PV system capacity factor (%)	6.87
Electric transmission losses factor		0.90		
Utilization factor		1.00		
Discount rate (% p.a.)		5.0	Annuity factor	12.46
Lifetime (year)		20		

	NPV	Annual			Distribution
	(USD)	(USD/year)	(USD/kW)	(USD/kWh)	(%)
Investment	526667	42261	5267	0.70	75.43
O&M costs	135007	10833	1350	0.18	19.34
Social costs	1252	100	13	0.00	0.18
Retrofit costs	43472	3488	435	0.06	6.23
Salvage value costs	-8166	-655	-82	-0.01	-1.17
Total costs	698231	56028	6982	0.93	100.00
Revenue	62587	5022	626	0.08	IRR (%)
Social value	776079	62275	7761	1.03	
Net profit	140434	11269	1404	0.19	8.0

第４章　第１７回ＩＥＡ／ＰＶＰＳタスクＩ専門家会議

17th IEA-PVPS, Task 1 Meeting on 9th- 11th October 2000 in Munich, Germany

Dear Colleagues,

In the following we will provide you with some more information about the forthcoming IEA, Task 1 meeting in Munich. The attached site plan will facilitate to find the various locations.

Location of meeting:

The meeting will be held at the

European Patent Office (EPO)
Room- No. **106 on 9th** and **108 on 10th** October
Erhardtstr. 27
80331 Munich

EPO is centrally located on the river side 'Isar', just on the opposite side of the Deutsche Museum (Technical Museum).

We will pick you up on **9th October at 8.45 h** in the lobby of **Hotel Isartor**.

Accomodation

We selected two small hotels in the tourist/comfort category close to our meeting location (about 200 m), and about 500 m to Isartor (S-Bahn and U-Bahn station) with different prices.

The two options are:
- Hotel Isartor (***) and
- Hotel Advokat (*** and 'designer' hotel).

Both hotels are located on the same road (Baaderstr.), opposing each other and very close to the city centre (Marienplatz).

In the Hotel Isartor building you will find an Italian restaurant ' Lago di Garda', perhaps the right place for the informal meeting on Sunday evening

Reaching 'Isartor'

A taxi from the airport will cost approximately DEM 120,--.

Alternatively, public transport (S-Bahn, the local fast train) is also available and is as convenient.
S 8 is running every 20 minutes (departure '06/'26/'46) from the airport to city center. The travel will take about 35 minutes to 'Isartor' and will cost about DEM 15,00 for a one-way ticket or DEM 12,80 for 8 strips of a 10 strip ticket.
You also can go by **S 1** (departure '16/'36/'56), but it takes more time, about 48 minutes.

Reaching the Hotel

From Isartor in a 5 minutes walk to the Rumfordstrasse and then to the Baaderstrasse. Look at the attached site plan.

Technical Visit

The technical visit is scheduled for Wednesday the 11th October.We will visit Siemens Solar for a short workshop and than the 1 MWp PV plant at the new Trade-Fair Center Munich-Riem. The temporary programme see below.

Tipps for those colleagues, who intend to come to Munich before our official meeting.

- a lot of public museums can be visited without admission fee on Sunday
- the main concert hall 'Gasteig' is to reach via Ludwigsbrücke (about 800 m from hotel)
- there are special prices for a **Single Day Ticket** (16,--DEM for the total area, 8,--DEM for the inner area) and a **Partner Day Ticket** valid for the whole Munich Transport Authority (MVV). All tickets are available on the ticket vending machines.

If you have any questions about the meeting don't hesitate to contact us.

We are pleased to welcome you in Munich.

Kind regards

Peter Sprau and Ingrid Weiss
WIP-Munich

Fax: +49-89-7201291
e-Mail: wip@wip-munich.de

International Energy Agency - Implementing Agreement on Photovoltaic Power Systems: Task 1 - Exchange and Dissemination of Information

17TH TASK 1 PARTICIPANTS' MEETING, 8-11 OCTOBER 2000 – FINAL MEETING SCHEDULE / AGENDA

European Patent Office (EPO), Rooms 106 & 108, Erhardtstr. 27, MUNICH
(EPO is located next to the river Isar, opposite the German Technical Museum)

Dates & Times	Activities & Key Parties	Outcomes

Sunday 8 October 2000
19:00 – For those interested, meet in lobby of Hotel Isartor (Baaderstr.)
19:00 – 21:00 Informal meeting over dinner to confirm arrangements, discuss matters of interest & set the scene for 17th Task 1 meeting

Monday 9 October 2000 –
8:45 Meet in lobby of Hotel Isartor
Meeting - Room 106, European Patent Office

9:00 – 10:30	Item 1: Introduction & welcome by hosts	
	Item 2: Introduction of meeting participants, new members & apologies	
	Item 3: Adoption of Agenda for 17th meeting	
	Item 4: Matters arising from Minutes of 16th meeting	
	Item 5: Matters arising from ExCo meeting in Quebec, Canada (April 2000)	Information for Task 1 members
10:30 – 11:00	*Break*	
11:00 – 12:30	Item 6: International Survey Report: ❑ Comments on content of ISR5 (eg need for better presentation of results in 3.3?) ❑ Comments on production of ISR5 (incl. numbers per country etc) ❑ Plans for ISR6 (incl. photos, technical writer contract etc) Item 7: National Survey Reports: ❑ Comments on content & schedule of previous NSR (labour places & value of business re-visited)	Flagging of all changes that need to be discussed prior to, and endorsed at, the 18th Task 1 meeting. Decisions on any changes to format and content; Agreement on time schedule for next NSR.
12:30 – 14:00	*Lunch*	

14:00 – 15:30	Item 8: Public PVPS website: ❑ Each participant to briefly comment (< 5 mins) on response of target audience in their country, especially - what would they want improved? (*Sample questionnaire distributed*) ❑ What should we, as Task 1, do now about the above?	Identification of any matters that need to be referred to the ExCo eg costs or policy changes. Identification of improvements to be implemented.
15:30 – 16:00	*Break*	
16:00 – 18:00	Item 9: Country 'reports' (short informal presentation) by willing participants, and discussion. Other Task reports (eg Task 2 presentation by German PVPS colleagues)	Information for Task 1 members

Hosted dinner in typical Bavarian restaurant at 7.30 pm

Tuesday 10 October 2000 – Room 108, European Patent Office

9:00 – 10:30	Item 10: Communication matters: ❑ Task 1 communication ❑ Inter-task communication – progress (G Watt) ❑ National communication (with PVPS members & target audiences) – meeting participants will be expected to comment briefly (5 mins) on these two items, or refer to their national communication strategy ❑ CERT communication strategy – status (G Watt) Item 11: PVPower newsletter (P Cowley)	Clear understanding of issues that Task 1 members need to address Feedback on past issue; Plans for future.
10:30 – 11:00	*Break*	
11:00 – 12:30	Item 12: Special Information Activities (1) – Frequently Asked Questions – status; selection of useful/representative examples; proposals for dissemination of results (A Claverie) Item 13: Special Information Activities (2) – Added Value of PV Systems: ❑ Report on Glasgow workshop (members of Working Group) ❑ Document Production Plan (G Watt) ❑ Number of copies of report	Information for Task 1 members Dissemination plan Information for Task 1 members; Endorsement of proposed Document Production Plan.
12:30 – 14:00	*Lunch*	
14:00 – 15:30	Item 14: Special Information Activities (3) - Discussion on 'Market	An agreed outline of activities such as

	Implementation of PV Systems', and potential new work in general (*discussion paper circulated*) All participants should be prepared to provide comments and, where appropriate, offer to lead and/or host activities that may arise from this discussion	workshops, briefing notes, reports etc that Task 1 can develop to firstly, build on the work carried out for "Added Value", and secondly, capitalize on the wider interest in market implementation activities.
15:30 – 16:00	*Break*	
16:00 – 17:30	Item 14 continued Item 15: Next meetings - main issues, location & timing.	

Own arrangements for dinner

Wednesday 11 October 2000

Technical visit & workshop
9:00 Depart from Isartor/Advokat Hotels by bus
9:30 Presentation by G. Oswald, CEO Siemens Solar GmbH "Developments in solar energy from a global player's point of view – the good and the bad news"; discussion.
10:45 Presentation by M. Cameron, EPIA "The role of the European PV industry (EPIA) in the international PV market".
11:00 Presentation by P. Sprau, WIP "The effects of the new financing schemes on the German PV market"; discussion.
11:30 Presentation by A. Sobirey, WIP "The state of the art of grid-connected PV plants" (monitoring results of selected German PV plants including the 1 MW PV plant on the roof of the Trade Fair Centre, Munich-Riem; discussion
12:30 -13:30 Visit the PV plant Munich-Riem.
13:30 – 14:30 Lunch
14:30-15:00 Return to Isartor/Advokat Hotels by bus

平成１２年１０月３１日

海　外　出　張　報　告　書

（第 17 回 IEA PVPS タスク I 専門家会議）

1. 出張者

ＮＥＤＯ太陽技術開発室	総括主研　神門　正雄
〃	※主査　脇　　栄一
	（※９日のみ参加）

2．同行者

ＰＶＴＥＣ	課長　山本　修二

3．出張目的

第１７回 IEA PVPS タスク１専門家会議に参加し、PV システムに関する各国の動向調査および情報交換を行う。

4．日 時

2000 年 10 月 9 日（月）～ 11 日（水）

5．会議場所

ドイツ ミュンヘン　European Patent Office 会議室

6．参加国および参加者

オーストラリア	：Mr. Greg Watt（Australian PVPS Consortium Secretariat）**OA**
カナダ	：Mr. Ray Thomas（Newsun Technology Ltd.）
デンマーク	：Dr. Bent Sorensen（IMFUFA）
フランス	：Mr. Andre Claverie（ADEME）**ExCo**
ドイツ	：Mr. Hans Peter Sprau（WIP）
	Mr. Reinhard Dahl（PT-BEO）
	Ms. Ingrid Weiss　(WIP)
	Dr. Murray Cameron（Chief Executive European Photovoltaic Industry Association）
	Mr. Cristoph Heunnekes（Jeulich BEO）**ExCo**
	Mr. Hermann Laukamp（Fraunha ISE）
	Ms. Ulrike Jahn（Institute for Solar Energy Research – ISFH）
イスラエル	：Dr.Yona Siderer（TEL-AVIV University）
イタリア	：Mr. Salvatore Guastella（CESI）
日本	：神門正雄（NEDO 太陽技術開発室 総括主研）

脇栄一（NEDO 太陽技術開発室 主査）
山本修二（PVTEC 技術部 課長）
ノルウェー　：Mr. Bruno Ceccaroli（Solar Silicon AS）
スウェーデン：Mr. Lars Stolt（Uppsala University）
Mr. Olle Luundberg（Upsala University）
スイス　：Mr. Pius Heusser（Nova Energie GmbH）
英国　：Mr. Paul Cowley（IT Power Ltd.）
Mr. John Knight（Halcrow Gilbert）

以上 12 カ国 22 人。今回欠席はオーストリア、EU、フィンランド、韓国、メキシコ、オランダ、ポルトガル、スペイン、米国。

７．議事次第

＜１０月９日（月）　９：００～１８：００＞
（１）開会・挨拶
（２）参加者の確認
（３）アジェンダの確認
（４）前回議事録事項
（５）執行委員会（カナダ）事項
（６）International Survey Report
（７）National Survey Report
（８）ホームページ
（９）各国報告事項

＜１０月１０日（火）　９：００～１７：３０＞
（10）コミュニケーション事項
（11）ニュースレター
（12）特別活動　(1)問答集
（13）特別活動　(2)ＰＶの付加価値
（14）特別活動　(3)Market Implementation
（15）次回予定

＜１０月１１日（水）＞
テクニカル　ビジット

８．議事内容

（１）開会・挨拶
OA の Mr. Greg Watt より開会の宣言。
続いてホスト国を代表して Mr. Peter Sprau（独 WIP）より歓迎の挨拶。
・ミュンヘンはいわばドイツの Secret Capital で、南ドイツを代表する都市

・先週はビール祭りが盛大に行われた。
・ 以前オリンピックも開催され、現在は PV の普及にも力を入れている

（2） 参加者の確認
出席者全員の自己紹介。
OA より今回不参加者の Apologies の紹介。

（3） アジェンダの確認
OA より今回会議の AGENDA の確認が行われ、原案通り承認。

（4） 前回議事録事項
OA より第 16 回タスクＩ専門家会議（2000 年 3 月 14 日～17 日 イタリア ナポリ）
議事録の確認があり、原案通り承認された。

（5） 執行委員会（カナダ）事項
OA より第 15 回 ExCo 会議（2000 年 4 月 17 日～20 日 カナダ ケベックシテイ）の
会議概要報告。要点は
① OA Meeting での検討事項、②Implementing Agreement の改訂、
② Non-IEA 参加国の参加問題、④議長、副議長の再選問題、
⑤ Market Implementation の検討、⑥第 4 回 IEA エグゼクティブ会議の日本開催。

（6） International Survey Report
2000 年度版#5 ISR についての内容検討。
・Mr. P. Sprau（独）より、コストや価格に関する情報（7 頁）が少ないとの指摘。
この機会を利用して同氏より PV のシステム価格の推移についてドイツでは 1999 年から 2000 年にかけて価格上昇が続いている旨説明があった。システム価格について参加の各委員より以下の意見が出された。
・大きなプロジェクトについて 1～2 件のケーススタディをしてはどうか（仏）
・各国毎に価格レンジのチャートを作るのも良い。（英）
・特定のリファレンスシステムを作ってはどうか。
・モジュールコストかそれともモジュール価格か。どちらにすべきか。為替レートを考慮し、典型的なモジュール価格で表示すべきでは。

議論の結果、以下の項目が確認された。
＊ 次回会議（2001 年 3 月）までに価格リファレンスガイドラインを作る。
＊ #5 ISR については 2000 部印刷（以前は 3250 部）する。
＊ 1.3 項（1 頁）の Definitions、symbols and abbreviations を充実する。
＊ PV システムについては内容を明確にするためシステムの Breakdown を行う。
＊ 為替レートは年間の平均値とする。

＊IEA PVPS の website 上の個人名はオリジナルの spelling とする。（現在違うものになっているため）

（7） National Survey Report

NSR のデータについて 5 月末よりも早くデータが出せないかとの要望が出されたが、データ精度の問題や時期的な観点から無理であり、どうしても早く入手したい場合は各国別に要請してその了解のもとに入手することになった。また、NSR のフォーマットに関し、PV 産業による雇用創出効果（Number of employees＝Value of business）を入れてはどうかとの意見も出された。

確認事項は以下の通り。

・NSR は今まで通り 5 月末、ISR は 9 月末までに完成とする。

・各国別の NSR はそれぞれの国の Target Audience に配布できる。

・発電コストについてデータ投入を検討する。

（8） ホームページ

IEA PVPS の Website の改良について議論が行われ、下記の意見が出された。

・フロントページ：見やすくもっと分かりやすい写真などを使用する。

・内容：PV とは何か、PV の benefit は何か、PV の動向はどうかなどもっと内容を充実させるべきである。

・リンク：数を増大しもっとリンクをはる（例 NOVEM、ADEME、NEDO、PVTEC、ENEL、ENEA、各 TASK など）

・PVPS の活動内容：最新の情報を盛り込むべきである。また、誰にコンタクトしたら良いか明示する。

以上の内容を ExCo 会議で要望することになった。

（9） 各国報告事項

ドイツの参加メンバーより最新の Status Report に基づき Task Ⅶおよび Task Ⅱの活動状況報告。

続いて各国の PV 状況報告。

・オーストラリア：現在特別なプログラムはないが、系統連系 PV システムを中心に拡大中。

・スウェーデン：緑の党（Green Party）の活動が活発。政府の International Committee が PV のサポートに 4 年間のコミットをした。

・英国：住居、ビル開発等の 100-rooftop 計画がスタート。来月（11 月）BIPV に関する新 PV R&D 計画が検討される。グリーンピース党が PV に関与を始めた。PV マーケティングに関する商業的指針（Commercial Initiative）が導入される予定。

また“Solar Century”キャンペーンを開始する。

・スイス：来年も基本ポリシーの変更なし。Per Capita の PV 普及量世界一を目指す。

・イタリア：Highland の地域政府の主導で新たに 1MW の PV プラントを設置する。将来はもっと増やす予定。10,000 rooftop 計画は来年スタートを期待。

・デンマーク：既存プログラムを継続中。Emergency（緊急）用の PV システムも検

討中。BIPV に関しては助成金（Subsidy）をベースに 300-roof プログラムを推進。

・ドイツ：100,000rooftop 計画推進中。低金利ローン提供。グリーンパワー供給増大。
2003 年までに 300MW 導入。

・EU：RE に関する最新のガイドラインを作成。Climate Change（CDM）が RE にとって大変重要。100MW PV Initiative（2～3 年計画）を 2001 年 3 月に策定予定。

・カナダ：特に大きなニュースはない。石油、ガス価格高騰のため RE（PV）に関するインタビューが行われたが PV に対する政府のイニシャティブはない。ハイウェイ用道路灯のバックアップに PV が注目されている。中国で PV のパイロット生産が始まった。Off-grid が中心だが、BIPV にはグリーンピースが推進を呼びかけている。グッドニュースとして Per capita の PV 導入量はスイスと並び世界一の水準になった。

・フランス：ADEME と EDF の協力のもと、US$2.6mil.を投資し地域電化（Rural Electrification）を推進中。国内 PV メーカー3 社（Photo Waff、Apex など）On-grid BIPV を今後 3 年以内に 500KW 導入し、5Euro/W を実現する。Off-grid は 1500KW/年を計画。

・ノルウェー：PV Cell に関しては Scanwafer 社で年産 8.5MW を達成。工場では 40MW/年を計画中。船舶用リモートキャビンやナビゲーション用 PV の輸出を始めた。Technical University で PV の Sun wall ファサードを取り付けた。

＊第 4 回 Executive Conference の日本開催の可能性について質問があり、本件は、NEDO 小川室長より、第 16 回 ExCo 会議で日本の状況、考えを発表するとの説明が行われた。

＊Mr. A. Claverie より第 3 回 Executive Conference（ベニス）の Proceedings が発行されてないとの指摘があった。これに対し一般に Executive Conference は Proceeding を発行しないとの説明がなされた。

＊米国の Expert である Mr. Chuck Linderman より今回参加できないことに対する Apology があった旨 OA より説明された。

（10）コミュニケーション事項

1）タスク間のコミュニケーション

・Task 1 の Website についてアドバイスがあれば Mr. P. Huesser または Mr. G. Watt に E-mail を入れる。

・Website 上に緊急な事項を掲載する。

・役に立つ書類関係は Task 1 メンバーには必ず送付する。

2）国内のコミュニケーションについて

・各国とも Target Audience を明確にする。

・Task 1 の Website 評価のためにアンケートを行う。

OA より最新版の National Communication Strategy を全員に E-mail する

（11）ニュースレター

1）#13 Newsletter：

・ニュースレター "PV POWER" に PVPS の Website アドレスが記載されていないので今後載せるべきであるとの指摘があった。

・京セラの記述やIT Powerの名前が多く掲載されており、会社の宣伝になるようなことは慎むべきであるとの意見が出たが、記事が中立的でかつ全員にとって有用な内容であればOKであるとの結論であった。

・"PV POEWER"の作成に当たりガイドラインを作るべきとの意見に基づき、OAから後日Circulateすることになった。

2）#14 Newsletter ：

次回作成予定の#14 "PV POWER"にどのような記事を掲載するか検討が行われ、以下のような項目が候補に挙がった。

・イタリアの10,000ルーフ計画
・価格の低下傾向について
・日本のPV助成金の2000年度下半期状況（1日で10,000件の申し込みが殺到）
・PV材料の円グラフ
・イスラエルのプロジェクトについて
・Task 9の活動状況について
・フランスにおけるRural PVシステム
・ベルリンでの中央駅300KWルーフトップPVシステム

＊その他推薦すべき記事内容があればできるだけ早く担当のIT Powerに連絡する。

（12）特別活動 (1)問答集

Mr. A. Claverie（仏）よりPVに関するQ&A集（案）が提示され、検討がなされた。Questionの定義は"Real Question"かそれとも"Any Question"かをめぐって議論が行われた。例えばIEA/PVPSとは何か、PVとは何か、PVのコスト、ライフタイム、環境への影響、どこまで範囲を広げるか、またTarget Audienceは誰かなど。Task 1で作成するQ&A集はMr. A. ClaverieのDraftを基に作成することになった。

（13）特別活動 (2)ＰＶの付加価値

Mr. P. Huesserより、グラスゴーで行われた第2回付加価値ワークショップの状況報告が行われた。過去2回分のワークショップ発表資料をもとに最終レポートを作成する旨OAより発表があり、下記のごとく取り決められた。

1）印刷部数は1000部とする。
2）配布は各国申請部数に基づく。日本は200部。
3）各ExCo ： 2部 、 Executive Secretary ：3部、各OA ： 1部
4）作成スケジュール：

1999年	11月初	1st Draft
2000年	1月	ExCo承認
	2月	印刷、配布

（14）特別活動 (3)Market Implementation

先回のExCo会議（2000年4月ケベックシティ）で提起されたMarket Implementation（ REWPよりの課題）についてTask 1の中で議論が行われた。OAより、Market Implementation研究課題のいきさつについて説明があり、続い

て以下の点につき Task 1 としての見解をまとめることになった。

1）Task 1 としては何をすべき（ができる）か。

2）Target audience(s)は何を求め、必要としているか。

3）過去の成功例に基づいた構築は可能か。

4）リーダー国をどうするか。

この様な観点から、各人の意見は次の如くであった。

・小規模系統連系 PV プラントにおける世界共通の発電コスト計算方法（Methodology）を確立すべき。

・Market Implementation という言葉だけでは何を意味しているか不明である。よりビジネスに近い概念なのか、それとも各国の政策なのか。

・Promotional Initiatives（deployment）ならばすでに ISR にある。

・各国政策や付加価値、コストなども包含するのではないか。

議論の結果、下記アイデアを ExCo に提示することになった。

＊ リーダー国（ワーキンググループ）はドイツ、スウェーデン、デンマーク、日本

＊ 作業スケジュールは次の通り。

コンセプト作成 ExCo への提示	2000 年 10 月
活動プラン 1st Draft	12 月
活動プラン 最終 Draft	2001 年 2 月
Document 作成プラン	2 月
Activities 1	↓
Activities 2	↓
Activities 3	↓
	7 月
Draft レポート	8 月
最終レポート	9 月
ワークショップ	10 月

(15) 次回予定

第 18 回専門家会議	2001 年 3 月 21 日～23 日	デンマーク
第 19 回専門家会議	2001 年 10 月 4 日～6 日	サクラメント
第 20 回専門家会議	2002 年 3 月	ｲｽﾗｴﾙ（またはﾉﾙｳｪｰ）
第 21 回専門家会議	2002 年 9 月	ﾉﾙｳｪｰ(またはｲｽﾗｴﾙ)

但し、20 回と 21 回に関しては、国情、気候の関係からイスラエルとノルウェーが相談して時期を決定することになった。

＜１０月１１日（水）＞

テクニカル ビジット

◇Siemens 社訪問

Siemens Solar GmbH 社を訪問。同社は Siemens AG（世界的な電気・電子機器大企業）と Bayernwerk AG（ドイツにおける有力なエネルギー会社）のジョイントベンチャー企業。

1）事業内容は下記の通り。

・ソーラーセル、モジュールの開発・製造・販売
・現在まで 180MW の PV を全世界に供給
・年商：1 億 5000 万マルク
・従業員：500 人
・生産能力：23MWp
・R&D 投資額：年間収入の 8%
・投資額：年間収入の 7%

2）Siemens 社の考え

・将来石油の価格は高騰する。(2010 年頃 US$40～70/B)
・来世紀 PV は本格的にテイクオフする。
・産業の重要な要素は①製品、②市場、③プレーヤー
・製品力は充分。市場は未成熟（2/3 は助成金に依存)、プレーヤーは苦闘
・ソーラーの世紀にするためには市場育成、技術力、挑戦が大事
・1997 年には世界で 110MWp が生産され、40%の成長を実現した。
・今後の年成長率は 15%位（最高で 25%）原動力は先進国での系統連系システム
・PV による世界の発電量はｴﾈﾙｷﾞｰ全体の約 1%（2025～2040 年）およそ 300TWｐ
・100TWp で 20 億人の無電化人口に供給可能
・実現のためには年 1000 億ドルの投資と 50GWp の出荷・設置が必要。
・現時点ではどの PV 技術が年５０GWｐの出荷を実現できるか不明。
・しかし今後 10 年から 15 年以内に 100MWp～1GWp の生産が可能な方法を見つける必要がある。
・1GW の生産のために 15,000 トンのシリコンが必要。これは現在の電子産業での需要に匹敵する。
・シリコンの消費を減少させるため、15t/MW から 10t/MW にする必要があるが当面シリコンの不足は解消できない。
・このため薄膜技術の開発を急ぐ必要がある。今後 10 年間は薄膜技術が主流に成るだろう。
・今後 PV 産業界はモジュール生産のために 20 億ドルの投資と 60 億ドルの助成金が必要。
・政府、金融、産業界の政策決定者および何百万人のエンドユーザーの教育が必要。
・無電化地域や過密都市での PV 普及のために Micro Banking や Micro Service のインフラ整備が求められる。

◇PV Plant 訪問（New Munich Trade Fair Center)

ミュンヘン市郊外の New Munich Trade Fair Center を訪問した。概要は下記の通り。

出力	：1,016KWp
セル	：単結晶シリコン(1 モジュール＝84 セル) Siemens 製
セル効率	：15%
モジュール数	：7,812 フレームレス
モジュール出力	：130W

総屋根面積（6 Halls）；66,000 ㎡

PV 敷設面積　：38,000 ㎡

架台　：軽量 屋根設置型　28°　南向き

インバーター　：出力 330KW（3 units 構成）

電力供給　：20,000 Volts 系統連系　約 1mil. KW/年

電力用途　：New Munich Trade Fair Center の年消費量の約 4%半分を供給

稼動時間　：約 1,000 時間/年

CO_2 削減量　：1,000ton/年

耐久年数　：20 年以上

International Energy Agency - Implementing Agreement on Photovoltaic Power Systems

Task 1 - Exchange and Dissemination of Information

SUMMARY

17TH TASK PARTICIPANTS' MEETING
MUNICH, GERMANY, 8-11 October 2000

Item 1: Introduction & welcome by hosts

Greg Watt welcomed meeting participants and thanked the German members for their excellent meeting arrangements. Peter Sprau welcomed Task 1 to the European Patent Office and Munich, and outlined arrangements for the following three days.

Item 2: Introduction of meeting participants & apologies

Meeting participants were Greg Watt (Australia), Raye Thomas (Canada), André Claverie (France), Bent Sørensen (Denmark), Peter Sprau, Ingrid Weiss, Ulrike Jahn, Hermann Laukamp, Reinhard Dahl, Christoph Huennekes (Germany), Yona Siderer (Israel), Salvatore Guastella (Italy), Masao Kando, Eiichi Waki & Shuji Yamamoto (Japan), Lars Stolt & Olle Lundberg (Sweden), Pius Hüsser (Switzerland), Paul Cowley (United Kingdom), Bruno Ceccaroli (Norway), John Knight (Halcrow Gilbert) and Murray Cameron (EPIA). New, changed or visiting participants (underlined) were welcomed.

Apologies were received from Peter Ahm (Denmark), Kyung-Hoon Yoon (Korea), Astrid de Ruiter (The Netherlands) and Charles Linderman (USA)

Item 3: Adoption of Agenda for 17th meeting

The agenda as circulated was adopted.

Item 4: Matters arising from Minutes of 16th meeting

Greg Watt noted that all the action items arising from the 16th meeting would be discussed under subsequent agenda items.

Task 1 participants are to refer to Attachment 1 of this document for an updated summary of new actions requiring attention.

Item 5: Matters arising from ExCo meeting in Quebec City, Canada (April 2000)

Greg Watt summarized these as follows:
- Task 1 has been asked to consider 'market implementation';
- Task 1 is to develop policies for the task websites;
- The Task 1 proposal for enhancing inter-task communication was approved;
- Task Status reports are to contain 'performance indicators' of task participants' attendance at meetings and contribution to task work;
- ISR5 is to remain at 16 pages in length – subsequent ISRs may be longer (and this was written into the tender for the technical writer for ISRs 6 & 7);
- In principle, all countries should receive the same number of copies of all reports, except for the Annual Report and the ISR (however there was no guidance as to what this number should be);
- The Chairman does not want countries omitted from the ISR for not providing data – instead a footnote and the previous data should be included;

- The proposal for a public report on "Added Value of PV Systems" was endorsed, and a document production plan was expected for the next ExCo meeting;
- The amended Task 1 objective ("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 PV power systems") was endorsed;
- The Task 1 OA was to develop a tender document for the position of technical writer for ISRs 6 & 7;
- 2000 copies of ISRs will be printed – Task 1 was requested to produce a new list of numbers per country;
- The ExCo public website committee was dissolved;
- The Task 1 guidelines for producing public PVPS documents were endorsed.

Item 6: International Survey Report

A number of matters concerning ISR5 were raised – some as a result of feedback from target audiences - as follows:

- Layout is to be improved with the report length increasing to 20 pages for ISR6;
- Table 2.1 is to again report both off-grid domestic and non-domestic (for nearly all countries);
- EU data are to be included in Table 2.3 (budgets);
- Some reporting of labour places should occur;
- Table 3.1 is to report both single and multi crystalline module production;
- Section 3.1 is to include a graphic example of module price trends;
- Section 3.3 is to include a graphic example(s) of system price trends for a specific application(s);
- Background colour eg Table 4.1 is to be lightened to facilitate better photocopying;
- Non-IEA country information will be actively sought for ISR6;
- Exchange rate information (annex B) will be sourced from the IEA;
- Photos will be chosen at the March meeting.

The 2001 schedule for ISR6 is as follows:
March – All above proposed changes must be endorsed at the Task 1 meeting;
End May – All National Survey Reports to be emailed to Technical Writer;
Early July – 1st draft of the ISR emailed to Task 1 participants by Technical Writer;
Early August – 2nd draft of the ISR emailed to Task 1 participants by Technical Writer. Task 1 participants are expected to discuss the draft with their ExCo member at this stage.
Mid August – Final draft of the ISR sent to graphic designer by Technical Writer;
End August – Technical Writer provides 'wet proofs' for final checking by selected Task 1 participants;
Early September – Technical Writer initiates printing;
Mid September – Technical Writer organizes bulk distribution of reports by courier.

With the print run decreasing from 3250 to 2000 and with the availability of ISRs on the website, Task 1 participants had been requested to nominate the number of printed copies that their country would like to receive. Based on the eight responses received and some deliberation about the relative contributions of various countries, the following distribution numbers were chosen.

IEA-PVPS TASK 1 – Distribution numbers for ISR numbers 6 & 7

COUNTRY	PREVIOUS NUMBERS	UPDATED NUMBERS
Australia	50	40*
Austria	30	10#
Denmark	70	65#
Canada	100	90#
Finland	150	120*
France	150	120*

Germany	200	185#
Italy	170	160#
Japan	150	80*
Korea	70	60#
Netherlands	200	185#
Portugal	100	20#
Spain	100	20#
Sweden	70	50*
Switzerland	150	150*
USA	200	185#
EU	50	10#
Mexico	20	18#
Norway	10	10#
Israel	50	100*
UK	200	185**
Secretary	960	137#
TOTALS	3250	2000

* requested
** requested 200
# assigned

(Postscript: Halcrow has been selected by the ExCo to continue as Technical Writer for the next two years, following evaluation of eight proposals received from five countries).

Item 7: National Survey Reports

The following matters were raised and are to be included in a revision of the NSR guidelines to be circulated by Greg Watt:

- labour places data are again to be reported;
- countries having a significant PV programme (eg on-grid distributed) or a well documented market segment (eg off-grid domestic and/or non-domestic) <u>plus</u> access to the required data (eg as presented for residential systems by both Germany and Japan during the meeting) should include data on system prices for a number of years;
- module prices should be reported for a number of years;
- off-grid domestic and non-domestic are again to be reported separately if possible;
- exchange rates are no longer required to be provided.

NSRs are again to be completed by 31 May 2001, with progress to be reported at the March Task 1 meeting.

Item 8: Public PVPS Website

The meeting discussed feedback to the website questionnaire that has been circulated by some countries, and the opinions of Task 1 participants and visitors to the meeting. The following table represents a synthesis of these discussions, for presentation to the webmaster and interested ExCo members.

PRIORITY	TOPIC	POINTS RAISED
High	Downloadable documents	1. Some downloads are missing 2. All downloads should be in PDF format 3. More downloadable information required, including photos and graphics 4. Access to presentation type information, eg single

		graphics from the ISR (with copyright & disclaimer)
Medium	Links	5. More external links - first priority is ALL sponsoring organisations of PVPS participants 6. Links to other IEA Implementing Agreements, & IEA statistics and information programmes 7. All links require quality control and short descriptor
Medium	Theme	8. Concentrate on professional audience, but do not ignore the general audience 9. More statistics, analyses and conclusions for professional audience – to better reflect what PVPS does 10. FAQs (from Task 1) for general audience 11. Contents too limited – include current 'news' etc
Medium	Front page	12. Negative responses to current page - not attractive, not good for high resolution 13. Suggested PVPS background – eg Figure 2.1 from ISR or Figure 1.1 from Task 2 report
Lower	Navigation	14. Back to home page not obvious 15. Site map should be more prominent 16. Search not working properly 17. Some internal links fail
Ongoing	General	18. More pictures and graphics 19. Need webmaster contact re problems, updating etc 20. Replace with database supported website 21. Webmaster to attend Task 1 meetings for relevant Task 1 agenda item

Greg Watt outlined the proposed policy for task websites, as follows:

- Subsidiarity
- Consistency with public website content
- Clear link to public website
- No advertising
- Encourage access via public website
- Responsibility of relevant OA
- Common introductory statement & disclaimer.

Item 9: Country reports etc

Each participant at the meeting provided a short, informal overview of current issues influencing implementation of PV in their country (or industry association, in the case of EPIA). An electronic version of the Japanese presentation has subsequently been circulated.

Our visiting German PVPS colleagues gave presentations on the work being carried out within Tasks 2 & 7. Considerable detail on the situation in Germany was presented at the workshop following the meeting.

Item 10: Communication matters

Greg Watt noted that progress toward enhancing inter-task communication was slow, and that this would be raised at the Operating Agents and ExCo meetings.

National communication strategies were discussed. To date these have been prepared by Australia, Denmark, Finland, France, Germany, Japan, Sweden and the UK. These will be placed on the Task 1 website (although most have been previously circulated). Participants were reminded that these documents (1) provide helpful information on how other countries manage their national PVPS communication, and (2) encourage a closer working relationship between PVPS participants within a country. Shuji Yamamoto presented an updated version of the Japanese approach (*an electronic version has subsequently been circulated*).

Greg Watt outlined the CERT communication survey that had been circulated to OAs, ExCo members etc, and will report to Task 1 on feedback when received from the IEA Secretariat.

Item 11: PVPower newsletter

Participants proposed that a short 'policy' document be written regarding PVPower. Greg Watt is to prepare this before the March meeting.

The following matters were raised regarding format etc from PVPower 13:

- Longer articles (such as those on pages 4 and 5) should contain sub-headings;
- 'New on the net' needs some attention – selection of items is to be thematic rather than ad-hoc, and is to clearly focus on target groups. The section should describe and evaluate sites. Task 1 participants are to consider this section carefully in the draft for PVPower 14;
- The public website address should feature more prominently in PVPower;
- It is important to ensure that references and contacts etc are consistent with those being quoted on the website.

Paul Cowley outlined the proposed contents for PVPower 14 – ISR5, Added Value, FAQs, Task 2 report, Italian rooftop programme, price curves, HIP-HIP etc – and requested that other material be sent to him by 26 November. A draft will be put on the Task 1 website around mid-December.

Future meeting agendas are to contain information on proposed contents for the next newsletter.

Item 12: Special information activities (1) – Answers to frequently asked questions

André Claverie outlined the (limited) responses that he had received to the framework document produced by France; only a handful of Task 1 participants have provided examples of these questions (and the answers) from their countries. There was some discussion about the value of what had been collected, and what should be done with the material.

Participants agreed that a selection of useful/representative examples should be made and posted on the public website, as these would provide a useful source of more general PV information that Task 1 participants could refer some audiences to.

Item 13: Special information activities (2) – Added Value of PV Systems

Pius Hüsser reported on the Glasgow workshop, organized by the Task 1 Working Group (Japan, Australia, Switzerland, the UK and the Netherlands) held on 5 May 2000 in conjunction with the European PV Solar Energy Conference. The workshop was regarded as successful, attracting about 50 participants from a range of countries and backgrounds. The papers from the workshop were of very high quality and were posted on the Task 1 website for access by Task 1 participants and other interested parties.

The technical writer (Dr Muriel Watt, Australia) for the final report has been contracted by NEDO/PVTEC, Japan. The draft Document Production Plan was discussed and endorsed, and participants were requested to nominate the number of printed copies that they require. All details concerning this report (including numbers of copies) are contained in the final Document Production Plan, which is provided as Attachment 2 to this summary.

Item 14: Discussion on market implementation and potential new work in general

Greg Watt discussed the principles, circulated before the meeting, to keep in mind when discussing potential new activities – namely, What can/should Task 1 do? What does our target audience(s) want/need? Build on past successes, and A country must be prepared to lead and/or host activities. Task 1 participants were encouraged to think about activities resulting in workshops, briefing notes, reports etc that Task 1 can develop to firstly, build on the work carried out for "Added Value", and secondly, capitalize on the wider interest in market implementation.

Shuji Yamamoto gave an excellent presentation on factors concerning marketing/market implementation of PV (*an electronic version has subsequently been circulated*).

The meeting supported the concept of a new special information activity on the methodology for costing energy from PV systems. Peter Sprau presented an example of the annuity calculation approach currently being used in Germany. Sweden expressed an interest in leading this activity – with major contribution expected from Denmark, Germany, Norway and Japan. This work will build on earlier research carried out in Denmark, and will provide useful support of PV marketing through publication of an IEA-PVPS report encompassing background information, methodology and calculation tools.

This activity will consider both direct costs and indirect costs, and promote the LCA approach. There should be collaboration with both Task 5 (Activity 54.2 – Financial Aspects) and Task 7 (Activity 3.3 – Economics of BIPV).

The timetable for this activity was discussed, with the following being agreed:

Concept presented to ExCo	October 2000
Activity plan to Task 1	December 2000
Endorse Document Production Plan	March 2001 Task 1 meeting
Presentation of plans to ExCo	April 2001 ExCo meeting
Draft report	August 2001
Final report	September 2001
ExCo approval & publication	October 2001

Item 15: Next meetings

The 18th Task 1 Participants' meeting will be held in **Denmark, 21-23 March 2001.** The meeting will be held over two days in Copenhagen, with everyone then traveling together by train to the West of Denmark for the technical tour.

The 19th Task 1 Participants' meeting will be held in the **US** in late September/early October at a time and place to be confirmed.

The 2002 meetings are proposed to be held in **Israel** and **Norway**.

Attachment 1

SUMMARY OF KEY TASK 1 ACTIONS

ACTION	RESPONSIBLE PARTY	TIMING
1. Compile Task 1 contacts list for Task 1 website	Greg Watt	November 2000
2. Add National Communication Strategies to Task 1 website	Greg Watt / Pius Hüsser	November 2000
3. Circulate survey pro-forma developed by Paul Cowley - please use!	Greg Watt	November 2000
4. Circulate first draft of "Added Value" report	Greg Watt	10 November 2000
5. Provide Paul Cowley with news stories for *PVPower*	All Task 1	Before 26 November for #14 ,and ongoing
6. Amend and circulate NSR guidelines	Greg Watt	November 2000
7. Comment on first draft of "Added Value" report	All Task 1	Before end November 2000
8. Approve final draft of "Added Value" report & discuss with ExCo member	All Task 1	Before Christmas 2000
9. Prepare draft activity plan for "Costing of PV energy"	Olle Lundberg & Greg Watt	December 2000
10. Prepare draft Document Production Plan for "Costing of PV energy"	Greg Watt	Before next meeting
11. Commence work on "Costing of PV energy"	Sweden, Denmark, Germany, Japan & Norway	January 2001
12. Develop ideas and offer to lead future special information activities that could be discussed in detail at the next Task 1 meeting	All Task 1	January 2001
13. Develop ideas for PVPS workshops that could be developed for EPVSEC in October 2001	All Task 1	Before next meeting
14. Advise ExCo and webmaster of Task 1 suggested improvements for the website	Greg Watt	Ongoing
15. Amend and circulate ISR6 'format and content'	Greg Watt	Before next meeting
16. Write 'policy' for *PVPower*	Greg Watt	Before next meeting
17. Finalize "Answers to frequently asked questions", and provide to webmaster	André Claverie	Before next meeting

Attachment 2

DOCUMENT PRODUCTION PLAN

1. Title (final)

Added Value of PV Systems

2. Report number

Report IEA-PVPS T1-09:2001

3. Author or editor

Japan is the lead country for this activity. The technical writer is Dr Muriel Watt (Australia) under contract to NEDO/PVTEC (Japan).

4. Purpose of document

To date two specialist IEA-PVPS workshops have been held concerned with the added value of PV systems, the first in Japan and the second in Scotland. It is now planned to produce a short (~40pp) public IEA-PVPS report summarising the workshops and other discussions and investigations.

5. Subtask connection (if any)

Special Information Activity

6. Abstract

To be developed

7. Table of contents or major chapter headings (indicative)

Foreword
Abstract and Keywords
Acknowledgments
Executive Summary (~4 pages, able to be used as a stand-alone document)

Introduction (3 pages)
- *Definition of added value for this study*
- *Renewable energy policy issues (not adequately addressed) – credit for capacity, reliability, environmental and social externalities, LCA, network pricing*
- *Business 'drivers' for renewables – for governments, utilities (competitive markets, network benefits, DSM); architects and developers; customers*
- *Purpose of this 'special activity'*
- *Structure of this report*

1. The status of PV applications worldwide (2 pages)
- *Market size (IEA countries) and growth rates by applications (from ISR)*
- *Current innovations and trends in applications in the built environment*

2. Key barriers to the implementation of PV in the built environment (3 pages)
(these may not apply uniformly in each country)
Cost and price
- *high capital cost/low operating cost systems require a new approach to project financing;*
- *cost reductions will depend largely on research and innovation, increased market/production levels and increased experience with system design & installation;*
- *the price of PV electricity is uncompetitive at the retail level, often even if externalities are built into retail electricity prices*

Electricity industry issues

- *negative aspects of developing competition (ala earlier report);*
- *lack of promotion of distributed generation through cross-subsidies embodied in retail pricing regulations;*
- *the lack of true least cost planning frameworks in utilities and/or regulators;*
- *negative consequences of disaggregation of vertically integrated utilities and separation of wires and retail businesses;*
- *market access for small players*
- *non-uniformity in grid connection and metering arrangements.*

Market knowledge and confidence about quality

- *a lack of targeted information – potential users, trades & professionals*
- *a lack of appropriate certification, standards and guarantees for systems and components.*
- *few demo systems – in some countries – with little public data on performance*

3. Summary of potential additional values offered by PV (10 pages)
(quantifying where possible)
Matters For Policy Makers

- *emission reductions*
- *sustainability –incl. energy supply security & clean air targets*
- *business development and employment growth*
- *increasing awareness of energy savings*

Benefits For Business
Utilities

- *peak lopping*
- *reduction of network losses*
- *power factor improvement, reduced voltage fluctuation in distribution lines*
- *targeted DSM*
- *delayed/deferred line upgrades*
- *improved summer system reliability*
- *marketing green products*

Architects and building developers

- *design features*
- *reduced air conditioning load*
- *sound proofing*
- *replacement of other building materials*
- *energy security*

Customers

- *noiseless*
- *low heat generation*
- *image*
- *independence*
- *commitment to environment protection*

4. International case studies addressing the questions of added value (10 pages)
(from the workshops and subsequent discussions – what some governments, utilities, planners, developers etc have actually done to incorporate some of the above in the decision making process)

5. Overcoming the key barriers to the implementation of PV in the built environment (5 pages)
(addressing 3. with the material from 4. & 5.)

6. Summary and conclusions (2 pages)

References

Annex 1 Sapporo workshop summary (to be provided)
Annex 2 Glasgow workshop summary (to be provided)

8. Intended audience

The report will be a high quality printed document, targeted at key decision makers in government, electricity utilities and industry.

9. Category: Published Report or Internal Working Document

Published report.

10. Responsibilities of specific Task participants for its preparation

The technical writer is responsible to the Task 1 Added Value working group (Task 1 participants from Japan, Switzerland, the UK and The Netherlands), through the Task 1 Operating Agent. The Task 1 Operating Agent will be the main point of contact for the technical writer.

11. Person responsible for printing

Production, printing and mailing of the report will be the responsibility of NEDO/PVTEC, Japan.

12. Details regarding how hard copies of the document can be obtained/purchased

Task 1 participants should be approached regarding free bulk copies. An order form for additional copies will be included with the ExCo report approval ballot. The report will also be able to be downloaded from the public PVPS website.

13. Expected number of copies to be published and proposed allocation

It is anticipated that 1000 copies of the report will be published and disseminated free of charge as follows (as per the Handbook of Policies and Procedures):

- number of copies to each Task 1 participant as per following table
- 2 copies to each ExCo member
- 2 copies to the Executive Secretary
- 1 copy to each Operating Agent
- 1 copy to the IEA Secretariat.

IEA-PVPS TASK 1 – Distribution numbers for “Added Value” report

COUNTRY	NUMBER
Australia	50
Austria	20
Denmark	20
Canada	50
Finland	20
France	50
Germany	50
Italy	30
Japan	270
Korea	20
Netherlands	50
Portugal	20
Spain	20
Sweden	30
Switzerland	50
USA	70
EU	20
Mexico	20
Norway	20

Israel	50
UK	70
TOTAL	1000

Additional copies may be ordered at a cost to be decided.

14. Production schedule with expected dates:

14.1 distribution of the first draft to Task 1 participants for review – 10 November 2000
14.2 approval of final draft by Task 1 participants – mid December 2000
14.3 ExCo review and approval – January 2001
14.4 publication and distribution of document – February 2001

15. Dissemination and publicity plans

Task 1 participants will be responsible for providing printed copies of the report to the target audience in their respective countries. The report will be listed and also able to be downloaded as a .pdf document from the public PVPS website. An electronic version of the Executive Summary will be provided to all Task 1 participants for translation, broadcast email or whatever dissemination they consider appropriate (eg brochures). The report will be referred to in the Task 7 Executive Report dealing with the various Task 7 activities concerning non-technical factors. An article about the report and its availability will be placed in the February 2001 issue of PVPower (No. 14).

16. Plans to assess impact of product

An ongoing component of Task 1 work is to gather feedback from target audiences on the usefulness of material that is produced by the IEA-PVPS Programme. Results for this report will be reported in the September 2001 Task 1 Status Report.

International Energy Agency
Photovoltaic Power Systems Programme

Answers to frequently asked questions about solar photovoltaic electricity

An international perspective

Draft 6
2000-12-28

IEA–PVPS T1 xx :2000

Contents

Foreword

This document has been prepared by Mr André Claverie and Mr Greg Watt, IEA–photovoltaic power system programme Task 1 participants. It follows discussions where it was proposed to develop a set of answers to the questions asked most frequently by the target IEA–PVPS audience (utilities, industry, public and private users, governments, non governmental bodies, developers and installers, financial institutions, research organizations, etc.).

Introduction

Photovoltaic experts such as those working within the IEA–PVPS cooperative programme have to answer basic questions asked by a variety of people.

There are many sources of information available to assist with answering these questions, however the PVPS target audience needs up-to-date and reliable information.

The IEA–PVPS website (www.iea-pvps.org), the newsletter "PV Power", the annual technical survey reports *"Trends in photovoltaic applications in selected IEA countries"*, the workshops and the conferences provide a wealth of information but they do not necessarily answer these basic questions in the appropriate way. Through this project, Task 1 has developed consensus answers for the target audiences.

1 Scope and objectives

The outcomes of this project, 'Answers to frequently asked questions about solar photovoltaic electricity – an international perspective', will provide the IEA–PVPS target audience (utilities, industry, public and private users, governments, non governmental bodies, developers and installers, financial institutions, research organizations, etc.) with state-of-the-art basic knowledge and understanding of photovoltaic power systems particularly those systems which are on-grid distributed.

The questions and answers cover:

– **Technical aspects:** photovoltaic systems and components (photovoltaic modules, inverters, charge regulators, storage, etc.) and applications.

– **Economical aspects**: prices, costs, etc. and commercial aspects (guarantees, etc.), Added value to the use of photovoltaic power systems.

– **Environmental aspects:** environmental impacts in the process of manufacturing, in the process of daily use, when decommissioning, etc.).

– **Social aspects:** Impact on social development, etc.

– **Other aspects.**

LIMITS: The project will not enter into the technical details or working principles of photovoltaic cells and photovoltaic modules, or the manufacturing processes of the various photovoltaic system elements (storage batteries, charge controllers, inverters, etc.) and their applications.

2 Definitions

For the purposes of this report, the terms, abbreviations and definitions given in this section apply.

PV: abbreviation of photovoltaic (adjective) or photovoltaics (noun).

PVPS: abbreviation of photovoltaic power system.

photovoltaic power system: set of interconnected elements such as photovoltaic modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a photovoltaic power capacity of 40 W or more. The typology is different according to application: see off-grid and on-grid photovoltaic systems.

off-grid domestic photovoltaic 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 battery).

off-grid non-domestic photovoltaic system: system used for a variety of applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. which are not connected to the utility grid. Usually a means to store electricity is used.

on-grid distributed photovoltaic system: system installed on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected domestic photovoltaic systems and other grid-connected photovoltaic systems on commercial buildings, motorway sound barriers, etc. These may be used for support of the utility distribution grid.

on-grid centralized photovoltaic system: power production system performing the function of a centralized power station (also said centralized photovoltaic power plant).

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 are 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 are not included. Equally the additional transport costs of installing a telecommunication systems in a remote area are not included.)

demonstration programme: project to demonstrate the operation of photovoltaic power systems to the general public and potential users/owners.

market deployment initiative: initiatives to encourage the market deployment of photovoltaic power systems 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.

final annual yield: total photovoltaic energy delivered to the load during one year per kilowatt of power installed. Unit: kWh per kW

performance ratio: ratio of the final annual yield to the reference annual yield, where the reference annual yield is the theoretically annual available energy per kilowatt of installed power.

stand-alone photovoltaic system: autonomous system with storage batteries (see off-grid photovoltaic system).

Installed power: power delivered by a photovoltaic module (a PV array, a PV system, etc.) under standard test conditions (irradiance of 1 000 W/m², cell junction temperature of 25 °C, AM1,5 solar spectrum). Also said STC maximum output power. Unit: W.

W: symbol of SI unit of power called watt. In this report it is understood maximum power under standard test conditions (STC). Also written Wp but not recommended. Multiples like kW (10^3 W) or MW (10^6 W) are also used.

kWh: symbol of kilowatt-hour, unit of energy (power expressed in kW multiplied by time expressed in hours)

photovoltaic (solar) cell: a basic photovoltaic device, which generates electricity when, exposed to a light such as the solar radiation.

photovoltaic module: the smallest complete environmentally protected assembly of interconnected photovoltaic cells.

photovoltaic panel: a group of modules fastened together, pre-assembled and wired, designed to serve as an installable unit in an array.

photovoltaic array: a mechanically integrated assembly of modules and panels together with support structure to form a d.c. power producing unit.

standard test conditions (STC): testing conditions to measure photovoltaic cells or modules maximum output power. Irradiance = 1 000 W·m², with the reference solar spectral irradiance distribution, air mass = 1,5, and cell or module junction temperature of 25 °C.

3 Answers to frequently asked questions

Questions and answers (Q&A) are put under specific items: technical, economical, environmental, social and others.

3.1 Technical aspects

What is a photovoltaic power system?

The photovoltaic (PV) process converts sunlight - the most abundant renewable energy source on the planet - directly into electricity. The equipment required for this process has no moving parts and as a result requires minimal maintenance. In addition, the electricity is generated with no emissions and no noise. The basic power-generating element is a photovoltaic module. Modules are made out of photovoltaic cells. A photovoltaic cell consists of two or more thin layers of semiconducting material, most commonly silicon. When the cell is exposed to light, electrical charges are generated and this can be conducted away by metal contacts as direct current (d.c.). The electrical output from a single cell is small (around 0,6 V), therefore multiple cells are connected together to provide a more useful output. Cells connected in this way are encapsulated (usually behind glass) to form a weatherproof photovoltaic module.

Multiple modules can likewise be connected together (then called panel, array) in order to provide sufficient power for common electrical uses.

What is an on-grid photovoltaic system, and what are its main features?

An on-grid photovoltaic system consists mainly of the photovoltaic (PV) modules that convert sunlight into direct current electricity and an inverter that converts the direct current to alternating current to make the electricity compatible with the local electricity grid. Various mounting systems can be used to support the PV modules on the roof, on the ground or on a building façade. Increasingly architects and builders are integrating the PV system into the building design. Most on-grid applications do not require storage batteries.

About ten square metres of photovoltaic modules would rate a power of 1,2 kW and, depending on the mountings used, weighs about 150 kg. Silicon, glass and metal would typically be the main construction materials involved. Over a period of time such a photovoltaic array would produce roughly one third to a half of the energy requirements of a typical household in northern Europe. Photovoltaic systems can be large or small to suit different applications (for example a house or commercial/industrial building), and can also be sized according to the proportion of electricity that is to be provided by the system.

Could one power a house and become independent from the electricity utility grid?

Installing a PV system on top of one's roof or in place of a roof is possible and there are around 50 000 house in OECD countries equipped that way. Nevertheless one still need grid connection to power the house when the weather is bad. So one must not disconnect. Over the whole year a PV power system might produce the amount of electricity consumed (excluding electric heating). In the case of net metering the electricity bill would be zero and even one might earn money if the electricity buy-back rate proposed by the utility company is more attractive.

Can one heat a house with a photovoltaic power system?

Theoretically yes since a photovoltaic power systems produce electric current. But it is wiser and cheaper to install a solar thermal hot water system.

How much will I need to power a home?

A typical domestic photovoltaic power system of 1,5 kW (12 m^2) would produce around a third (northern Europe) to a half of the annual demand of an average urban family household (taking the average demand to be around 10 kWh per day). However, calculating the system size depends on many factors, for example whether the system is grid connected, energy demand of the household, etc.

These factors will all be taken into account by a system installer when designing a photovoltaic system.

Is the technology reliable, and how long does it last?

Although PV is a relatively young technology in terms of market application, the experience accumulated confirms PV energy as a proven technology able to generate electricity for 25 years or more without intervention. This, and extensive testing, allows the module manufacturers to offer extensive guarantees of performance. Photovoltaic modules are tested to local and international standards such as those of technical committee 82 of the International Electrotechnical Commission (www.iec.ch)

What factors should one consider before installing a PV power system?

The decision to install a photovoltaic power system should take into account the following:

The photovoltaic modules (whether mounted on the roof or elsewhere) should have access to considerable direct sunlight all year. This means mainly unimpeded exposure to a semi-circle of most of the sky when looking south (northern hemisphere) or north (southern hemisphere), with a low likelihood of significant trees or buildings close by in this direction in the future.

How can one connect a photovoltaic system to the grid?

Connecting a photovoltaic power system to the electricity network will require permission from the Network Operator. The operators have different policies when it comes to connecting PV systems to their networks, and so different rates will be paid for exported electricity. The system installer will make the necessary arrangements for grid connection.

What must one do to operate the photovoltaic array effectively?

Once installed, the photovoltaic array (module assembly) requires very little attention from the householder or building owner. The photovoltaic module contains no moving parts and costs nothing to run, using no fuel or consumables. It operates silently and safely, produces no wastes and requires only minimal maintenance (such as cleaning dust from the module surface in dry dusty places).

Will an on-grid PV power system still work when the grid is out of order?

No, in case of a lack of power coming from the grid, the inverter of the photovoltaic system will shut off to protect people repairing the grid. But it is possible to have a system with a self-regulating inverter and a storage battery back up to operate independently from the grid. These photovoltaic systems are normally more expensive than simple grid connected systems.

Will photovoltaic modules produce electricity although there is no sun (cloudy sky or fog)?

Yes, photovoltaic modules work also under these conditions but will produce much less electricity than with direct sun light.

Do photovoltaic modules need to be cleaned and how often?

Usually no. Rain does the job. In dry areas and low latitudes sweeping dust might be necessary. Means depend upon situation and application.

To have installed a system, who should one contact?

System installers usually carry out installations of domestic photovoltaic systems. Contact Professional associations.

What is the land area covered by a centralized photovoltaic power station?

Pilot photovoltaic power plant such as that of Erga in Italy occupies 1,2 ha (12 000 m²) per megawatt of power installed. A project within the IEA–PVPS cooperative programme is carefully studying all the implications (economical, technical, sociological, financial, etc.) of equipping desert areas with photovoltaic power plants.

How much energy does a photovoltaic power system produce per year?

Being a centralized power plant system or an on-grid distributed "PV roof", the electricity production will depend upon the geographic situation. In Italy the 3,3 MW demonstration photovoltaic pilot centralized power system produces 1 300 kWh per kilowatt of power installed (this plant produces 5 000 MWh per year, the equivalent annual consumption of 2 000 families). With systems using concentrated light (such as the pilot plant installed in the Canary Islands) it reaches 1 400 kWh per kilowatt of power installed. Practical limit is 1 600 kWh per kilowatt of power installed. The power ratio is 75 % to 80 %.

In Japan a photovoltaic power system of 1 kW will produce in average 1 200 kWh of electricity per year. In Germany, 600 kWh to 1 000 kWh per year of electricity per kilowatt installed.

The photovoltaic modules never pay back the amount of energy they consume in the process of their construction, do they?

False. Studies show that photovoltaic modules made out of crystalline silicon pay back their energy content in 3 to 5 years, while new type of module made out of thin films pay back in 2 to 3 years. Technological progresses will considerably shorten this energy payback time. Most of the companies guarantee their photovoltaic modules 25 years.

What is the lifetime of photovoltaic modules?

There is no consumption of matter in the process of converting solar light into electricity through the semiconductors the photovoltaic cells and the photovoltaic modules are made of. So the lifetime is theoretically infinite. The only limitation is the way the PV modules (weather proof encapsulated photovoltaic cells) are able to withstand the aggressive environment they are put in. Some manufacturers guarantee their modules up to 25 years. There are many photovoltaic modules installed by the beginning of the PV terrestrial era in 1970s and still working well. Humid and salty climates are very restricting (water and electricity do not like each other) nevertheless module resist well. International Standards like IEC 61215 and IEC 61646 tests under harsh conditions the resistance of photovoltaic modules. When buying a photovoltaic module it is recommended to refer to International Standards of the International Electrotechnical Commission (www.iec.ch).

Does photovoltaic technology need bright sunshine to work properly?

The electrical output of a photovoltaic module is dependent upon the intensity of the light to which it is exposed. So photovoltaic modules will tend to generate more electricity on bright days than when skies are overcast. However, photovoltaics do not need to be in direct sunlight to work, so even on overcast days a PV module will be generating some electricity.

Are PV systems suitable for use in northern countries?

Photovoltaic systems have been used in Canada, Germany, Finland over the last 20 years or more for many applications, particularly in remote areas where grid connection is impractical, such as weather monitoring stations, marine navigation aids, week-end cottages, etc.

Over the last few years photovoltaic technology has also started to be introduced into urban areas, incorporated into the roofs and facades of homes, offices and factories.

A modest sized domestic grid connect PV system will provide a substantial portion of a households electricity needs for over 6 months of the year and installations on commercial buildings are particularly suitable, contributing towards the daytime demands of an office.

Over 300 MW of on-grid photovoltaic system are already installed in OECD countries (1999).

What applications are there for photovoltaic power systems?

Photovoltaic technology has many applications, both for off-grid systems and on-grid in the case of integration onto buildings situated in urban environment. Photovoltaic systems have been used for many years in applications such as powering remote dwellings, telecommunication repeater stations, monitoring stations, to name just a few examples.

Photovoltaic technology is also widely used in the developing world. The technology is particularly suited where electricity grids are unreliable or non-existent, with remote locations often making photovoltaic power supply the most economic option. In addition, many developing countries have a high level of solar irradiation year round.

In more recent years, photovoltaics has become more widely used in urban areas, where it can be integrated into new buildings or mounted onto existing buildings. This is a rapidly growing application. Photovoltaic technology is ideally suited to the urban environment, providing pollution and noise free electricity without using extra space.

How long will photovoltaic systems last?

The average lifetimes of a PV module can be in excess of 25 years, crystalline silicon modules in particular have a very long life span. In addition, they require very little maintenance. Other system elements will have a varied lifespan; for example storage batteries in stand-alone systems can last between 2 years and 12 years depending on type, price and maintenance schemes. Lead-acid accumulators are mostly used.

What is the difference in energy, coming from the sun, between places near the equator and further north or south?

In Sahara a typical annual value is 2 500 kWh/m^2 and in for example Sweden a typical annual value is around 1 000 kWh/m^2. So, even quite far from the equator photovoltaic modules can generate electricity.

What is the theoretical maximal efficiency for photovoltaic cells?

The practical limit of the conversion efficiency for photovoltaic cells is around 30 % (single junction. At laboratory level in 2000 the record efficiency is 25 %). This is due to material properties of the photovoltaic cell, which limits the absorption of the sunlight. The energy from the sun (photons) has a spectral distribution and only a limited range of this distribution can be absorbed effectively (around 400 nm - 800 nm, visible light). Some of this absorbed energy will also be lost as heat. Under concentrated light conversion efficiency more than 40 % is achievable.

What are peak power and peak-watt (Wp)?

Peak power and peak-watt (Wp) are the terms used by photovoltaic professionals. These terms refer to measurement of the maximum power output of a cell or a module under standard test conditions (STC): incident irradiance = 1 000 $W \cdot m^{-2}$ (bright sunshine) with the reference solar spectral irradiance, air mass = 1,5 and a cell or module temperature of 25 °C. The SI unit is watt (W). The power of an installed photovoltaic system refers always to STC maximum power.

3.2 Economical aspects

How much does it cost of installing a photovoltaic power system?

Typically the cost of installing a PV system having a power of one kilowatt (1 kW) is around 5 000 USD (1999). Although there would be variation from case to case, about two thirds of this investment would be for the PV modules, and the inverter and installation would account for roughly 10 % each. The remaining costs are due to support structures, electrical cabling and equipment, etc. It should be noted that at today's prices for electricity generated by a PV system compared to electricity from the grid produced by traditional fossil fuels, installing a on-grid PV system (even with a significant subsidy) will not provide a commercial return, and this is not likely to change in the near-term.

Why using and install a photovoltaic power system?

Using the sun's energy to produce electricity avoids the environmental problems associated with fossil fuel power stations such as greenhouse gas emissions, local air pollution and acid gases. Also, in contrast to other environmentally friendly renewable energy options such as wind power and hydropower, photovoltaic power electricity is readily applicable right where people live and work. Contrary to earlier opinions, recent studies have shown that the time taken for photovoltaic modules to produce the amount of energy consumed during their manufacture is considerably less than their operating lifetime.

There are many reasons to install a photovoltaic system:

– It is the most practical and economically viable option for many applications in remote areas away from the electricity network;

– It is completely pollution free. Installing a small domestic system of around 1,5 kW would provide around 1 500 kWh of electricity every year, this would avoid around half a tonne of CO_2 annually;

– PV can be integrated into the fabric of a building;

– Electricity can be supplied at the point of use;

– The system will run silently;

– There is very little maintenance required for a PV system. After the initial installation costs, there are no further fuel costs;

– PV systems are modular, and can be added to at any time.

How much would it cost to have a photovoltaic power system on one's roof? Is it viable?

The demonstration programmes for the promotion of photovoltaics in Japan, the USA, or the European Union have fixed a price of installed system 5 000 EUR per kilowatt. Some electricity companies do it for 5 000 USD per kW in the USA. The economic viability of such an investment will depend upon the price the electricity company will buy the PV current produced by the photovoltaic system.

What is the price PV current is paid-back by electricity utilities?

Countries and companies have different policies. In Germany it is fixed by law at 0,99 DEM per kWh, in Japan XX JPY per kWh, in the Netherlands XX NLG per kWh, in France 0,096 EUR per kWh (equivalent to net metering), etc. The economic viability of the PV system depends upon the initial investment and the utility's payback rate.

Is the electricity cost produced by photovoltaic system competitive with conventional sources?

Today photovoltaic electricity is not competitive with conventional sources of energy. Nevertheless, in places where the electricity grid is not available, stand-alone PV systems are cost competitive. These PV systems provide a new energy service other sources cannot meet.

The production cost in a centralized power production like the 3,3 MW photovoltaic plant in Italy is around 0,41 EUR per kWh. Increasing the size of the plant, and using less costly materials in future will make better proposition but it will take time for being competitive with fossil fuels.

3.3 Environmental aspects

Are photovoltaic cells and modules made out of toxic materials?

Most of the photovoltaic cells used are made out of silicon, which is non toxic. Concerning photovoltaic modules they are made of glass, plastic and aluminium frame.

Are photovoltaic cells environmental friendly?

During their electricity generation (> 25 years) there is no impact on the environment. Nothing is consumed and no pollution is made. During production and especially material purification they do have some influence on the environment. For silicon photovoltaic cells the silicon has to be very pure and this purification process is energy demanding. Some photovoltaic cells not made out of silicon, contain some environmental unfriendly materials such as cadmium (Cd) and have to be recycled with precaution. But this question can be handled without difficulty by industry as it is in the electronic industry making semiconductor chips.

3.4 Social aspects

Are developing countries able to appropriate photovoltaic technology?

Non OECD countries know already photovoltaic systems. Some like India, China, South Africa, manufacture photovoltaic modules and electrochemical storage batteries at least for the automobile sector (nevertheless, note that these batteries, though cheap, are not well suited to the photovoltaic type of charging-discharging constraints). Other countries like Morocco, Brazil, etc. have programmes to promote the use the technology in off-grid applications. Bringing basic electricity services to rural areas, pumping drinking water are popular applications along with powering telecommunication repeater stations, etc.

3.5 Others aspects

What countries do for promoting the use of photovoltaic electricity? Why?

A report published by the International energy agency (IEA) describes the situation in selected OECD countries. The annual International survey report *Trends in photovoltaic applications in selected IEA countries (IEA-PVPS, Task 1)* prepared by the cooperative programme on photovoltaics, provides statistical data about industry trends starting in 1992, describes national policies and current achievements in the field. Also the IEA–PVPS programme annual report describing the annual achievements, is well documented with photographs, and tells the involvement of countries in the promotion of photovoltaics. Copies are available from IEA Internet site www.iea-pvps.org.

Annex A

A.1 List of participating Task 1 countries

AUS, CHE, FRA, GBR, KOR

A.2 Exchange rates (average 2000)

1,00 EUR=1,020 USD

Annex B Country individual contributions

This annex is here for drafting purpose. It is a gathering of countries' contributions and will be removed when printing the final document.

1 *AUSTRALIA*

Technical aspects

AU1 What is a grid-connected PV system, and what are its main features?

AU1 A grid-connected PV system consists mainly of the modules that convert sunlight into direct current electricity and an inverter that converts the direct current to alternating current to make the electricity compatible with the local electricity grid. Various mounting systems can be used to support the modules on the roof, on the ground or on a building façade. Increasingly architects and builders are integrating the PV system into the building design. Batteries are not required for grid-connected applications.

The modules required to produce one kilowatt (kW) of electricity under ideal conditions would cover an area of about ten square metres and, depending on the mountings used, the system could weigh about 150 kg. Silicon, glass and metal would typically be the main construction materials involved. Over a period of time such a system would produce roughly one fifth of the energy requirements of a typical electric house. Systems can be large or small to suit different applications (for example a house or commercial / industrial building), and can also be sized according to the proportion of electricity that is to be provided by PV.

AU2 Is the technology reliable, and how long does it last?

AU2 Although PV is a relatively young technology in terms of market application, the experience accumulated in Australia and elsewhere confirms PV as a proven technology able to generate electricity for 20 years or more without intervention. This, and extensive testing, allows the module manufacturers to offer extensive guarantees of performance. Australian PV modules are tested to local and international standards. An accreditation scheme for suppliers is operated by the Solar Energy Industries Association of Australia.

AU3 What factors should I consider before installing a PV system?

AU3 The decision to install a grid-connected PV system should take into account the following:

The modules (whether mounted on the roof or elsewhere) should have access to considerable direct sunlight all year. This means mainly unimpeded exposure to a semi-circle of most of the sky when looking north, with a low likelihood of significant trees or buildings close by in this direction in the future.

Grid-connected PV can play an important role in the move towards a sustainable energy future but must be considered in conjunction with other practical and more cost-effective solutions available to the householder or building owner, such as solar hot water and energy efficient appliances.

AU4 What must I do to operate the system effectively?

AU4 Once installed, the grid-connected PV system requires very little attention from the householder or building owner. The grid-connected PV system contains no moving parts and costs nothing to run, using no fuel or consumables. It operates silently and safely, produces no wastes and requires only minimal maintenance (such as cleaning dust from the module surface).

PV modules represent a valuable investment and security can be a concern for remote applications. However, integration of the system into the built environment where people are living and working reduces these concerns considerably.

AU5 Who should I talk to regarding installing a PV system?

AU5 The following organisations should be contacted early in the process of deciding to install a grid-connected PV system:

The local electricity supply company will arrange connection to the grid, including any requirement for additional metering to measure the electricity produced by the PV system. The company will also negotiate the financial arrangements relating to the electricity produced and consumed at the premises. Typically the Customer Services (or similar) division should be contacted.

The local shire council will want to ensure that any installation does not have an adverse visual impact on neighbours. The potential for this to be an issue will vary with the characteristics of the PV system (for example whether free standing or integrated into the building design), and, similarly, various councils will have different requirements regarding the need for a Development Application.

The insurance company providing building cover will need to be advised of the increased value of the premises due to the PV system, and may wish to discuss existing or new legal liability cover.

SEDA's Energy Smart Allies Directory contains a list of suppliers and manufacturers in the energy efficiency and renewable energy industries.

The Solar Energy Industries Association of Australia can be contacted for a listing of accredited suppliers of PV systems.

Economical aspects

AU6 How much does it cost?

AU6 Typically the cost of installing one kW of PV is around 10 000 AUD. Although there would be variation from case to case, about two thirds of this investment would be for the PV modules, and the inverter and installation would account for roughly 10% each. The remaining costs are due to support structures, electrical cabling and equipment etc. It should be noted that at today's prices for electricity generated by a PV system compared to electricity from the grid, installing a grid-connected PV system (even with a significant subsidy) will not provide a commercial return, and this is not likely to change in the near-term.

AU7 Why grid-connected PV?

AU7 Using the sun's energy to produce electricity avoids the environmental problems associated with fossil fuel power stations such as greenhouse gas emissions, local air pollution and acid gases. Also, in contrast to other environmentally friendly renewable energy options such as wind and hydro power, grid-connected PV is readily applicable right where people live and work. Contrary to earlier opinions, recent studies have shown that the time taken for PV systems to produce the amount of energy consumed during their manufacture is considerably less than their operating lifetime.

These important contributions to a sustainable energy future have been recognised worldwide with the announcement of programs such as ......(update).

Currently Australia's per capita production and usage rates of PV are amongst the highest in the world, mainly for applications not connected to the electricity grid. Australia has well established and internationally respected research activities and a number of successful local manufacturers. To maintain or improve Australia's competitive position with regard to PV it will be necessary to keep pace with the growing international interest in grid-connected applications.

2 SWITZERLAND

Technical aspects

CH1 Can I heat my house with photovoltaic solar cells

CH1 If you invest a lot of money, yes. But it would be wiser to install a heat pump system and install a much small PV system to produce the needed electricity to drive the heat pump. Since in Switzerland we do not have plenty of sun during winter time, the PV system should be grid connected. It will produce the needed energy more during summer, using the grid as a seasonal storage system.

CH2 Will my grid connected PV system still work without grid (Power cut) ?

CH2 No, in case of a power cut, the inverter will shut off to protect people repairing the grid. But it is possible to have a system with a self regulating inverter and battery back up to operate independent from the grid. These systems are normally more expensive than simple grid connected systems.

CH3 Will photovoltaic solar cells produce energy although there is no sun (cloudy sky or fog)?

CH3 Yes, they work also under these conditions but will produce much less energy than with direct sun light although the conversion efficiency might be higher due to lower temperature. But the rule is: There comes nothing from nothing (No sun no power).

Environmental aspects

CH1 Are photovoltaic solar cells made out of toxic materials?

CH1 Most of the cells used are made out of silicon, which is non toxic. For extraterrestrial applications, also GaAs-cells are used, but since they are very expensive, they will not be used for standard applications. Also the new CdTe-cells have been tested carefully, and the also withstand fire and other impacts.

3 FRANCE

Technical aspects

FR1 Could I power my house and become independent from electricity utility grid?

FR1 Installing a PV system on top of your roof or in place of your roof is possible and there around 20 000 house in OECD countries equipped that way. Nevertheless you still need grid connection to power your house when the weather is bad. So do not disconnect. Over the whole year your PV system might produce the amount of electricity you will consume (excluding electric heating). In the case of net metering your electricity bill will be zero and even you might earn money if the electricity buy-back rate proposed by your utility company is more attractive.

FR2 Do PV modules (panels, array) need to be cleaned and how often?

FR2 Usually no. Rain do the job. In dry areas and low latitudes sweeping dust might be necessary. Means depend upon situation and application.

FR3 The PV captors (cells, modules, panels, systems, etc.) never pay back the amount of energy they consume in the process of their construction, do they?

FR3 False. Studies show that PV modules made out of crystalline silicon pay back their energy content in 3 to 5 years, while new type of module made out of thin films pay back in 2 to 3 years. Technological progresses will considerably shorten this energy pay-back time.

FR4 What is the lifetime of modules?

FR4 There is no consumption of matter in the process of converting solar light into electricity through the semiconductors the modules are made of. So the time-life is theoretically infinite. The only limitation is the way the modules are able to withstand the aggressive environment they are put in. In general the manufacturers guarantee their modules to 25 years. There are many PV modules installed by the beginning of the terrestrial era of photovoltaics 30 years ago and still working well. Humid and salty climates are very restricting (water and electricity do not like each other) nevertheless module resist well. An International Standard like IEC 61215 tests under harsh conditions the resistance of PV modules. When buying a module refer to International Standards.

FR5 What is the land area covered by a central PV power station.

FR5 Pilot PV power plant such as that of Erga (ENEL Group) in Italy occupies 1,2 ha (12 000 m²) per megawatt of power installed.

A project within the IEA–PVPS co-operative programme is carefully studying all the implications (economical, technical, sociological, etc.) of equipping desert areas with PV systems. A preliminary investigation shows that 4 % of desert areas in the planet Earth would produce enough electricity to feed the World today.

FR6 How much energy does a power plant produce per year?

FR6 Being a centralised power plant or a « PV roof », the electricity production will depend upon the geographic situation. In Italy the 3,3 MW pilot plant produces 1 300 kWh per kilowatt installed (this plant produces 5 000 MWh per year, the equivalent consumption of 2 000 families. With systems using concentrated light (Canary Island) it reaches 1 400 kWh per kilowatt of power installed. Practical limit is 1 600 kWh per kilowatt of power installed. The power ratio is 75 % to 80 %.

In Japan a power system of 1 kW will produce 1 200 kWh of electricity per year. In Germany 600 kWh to 900 kWh of electricity per kilowatt installed.

Economical aspects

FR7 How much would it cost me to have a photovoltaic system on my roof. Is it viable?

FR7 The demonstration programmes for the promotion of photovoltaics in Japan, the USA, or the European Union have fixed a price of installed system of 5 000 EUR per kilowatt of power. Some electricity companies do it for XX USD per kW in the USA. The economic viability of such an investment will depend upon the price the electricity company will buy your PV current produced by your PV system.

FR8 What is the price PV current is paid-back by electricity utilities?

FR8 Countries and companies have different policies. In Germany it is fixed by law at 0,99 DEM/kWh, in Japan XX JPY/kWh, in the Netherlands XX NLG/kWh, in France 0,64 FRF/kWh, etc. The economic viability of the PV system depends upon the initial investment and the utility's pay-back rate.

FR9 Is the electricity cost produced by PV system competitive with conventional sources?

FR9 Today PV electricity is not competitive with conventional sources of energy. Nevertheless, in places where the electricity grid is not available, stand-alone PV systems are cost competitive. These PV systems provide a new energy service other sources cannot meet.

The production cost in a centralised power production like Serre Plant (3,3 MW) in Italy is around 0,41 EUR/kWh. Increasing he size of the plant, and using less costly materials in future will make better proposition but it will take time for being competitive with fossil fuels while they last !).

Other aspects

FR10 What do other countries do for promoting the use of photovoltaic electricity ? Why?

FR10 An interesting report published by the International energy agency describes the situation in selected OECD countries. The International survey report prepared by the co-operative programme on photovoltaics, provides statistical data about industry trends starting in 1992, describes national policies and current achievements in the field. Also the annual report describing the annual achievements of this programme, is well documented with photographs, and tells the involvement of countries in the promotion of photovoltaics. Copies are available from IEA internet site www.iea-pvps.org.

4 *GREAT BRITAIN*

Technical aspects

GB1 What is PV?

GB1 The photovoltaic (PV) process converts sunlight - the most abundant energy source on the planet - directly into electricity. The equipment required for this process has no moving parts and as a result requires minimal maintenance. In addition, the electricity is generated with no emissions and no noise.

A photovoltaic cell consists of two or more thin layers of semiconducting material, most commonly silicon. When the cell is exposed to light, electrical charges are generated and this can be conducted away by metal contacts as direct current (DC).

The electrical output from a single cell is small, therefore multiple cells are connected together to provide a more useful output. Cells connected in this way are encapsulated (usually behind glass) to form a weatherproof module
Multiple modules can likewise be connected together (then called panel) in order to provide sufficient power for common electrical appliances.

GB2 Doesn't photovoltaic technology need bright sunshine to work properly?

GB2 The electrical output of a PV cell is dependent upon the intensity of the light to which it is exposed. So PV cells will tend to generate more electricity on bright days than when skies are overcast. However, photovoltaics do not need to be in direct sunlight to work, so even on overcast days a PV cell will be generating some electricity.

GB3 Is PV suitable for use in the UK?

GB3 PV has been used in the UK over the last 20 years or more for many applications, particularly in remote areas where grid connection is impractical, such as weather monitoring stations, marine navigation aids, etc.
Over the last few years PV technology has also started to be introduced into urban areas, incorporated into the roofs and facades of homes, offices and factories.
A modest sized domestic grid connect system will provide a substantial portion of a households electricity needs for over 6 months of the year and installations on commercial buildings are particularly suitable, contributing towards the daytime demands of an office.
Over 1,5 MW of building integrated PV is already installed in the UK.

GB4 What applications are there for photovoltaic power systems?

GB4 PV technology has many applications in the UK, both for stand-alone systems and for integration onto buildings. PV has been used for many years in the UK in applications such as monitoring stations, radio repeater stations, telephone kiosks and street lighting to name just a few examples. There is also a substantial market for PV technology in the leisure industry, with battery chargers for boats and caravans, as well as for powering garden equipment such as solar fountains.
In more recent years in the UK, PV has become more widely used in urban areas, where it can be integrated into new buildings or mounted onto existing buildings. This is a rapidly growing market in the UK and throughout Europe. PV technology is ideally suited to the urban environment, providing pollution and noise free electricity without using extra space.
PV technology is also widely used in the developing world. The technology is particularly suited here, where electricity grids are unreliable or non-existent, with remote locations often making PV power supply the most economic option. In addition, many developing countries have a high level of solar radiation levels year round.

GB5 How long will a system last?

GB5 The average lifetime of a PV module can be in excess of 20 years, crystalline silicon modules in particular have a very long life span. In addition, they require very little maintenance. Other system components will have a varied lifespan, for example batteries in stand-alone systems can last between 2 and 15 years depending on type.

GB6 How much will I need to power my home?

GB6 A typical domestic system of 1,5 kW in the UK would produce around a third of the annual demand of an average family household (taking the average demand to be around 10 kWh per day). However, calculating the system size depends on many factors, for example whether the system is grid connected, energy demand of the household etc.

These factors will all be taken into account by a system installer when designing a system to power your home.

GB7 I'm interested in installing a system, who should I contact?

GB7 Domestic installations of PV systems are usually carried out by system installers. There are many PV-UK members located all over the country who can carry out these installations. Contact the British Photovoltaic Association (tel. 0118 932 4418) or visit the PV-UK website **Erreur! Signet non défini.** for further details.

GB8 How can I connect my system to the grid?

GB8 Connecting a photovoltaic power system to the distribution network will require permission from the Distribution Network Operator (DNO). The DNOs in the UK have different policies when it comes to connecting PV systems to their networks, and so different rates will be paid for exported electricity. The system installer will make the necessary arrangements for grid connection. (Application forms for DNO permission to connect a PV system to the electricity grid can be downloaded from the British Photovoltaic Association's website: www.pv-uk.org.uk.)

Economical aspects

GB9 Is PV expensive?

GB9 Over the last 20 years the price of PV modules have fallen dramatically, from around 15 GBP per Wp in 1980 to current prices of around 3 GBP per Wp. That means that a single module, typically generating 50 W of power under standard test conditions, now costs around 150-200 GBP.

The cost of a complete PV system - including power conditioning equipment and installation - can vary very widely depending on the application and system type, and so generalisations on system costs are difficult to make. To give a rough estimation, you could expect to pay between 8 000 GBP and 15 000 GBP on a typical domestic installation of 1,5 kW.

A more recent application of PV in the UK is its use as a building façade material. This use of PV on commercial buildings looks very favourable economically when compared to other building façade materials. For example, PV curtain walling (amorphous) can cost as little as 280 GBP/m^2, whereas stone cladding might cost around 300 GBP/m^2.

Others

GB10 Why install a photovoltaic power system?

GB10 There are many reasons to install a PV system:

It is the most practical and economically viable option for many applications in remote areas.

It is completely pollution free. Installing a small domestic system of around 1,5 kW would provide around 1 000 kWh of electricity every year, this would avoid around half a tonne of CO_2 annually.

PV can be integrated into the fabric of a building.

Electricity can be supplied at the point of use.

The system will run silently.

There is very little maintenance required for a PV system.

After the initial installation costs, there are no further fuel costs.

PV systems are modular, and can be added to at any time.

5 SWEDEN

SE1 What are photovoltaic solar cells?

SE1 Photovoltaic solar cells are semiconductor devices that convert light directly into electricity. Photovoltaic cells have no moving parts and do not consume any material. Note the difference from thermal solar cells which heats water, a totally different technique.

SE2 How does a photovoltaic solar cell work?

SE2 The energy radiation from the sun (photons) is absorbed and their energy is thereby transformed to electrons in the photovoltaic cell. These electrons are then put in movement by a built-in electric field. The sun light has been converted to electric energy.

SE3 Do photovoltaic solar cells work in cold climates?

SE3 In fact, photovoltaic solar cells works generally better at lower temperatures. However, in cold climates there might be side effects as, lower intensity of light, snow etc. which decreases the output power from the photovoltaic solar cells.

SE4 What is the difference in energy, coming from the sun, between places near the equator and further north (or south)?

SE4 In Sahara a typical annual value is 2 500 kWh/m^2 and in for example Sweden a typical annual value is around 1 000 kWh/m^2. So, even quite far from the equator photovoltaic solar cells can generate considerable amounts of electricity.

SE5 Do photovoltaic solar cells work in cloudy weather?

SE5 Yes, but their output is reduced. Since a flat photovoltaic panel has a 180 degree window, the sun shine does not have to be direct. A day with a bright overcast they can still generate 50-70 % of their maximal output. When the sky is really dark they may not give more than 5-10 %.

SE6 What kind of photovoltaic solar cells exist?

SE6 There are a number of different types of photovoltaic solar cells, they are usually divided depending on their absorbing layer. The by far most common photovoltaic solar cell used today is made of silicon. Further more silicon can be divided by their ordering of atoms from the single crystal, which has the highest efficiency but is expensive, to the amorphous silicon photovoltaic cells which have lower performance but are relatively cheap. The amorphous silicon cells belong to a group of photovoltaic cells which are called *thin film photovoltaic cells.* These photovoltaic cells have extremely thin active layers, in the order of 0,001mm. Two other promising thin film photovoltaic cells which have increased their market share lately are the CIGS solar cells (made out of Cu, In, Ga and Se) and the CdTe photovoltaic solar cells.

SE7 How is the efficiency for a photovoltaic solar cell measured?

SE7 The efficiency is the quote between the photovoltaic cell output effect and the incoming effect at standard conditions. The standard conditions corresponds to a clear day when the sun is 48 degrees over the horizon and the solar panel directed towards the sun and a temperature of 25°C. The effect coming from the sun during these conditions is 1 kW/m^2. The measurement is normally made indoor with lamps and filters.

SE8 What is the theoretical maximal efficiency for photovoltaic solar cells?

SE8 The theoretical limit of the efficiency for photovoltaic solar cells is around 30 %. This is due to material properties of the photovolataic cell, which limits the absorption of the sunlight. The energy from the sun (photons) has a spectral distribution and only a limited range of this distribution can be absorbed effectively (around 400 nm - 800 nm, visible light). Some of this absorbed energy will also be lost as heat.

SE9 What are the drawbacks with photovoltaic solar cells?

SE9 Photovoltaic solar cell power is expensive compared to conventional generated power. An other drawback is that in northern climates there is often a miss match between generation and need (during the dark cold winter the need of electricity is high but the generation low), this leads to a storage problem.

SE10 Why not use wind power instead of solar photovoltaic power?

SE10 Wind power and solar photovoltaic power are not competitors they should be used as complements. Photovoltaic power can be integrated into a building (e.g. roofs and facades) using no extra space.

SE11 What are the advantages with thin film photovoltaic solar cells?

SE11 First of all their active layers are thin, in the order of 0,001mm. This leads to low material consumption and relatively short production time, which means lower price. The most used silicon photovoltaic modules today, have to be build up from connecting separate cells. Thin film photovoltaic solar modules can be made as modules directly.

Environmental aspects

SE12 Are photovoltaic solar cells environmental friendly?

SE12 Yes and No, during their electricity generation (> 20 years) there is no impact on the environment. Nothing is consumed and no pollution is made. During production and especially material purification they do have some influence on the environment. For silicon photovoltaic solar cells the silicon has to be very pure and this purification process is very energy demanding. Some photovoltaic solar cells contain very environmental unfriendly materials such as cadmium (Cd) and have to be recycled with precaution.

DRAFT

ACTION	RESPONSIBLE PARTY	TIMING
1. Compile Task 1 contacts list for Task 1 website	Greg Watt	November 2000
2. Add National Communication Strategies to Task 1 website	Greg Watt / Pius Hüsser	November 2000
3. Circulate survey pro-forma developed by Paul Cowley - please use!	Greg Watt	November 2000
4. Circulate first draft of "Added Value" report	Greg Watt	10 November 2000
5. Provide Paul Cowley with news stories for *PVPower*	All Task 1	Before 26 November for #14 ,and ongoing
6. Amend and circulate NSR guidelines	Greg Watt	November 2000
7. Comment on first draft of "Added Value" report	All Task 1	Before end November 2000
8. Approve final draft of "Added Value" report & discuss with ExCo member	All Task 1	Before Christmas 2000
9. Prepare draft activity plan for "Costing of PV energy"	Olle Lundberg & Greg Watt	December 2000
10. Prepare draft Document Production Plan for "Costing of PV energy"	Greg Watt	Before next meeting
11. Commence work on "Costing of PV energy"	Sweden, Denmark, Germany, Japan & Norway	January 2001
12. Develop ideas and offer to lead future special information activities that could be discussed in detail at the next Task 1 meeting	All Task 1	January 2001
13. Develop ideas for PVPS workshops that could be developed for EPVSEC in October 2001	All Task 1	Before next meeting
14. Advise ExCo and webmaster of Task 1 suggested improvements for the website	Greg Watt	Ongoing
15. Amend and circulate ISR6 'format and content'	Greg Watt	Before next meeting
16. Write 'policy' for *PVPower*	Greg Watt	Before next meeting
17. Finalize "Answers to frequently asked questions", and provide to webmaster	André Claverie	Before next meeting

'Where to' for Task 1 Special Information Activities after "Added Value"
(discussion under agenda item 14)

The aim of this note is NOT to define what our new activities should be – this must come from the group discussions of Task 1 participants. However I would like this note to provide a framework for our discussions.

Several ideas for new activities have been proposed/suggested etc:

1. Something relating to market implementation of PV systems
2. Costing of energy from PV systems
3. Value of PV business

I suggest that we could apply the following **principles** when discussing new activities:

Firstly, we must think about what can (and should) PVPS do that is unique (eg compared to governments, consultants, academics etc) & also **what can /should Task 1 do** compared with the other PVPS tasks? (for example, I would suggest that we are well placed to promote international workshops, carry out broad surveys and develop targeted information packages rather than carrying out very specific and detailed investigations).

Secondly, we should be aware that **what our target audience(s) want/need** may not be the same as some of the issues that we (Task 1/PVPS in general/IEA) think are important (maybe a larger component of our Special Information Activities should involve actually communicating with the target audience!).

Thirdly, we should try to **build on our past successes** rather than jumping to something very different as we tend to have done in the past (this will help to maintain the links to our target audiences and provide some continuity to our work).

Finally (and very importantly), for a new activity to 'get off the ground' we must have a **lead country** or countries (that can then be supported by a 'working group' etc).

As an example, in the following table I have applied the above principles to the three ideas for new activities. I would encourage you to think further about this, fill in the gaps, add information and be prepared to contribute to the discussion during our meeting! I hope that this will provide a framework for our discussions under agenda item 14.

Greg Watt

	Market implementation (MI)	Costing of energy	Value of business (VoB)
What can/should Task 1 do	❑ It would appear that most individual countries have already done extensive research on barriers, policies etc.[1] ❑ PVPS Task 7 will produce a number of relevant reports[2] ❑ Amenable to workshops, surveys & targeted info packages	❑ What are the important issues to resolve? Eg Is there consistency in the methods employed in the various countries? ❑ Is there scope for an IEA Recommended Procedure (as with wind energy)?	❑ Amenable to workshops attracting a broad range of participants.
What our target audience(s) want/need	❑ Do we know who are the key MI players, what drives them & what they need to know? ❑ Is a real issue that the key MI players do not know what information is already available?	❑ Do we know who would use this information, and what level of detail is required?	❑ VoB and labour places appear to be a common point of interest in most countries
Build on our past successes	❑ "Added Value" has provided the 'why' of grid-connected PV ❑ A logical next step would be to look at 'how' grid-connected PV is implemented (and, for example, what makes for a successful project/ programme)		❑ Not addressed in "Added Value", but certainly related ❑ Follows on from discussions about content of NSRs/ISR, and our inability to resolve these issues.
Lead country	❑ Netherlands has expressed a degree of interest	❑ Germany and Denmark have expressed some interest	

[1] For example see the recent comprehensive US DOE report, May 2000 - Making Connections: Case Studies of Interconnection Barriers and their Impact on Distributed Power Projects http://www.eren.doe.gov/distributedpower/barriersreport/

[2] Survey of Market Barriers; Potential of BIPV; The Economics of BIPV; Strategies for Barrier Removal; and an executive summary report covering the four documents

第５章　付加価値ワークショップ

IEA International Energy Agency Photovoltaic Power Systems Programme

TASK 1 – EXCHANGE & DISSEMINATION OF INFORMATION ON PHOTOVOLTAIC POWER SYSTEMS

IEA-PVPS

Workshop on the added value of PV Systems

May 5th, 9:30 - 15:30, Glasgow

The aim of this workshop is to identify and discuss the different added values of grid-connected PV for various target groups. Acquiring insights into these issues will help the development of strategies which can be used to influence policy and decision makers.

The workshop is aimed at renewable energy experts involved in market development of PV. Participants are invited to attend and to contribute actively towards the workshop.

The workshop will be hosted by The International energy Agency Photovoltaic Power Systems Task 1 members, EA Technology (UK) and NEDO/PVTEC (Japan).

The programme will include international speakers covering a range of PV added value Topic areas including:

- Environmental.
- Social/ Fiscal/Economic.
- Energy saving.
- Architectural integration.
- Other.

To register for this event please visit:-

www.novaenergie.ch/glasgow

and fill out your name, company and address <u>or</u> return the attached registration slip to:

John Stones
EA Technology Ltd
Capenhurst
Chester
CH1 6ES.

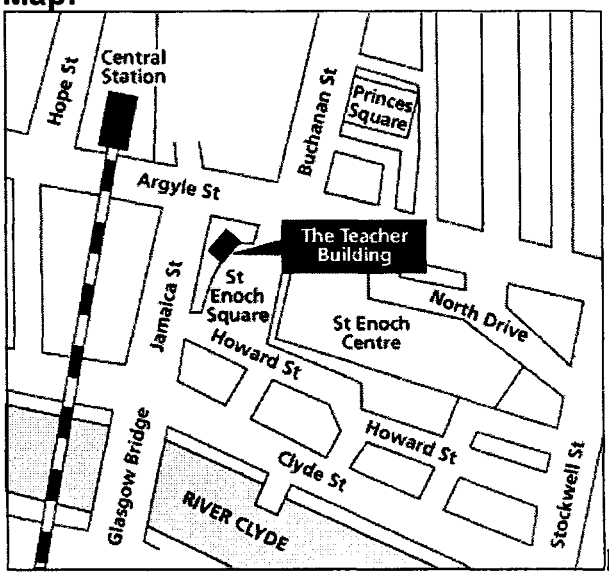
And then Just come along on the day. Participation in the workshop is **free of charge**.

The workshop will be held at:

IEE Scottish Engineering Centre
The Teacher Building
14 St. Enoch Square
Glasgow.

The Teacher building is located in:
St Enoch Square in the centre of Glasgow.

Map:



Re

Registration details. Please fill in and place in Workshop tray/ envelope provided.

Name
Company & Position
Address
Telephone
Fax
Email address

TASK 1 – EXCHANGE & DISSEMINATION OF INFORMATION ON PHOTOVOLTAIC POWER SYSTEMS

Workshop on the added value of PV Systems

DATE 5th May, 2000

VENUE IEE Scottish Engineering Centre
The Teacher Building
14 St. Enoch Square
Glasgow.

Programme

09:00	Opening Speech **Greg Watt** (Task I Operating Agent.) (Aus).
09:05	Welcome Speech **John Stones** (EA Technology Ltd.) (UK).
09:10	Keynote Speech **K. Kurokawa** (Japan).
09:35	Swiss Solar Stock Exchange **Stefan Nowak** (NET Ltd.) (CH).
10:00	The Solar Office **David Lloyd** (Studio E architects) (UK).
10:25	**Coffee Break**
10:50	Bebbington Zero Energy Development **Chris Twinn** (Ove Arup) (UK).
11:15	Creating a global market **Karl Mallon** (Greenpeace (Int'l)) for PV.
11:40	Discussion session
12:05	**Lunch Buffet**
12:35	Energy Payback Time **K.Kato** (Japan).
13:00	PV: Not the Payback Period **Paul Ruyssevelt** (ESD) (UK).
13:25	Non-interruptible PV supplies **Robert Kroeni** (Enecolo AG) (CH).
13:50	New Incentives in Israeli Solar Projects **Yona Siderer**, Consultant (ISR)
14:15	Free Discussion with expert panel.
14:45	Summary and Closing Speech **Greg Watt.**

Programme may be subject to change

平成１２年５月３１日

海　外　出　張　報　告　書

(第2回IEA/PVPSタスクⅠ付加価値ワークショップ)

１．出張者

ＮＥＤＯ太陽技術開発室	総括主研	神門　正雄
	主査	脇　　栄一

２．同行者

東京農工大学	教授	黒川　浩助
電子技術総合研究所	主任研究官	加藤　和彦
電子技術総合研究所	研究官	大谷　謙二
富士総合研究所	主事研究員	河本　桂一
太陽光発電技術研究組合	課長	山本　修二

３．出張目的

IEA/PVPSタスクⅠ付加価値ワークショップに参加し、PVシステムの付加価値に関する各国の意見調査および情報交換を行う。

また、当ワークショップの準備作業グループのリーダー国として運営する。

４．出張場所

イギリス（グラスゴー）

会議場所：The Teacher Building　IEE Scottish Engineering Centre 1F会議室

５．会議期間

平成１２年５月５日（金）９：00 ～ 15:30

６．参加国及び参加者

延べ約45名（一部詳細は添付の通り）

７．ワークショップ議事

１．開催の挨拶:Greg Watt

２．歓迎挨拶:John Stones

３．基調講演:Kousuke Kurokawa

４．スイスソーラー　ストック交換:Stefan Nowak
５．ソーラー　オフィス:David Llord
６．Bebbington Zero Energy開発:Chris Twinn
７．Creating a Global Market:Karl Mallon
８．ＥＰＴ:Kazuhiko kato
９．PV,Not the Payback Period:Paul Ruyssevelt
１０．Non-Interruptible PV Supplies:Robert Kroeni
１１．New Incentives in Israeli Solar Projects:Yona Siderer
１２．総括まとめ:Greg Watt

８．議事概要

1. 歓迎挨拶

まず、タスクＩのOAであり今回ワークショップ議長のMr. Greg Watt（豪）より開会の宣言。

続いてホスト国イギリスを代表してMr. John Stones（EA Technology Ltd. タスクＩExpert）より歓迎の挨拶。

2. 出席者確認

出席者全員の自己紹介。今回参加者の立場や目的を確認。

3. Keynote Speech

黒川教授より、先回札幌での第1回ワークショップでの成果および分析結果を基に、現在（2000年）から2010年にいたるビジョンを発表した。

PVの付加価値については、従来の発電能力（KWh）からもっと幅広い観点でとらえる必要性があるとし、その柱として次の４点が提示された。

・Principal & Electrical（EPT、No Fuel、Rural Electrification、Emergency）
・Architectural（Low Energy Building、Heat Insulation、Sound Barriers、BIPV Cost Merit
・Environmental（CO2 Emission Reduction、No Sound、No Pollusion、Green & Comfort）
・Socio-Economic（Induced Employment & Production、Educational、Urban Development）

4. Mr. Stephan Nowak（NET Ltd. スイス）

Mr. S. Nowakより、スイスにおけるPV発電電力の証券市場について説明。これは、電力会社が仲介者となって、PV電力発電者とPV電力ユーザーとを結び付けるシステムである。

１）ポイントは次の通り。

・電力会社は発電者と長期契約を結ぶ（約10年）
・電力会社は顧客開拓のマーケティングを行い、1年契約を行う。

・電力の購入・販売価格はその都度変動する。

2）現状48システムが契約中であり、すでに1620KWpが設置された。顧客数は5700件（全体の2.8 %）で現在1.2GW分の申し込みがある。

3）市場拡大のために適切なマーケティングが必要である。

・環境、エコロジーへの取り組み、持続性、非核政策

・顧客への適切なマーケティング

・電力会社への適切なマーケティング

4）成果

・顧客数の増加　：10倍

・発電キャパシティ　：3.4MWp

・申し込みエネルギー量：3.5Gwh

6. Mr. David Lloyd（Studio E architects英国）

Studio E ArchitectsのMr. D. Lloydより「The Solar Office」の説明。

The Solar Officeは全体エネルギー戦略を適用した数少ない例のひとつであり、ヨーロッパで今までに採用された最も大きなファサードを有する最初のPV搭載型オフィスビルである。

設計思想は、エネルギーの保存（節約）で、その消費量が最少になるようにPVを外面に用い、将来的にはエネルギーの自給、環境保全を目指している。ビルのテナントが使用する電力は、通

常エアコン装備の場合の消費量400kWh/m²/年に対し、85kWh/m²/年を目標としている。

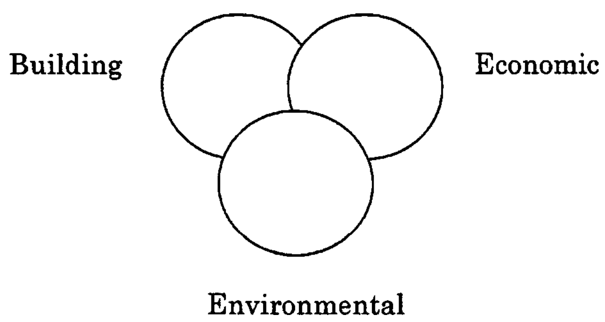
ビルの外面全体でPVが発電する電力73kWpのアレイから得られる年55,100kWhの電力は消費全体の1/3から1/4にもなる。また夏季の余剰発電量は国営の系統連系に送電される。

8. Mr. Chris Twinn（Ove Arup英国）

Mr. C. TwinnよりPVの社会性について説明。

PV社会が発展するためには下図のような3要素が必要。

Sustainability（持続可能性）



要点は次の通り

・PVは未来そのものである

・コスト低減が大事

・英国では大規模PVへの取り組みが主流。小規模の系統連系PVが弱い

・今後はPVによる社会的貢献が必要となる。

10. **Mr. Karl Mallon（Greenpeace Int'l for PV）**

Mr. K. Mallon（蘭 グリーンピース）よりPVの世界市場拡大の必要性について説明。

既存の化石燃料を使用した電力からPVへの転換を進める。BPなど石油会社はCO_2排出の削減を行うべきである。環境改善、社会への貢献を行うためクリーン度向上のメカニズムを創造する。

世界的なPV市場（特に一般住宅への普及）の拡大が大事。

12. **Mr. K. Kato（電総研 日本）**

電総研加藤氏よりEPTの説明。

PVシステムを製造する時に投入したエネルギーがPVのライフサイクル（20年と想定）で生み出

されるエネルギーにより何年で回収できるかというEPTを計算し、年間生産量が10MWの場合で

1.6～2.4年、100MWの場合は1.1～1.7年、またCO_2の排出量は年産10MWの場合14～20g-C/kWh、

2.30MWで11～18g-C/kWh、100MWの場合8～13g-C/kWhという結果を得た。

14. **Mr. Paul Ruyssenvelt（ESD英国）**

Mr. P. RuyssenveltよりPVシステムの投資回収（費用対効果）の説明。

PVシステムのコストと実際の用途との間には密接な関係があり、投資に見合う用途に使用する

ことが大事である。具体的な分析では、ビルのファサードのような場所にはPVの価値が最も大

きく発揮される。

10. **Mr. Robert Kroeni （Enecolo AGスイス）**

Mr. KroeniよりスイスでMr.最大級のビル搭載型PVシステムのモニタリング（1年間）について説明。

目的はビル（スイスユニオン銀行）にPVシステムを設置した場合にPVの発電状態や周辺装置、

測定装置などが正常に機能するかどうかの実験。具体的には2種類のインバーター（String型お

よびCentral型）の性能比較、UPS（Uninterruptible Power Supply）システムの働き、信頼性評価など。
銀行のように片時もコンピューターのダウンタイムが許されない電力系統にPVシステムがUPSを理想的にバックアップできるかどうかの実験結果は、概ね良好であるが、高度の信頼性を確保するためには最適システムの設計や高度なノウハウが必要である。

11. Ms. Yona Siderer（Consultantイスラエル）

Ben-Gurion大学のDr. Yona SidererよりイスラエルにおけるPVの普及政策および具体的なプロジェクトについて説明。
要点は下記の通り。

- ソーラープロジェクトの拠点はNitzana、Yeruham、Kibbutzの3個所
- Nitzanaにおけるプロジェクト：12年前から教育目的でスタート。太陽エネルギーの教育およびソーラーデモパークの建設（予算150万米ドル）
- Yeruhamにおけるプロジェクト：ソーラーシティ計画の実行。ソーラー技術の専門的教育実施
  および100軒のソーラーパネル付き住宅の建設。（予算800万米ドル）
  周辺機器の生産計画 － ソーラーランプ、街灯ポール、ホームソーラーシステム、小型輸送機器およびソーラーおもちゃ、農業用塩水ソーラー温室、ソーラークーラーおよび冷蔵庫、脱塩装置、3～10MWの小規模ソーラー発電所建設。
  （予算1000万米ドル）
- Kibbutz Samarにおけるプロジェクト：
  4.5kWのPVステーションは既設。今後200kWに増設予定。（予算100万米ドル）
  － バッテリーなし。系統連系接続
  － 年間出力410,000kWh
  － 年間CO2排出削減400～500トン
  － 耐用年数30年
  付加価値として電力供給と自然保護。
- 資金問題：
  － イスラエルは1面では先進国、他面では発展途上国。ソーラーでは両面がある。
  科学技術上は先進国だが移民などの生活向上面では発展途上国。ムーディーズによる国家の格付けは近々A to Aに。ローン金利低下や中長期の経済的改善などのメリットがある。
  － 米国とイスラエル外務省がイスラエルのOECD加盟を検討中。実現すれば発展に寄与する。
  － 最近の法制化により独占企業であるIEC（Israel Electrical Company）が20%までの民間電力を買い付ける義務ができた。系統連系促進が可能。

－ 新工場建設に政府補助金30%拠出および各種税の免除措置が適用。

12. **Summary and Closing Speech（Mr. Greg Watt）**

議長より今回のゲストスピーカーの発表内容について簡略なまとめがあった。また今後の予定は下記の様になった。

アクションスケジュール	成果物	作成担当	取り扱い
第1回付加価値ワークショップ（札幌）	Proceedings	日本	Internal用資料
第2回付加価値ワークショップ（グラスゴー）	Proceedings	英国	Internal用資料
最終版作成	Summary Report	豪州	External用資料

最終版はMr. G. Wattが原稿推敲、編集を行い、Draftを第17回タスクＩ専門家会議（10/9~10ミュンヘン）に提示、タスクＩメンバー合意のもとIEA PVPSの承認を得て外部配布用レポートとして年内に作成することになった。

以上

International Energy Agency

Implementing Agreement on Photovoltaic Power Systems

Task 1

Exchange and dissemination of information on photovoltaic power systems

Report IEA-PVPS T1 – 09: 2001

ADDED VALUES OF PHOTOVOLTAIC POWER SYSTEMS

March 2001

Prepared by:

Dr. Muriel Watt, Centre for PV Engineering, University of NSW, Australia

On behalf of NEDO/PVTEC, Japan

To obtain additional copies of this report or information on other IEA-PVPS publications, please visit the IEA-PVPS website (www.iea-pvps.org) or contact your national PVPS Task 1 participant (details available on the website)

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 (PVPS) Programme is one of the collaborative R & D agreements established within the IEA. Since 1993, a variety of joint projects have been conducted in the applications of photovoltaic conversion of solar energy into electricity. The Programme, whose mission is "to enhance the international collaboration efforts through which photovoltaic solar energy becomes a significant renewable energy source in the near future", is divided into nine Tasks which address specific aspects of photovoltaic technology development and implementation. Further details about the Programme are available on the PVPS website www.iea-pvps.org .

This report has been prepared as a special information activity within PVPS Task 1, which facilitates the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. Participating members 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), the United States of America (USA), as well as the European Commission. It has also had input from Task 7, which aims to enhance the architectural quality, the technical quality and the economic viability of photovoltaic power systems in the built environment and to assess and remove non-technical barriers for their introduction as an energy-significant option.

The special information activity "Added Values of Photovoltaic Power Systems" has involved two international workshops and exchange of information between interested parties, with Japan as lead country supported by Australia, The Netherlands, Switzerland and the United Kingdom.

This report has been prepared by:

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with the assistance of Tony Schoen, IEA-PVPS Task 7 and under the supervision of PVPS Task 1 members. It incorporates the deliberations of two workshops on Added Value, held in Sapporo, Japan in September, 1999 and in Glasgow, Scotland in May, 2000.

Abstract

The structure, ownership and operation of electricity systems around the world are changing in response to industry restructuring, the availability of new technologies and increasing environmental awareness. At the same time, many countries have yet to provide basic energy services for their populations, particularly in areas not served by the electricity grid. Large scale, central power generation and distribution which characterized the electricity industry for much of the 20th century is being challenged by new technologies, which are cleaner, faster to deploy and better matched to local requirements. Higher values are being placed on ancillary services, such as power system reliability and voltage stability, so that a simple comparison of energy cost is no longer appropriate as a measure of competitiveness. Solar photovoltaic electricity is unique amongst the new energy sources for the wide range of energy and non-energy benefits which can be provided, while the use of photovoltaic power systems as an integral part of a building provides the greatest opportunity for exploiting non-energy benefits and for adding value to the photovoltaic power system.

This report documents the potential added values or non-energy benefits photovoltaic power systems can provide, the current state of market development and the key barriers faced by renewable energy technologies generally and photovoltaic power systems in particular. Means by which non-energy benefits may be used to overcome barriers to the use of photovoltaic power systems are then discussed, with specific attention to the use of building integrated photovoltaics.

Keywords

Ancillary services, building integrated photovoltaics, capacity credit, competitive markets, distributed generation, externalities, green power, micropower, peak lopping, photovoltaic power systems, power factor correction, renewable energy, restructured utilities, solar photovoltaic electricity, sustainable development.

Glossary

Ancillary services: resources used to maintain power supply quality, such as reliability, voltage and frequency stability and waveform purity.

Cogeneration: the simultaneous production of electricity and heat, usually for commercial or industrial use.

Clean Development Mechanisms (CDMs): intended to help industrialized countries achieve their Kyoto Protocol emissions reduction targets while helping developing countries achieve their sustainable development goals. Emissions reductions resulting from CDM projects within developing countries will be available, at least partially, to the project funders.

Distributed resources: small scale generating, storage or demand management plant, sometimes referred to as micropower, and typically connected into the electricity distribution, rather than transmission, network. These can include photovoltaic power systems, wind generators, batteries or other storage devices and appliances, such as solar water heaters, which reduce electrical load on the distribution network.

Emissions trading: a mechanism to control the increase in greenhouse gas emissions by setting emission limits, allocating permits and allowing emitters to trade permits amongst themselves as a means of achieving the lowest cost emission reductions overall.

Fossil fuels: energy sources derived from ancient plant and animal matter trapped on the earth's surface over geological time. These include coal, oil and natural gas, all of which are non-renewable over any human timeframe.

Greenhouse gas emissions: emissions of gases which collect in the atmosphere and contribute to the Earth's "greenhouse" effect. Increasing concentrations of gases, such as carbon dioxide, methane and nitrous oxide are currently producing an enhanced greenhouse effect, because they are accumulating at a rate faster than they can be dispersed. The combustion of fossil fuels is thought to be a major cause of this enhanced effect, which in turn is expected to contribute to higher average global temperatures over the next century.

Photovoltaic power system: a system including photovoltaic modules, inverters, batteries (if applicable), and all associated installation and control components, for the purpose of producing solar photovoltaic electricity – also commonly referred to as PV or photovoltaics.

PV or photovoltaics: see above.

Renewable energy: energy sources derived directly or indirectly from the energy of the sun, the earth's core or from lunar and solar gravitational forces and which are therefore renewable over time. These include solar, wind, biomass, tidal, wave, hydro and geothermal energy.

Sequestration: removal of greenhouse gases from the atmosphere by the use of plants, storage devices or other technological means.

Vertically integrated utilities: whereby generation and transmission and sometimes also distribution and retailing of electricity are combined in a single organisation.

Acknowledgments

This report was conceived and guided by the Japanese IEA-PVPS members and experts from NEDO and PVTEC. It is based on presentations made and discussions held at workshops organized by IEA-PVPS Task 1 in 1999 and 2000. It also has input from the work of Task 7. Greg Watt, the IEA-PVPS Task 1 Operating Agent, provided valuable assistance in developing the structure of the report and in eliciting key resource documents.

Executive Summary

While solar photovoltaic electricity, particularly in off-grid applications, is an important market for photovoltaic power systems in developing countries, this report focuses more closely on market development for grid-connected photovoltaic power systems in the IEA-PVPS member countries. However many of the issues which need to be addressed, particularly those relating to the electricity industry and energy policy, are the same for both industrialized and developing countries.

Many renewable energy and energy efficiency technologies meet the definition of "distributed resources" which can be strategically located within electricity distribution networks to reduce the need for external energy supplies, while also providing a range of electrical system, environmental, architectural and socio-economic benefits. Solar photovoltaic electricity is unique amongst the new energy sources for the wide range of energy and non-energy benefits which can be provided, while the use of a photovoltaic power system (often referred to as PV or photovoltaics) as an integral part of a building provides the greatest opportunity for exploiting non-energy benefits and for adding value to the photovoltaic power system.

Photovoltaic power systems installed on the surfaces of buildings, allow the possibilities of combining energy production with other functions of the building envelope, including structural support, weatherproofing, shading or solar thermal collection. Cost savings through these combined functions can be substantial. Additionally, no high-value land is required, no separate support structure is necessary and electricity is generated at the point of use. The latter contributes directly to the building occupant's electricity requirements while also avoiding transmission and distribution losses and reducing capital and maintenance costs for utilities. The integration of the photovoltaic power system into the architectural design offers more than cost benefits, however. It also allows the designer to create environmentally benign and energy efficient buildings, without sacrificing comfort, aesthetics or economy, and offers a new and versatile building material.

A number of projects around the world show an emerging market for grid-connected building integrated photovoltaic power systems, despite the fact that solar photovoltaic electricity is still more expensive than grid power. The market for grid-connected photovoltaic power systems in IEA member countries is therefore growing rapidly and now accounts for more than 50% of installed capacity.

This report shows that solar photovoltaic electricity can contribute significantly to reductions in greenhouse gas emissions from the electricity sector: Lifetime CO_2 emissions with current photovoltaic power system technologies are 85 to 94% less than those from coal fired power stations and will be 95 to 97% less with new technologies. Solar powered manufacturing plants can operate as "solar breeders" ensuring a sustainable technology in the long-term.

Solar photovoltaic electricity can contribute to improvements in air quality. When it displaces coal fired generation, the NOx emissions are typically reduced by 50% and SOx emissions by 90%, making solar photovoltaic electricity a valuable addition to clean air policies. For improving urban air quality, photovoltaic power systems can play a role in facilitating the introduction of electric vehicles, either by powering the vehicle directly or by providing power to recharging stations.

Solar photovoltaic electricity can assist in securing energy supplies in both the long-term and short-term. With fossil fuel resources expected to be depleted this century,

photovoltaic power systems provide a means of maintaining electricity supplies in industrialized countries and providing electricity to the developing world without concern for fuel supply security. Dispersed photovoltaic power systems feeding into electricity distribution networks, or operating independently, can provide more reliable electricity supplies during power outages caused by summer peaks or emergency situations.

The production of photovoltaic power systems is a high technology industry which can create new jobs in manufacturing, distribution, installation and maintenance. Dispersed application means that employment is created in regional areas, as well as in industrial centres. Direct employment in the PV industry world-wide is expected to be between 250,000 and 300,000 by 2010.

The modularity of photovoltaic power systems provides benefits to electricity utilities by allowing for generation to be expanded, or reduced, to match demand more easily than with large central generation plant. Lead-times are also shorter, exposure to fuel price volatility is reduced and grid augmentation can be avoided. Hence financial costs and risks are reduced. On-site or local generation also reduces transmission and distribution losses. Dispersed generation reduces the likelihood and impact of large scale power outages while smoothing output fluctuations from individual power systems. It can be especially valuable in dealing with summer peak loads, where the effective load carrying capacity, or firm power output, can exceed 80% of the PV rated output.

For customers, the photovoltaic power system offers a range of benefits which can significantly increase its value. These include providing aesthetically pleasing, non-intrusive, multi-function building elements, ensuring supply reliability, reducing energy and peak demand charges and contributing to environmental protection. For society as a whole, photovoltaic power systems provide a means of delivering more sustainable energy systems for both rural and urban developments.

Nevertheless photovoltaic power systems face a number of barriers to their entry into the mainstream energy and building markets. These include high capital costs and associated financing problems; immature products and service delivery chains; a lack of information, expertise, standards and demonstration systems; electricity industries that still favour the central generation paradigm; and electricity markets that do not yet account for environmental externalities. Some of these barriers can be overcome by assessing both the energy and non-energy benefits which can be provided by a photovoltaic power system, thus making it a cost effective option even with current costs and energy prices.

Introduction

At the start of the 21st century, the structure and composition of many electricity systems around the world are changing. Industry restructuring, which commenced in the 1990's, is beginning to challenge the "natural monopolies" of large scale, central power generation and distribution which characterized the industry for much of the 20th century. New technologies, which are cleaner, faster to deploy and better matched to local requirements are attracting the interest of industry, investors and local communities. At the same time, an increasingly digitized world is placing higher value on power system reliability and voltage stability [Dunn, 2000], so that a simple comparison of electricity cost is no longer appropriate as the only measure of competitiveness. Rather, technologies will increasingly be measured by their ability to meet new market needs [Bower & Christensen, 1995]. Many renewable energy and energy efficiency technologies meet the definition of "distributed resources", which can be strategically located within electricity distribution networks to reduce the need for external energy supplies, while also providing a range of electrical system, environmental, architectural and socio-economic benefits. Photovoltaic power systems (often abbreviated to PV or photovoltaics) are unique amongst the new energy technologies for the wide range of energy and non-energy benefits which can be provided, while the use of photovoltaics as an integral part of a building provides the greatest opportunity for exploiting non-energy benefits and for adding value to the photovoltaic power system.

Photovoltaic power systems are already widely used as a cost effective option for small scale power supplies in remote areas. Here the difficulties and costs associated with fuel transport or with maintenance support are high and well recognized, making photovoltaic power systems an attractive option. Despite this, large scale centralized power supplies continue to be supported over distributed options by utilities and governments in rural areas of both industrialized and developing countries.

For grid-connected photovoltaic power systems, comparisons continue to be made almost entirely on the basis of electricity cost which, despite consistent cost reductions over the past three decades, typically remain higher than those available from centralized, fossil fuel or nuclear plants. However, even in grid supplied areas, values other than kWh energy cost are important. For utilities these include ancillary services, such as power quality and reliability, and capacity values. For customers and society they include power quality, reliability, environmental impact, convenience, security and employment. Nevertheless, present arrangements for ancillary services and network augmentation or extension in electricity markets continue to focus on the larger participants in the electricity market, and distributed options such as photovoltaics do not yet receive equal consideration. In addition, regulation of the electricity industry with respect to climate change is still in its infancy, so that no value is yet placed on emission free generation.

Although many of the benefits cited in the report are recognized, they are rarely attributed a value which could, for instance, be applied to project cost/benefit assessments. In fact, it is easier to attribute value to some of the benefits than to others. This report is a first step at documenting the "added values" of photovoltaic power systems. This will help the non-energy benefits to be more readily quantified and incorporated into project evaluations, and also help identify aspects of existing energy policies which require modification so that the full potential of photovoltaic power systems and other renewable and distributed generation technologies can be realized.

Although solar photovoltaic electricity in developing countries, particularly in off-grid applications, is a major market for photovoltaic power systems, this report focuses more closely on market development for grid-connected photovoltaic power systems in the IEA-PVPS member countries, especially building applications. However, many of the issues which need to be addressed, particularly those relating to electricity industry and energy policy, are the same for both industrialized and developing countries. As an example of international recognition of the issues facing renewable energy introduction in both industrialized and developing countries, a recent meeting of the G8 countries, which comprises the US, UK, Japan, Italy, Canada, Germany, France and Russia, set up a renewable energy task force [www.renewabletaskforce.org] to examine:

- Barriers to renewable energy diffusion and opportunities for overcoming them
- Examples of successful market development and initiatives the G8 countries might take
- The relevance of commercial versus non-commercial markets for renewable energy service provision to the poorest countries and communities
- Priorities and potential for renewable energy capacity building, market development and trade in developing countries, taking account of local political, institutional and investment conditions
- The role of subsidies, green certificate trading and export credits in renewable energy trade and development
- The role of renewable energy R&D
- The importance of renewable energy advances in industrialized countries for accelerating diffusion in developing countries
- How public/private partnerships, or other useful mechanisms, can be promoted
- The role and relative importance of renewable energy service provision to urban and rural populations.

The subject of this report provides information specific to photovoltaic power systems which addresses many of the questions posed by the G8 task force.

This report is based on the outcomes of workshops organized by IEA-PVPS Task 1 which were held in 1999 and 2000. It also has input from Task 7, the IEA-PVPS Task which deals specifically with photovoltaics in the built environment. The report is structured as follows:

- Chapter 1 of the report defines "added value" and outlines key drivers for renewables;
- Chapter 2 provides background material on the current status of photovoltaic power system manufacture and use;
- Chapter 3 outlines the added values or non-energy benefits that photovoltaic power systems can provide, and provides case studies which quantify various added values in different market sectors and different countries;
- Chapter 4 documents the key barriers faced by renewable energy technologies generally and photovoltaic power systems in particular;
- Chapter 5 summarizes the means by which non-energy benefits may be used to overcome barriers to the use of photovoltaic power systems.

1. Renewable Energy and Added Value

1.1 Definition of Added Value

As with most assessments of value, the value which can be attributed to a photovoltaic power system (PV or photovoltaics) depends on the perspective from which it is being viewed. Hence the electricity industry will value electrical output and network benefits, the building industry will value building function and aesthetics, while governments and the community will value environmental benefits, employment creation and energy self-sufficiency. At present, few of the non-energy benefits of PV or other renewable energy technologies are quantified in a way which would reflect their value to the different interest groups. Quantifying both energy and non-energy values is critical to illustrating the cost effectiveness of PV and hence to facilitating its entry into the mainstream energy market. Figure 1.1 illustrates the process of developing cost-effective PV systems, from the current stage where incentives are used to buy down the effective cost, through increasing acceptance and quantification of the added values PV can offer, which serve to reduce the net cost of PV generated electricity and eventually lead to situations where PV is more attractive than conventional energy sources.

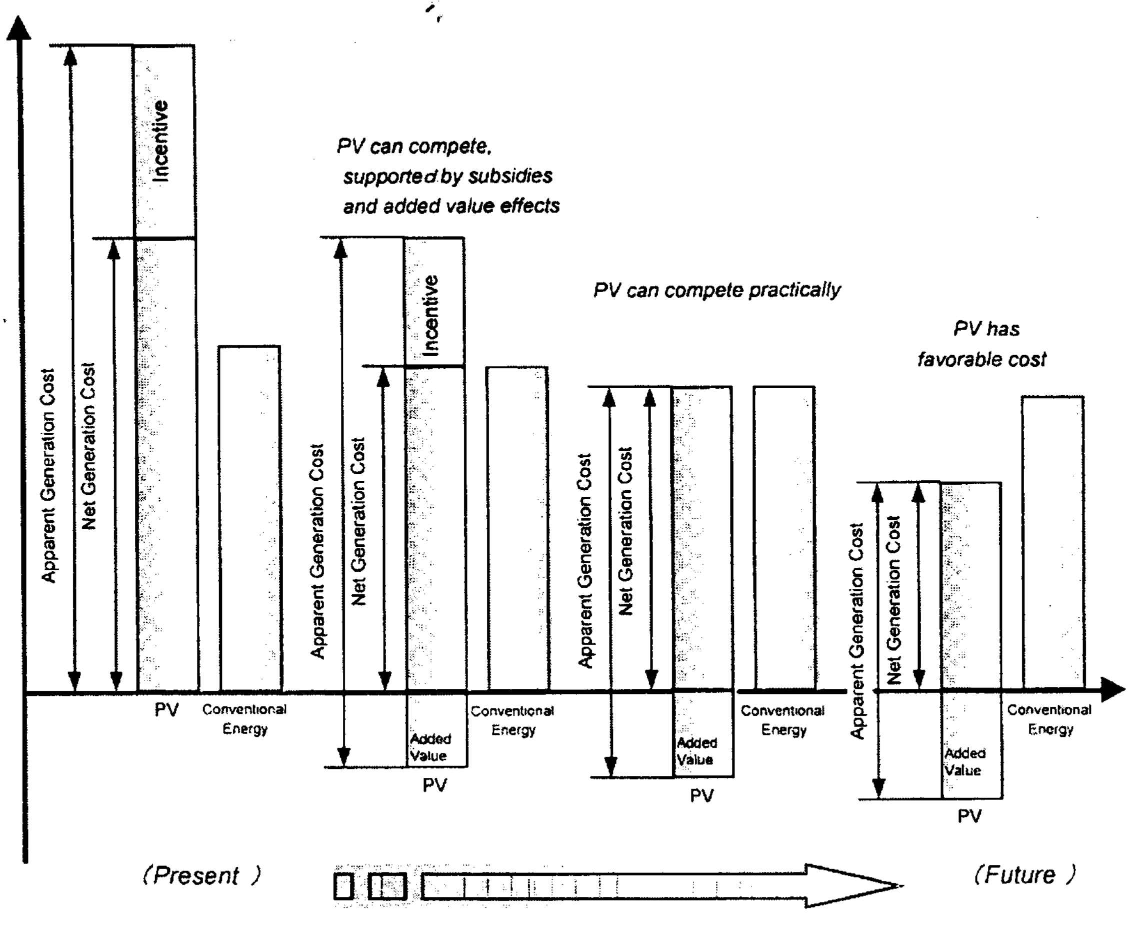

Figure 1.1: The Impact of Non-Energy Values on Apparent PV Generation Costs [Konno, 1999]

1.2 Drivers for Renewables

Documenting and quantifying added values can provide links to key government, utility and industry drivers and will become increasingly important in addressing customer preferences in competitive energy markets. There are a number of key drivers which are impacting at various levels on renewable energy development and use around the world. These include internationally coordinated greenhouse gas reduction policies and clean air policies generally, the introduction of competitive energy markets, the need to create employment and new types of industrial development and the need to maintain or achieve energy supply security, as discussed below.

Photovoltaic power systems offer electricity supply with **low environmental impact** relative to almost all other electricity options, hence fitting well with many environmentally driven programmes or objectives at the international, national, regional or individual level. Greenhouse gas and other air and water emissions are low, land use and visual impacts, particularly for building integrated systems, are low, noise levels are low, resource depletion is minimal and a high proportion of components can be recycled.

Greenhouse gas reduction strategies are beginning to be a key driver for renewables. Over this century energy efficiency and renewables are set to become essential parts of the energy supply and demand mix, with the costs of renewables falling due to technology development and scale-up of manufacture. Most countries include some renewable energy programmes in their greenhouse gas reduction strategies. The emphasis on renewables varies, with some countries seeing major industry development and export opportunities, in addition to internal emissions reductions.

Clean air programmes are another key driver for renewables in many countries, usually on a regional basis and aimed at reducing local air pollution. Acid rain and NO_x have been targets in the past. However, government policy in many countries is increasingly being focussed on greenhouse gas reduction and, although solar photovoltaic electricity may play only a minor role in the short-term, renewable energy programmes are included in most government climate change strategies.

The **job creation potential** of renewables has been identified as an important benefit and a key objective in many countries, with renewables typically providing a range of new employment opportunities dispersed over a wide geographical area. Employment is a key driver for governments, with location and skill levels being important parameters. Large incentive packages are offered by some governments in order to attract PV manufacturing facilities [Engler, 2000].

Energy security is a driver for both governments and industry. Renewables can contribute to energy supply security by increasing the use of indigenous resources and diversifying fuel sources. Short-term security of supply was a major driver both for national governments and for international organizations during the 1970s and early 1980s, resulting for example in the Japanese Sunshine Project, the formation of the International Energy Agency, and driving research into alternative sources of energy and energy efficiency [ATLAS Project, 1999]. Short-term supply security, to avoid black-out or extreme electricity prices in periods of high demand or adverse weather conditions is of increasing concern in many parts of the US and Australia, and has long been a concern in developing countries. Long-term security of supply is now becoming an important driver, with the prospects of fossil fuel resource depletion this century, concerns about environmental impacts of energy systems, and price increases associated with both issues.

Competitive electricity markets are being introduced in many countries and utilities are increasingly aware of the attractiveness of a green image to contestable customers [IEA-PVPS,1998]. This has been a useful driver for PV, with many utility funded systems now installed around the world, despite relatively high electricity costs. The short lead time required for project development and completion, the relative ease of siting and the high local presence possibly all favour PV over many other renewable energy technologies. Low levels of emissions, noise and visual intrusion reinforce PV's environmental credentials. For utilities, ancillary network service values, such as reliability, voltage stability and management of peak demand can be strong drivers, as can the desire to defer expenditure on network augmentation. These values can be difficult to quantify. However, documentation of case studies, such as those contained in this report, which illustrate site specific benefits gained, will assist in building up a database of the range of values which can be expected.

Function and design are drivers for architects and developers. The potential of PV products to perform a variety of building functions, in addition to energy generation, gives them a significant advantage over other energy technologies and will therefore become more important as the grid-connected PV market is developed. For this market, high value is also placed on convenience and aesthetics, as well as the ease of installation, modularity and low maintenance offered by PV systems.

This report aims to summarize the added values PV can offer and to match these against the key international drivers, so that the values can be better recognized, quantified and used to overcome current barriers to increased renewable energy use.

2. The Status of PV Applications

PV production levels have been growing steadily over the last 30 years, but escalated rapidly over the last decade, as shown in Figure 2.1. Production is expected to reach 380 MWp by 2005 and 940 MWp by 2010 [Allied Business Intelligence, 2000].

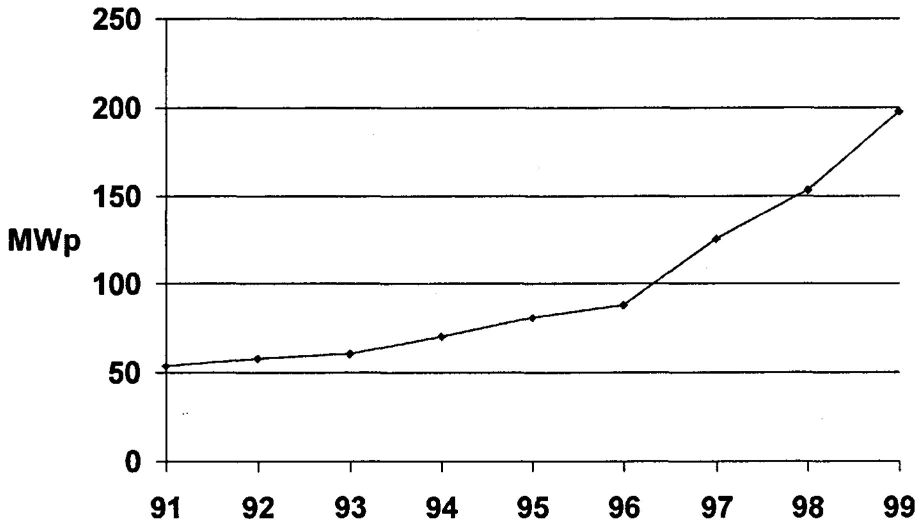

Figure 2.1 - World PV production during the 1990s
[based on figures reported in Photovoltaics Intelligence Report and Solar Flare, 1991-99]

2.1 Market Size and Growth Rates in IEA Countries

By the end of 1999, 516 MWp of PV power had been installed in the twenty countries participating in the IEA Photovoltaic Power Systems Programme. The increase in installed capacity between 1992 and 1999 is shown in Figure 2.2, broken down into primary applications [IEA-PVPS, 2000/2 – www.iea-pvps.org]. Although the worldwide installed power is significantly higher than this, it is indicative of the global trend.

Between 1992 and 1998 the total installed capacity grew by 20-28% per annum. This increased to 31% between 1998 and 1999, with 60% of 1999 installations occurring in Japan. Collectively Japan, the USA and Germany accounted for 87% of the 121 MWp installed in 1999, although Switzerland remains the country with the highest installed power per capita [ibid].

Figure 2.2 shows that traditionally most PV systems were for off-grid applications. This is still true in the majority of the reporting countries and in Australia, Canada, Finland, France, Israel, Korea, Mexico, Norway, Portugal and Sweden over 90% of the total installed capacity is off-grid. This encompasses a wide range of applications: in Canada, Finland, Norway and Sweden, the majority of off-grid PV systems are used for seasonal/recreational buildings and remote cabins. In France, Israel and Mexico, PV is used as a strategy for rural electrification. In Australia, Korea and Japan most off-grid systems are non-domestic - providing power for pumps, agriculture, traffic signals and, in particular, telecommunications. For remote areas, PV provides a commercial alternative to diesel and central grid supplies.

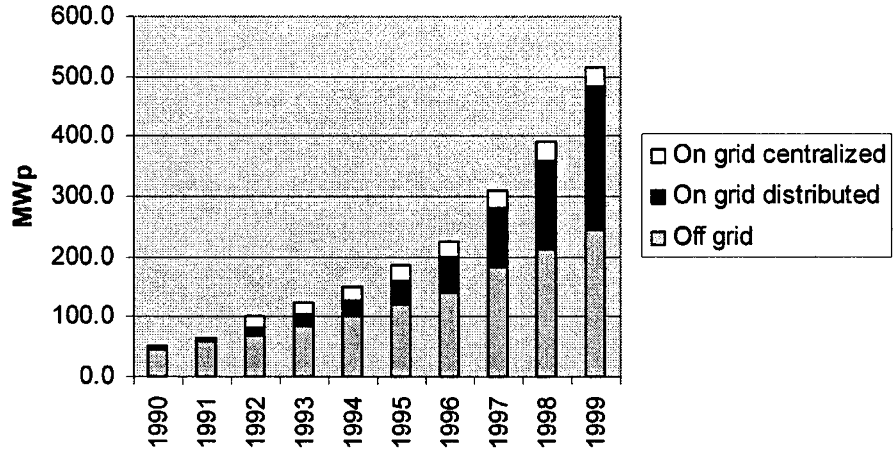

Figure 2.2 - Cumulative installed PV power by application in IEA-PVPS member countries

However the overall trend, as shown in Figure 2.2 and more explicitly in Figure 2.3, is a steady increase in the proportion of PV power that is grid-connected. In 1992 only 29% of the installed capacity was connected to the grid, by the end of 1999 this had reached 53%. This is due almost entirely to a proliferation of on-grid distributed systems [ibid].

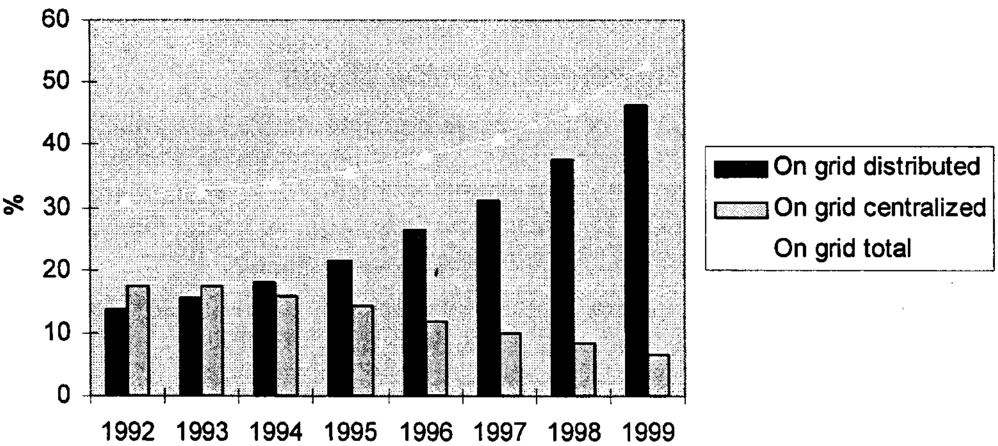

Figure 2.3– Trends in centralized and distributed grid-connected PV power in IEA-PVPS member countries (% of total installations)

The rise in on-grid distributed applications is driven mainly by the large government subsidy programmes in Japan, Germany, the USA and the Netherlands, which focus on

PV in the urban environment. Although not yet significant in absolute terms, it is worth noting that the on-grid distributed market is actually expanding most rapidly in Denmark and the UK (countries with a relatively small PV market at present) and in countries such as Australia and France where, traditionally, PV has been used for off-grid applications.

2.2 Applications in the Built Environment

Increasing cell efficiency and reducing installed cost have been the primary focus of research efforts aimed at improving the economics of PV. However, effective cost reductions can also be achieved through the integration of photovoltaics into the built environment (building integrated PV or BIPV), thereby displacing conventional building materials and providing a range of other values. PV installed on the surfaces of buildings allows the possibility of combining energy production with other functions of the building envelope, including structural support, weatherproofing, shading or solar thermal collection [Schoen, 1996].

Cost savings through these combined functions can be substantial. For instance, conventional cladding costs for expensive facade systems may equal or exceed the cost of PV modules. Additionally, no high-value land is required, no separate support structure is necessary and electricity is generated at the point of use. The latter contributes directly to the building occupant's electricity requirements while also avoiding transmission and distribution losses and reducing capital and maintenance costs for utilities. The integration of PV into the architectural design offers more than cost benefits, however. It also allows the designer to create environmentally benign and energy efficient buildings, without sacrificing comfort, aesthetics or economy, and offers a new and versatile building material [ibid].

A number of projects around the world show an emerging market for grid-connected PV systems, despite the fact that electricity from PV still is more expensive than grid power. Pioneers in this field are beginning to install PV for energy-efficiency and ecological reasons as well as for reasons of aesthetics and prestige. On the other hand, electric utilities view building integrated PV as a decentralized power source with a large potential for the future and are correspondingly starting to construct and operate building integrated PV systems.

Creative partnerships between PV manufacturers and building material suppliers are beginning to emerge [Siemens, 2000], with the aim of developing products for this potentially large new market. The challenge is to meet market expectations and to develop photovoltaics into a cost-effective and clean power source, available to the utility companies and the building owners of the 21st century. The interest of the photovoltaics research and development community and the PV industry, together with architects, the building industry and property developers, is required in order to take up this challenge effectively on national and international levels.

3. Added Values Offered by PV

The diverse benefits offered by PV have different values in different sectors. There is obvious overlap, nevertheless, key values are discussed below from the perspective of governments and planners, utilities, building designers, end use customers, the environment and the education sector. Examples of work undertaken in IEA-PVPS member countries on the diverse benefits of PV are also given. They serve to quantify values and to illustrate their relative importance in different parts of the world.

3.1 Values for Governments and Policy Makers

3.1.1 Net energy benefits and greenhouse gas emission reductions

Greenhouse gas reduction strategies are becoming key energy policy drivers in industrialized countries. Although increased use of PV is not necessarily the lowest cost greenhouse gas reduction option in the short-term, in the longer-term PV is one of the most attractive and versatile emissions free electricity technology options. Hence, most countries have included some PV programmes in their greenhouse gas reduction strategies as a means of fostering development of the technology and the market.

The emissions reduction benefits offered by PV depend on the technologies used and the energy sources being displaced. Estimates of the time required for PV to "pay back" the energy used in its manufacture range from less than 2 years for standard unframed thin film modules to 10 years for standard framed crystalline silicon modules [Nieuwlaar & Alsema, 1997]. For systems specifically designed for rooftops, but still using existing technology, Alsema [1998] narrows this down to between 3 and 8 years. New production processes and increased production volumes are expected to reduce payback times to less than 1 year for modules and less than 2 years for complete systems [ibid]. Alsema [1998] calculates life cycle carbon dioxide emissions from PV generators to be only 6-15% of those from coal fired power stations and 11-26% of the average EU generation mix, as shown in Figure 3.1. He expects them to drop to 2-3% of coal and 3-5% of the average within a decade.

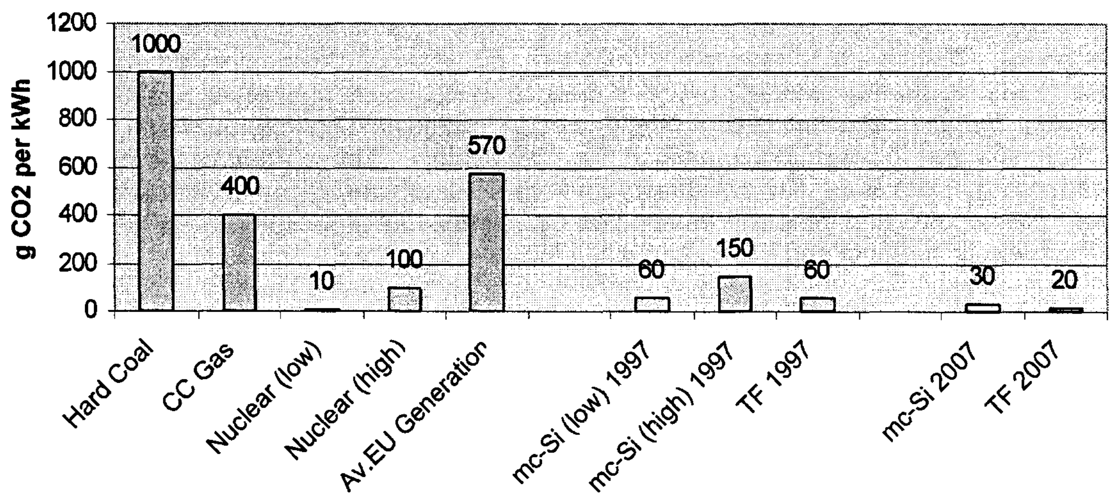

Figure 3.1 – Life cycle CO_2 Emissions for Grid-Connected Rooftop PV Systems (under 1700 kWh/m2/yr) and for Conventional Power Systems [Alsema, 1998]

Kazuhiko Kato of the Electrotechnical Laboratory, MITI, Japan has evaluated the primary energy requirements (PER) and carbon dioxide emissions from the manufacture of different PV technologies and used this to assess the net energy benefits and the greenhouse gas reduction potential of rooftop PV systems in Japan [Kato, 2000].

Three PV technologies were studied: thin film cadmium telluride (CdS/CdTe), flat plate polycrystalline silicon (poly-Si) and thin film amorphous silicon (a-Si) at three different levels of production: 10, 30 and 100 MW per year. The total primary energy requirement for poly-Si modules ranges from 15.7 MJ (100 MW/yr) to 25.4 MJ (10 MW/yr) per Watt of production; for a-Si the range is 10.3 MJ to 21.6 MJ per W and for CdS/CdTe 10.2 MJ to 17.5 MJ per W. For poly-Si, half the total PER can be attributed to cell and wafer production. Based on these figures, PV is calculated to generate between 29 and 73 g CO_2 per kWh. Hence, a 3 kW rooftop PV system in Japan, including balance of system PERs, can be expected to pay back the energy used for its manufacture in 1.1 to 1.7 years for production levels of 100 MW per year and 1.6 to 2.4 years for 30 MW per year. Over a 20 year life, it can save approximately 26 t of CO_2 emissions, based on displacing current Japanese electricity which has a CO_2 intensity of 418 g CO_2 per kWh.

In Australia PV is calculated to release around 104 g/kWh produced, compared with 932 g per kWh for existing black coal fired electricity plants and 439 g from combined cycle gas plants [BHP, 2000], representing CO_2 emissions reductions of 89% and 76% respectively. Hence 1 kWp of grid-connected PV in Australia at present, with predominantly coal fired power, would save 45 t CO_2 over a 30 year life.

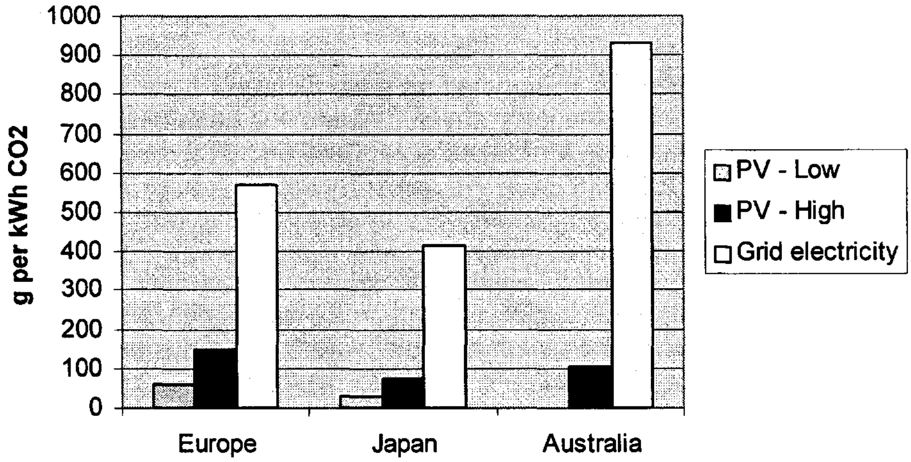

Figure 3.2 - Comparison of CO_2 emissions from PV and grid electricity in Europe [Alsema, 1999], Japan [Kato, 2000] and Australia [BHP, 2000].

Hence, with existing technology, PV systems can be expected to generate at least 3 times, and most probably more than 10 times, the energy required for their manufacture over their lifetime of operation. Carbon dioxide emissions are reduced by 85% or more compared to coal fired generation, making PV an important technology to include in plans for long-term, sustainable energy systems. Expected reductions in PV manufacturing energy requirements will reduce energy payback periods to less than 2 years. Hence, if PV is used to power PV component factories, it can operate as a "solar breeder" technology, with a sustainable long-term future.

From the viewpoint of PV as a building material, Ruyssevelt [2000] argues that PV is the only building component required to show an energy payback time. Atria, glass facades or marble cladding are routinely used, even when they reduce thermal comfort levels in a building, or require additional heating, cooling or lighting. If PV is included in the building or renovation brief from the start, he argues that payback time should not be an issue. PV should be treated like any other building component, with added benefits of electricity output, PR value, sustainability and, at present, the opportunity for funding assistance [ibid].

3.1.2 Clean air targets

Clean air programmes have been put into place in many countries, usually on a regional basis and aimed at local air pollution. Programmes typically target local emissions from vehicles, and combustion of coal, natural gas, oil and biomass.

More recent clean air policy proposals acknowledge global issues and incorporate greenhouse gas reduction strategies. For instance, the US Clean Air Partnership Fund has broadened the reach of clean air programmes to include support for reductions in greenhouse gases and other air pollutants. In Australia, the NSW air quality management plan deals with local, regional and global issues. Clean air policies can be an especially strong driver to promote renewable electric transport systems. In California, where clean air policies are directed at transport systems, PV powered recharging stations for electric vehicles are being installed [Trends in Renewable Energies, 1999], free charging from renewable sources, up to 5000 miles per year, is being offered by one utility [TenderLand, 2000] and a manufacturer of electric bikes offers PV recharging kits [Zero Air Pollution, 1999].

NO_x and SO_x trading is already being used as part of clean air policies in some countries and offers opportunities for PV to play a role. Where PV generation displaces coal fired power generation, life cycle NOx emissions are halved and SOx emissions are reduced by 90% [BHP, 2000]. In future it may be administratively useful to establish standard emissions trading procedures which can be applied to the full range of pollutants – NO_x, SO_x, CO_2 and others – with clear links between clean air and PV policies. Clean air policies are already beginning to impact on standby generation plant and plans for increased use of distributed generation [Trends in Renewable Energies, 2000]. Clean air policies in Texas may restrict the use of distributed generation plants using diesel or waste fuel [ibid] and provide more opportunities for photovoltaics and other low emission options.

3.1.3 Energy supply security

Traditionally, most government and utility planning has been directed at short-term security of supply, or "keeping the lights on" [ATLAS Project, 1999]. Priorities are thus to ensure smooth day-to-day operation of the national power and fuel supply systems, and cope with short-term disruptions such as unexpectedly cold weather, international price fluctuations or industrial action in the fuel supply industry. These concerns have been addressed by measures such as ensuring stockpiles of fuel, ensuring over-capacity of plant or entering into long-term supply contracts. By contrast, long-term security of supply is concerned with looking ahead to the future depletion of fossil fuel resources and responding to environmental impacts that may seriously curtail their use [ibid].

For countries or regions dependent on imports of fossil fuels, PV offers the prospect of local electricity supply security both in the short-term and in the long-term. In the short-term, the installation of photovoltaics on household, commercial and light industrial buildings can reduce peak electricity demand and improve energy supply security. PV can contribute to long-term energy supply security by reducing reliance on depleting fossil fuels, by increasing the use of indigenous resources and by diversifying fuel sources.

The importance of security of supply as a driver for energy research and development changes over time. When there are significant oil price rises, short-term security of supply is a major driver both for national governments and for international organizations. In the 1970s, this resulted in the formation of the International Energy Agency and drove research into alternative sources of energy and energy efficiency. In periods of low energy prices and increased production of oil and gas, security of supply recedes as an issue for many countries, although it is still important for countries such as Japan with few indigenous fossil fuel resources. Nevertheless, for socio-economic reasons, the use of indigenous resources is important in all countries.

In countries such as Australia, with high levels of local coal use and export and high per capita greenhouse gas emission levels, the challenge of reducing emissions and diversifying away from fossil fuels is an important long-term supply security issue.

3.1.4 Industry development and employment growth

The job creation potential of renewables has been identified as an important benefit and a key objective in many countries, with renewable energy industries providing major new job creation prospects [Singh, 1999; Renner *et al*, 2000]. Some countries see major industry development and export opportunities, in addition to internal emissions reductions. Canada's *Action Plan 2000* [Government of Canada, 2000] aims to reduce greenhouse gases as well as transforming the country into a world leader in sustainable development. Several governments have linked emissions reduction and employment creation by using taxes on fossil fuels to assist industry development and job creation in areas with high unemployment [Environmental Science & Technology, 1998]. Some European countries and US States are actively pursuing the establishment of renewable energy manufacturing facilities, for instance, by the use of tax incentives, offers of land, purchase guarantees and other means [Interstate Renewable Energy Council, 1999]. Despite negative perceptions of the employment consequences of sustainable energy development, linked mainly to reduced employment in fossil fuel industries, the overall impacts are positive for most countries [Renner *et al*, 2000]. In the future, the potential employment benefits of renewable energy technologies may become an increasingly important factor influencing government policy.

Although still relatively small, the PV industry is growing fast. The European Commission anticipates world-wide employment of 261,000 by 2010, if the PV market continues to grow at 20% per annum [European Commission, 1996] and if current market barriers are removed. The European PV Industry Association estimates PV could directly employ 294,000 people by 2010 for production, installation and maintenance [Eurosolar, 1999]. In the US, the PV industry already employs 20,000 people directly and estimates that 3,800 jobs are created for each $100 million of PV sales [Solar Energy Industries Association, 1999]. Installed PV capacity is expected to grow at 19.4% and be the fastest growing source of electricity generation in the US over the next 20 years [US EIA, 2000].

For both developed and developing countries, one of the important aspects of the job creation potential of PV is the diversity both of skills required and job locations. The scope for PV use is widespread, in both urban and rural areas and thus there are opportunities for new manufacturing and service industry development and associated professional and trade level employment creation in urban and regional areas. A shift from centralized supply to distributed resource use would also favour the use of PV and demand side options. Hence, even if the labour intensity of PV manufacture reduces with capacity increases and automation, there will be regional development benefits in the locations in which they are used.

3.1.5 Examples of government programmes driven by added values

The European Union has developed an Energy Strategy and Action Plan which aims to double renewable energy contributions from 6% to 12% of Europe's energy supply by 2010 based on a combination of expected added values [Scowcroft, 2000]:

- Environmental benefits: to assist in meeting its Kyoto target of an 8% reduction in greenhouse gas emissions by 2010 compared with 1990 levels. CO_2 reductions of 402 Million tonnes per year by 2010 are expected.
- Economic and employment benefits: strengthening Europe's competitive edge in the global renewables market, thereby capturing employment and manufacturing niches, plus associated education opportunities. This is supported by investment subsidies, tax credits and market incentives offered by EU member countries. Renewable energy business is expected to be worth 17 billion EUR by 2010, creating 350,000 extra jobs.
- Security of supply: reducing fuel imports by 17.4% between 1997-2010 (21 billion EUR savings).

The Netherlands has run a staged PV development programme for a decade and is looking to a new "PV Covenant" for the next 10 years. The programme aims have been to reduce costs by development of supportive infrastructure, gaining experience and increasing the market for PV, especially as a building product [Schoen, T, 2000]. PV use is supported because it will increase the country's energy self sufficiency, reduce greenhouse gases and provide a new industry with potentially large internal and export markets. The density of development in the Netherlands makes PV an attractive choice for installation on buildings and other structures, such as highway noise barriers.

The initial phase of the programme was to establish R&D infrastructure and to gain experience with PV installation and use. The second phase continued support for R&D, but also aimed at increasing public acceptance of the technology, developing easy to use BIPV and stand-alone PV products and reducing non-technical barriers by increasing PV expertise amongst utilities, planners, architects and builders. Demonstration system sizes and density have been gradually increased from several kWp to 1 MWp and plans now include a target of 250 MWp installed capacity around the country by 2010 [ibid].

The Australian Government has launched a comprehensive package of renewable energy programmes as part of its greenhouse gas reduction strategy [Walsh, 2000]. The greenhouse strategy is supported by funding of AUD 1 billion over 5 years and includes the establishment of an Australian Greenhouse Office, which links to government portfolios of industry, science and resources, environment and heritage, agriculture, fisheries and forestry, transport and foreign affairs.

Renewables programmes are aimed at industry and export market development as well as greenhouse gas reduction. They include:

- a mandatory target for renewable electricity
- renewable energy "showcase" demonstration projects
- venture capital for new companies
- commercialization funds

- rebates for displacement of diesel fuel in remote area power systems
- rebates for building integrated PV systems
- a renewable energy action agenda and
- a comprehensive renewable energy web site.

The Japanese Government has targeted both the development of new BIPV products as well as an increase in installed BIPV capacity. The main impetus behind BIPV research has come from the New Energy Development and Industrial Technology Organization's (NEDO) New Sunshine Programme, which focuses on sustainable economic growth and the resolution of energy and environmental problems. Extensive research on electricity network issues related to distributed PV systems has also been conducted at the Rokko Island research facility.

The development of specific BIPV products is considered a high priority in reducing costs and increasing consumer acceptance of PV. R&D projects funded by NEDO to investigate BIPV building elements typically involve a PV manufacturer, a construction materials company and a construction company. Projects include development of exchangeable shingles, prefabricated roof panels, heat insulated roof panels, glass curtain walls, metal curtain walls and flexible roofing sheets. A second phase of the R&D focuses on improving costs, performance and design. Innovative concepts being examined include durability, colour, flexibility, fire resistance, strength, light weight and integration with building components [Yamaguchi, 2000]. Fire resistance has been of particular importance in Japan and is incorporated in many of the new BIPV products. An interesting product which illustrates durability and strength is a semi-transparent PV decking material, which can be walked on, and is illuminated from below at night, providing a useful and attractive material for public areas, as well as for residential use [Ito, 2000].

The Ministry of International Trade and Industry (MITI) subsidizes individual residential BIPV installations and aimed to have 70,000 systems installed by 2001. This scheme is administered by the New Energy Foundation (NEF) with users eligible for a 30-50% rebate on installation costs. This scheme has been very popular and often over subscribed. NEF also provides grants under its Field Test (FT) programme for installations of 10 kWp or more on public or industrial sites, on the basis that performance information is made public. Low interest loans are also available to corporations wishing to install systems. In addition to subsidies for system installation, net metering (with buy back rate same as selling rate) has been legislated since 1992, with encouragement given for utilities to pay a 10% premium for renewable energy.

As a result of these programmes, the typical cost of a 3 kWp residential PV system had decreased to 3 million Yen by 1998, between one third and one quarter of the cost 5 years previously [Yamaguchi, 2000]. PV production capacity increased from less than 15 MWp to 50 MWp in the decade 1988 to 1998; installed capacity is now over 130 MWp and is expected to reach 5,000 MWp by 2010. Over 76% of 1998 sales were for residential systems [ibid], with 30,000 systems already installed and 10,000 being added each year [Ohno, 2000]. The FT programme has resulted in 2 MWp installed on 73 systems, again showing significant cost decreases in the first 5 years of operation [Ito, 2000].

The US Government's Million Solar Roofs Initiative was announced in 1997 and is aimed at installing a million solar water heaters and PV systems on US rooftops by 2010. The Initiative expects to achieve reduced greenhouse gas emissions, high technology job creation and a competitive US solar energy industry. By October 2000 more than 100,000 roofs had been installed, almost double the 51,000 target set for 2000 [US DoE, 2000/2].

The target for federal government buildings is 20,000 solar roofs by 2010. The government is using its own sites for demonstration, to showcase the technology and to develop construction methods on which future systems can be based. A 2800 module, 100 kWp system recently installed at the Maryland Federal Center near Washington DC also includes an educational kiosk and will be open for public tours [ibid].

Both Federal and some State governments in the US use their buying power to offer low interest loans for renewable energy systems [US DoE, 1999], in order to reduce the risks and the lifetime costs.

Spain already has an active PV industry, with 3 manufacturers and a large export market. The **Spanish Government** has begun a comprehensive programme of renewable energy development which will assist PV further. It is aimed at reducing fuel imports, improving the efficiency of energy use, improving environmental quality and providing jobs and social development [Chevelet, 2000]. The programme includes:

- a Royal Decree which requires utilities to pay an additional 0.36 EUR per kWh for renewable electricity from grid-connected systems less than 5 kWp and 0.18 EUR for systems between 5 kWp and 50 MWp;
- laws for grid interconnection, which include technical requirements, and waiver of taxes and legal approvals;
- a renewable energy target of 12% of electricity by 2010, with associated work on analyses, identification of barriers and development of procedures and incentives.

3.2 Values for Utilities

Over the past half century, central generation has been seen as the most efficient way of delivering electricity to large numbers of consumers. This resulted from the economies of scale offered by large fossil fuel and nuclear generators, combined with the availability of low cost fuels and government support for infrastructure development. However, for PV, the lower energy density of the solar resource results in optimal sizes being smaller than for fossil fuel or nuclear systems, while economies of scale are achieved by increases in production volumes rather than installation size. Smaller scale generation, connected into the electricity distribution, rather than the transmission, network is referred to as distributed generation and includes building integrated PV systems. Table 3.1 summarizes some of the benefits offered by distributed generation, termed "micro-power" by Lovins and Lehmann [2000].

Table 3.1: Eight Hidden Benefits of Micropower [Lovins & Lehmann, 2000]

Benefit	Description
Modularity	By adding or removing units, micropower system size can be adjusted to match demand.
Short lead time	Small-scale power can be planned, sited, and built more quickly than larger systems, reducing the risks of overshooting demand, longer construction periods, and technological obsolescence.
Fuel diversity and reduced	Micropower's more diverse, renewables-based mix of energy

price volatility	sources lessens exposure to fossil fuel price fluctuations
"Load-growth insurance" and load matching	Some types of small-scale power, such as cogeneration and end-use efficiency, expand with growing loads; the flow of other resources like solar and wind, can correlate closely with electricity demand
Reliability and resilience	Small plants are unlikely to all fail simultaneously; they have shorter outages, are easier to repair, and are more geographically dispersed
Avoided plant and grid construction, and losses	Small-scale power can displace construction of new plants, reduce grid losses, and delay or avoid adding new grid capacity or connections
Local and community choice and control	Micropower provides local choice and control and the option of relying on local fuels and spurring community economic development
Avoided emissions and other environmental impacts	Small-scale power generally emits lower amounts* of particulates, sulfur dioxide and nitrogen oxides, heavy metals and carbon dioxide, and has a lower cumulative environmental impact on land and water supply and quality

* because of the technology often employed eg photovoltaics, wind, small hydro etc.

3.2.1 Reduced infrastructure costs and network losses

Distributed generation can offer reduced costs for infrastructure, such as line capacity and peak load generation facilities, as well as reduced network operating and maintenance costs. It can also serve to delay or eliminate the need for network augmentation. With network costs accounting for up to 50% of electricity bills, where retail competition has not been introduced, this is an important benefit, particularly where networks span large distances, where high load growth in some areas is leading to grid constraints or where lines are reaching the end of their expected life [Outhred & Watt, 1999]. Generation close to load centres also reduces network losses, which can be as high as 25% of electricity distributed through long rural lines.

3.2.2 Reduced financial risk

Another key advantage of decentralized PV systems over traditional centralized supplies is the lower risk it offers in upgrading capacity. The ability to follow load growth more closely by adding incrementally to supply reduces the period of over-capacity which inevitably follows the installation of a large system, and hence also the period of low prices experienced until load growth catches up. In periods of uncertainty, the risks associated with under-utilized assets may add considerably to the costs. Excess new capacity can also lead to premature retirement of older plant and hence reduce the returns on previous investments. PV systems offer further risk reductions: few management overheads related to ongoing fuel contracting or legal costs and no fuel price risks [Awerbuch, 2000]. Despite these acknowledged risks, PV systems continue to be assessed from an engineering economics perspective, whereas the use of capital asset pricing models, already used as the basis for "lean" manufacturing, would provide values for the reduced risks and uncertainty, as well as for the planning flexibility, reversibility and modularity offered by PV [ibid].

There is some utility recognition of the potential cost benefits of increasing network support through distributed generation in current planning processes or in their longer-term strategic thinking. As competition, and perhaps privatization, occurs in the electricity industry, the advantages of distributed generation may be more widely recognized. In the interim, regulatory processes must ensure that distributed resources are given equal access to the network and that central generation is not favoured simply because it is the existing paradigm.

3.2.3 Capacity credit and peak lopping

Compared to central PV stations, decentralized systems smooth output fluctuations and provide a better match to loads, therefore providing a higher capacity value from the utility point of view. This has been verified by studies undertaken in Japan [Ohtani, 1999] which show that regional output becomes more important for decentralized systems than the output from individual systems. More work is needed to determine optimum sizes and distribution of PV systems to gain maximum network benefit, however, short-term fluctuations due to moving cloud cover could be compensated for within a 10 km radius. The impact on effective capacity over larger areas, including entire interconnected networks, needs to be assessed. Improved weather forecasting is expected to allow better forecasts of PV output and hence higher reliability of output for utility planners.

For commercial and industrial customers, the capacity value that can be placed on a PV system is as important as its energy value, since billing has a strong demand component. From a utility perspective, it is difficult to attribute capacity credit to a PV system, because of the stochastic nature of the output and hence the relatively uncertain correlation with peak demand. However, on average, solar radiation levels are very reliable, so that, where air conditioning loads contribute significantly to peak demand a positive correlation would be expected with PV output. The value of PV could therefore be higher for utilities in areas with a summer peaking load.

From the customer's perspective, the effective load carrying capacity (ELCC) of PV can be especially high for commercial customers, with typically good matching between peak PV output and daytime air conditioning load. This correlation is not as high for residential customers in countries where peak loads are typically later in the day, but may be high for some residential customers with daytime peak loads.

Studies in Japan [Nanahara, 1999] show that PV output between 2pm and 3pm in summer averages 31% of rated PV capacity and for peak summer days output averages 39% of rated capacity. Correlation levels between PV output and peak demand vary over the country, however PV output on peak summer days is consistently higher than for average summer days in all except the northern most part of Japan [ibid].

Studies in the U.S. have shown that the correlation between summer to winter peak load and effective load carrying capacity is higher than that between average irradiance levels and ELCC [US DoE, 1996]. The ELCC can exceed 80% of PV rated output when the ratio of summer to winter peak load is greater than 1.5 [ibid]. Hence a 1 kWp PV system could be considered to have a dispatchable rating of 800 Wp. Using this approach, the US DoE has published a map showing the different PV ELCC across the US [ibid]. This map allows planners to target areas where PV would have a high value. These areas are not necessarily those with high solar radiation levels.

Perez *et al* [1999] have shown that the ELCC can be increased further by simple load control strategies aimed at optimizing load and PV output. They found that improvements of 10-25% are possible for photovoltaic power systems sized at 10% of the building load, resulting in an added value of USD 100 to 500 per kWp, depending on location, with a U.S. average of USD 300 per kWp for commercial buildings.

3.2.4 New business opportunities

Utilities are generally keen to take advantage of the positive customer image of utility reliability and the public interest in environmentally friendly energy sources in their development of PV businesses. Such perceptions, combined with the greater ability, compared with independent operators, to offer a variety of financial packages, and with the history of monopoly service, provides utilities with a competitive advantage in the market. Utilities have explored business opportunities in stand-alone PV systems, rooftop PV and Green Power products. Some utilities are specializing in providing renewable energy projects as a service to other utilities, to cater for green power markets or mandatory renewable energy targets. Green Power provides utilities with an opportunity to market a premium product, rather than just a commodity.

3.2.5 Image

Corporate positioning and image are important strategic factors for many utilities involved in competitive markets. An involvement in PV is being used by some utilities to demonstrate a commitment to the environment and as a sign that the organisation is dynamic and innovative. This is demonstrated by the large number of PV images now used in the advertising or marketing materials of utilities operating in a competitive market. In a fully competitive market customers can compare utility programmes and seek justification for claims made. The initial introduction of retail competition in the US has seen a significant level of customer interest in green products. Even in countries such as Australia, where full retail competition has yet to be introduced, almost all electricity retailers now offer green products. Although PV is not the cheapest technology for utilities, most still include some PV in their portfolios because even systems as small as 1 kWp can be installed in high visibility locations, close to customers, and provide a high technology, green image.

3.2.6 Examples of utility programmes

In Switzerland a "**stock exchange**" model has been used successfully to promote PV installation and solar photovoltaic electricity use [Nowak, 2000]. A Solar Stock Exchange was established in Zurich in 1995, whereby PV system owners sign long-term contracts with utilities for solar photovoltaic electricity, which is in turn sold to customers (see Figure 3.1). By early 2000, 42 systems with 1.62 MWp capacity had been installed; 5,700 customers had subscribed, representing 2.9% of the target population and purchasing 1.2 GWh per year of solar photovoltaic electricity. A subsequent national programme, "Energy 2000", has resulted in 90 Swiss utilities offering solar products to 3 million customers. By early 2000, 21,000 customers had subscribed for 3.5 GWh per annum at tariffs of EUR 0.6 to 0.9 per kWh and 3.4 MWp has been installed. A mix of products, marketing and models were used, with nearly 50% using the stock exchange model.

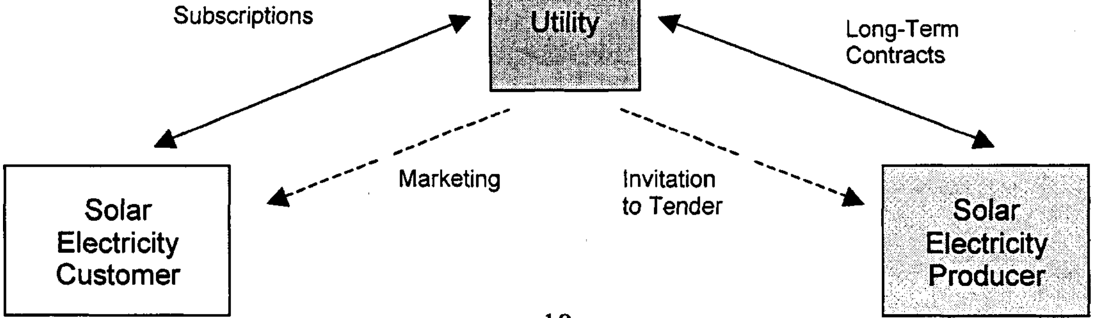

Figure 3.1: The Solar Stock Exchange Model [Nowak, 2000].

Green Power products have emerged as one means for utilities to offer differentiated products to domestic and business customers, with the intention of gaining new customers or increasing customer loyalty. Many utilities around the world now offer some form of Green Power, however, there is considerable variation between the schemes on offer and they are often offered to both contestable and franchise customers.

The growth in Green Power around the world reflects the increased focus placed on customer preferences as a result of restructuring. In many instances, the potential mobility of customers has forced utilities to look more closely at the attitudes and perceptions of customers, and to develop products and marketing approaches in response. However, Green Power can only work as a real marketing tool when customers have choice of retail supplier. Where such competition exists, Green Power programmes are proving to be an important element in customer choice and, in some US states, utilities have chosen to use State subsidies for renewables to lower the price for Green Power, sometimes to below the standard electricity tariff [Green-e Renewable Electricity Program, 1999].

To ensure customer confidence in the programmes, the Green-e programme in the US provides independent certification for Green Power schemes, publishing details and ensuring that utility claims are not fraudulent. Australian schemes are certified and now require labeling to distinguish levels of greenhouse gas reduction.

The reliance on Green Power and solar stock exchange models as means of increasing renewable energy use does, however, place the burden of environmental action on customers and individuals [IEA-PVPS, 1999], without necessarily changing the structure and operation of the energy sector. Government and community acceptance of a need for a transition to sustainable energy systems is necessary before renewables can play a significant role.

Minimum buy-back rates have been introduced in some European countries and US States for renewables based electricity generally or PV specifically feeding into the grid from small generators. Typically these rates are higher than standard bulk rates which would otherwise be paid, and have been effective in stimulating the PV market, particularly when the rates are guaranteed for long enough to achieve acceptable returns on investment [Goldstein *et al*, 1999]. Even if they are not much higher, the availability of standard rates removes uncertainty during the feasibility phase of new projects and reduces the time and cost otherwise associated with tariff negotiations.

In an effort to stimulate local PV and other renewable energy industries and drive down costs, some areas have introduced rates that are higher than retail tariffs. In particular, so called "rate based incentives" up to 10 times the retail tariff are being used in areas of Austria, Switzerland and Germany, usually as a result of consumer demand. The rates are funded from across-the-board levies and have time or capacity limits. Compared to Green Power schemes, the investment burden is shifted from the utility to the customer. However, tariff incentives are seen by some as more sustainable means of market development than one-off capital subsidies. In particular, with returns based on electricity generated, there is a high incentive to choose low cost and high efficiency systems, while capital cost subsidies typically apply to installed capacity without regard to performance.

Net metering can be a practical way to provide transitional support for small-scale grid-connected PV generators. A single meter is used to measure both the export of electricity to the grid and the import of electricity from the grid. This eases problems of market access for PV by reducing administrative costs and metering complexity. In addition to the simplicity and low cost of this arrangement, customers receive the retail rate for electricity exported to the grid until their exports exceed their imports. This in turn encourages appropriate sizing of PV installations and efficient energy use. Net metering is particularly useful once the performance of a technology is reasonably well understood, since the single meter removes the monitoring function that would otherwise be provided by a separate meter.

Typically, a cap is placed on installations qualifying for net metering, based on peak capacity installed or a percentage of electricity generated in the area. There is a move to encourage standard application procedures, as a further means of easing access, rather than using a system of individual contracts [State of Vermont Public Service Board, 1999].

Net metering is being encouraged by a resolution to the US Congress [NARUC, 1998] and has been regulated for in thirty US states [NREL, 1999]. For many utilities, net metering is seen as good marketing strategy, with minimal financial risk and the possible added value of distributed generation in grid constrained areas. It could also be a very cost effective means of reducing the need to purchase power during summer peaks, when spot prices have been as high as USD 50 per kWh. However, utilities can still apply high connection or supply charges as a disincentive.

3.3 Values for Architects and Building Developers

Enhancement of the building integrated PV market requires acceptance of PV by builders, architects and users. The physical characteristics of PV products for integration into buildings must therefore meet architectural requirements for colour, size, and materials. The challenge for the PV R&D community, together with architects and builders is to develop and demonstrate high-quality integration concepts that meet the industry's objectives as well as the architectural needs of buildings [Schoen, 1999].

3.3.1 Design features

The building envelope has several functions, each of which is an architectural concern. These functions include: sustaining the interior environment, protecting the building structure from the environment, structural requirements, exterior and interior aesthetics, and community planning requirements [Sick & Erge, 1996]. These functions are performed within certain economic and environmental constraints. PV offers a new and attractive building material which can be used to create new building designs which fit into an increasingly important architectural aim of demonstrating environmental sustainability. Architects are now beginning to explore the design possibilities of PV, integrating it into their buildings as day-lighting, shading and façade features. Aspects of BIPV elements which are important to these functions include the colour, shape and transparency of the PV module, although it must be remembered that custom designs will result in higher cost PV modules, while in general, product standardization is necessary for cost reduction.

Colour: There are several ways to alter the colour of PV building elements. One method is to colour the front of the PV encapsulation or the visible backing layers of the laminate. The appearance of the element is then a combination of the colouring and the PV cells themselves. Any transmitted light will also be coloured. Altering the tint and surface conditions of the front encapsulation can also provide different textures, similar to stone or metal. The alternative is to colour the PV cells themselves by means of thin film interference using antireflection (AR) coatings. Some PV cell manufacturers have already begun to develop coloured cells. The successful leasing of the ÖKOTEC3 building in Berlin, in an environment of office space oversupply, has been partly attributed to the highly attractive "iridescent blue" PV facade elements manufactured by Flachglas [Chehab *et al*, 1995].

Shape: Since many of the BIPV installations to date have been retrofits to existing buildings, or have been designed to fit into existing architectural styles, the predominant shapes and sizes of BIPV elements have been determined by the building elements they have displaced. Thus most BIPV elements are rectangular, like roof tiles and spandrel units. Economies of scale of manufacture favour the development of standard products, although this is not necessarily straightforward, given the diverse range of building styles found worldwide.

Transparency: Transparency of a BIPV element potentially affects both the exterior appearance and the interior environment of the building. Transparency in elements using crystalline cells is determined by the spacing of the cells. The transparency of an amorphous PV cell deposited on glass is achieved by the presence of pin-holes in the cell. The degree of transparency is set by the density and size of the pin-holes. Semi-transparent PV modules provide an attractive opportunity for architects to select the amount of light entering a glassed area while creating interesting shade patterns which change over the day. Acoustic and thermal insulation properties can be incorporated by adding appropriate layers of glass to the rear of the modules.

3.3.2 Roofing elements

The most common and readily accessible site on a building for installation of a PV system is often the roof. New PV roofing materials shaped to fit in with conventional roof tiles or sheeting can save materials and installation costs, without changing the look of the building. Similarly, transparent or semi-transparent PV modules can readily replace standard skylights, providing one of the most cost effective BIPV applications. Even standard PV modules installed over an existing roof can provide significant electricity output and a range of additional values offered by distributed generation, which are discussed below.

3.3.3 Load management

PV output is generally well matched to commercial building electricity usage patterns, thus providing potential value for load management. Net metering is not as important an issue as it is for residential customers, since net export would not usually be expected. PV systems on commercial premises can often qualify for business related investment and tax allowances, which add to energy and capacity values to influence the break-even costs.

The U.S. Department of Energy [DoE, 1998] has mapped the breakeven cost of PV for commercial premises across the country, taking into account the local solar resource, capacity values, tax allowances and tariffs. Several areas show breakeven costs above USD 6,000 per kWp, with some as high as USD 11,000 per kWp. However, commercial building developers are also interested in the net investment cost (cost less energy benefit) of a PV product compared to that of a standard façade or building element [Schoen, 1999, DoE, 1998], which may be in the range of USD 60 to 200 per m^2. Hence the building element value can be added to the breakeven costs, potentially raising even vertical structures from low breakeven costs of around USD 2,000 per kWp to reasonably competitive levels of USD 5,000 per kWp or more [DoE, 1998, Perez *et al*, 1999]. Further, the development of attractive and easy to install multi-purpose PV building products adds even more value to PV for commercial building customers. Energy savings up to 25% of the PV output are possible through improved insulation and shading [Perez *et al*, 1999].

3.3.4 Improved thermal performance

Insulation: PV can serve as an insulating element to improve thermal comfort levels. Studies on roofs of a railway station in Japan [Tanaka, 1999] have shown that the Predicated Percentage Dissatisfied level (PPD) dropped from 91% to 70% when PV was added. The average temperature under the roof dropped from 40°C to 30°C. Theoretical calculations subsequently made for a gymnasium, where the average surface temperature under the roof is 43°C, and another railway station, where the temperature is 38°C, shows that thermal radiation would be reduced by 35% and 31% respectively if PV were added [ibid].

Heating: Infra red radiation is largely transmitted by PV cells and contributes to heating the module and whatever is behind it. Heat generated by PV modules can be extracted to satisfy low grade heat demands, such as space or water heating, in a hybrid electric/thermal (PV/T) system. This can increase the energy efficiency and the cost effectiveness of the overall installation. Leender *et al*, [2000] have undertaken a review of currently available PV/T systems, finding them promising, but yet to be optimized.

The production of heat in PV/T systems will coincide with PV power production. Thus the availability of warm air would be highest in summer, when space heating is not required. If the heat is to be retained, thermal mass storage can be incorporated. Such a system has been installed in Switzerland [Posnansky & Eckmanns, 1995]. It provides 53 kWp of electrical and 115 kW of thermal energy. In conjunction with 9 kWp from a separate PV facade, the system provides approximately 70% of the electrothermal energy requirements of the factory. Thermal energy is extracted by passing air behind the PV panels and is used to heat the factory or can be stored for short periods in concrete slabs and underground for seasonal storage. Combined heat and power units using a-Si glass laminates are also under development. The PV layer effectively reduces the solar radiation available to the solar thermal system by around 10%. Since a-Si is not as temperature sensitive as crystalline Si, the PV cooling function is not critical.

Ventilation: In cases where building ventilation is important, passive ventilation can be achieved by the "stack effect" where warm air becomes buoyant and rises, thus creating an upward flow of air. The stack effect can be employed to ventilate the space adjacent to the column of moving warm air by extracting air through louvres or windows. The extraction of heat from the PV modules also helps to lower the PV operating temperature, which results in higher operating efficiencies for crystalline technologies.

Atlantis Energie has installed ventilated PV shingle roofs [Posnansky & Eckmanns, 1995]. Air enters a channel beneath the roof shingle through the eaves and rises to the ridge as it absorbs heat from the roof. During the heating months this warm air is drawn into the building while in warmer months it is vented to the exterior through vents in the ridge of the roof.

The Mataró Public Library in Spain has been equipped with a multifunctional PV façade, based on 6m high PV elements forming the southern wall of the building. Elements consist of laminates of spaced poly-Silicon cells, so that 15% of the incident light enters the building. An air gap separates this laminate from a second layer of clear glass. During the heating months air flowing up through this gap is preheated before passing to a conventional gas heater for the building. During the warmer parts of the year the hot air is ventilated in order to cool the PV and reduce heat gain into the building.

3.3.5 Sound proofing

The use of PV for sound proofing in buildings and highway barriers has been widely exploited in Europe, where dense urban development makes this a premium value. A 100 kW PV sound barrier was first installed in Switzerland in 1989. A variety of designs have since been developed and installed around Switzerland and Germany, some as a result of an international design competition [Frölich, 1999]. Conventional sound barrier materials cost between USD 250 to 485 per m^2 in Germany [ibid], which provides an indication of the material substitutional value available. Innovative designs are now using bi-facial PV cells, which allow the use of light from north and south facing surfaces, thus increasing the annual electricity output.

3.3.6 Shading

Shading elements are typically secured to the outside of the building envelope to limit the amount of daylight and heat entering through a window. They may be permanently fixed or moveable to track the sun over the day or year. Shading elements are well suited to accommodate PV laminates, as they are oriented towards the sun, often have a flat surface and allow rear ventilation. They can also be automatically controlled to track the sun. PV covered window blinds for use inside the building, behind the window glass, have also been suggested [Sala *et al*, 1996]. Shading devices are increasingly needed because of the trend to larger window sizes and the use of curtain walls in commercial buildings.

Seven kWp of PV window shades installed at the University of Texas are expected to generate 10,000 kWh of electricity a year, as well as to reduce the air conditioning load by 2,600 kWh [Applied Power, 2000]. The system will also contribute towards the Texas 1999 mandate for 2000 MW of new renewable energy generation by 2009.

PV covered shading for car parks is also of interest in areas with hot summers. In some cases, the PV power is available for charging electric vehicle batteries. The value of a PV shaded car park can be assessed in terms of the electricity and the parking revenue generated. An example in the US estimates the value of a PV covered parking space as USD 1,600 per annum from the solar photovoltaic electricity plus parking revenue of USD 8,212 per annum, resulting in a total value of USD 9,812 and a 10 year payback period with respect to the initial investment [Eiffert, 2000].

3.3.7 IEA activities

In order to encourage and assist architects to explore the use of PV the IEA-PVPS Task 7, PV in the built environment, has listed (Table 3.2) the criteria it would apply in evaluating BIPV systems [Schoen *et al*, 2000].

Table 3.2: Overview of IEA-PVPS Task 7 Architectural Criteria [Schoen *et al*, 2000]

1. NATURALLY INTEGRATED
The PV system is a natural part of the building. Without PV, the building would be lacking something - the PV system completes the building.
2. ARCHITECTURALLY PLEASING
Based on a good design, the PV system should add eye-catching features to the design.

3. GOOD COMPOSITION
The colour and texture of the PV system should be in harmony with the other materials. Often, also a specific design of the PV system can be aimed at (e.g. frameless vs. framed modules).
4. GRID, HARMONY AND COMPOSITION
The sizing of the PV system matches the sizing and grid of the building.
5. CONTEXTUALITY
The total image of a building should be in harmony with the PV system. On a historic building, tiles or slates will probably fit better than large glass modules.
6. WELL-ENGINEERED
This does not concern the watertightness of PV roof, but more the elegance of design details. Have details been well-conceived? Has the amount of materials been minimized? Are details convincing?
7. INNOVATIVE NEW DESIGN
PV is an innovative technology, asking for innovative, creative, thinking by architects. New ideas can enhance the PV market and add value to buildings.

Task 7 has also collated case studies of high profile and interesting BIPV demonstration projects, developed computer based design tools and organized design workshops. In 2000, Task 7 organized an international BIPV design competition, aimed at stimulating the interest of architects, building developers and students in developing innovative and practical uses of PV in the built environment. The judging criteria for assessing the entries are given in Table 3.3. Prizes were awarded in the categories of: Overall Winner; Exhibition Prize; Roofing Products; Facades; Other Building Products (sunshades, blinds, windows, louvres); Non-Building Structures (street lights); and New PV Products.

Table 3.3: Judging Criteria for IEA-PVPS Task 7 Design Competition for PV in the Built Environment [IEA-PVPS, 2000]

JUDGING CRITERIA
Visually attractive
Integration into the built environment. The product should fit well in the context for which it is intended.
Functional – the product should meet whatever function the type of product is expected to provide
There must be an identifiable market for the product (it is not the size of the market that counts)
The product should be innovative in some respect. This may involve innovative components, the assembly of the components or the application
The product should be reasonably simple to install, maintain and operate, where applicable
The performance/efficiency of the product is important. Thermal outputs can be considered as well as electrical outputs where appropriate. Demonstrate issues such as ventilation and shading have been considered to maximize output from the chosen PV technology
Practical and cost effective manufacturing method
Environmental issues. Demonstrate that environmental issues have been considered, including minimizing the energy payback of the system and the use of materials harmful to the environment
Flexibility/versatility of the design (able to use in various locations/orientations/markets, etc.)

The overall winner was Robert Webb of Robert Webb Associates, UK, for his design for PV panels as a ventilated rainscreen system over a lightweight stressed-skin timber construction. The judges admired the overall concept for the building and its consideration for environmental and passive solar issues in addition to electrical generation. Careful consideration had been given to the manner in which the different energy systems interact. While not being a category winner this entry had a holistic approach spanning a number of categories.

3.3.8 Commercial products

A range of specially designed BIPV products are now beginning to be available in some countries [Munro, Ruyssevelt & Knight, 2000]. These include:

- PV roof tile products, which can be readily integrated with conventional tiles.
- PV module support structures for both sloping and flat roofs, which are easy to install on new or existing roofs and onto which a range of PV modules can be attached.
- Total integrated roofing systems for sloping or flat roofs, incorporating supports and modules.
- Transparent and semi-transparent PV products for use in façades, windows and skylights.
- Fixed and tracking PV shades for awning and window shading.

There is an awareness of the need for the BIPV products to be seen as environmentally benign, with an emphasis on low energy and recycled materials. There is also a growing interest in purpose built multi-function building elements, providing daylighting, passive heating, insulation or other benefits. Combined systems offer architectural and aesthetic benefits and should allow for lower overall costs by avoiding duplication of collector area and support structures. Of particular interest are photovoltaic/thermal collectors (PV/T), which combine electricity production with water or space heating. Several are now available commercially. Extraction of the heat behind crystalline silicon PV modules has the added benefit of reducing module operating temperature, and hence improving efficiency. However, optimizing thermal and electrical output requires careful design.

In the United States, the PV:BONUS (Building Opportunities in the U.S. for Photovoltaics) programme, supported by the US Department of Energy aims to develop technologies and to foster business arrangements that cost-effectively integrate photovoltaics or hybrid products into buildings. Cost-effectiveness of the products developed is achieved through design, integration (i.e., components, system, or building integration), dedicated end-use applications, and technology bundling (e.g., PV/thermal hybrids) Hayter [1999]. The Department of Energy is interested in products that can replace commercial building products and can be installed without the need for specialized training. The ultimate goal of the PV:BONUS programme is market demonstrations of commercially viable products that lead to manufacturer commitments to pursue production and sales. Building designers are in general extremely interested in using the new products, especially when they are easy to integrate into the building envelope and/or with building systems. The partnerships developed between DOE, private industries and public institutions ensure that buildings-related issues are addressed, thus increasing the likelihood of success for all emerging BIPV products. With the building sector using one third of all energy and two thirds of all electricity produced in the US each year [ibid], the market for BIPV is significant.

3.4 Values for Customers

The benefits offered by PV to utilities, architects and developers also flow on to customers. Improved thermal comfort and soundproofing, reduced energy demand charges and interesting building design features are all of importance to customers. In addition, customer surveys around the world increasingly show an interest in the impacts of energy systems on the environment and on quality of life. Some customers are also interested in increasing their own energy self-reliance, others in portraying a clean image. The perceived benefits of PV depend to some extent on the perspective from which it is viewed. For instance [Watt *et al*, 1999]:

- a building owner may be interested in offset building costs, enhanced property value and improved rental prospects, compared to the investment made;
- a building occupier may attribute value to visual appeal and green image, as well as to reduced power bills, increased self reliance and reliability of supply;
- to the community, the value may be determined by visual amenity, enhanced property values, local employment, reduced power outages or brown-outs, safety and reduced local and global pollution levels;
- for the nation, the value may be determined by employment creation, pollution reduction, energy self reliance and impacts on fossil fuel requirements.

Some of these values are based on perceptions or preferences which are difficult to define or quantify. However, they are a key component of energy system choice and are particularly important when introducing new technologies into the marketplace. For BIPV products, market analysis is even more difficult than it is for conventional power system products, as building values are far less tangible. Recent surveys in the Netherlands [Schoen, 1999] of customers living in houses with PV indicate that PV was not a factor in deciding to purchase the house. However, customers expressed support for PV use generally, an interest in receiving more information about PV and in receiving a direct benefit from their systems (the latter from residents where PV ownership and hence benefits rests with the utility). General environmental awareness and concern was a factor in customer decision making. However, customers indicated a clear preference for PV products which offer additional benefits, such as architectural or aesthetic features.

3.4.1 Electricity supply costs

For remote customers, the option of stand-alone PV based power systems may save considerable costs otherwise associated with grid extension or with fuel delivery for gas or diesel based power systems. Low maintenance requirements are also an important factor for remote locations. In Canada alone, there are an estimated 12,000 homes which could potentially use PV systems. In Australia there are similar numbers, as well as up to 60,000 off-grid holiday homes. Summer holiday homes are also a potentially large market in Scandinavia and Europe.

Studies in the U.S. [Herig *et al*, 1999] indicate that the breakeven cost (when lifetime customer benefits balance costs) for PV in 15 US States is now over USD 4 per Wp, and above USD 7 per Wp in five States, taking into account the various tax regimes and incentives on offer, plus environmental costs, interest rates and capacity factors. Current PV system prices are between USD 4.5 and 7.5 per Wp. Hence, the combination of values attributed to PV from the various market sectors – utility, state government, regional development, environment etc. – combine to provide a tangible financial value which makes PV a competitive option in many areas.

3.4.2 Non-intrusive qualities

Compared to almost all other electricity generators, PV is noiseless, produces no on-site emissions, is relatively maintenance free and can be installed in a wide range of locations. Combined with its modularity, these characteristics make PV attractive for household, community or urban use, particularly as a replacement for diesel or petrol generators, but increasingly as a non-intrusive supplement or replacement for grid power.

3.4.3 Image

For commercial customers especially, but also for residential customers, on-site PV generation creates a strong green and high-tech image. This makes PV attractive for use in corporate buildings, housing developments at the high end of the market and for any person or group wishing to demonstrate environmental credentials. The Ökotech building in Berlin uses an expensive PV glass and granite façade to add class to the building, as well as to demonstrate environmental credentials and reduce electricity purchases [Hagemann, 2000].

3.4.4 Energy independence

PV obviously offers the opportunity for increased or total energy self reliance. In addition, the use of distributed PV systems can conceivably mitigate the onset and/or the effect of power outages caused by high summer demand or severe weather [Perez *et al*, 1997; Perez, 1998]. Recent electricity shortages and price fluctuations in areas of the US have led to a significant increase in customers investing in PV and wind systems for total or partial electricity self-reliance. This emergency value of PV can begin to be gauged by premium reductions or incentives offered by insurance companies for improved power reliability [Perez *et al*, 1999]. The authors conservatively estimate this at 10% of the insurance premium, which translates to a value of around USD 440 per kWp for a small commercial building.

It should be noted that grid connection guidelines in many areas require the PV system to disconnect when grid power fails. This removes the emergency benefit for both the customer and the utility. After the Kobe earthquake, guidelines in Japan were changed to allow self-operation of photovoltaic power systems when the grid fails, with a manual inverter switch-over.

The value of PV for general energy independence and in emergency situations is increased when storage is included in the system. However, storage increases the system cost and complexity. Work is needed to assess the cost-benefits of different levels of storage required to influence PV values from the customer and the utility perspectives. Nevertheless, many commercial, institutional and industrial buildings already include battery storage uninterruptible power supply (UPS) systems for emergency power supply. Studies carried out at a Swiss bank building [Kröni, 2000] show that connection of the building's PV system to the UPS battery system can extend emergency power availability significantly over the summer months. Standby time was increased by 200% for 20 or more days in June and July and between 5 to 15 days in March, April, May and August. An 80 kWp building integrated photovoltaic power system currently being installed in a new commercial building in Brisbane, Australia, will provide added value by feeding its output through a UPS system which supports the building's computer equipment [Wren & Barram, 2000].

Transportable PV systems are increasingly being used for temporary power supply in emergency zones, for medical services, water purification and communications. Interest in this market for PV is evidenced by the running of workshops on the topic [www.fsec.ucf.edu/PVT/].

3.4.5 *Environmental merits*

Environmental awareness is increasing worldwide, with surveys in many countries consistently showing community support for increased use of renewable energy sources. In the US, green power programmes introduced after electricity industry restructuring have often been oversubscribed, with a significant portion of customers who changed retailer doing so for purchase of a green power product. In both Japan and Australia, government grants for BIPV systems have had to be modified following overwhelming customer demand. Customer surveys in Switzerland indicate that environmental, ecological and sustainability issues are a high priority, so that the type of electricity product purchased was very important [Nowak, 2000]. Non-nuclear options were important, as were the adoption of new technologies and associated employment. For customers already purchasing a solar product, the provider, the price and the type of promotion were of medium importance, but for non-subscribers price was the most important factor.

3.4.6 *Customer preferences*

Marketing of the first generation of houses with PV has, perhaps understandably, been undertaken in a low key way. In Australia, PV systems on houses in the Solar Village near the Sydney Olympic site were placed so as not to be generally visible. In the Netherlands, ownership of the PV system was retained by the utility in early PV estates in Amsterdam. For the next generation of BIPV product, it would seem that customers require attractive, multifunctional PV products and that marketers must provide substantially more information on all aspects of their systems, so that customers can appreciate all features. Nevertheless, there is a need to identify more clearly what customers are looking for and what would make PV more attractive to them. In tandem with this is a requirement for rapid improvements in the development of codes and standards, permit procedures, interconnection guidelines and liability insurance issues which would make it easier for customers interested in PV to go ahead with a purchase [Herig *et al*, 1999].

Marketing strategies used in Switzerland to promote solar photovoltaic electricity products have found it important to offer choice of product, a clear description of benefits, not merely kWh produced, and an initial annual subscription, with the opportunity for renewal [Nowak, 2000]. Regular communication on the product, as well as general environmental information was essential, both with existing and potential new customers, using a variety of media, including mailouts, the internet and site visits [ibid].

3.5 Benefits for the Environment

Environmental costs can begin to be valued by referring to the current costs of emissions control and the cost of environmental damage caused by SOx, NOx and CO_2. Studies in the U.S. indicate that emission control values lie in the range of USD 0.75 to 11 per tonne of SOx; USD 0.82 to 15 for NOx and USD 9 to 22 for CO_2 [Herig *et al*, 1999]. The US Department of Interior, National Park Service [Denver Service Center Guideline 82-1] uses much higher environmental costs in evaluating electricity sources: SOx - USD 1,650 per tonne, NOx - USD 7,480 per tonne and CO_2 – USD 8.8 per tonne.

Since PV systems generate few emissions over their life cycle, if they are used to displace electricity from high emission sources, a small component can be added to the total PV break-even costs [ibid]. Values up to USD 0.035 per kWh have been estimated

[Buchanan *et al*, 1991]. Perez *et al* [1999] use a value of USD 0.027 for their calculations of externality value for commercial building PV systems, but note that this does not include a value for fossil fuel resource depletion. On average over the US this adds USD 800 per kWp to the breakeven cost [ibid].

3.5.1 Sustainable development

Environmental goals need to be added to economic and social goals, to achieve the "triple bottom line" of sustainable development [Twinn, C, 2000]. Twinn illustrates the operation of the triple bottom line approach in a zero fossil fuel energy development (ZED) in Beddington, UK, where the use of PV is integrated with an overall aim of sustainability. The developers aimed to achieve an affordable product and a desirable lifestyle, at the same time as:

- reconciling density with amenity and creating a sense of community in urban areas
- tying new developments into the needs of existing communities
- coping with increasing numbers of single parent families
- using existing stocks of brownfield sites
- encouraging bio-diversity back into urban areas
- reducing water consumption and stopping pollution of rivers & streams
- building using materials with low environmental impact, maximum durability and yet allowing for eventual recycling
- minimizing embodied energy in construction
- reducing the volume of waste produced by a household
- maximizing renewable energy harvesting in urban areas
- reducing the need for travel to work and for food
- reducing fossil fuel powered car use, encouraging walking, cycling & public transport.

The ZED houses reduce energy requirements for heating and hot water by 75% and for private car use by 90% [ibid]. Reducing energy demand allowed the relative contribution which could be made by PV to be significant.

The Solar Office at Doxford, UK, is another example of integrated planning for sustainable development [Lloyd Jones, 2000]. Careful design has allowed conventional office activity to be undertaken with an energy requirement of 85 kWh per m^2 per year, compared with 400 kWh per m^2 used in a standard office block. A 73 kWp inclined, semi-transparent PV facade provides between one quarter and one third of electricity requirements, while providing light and heat to the atrium behind it.

The building designers had to make some compromises to optimize PV output and to achieve the low energy building aims of:

- Controllable cross ventilation
- Glare free daylighting and solar control through windows
- Minimum winter heat loss through the building envelope
- Knowledgeable and sensitive building controls and management.

The importance of holistic design is illustrated by the designers' use of a wind trough along the façade to use winds at the exposed building site to assist with ventilation and cooling behind the PV system. Heat from behind the PV system is used for space heating in winter and to assist air flow through the building in summer. Compared with an equivalent standard office building, the Solar Office cost GBP 940 per m^2 rather than GBP 750 per m^2, but will save GBP 55,000 per year in energy costs and 375.6 tonnes per year of CO2. The PV component comprised around 50% of the façade cost.

Environmental criteria are now used by the Asian Development Bank for energy project evaluations [Rao, 2000]. The likely project effects evaluated are those on:

- human health
- flora and fauna, especially due to habitat disturbance
- soils, buildings, art works,
- social assets, including visual pollution, climate change, recreational activities.

The process followed is to:

- Determine emissions and resource usage
- Assess the changes in environmental quality
- Estimate the impacts of environmental change
- Assess the value of the impacts, including changes in well-being
- Aggregate the changes across effects, individuals and time.

In Poland, the environmental benefits offered by renewables are evident by the use of environmental funds to develop renewable energy projects [Pietruszko, 2000]. New energy legislation requiring energy enterprises to purchase from renewable generators, combined with a requirement to license small generators is providing opportunities for PV. Funds are available from a variety of sources, including:

- Ecofund, the "foreign debt for environment swap", which has priorities of:
  - abatement of the emission of gases causing global climate changes,
  - limiting cross-border sulphur dioxide and nitrogen oxides transportation,
  - reduction of the Baltic Sea pollution,
  - Poland's biological diversity protection.
- The Environment Protection Bank, which provides up to 7 years of credit for renewable energy projects;
- The National Fund of Environment Protection and Water Supplies Management, which provides loans and subsidies for:
  - environmental education, pilot projects regarding the implementation of technological advancement and new technologies with high level of risk or of an experimental nature
  - special provision for local or municipal authorities, units connected with health care, social aid, education.
- The Fund for Thermomodernisation of existing buildings, which includes installation of RE technologies.

3.6 Educational Opportunities

An educated population and a skilled workforce are considered a high priority in both industrialized and developing countries. Personnel trained in new technology areas such as photovoltaics are in high demand worldwide. In many countries, solar energy topics are being added to curricula so as to raise the awareness and interest of pupils from an early age. The UN Food and Agriculture Organization [FAO, 2000] cites the need for training, information and education on PV installation, operation, maintenance and repair services for agricultural applications in developing countries, including information aimed at women.

Many schools, technical colleges and universities around the world are now beginning to offer renewable energy courses, often available on the web or by distance learning. The Sandia National Laboratories has begun a listing of PV courses available in the US [www.sandia.gov/pv/training.htm].

3.6.1 Demonstration and training sites

An example of a comprehensive educational activity is in the ancient town of Nitzana in Israel, an educational settlement where some 15,000 pupils are exposed to the various educational programmes during the year. A new programme is now underway, called "BE'IKVOT HA'SHEMESH", the Hebrew saying for "Following the Sun", which has two modes of activity: teaching a solar curriculum and building a solar demonstration park.

For the solar energy curriculum, pupils learn about solar energy, the science and technology behind its exploitation, its merits, and the prospects for its further use in Israel and abroad. During their course the pupils visit the Sede-Boqer campus where they watch ongoing experiments aimed at module assessments, long-term monitoring of solar irradiation quality and intensity, and see the newly installed 400 square meter solar concentrating dish. They visit the solarium, housing a library and students' accommodation, and meet the architects who design passive solar houses and desert adapted buildings.

At the 10,000 square meter Solar Demonstration Park, pupils and other visitors gain hands-on experience with solar technology through various solar energy systems and facilities, tools, and an exhibition of balance of system equipment. Product manufacturers and suppliers anticipate an increase in orders coming from the solar-aware public.

3.7 Summary of Added Values

Table 3.4 provides a summary of the values which can be attributed to PV systems.

Table 3.4: Summary of Non-Energy Benefits Which Can Add Value to PV Systems [IEA-PVPS, 2000/4]

Category	Potential Values
Electrical	KWh generated; kW capacity value; peak generation and load matching value; reduction in demand for utility electricity; power in times of emergency; grid support for rural lines; reduced transmission and distribution losses; improved grid reliability and resilience; voltage control; smoothing load fluctuations; filtering harmonics and reactive power compensation.
Environmental	Significant net energy generator over its lifetime; reduced air emissions of particulates, heavy metals, CO_2, NO_x, SO_x - resulting in lower greenhouse gases, reduced acid rain and lower smog levels; reduced power station land and water use; reduced impact of urban development; reduced tree clearing for fuel; reduced nuclear safety risks
Architectural	Substitute building component; multi-function potential for insulation, water proofing, fire protection, wind protection, acoustic control, daylighting, shading,

	thermal collection and dissipation; aesthetic appeal through colour, transparency, non-reflective surfaces; reduced embodied energy of the building; reflection of electromagnetic waves; reduced building maintenance and roof replacements.
Socio-Economic	New industries, products and markets; local employment for installation and servicing; local choice, resource use and control; potential for solar breeders; short construction lead-times; modularity improves demand matching; resource diversification; reduced fuel imports; reduced price volatility; deferment of large capital outlays for central generating plant or transmission and distribution line upgrades; urban renewal; rural development; lower externalities (environmental impact, social dislocation, infrastructure requirements) than fossil fuels and nuclear; reduced fuel transport costs and pollution from fossil fuel use in rural areas; reduced risk of nuclear accidents; symbol for sustainable development and associated education; potential for international cooperation, collaboration and long-term aid to developing countries.

4. Key Barriers to the Implementation of Photovoltaic Power Systems

The main barriers facing the PV industry in increasing its market share, are summarized below under the general headings of cost, electricity industry and information issues. It should be noted that the barriers cited do not apply uniformly in all countries. The IEA-PVPS Task 7 has also prepared a report specifically on non-technical barriers to PV use in buildings [IEA-PVPS, 1999].

4.1 Cost and Price Issues

4.1.1 High capital cost/low operating costs

PV is a cost effective alternative to fossil fuels for many off-grid power supply applications. Nevertheless, compared to supply based on fuels such as diesel, kerosene or petrol, PV systems still suffer a disadvantage when seeking finance because of the relatively high initial capital costs, project development costs and transaction costs [Rao, 2000]. Hence, even though running costs are much lower, PV purchasers must pay significant up front costs, which typically require third party financing. In addition, it may be difficult to guarantee cash flows and financing agencies may view renewables projects as having limited marketability compared to conventional power projects [ibid]. In developing countries particularly, credit facilities for individuals are either non-existent or unregulated and customers are faced with significant financial risks. Even in developed countries it is not necessarily straightforward for individuals or companies to raise finance for independent power supply systems. In recent years, the Grameen Bank has provided useful finance in developing countries, while the advent of "Green Mortgages" [US DoE, 1999] and the interest of some utilities in supplying off-grid power [IEA-PVPS, 1998] may assist purchasers in developed countries. The Solar Bank [www.solarbank.com] (Figure 4.1) illustrates the impact of financing, compared with system efficiency improvements and cost reductions. Providing appropriate financing is therefore a critical component of successful PV marketing.

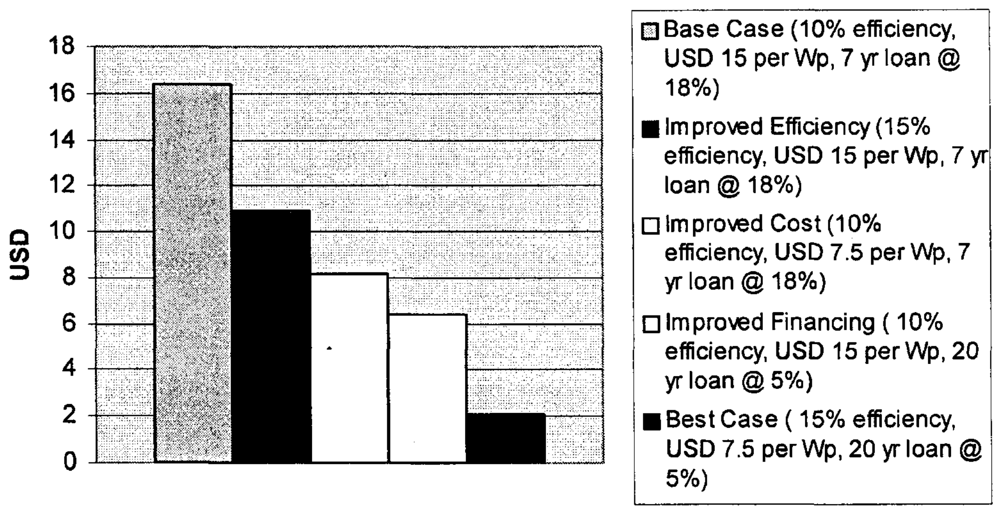

Figure 4.1: The impacts on monthly repayments for 50Wp household PV systems of improvements in system efficiency, capital cost and financing arrangements [www.solarbank.com].

4.1.2 Difficulties with project assessment

Straightforward and consistent procedures for assessing the financial viability of BIPV systems will assist architects and project developers to market the technology. Following from a survey of US architects, where project assessments were found to be difficult, Eiffert [2000] recommends the following approach:

- **Net benefits or life-cycle cost methods** – for designing and sizing BIPV systems. When net benefits increase and life-cycle costs decrease as system size or cost increases, the larger or more expensive system can be chosen. Savings – to – investment and adjusted rate of return methods are also suitable, provided incremental costs only are assessed.
- **Savings – to – investment ratio and adjusted internal rate of return methods** – for ranking investment alternatives. Best returns will result from choosing projects in descending order. Overall optimization can be achieved by combining assessments of design and cost with ranking methods.

In addition to the method of assessment, the relevant perspective of the building owner to future energy costs and to availability and cost of capital is important. As a guide, Eiffert [ibid] recommends defining a project as cost effective when the savings – to – cost ratio is greater than one; when the annual internal rate of return is greater than the discount rate; when the sum of all time adjusted costs over the required time period is lower than for competing energy systems; or when the simple payback period is less than the life of the PV system.

Of course, in making investment decisions, the direct energy savings, the indirect energy system benefits, as well as the non-energy benefits of PV systems, must be included in the analyses wherever possible. Awerbuch [2000] suggests the use of capital asset pricing models (CAPM), rather than engineering economic models for PV system assessment, as a means of including the values of risk reduction associated with known (up-front) costs, low operating costs, reliability and technical flexibility.

The International Performance Measurement & Verification Protocol (IPMVP) offers standardized procedures for project development and financial evaluation, which can assist in reducing up-front project establishment costs (www.ipmvp.org/). The IPMVP is a document which discusses procedures that, when implemented, allow owners, energy service companies (ESCOs), and financiers of energy projects to quantify energy conservation measures performance and energy savings. The IPMVP provides an overview of current best practice techniques available for verifying savings from both traditionally- and third-party-financed energy and water efficiency projects. The purpose of the IPMVP is to reduce major barriers to the expansion of the energy and water efficiency industries by helping to:

- Increase certainty, reliability and level of savings;
- Reduce transaction costs by providing an international, industry consensus approach and methodologies;
- Reduce financing costs by providing project measurement and verification standardization, thereby allowing project bundling and pooled project financing;
- Provide a basis for demonstrating emission reduction and delivering enhanced environmental quality;

- Provide a basis for negotiating the contractual terms which ensure that an energy project achieves or exceeds its goals of saving money and improving the building's operating environment.

4.1.3 Protracted approvals and installation procedures

Lack of familiarity with PV and with coordination of the PV installation with the building process, non-standard components and systems, as well as generic rather than buildings application specific PV products increases these costs for PV systems at present. The latter also contribute to poor or incorrect installation which can increase long-term maintenance costs. With limited long-term field experience, there is in any case little general knowledge regarding the likely system maintenance costs. Nevertheless some provision for maintenance, as well as an estimate of cost must be included in the economic analysis of a system.

With electricity utilities still uncertain about PV and about distributed generation more generally, procedures and costs for grid interconnection can be lengthy and high. They can include interconnection fees, metering calibration charges, engineering design and study fees, liability insurance, property easements, legal indemnities, monitoring and additional protection equipment. While these costs may represent a very small component of the overall cost of a large central generating plant, for small systems they can result in the project becoming non-viable. These issues are discussed further in Section 4.2, but point to the need for standardized procedures and interconnect guidelines. From the building side, another set of permits and fees can apply, which add further to system costs. These can include construction permits, electrical permits, and inspection fees. Again, lack of familiarity with BIPV often results in lengthy delays and high costs.

Uncertainty about procedures and requirements also impacts on ownership and responsibility and liability, which in turn impacts on legal costs and access to finance. Standard procedures, power supply agreements and maintenance contracts would reduce this uncertainty.

4.1.4 Low system efficiencies

Typical efficiencies for commercially available power system modules based on crystalline silicon are now around 12-15%, while for thin film products the range is 5-10%. Concentrator systems can have efficiencies up to 35%, but their use is more restricted. R&D continues on improving efficiencies by a range of methods, including reducing reflection and internal cell losses, using layers of different semi-conductors to capture a wider spectral range and incorporating reflectors, concentrators and ventilators into PV systems. Nevertheless, when losses through balance of systems components are included, especially non-optimal inverter operation, wiring and battery losses, many systems operate at relatively low efficiency. In addition, shading, PV module mismatches, accumulation of dirt or snow and non-optimal orientation also cause systems to operate at lower efficiencies.

The impact of improved efficiency on the customer price of PV electricity is illustrated in Figure 4.1. For each kWp of system capacity, a higher PV system efficiency reduces the surface area required, thus reducing both the material requirements for the PV cell, as well as for the module and the balance of system components, such as wiring. Hence, at module efficiencies of 20%, a target price of 0.2 USD per kWh and 1 000 USD per kWp can be achieved at area related system costs of 200 USD per m^2, but costs would need to be as low as 50 USD per m^2 if the efficiency is 5% [Kiess, 1997]. Based on material costs, a realistic lower limit to the area related cost of modules is around USD 100 per m^2, so that efficiency improvements remain an important component of cost reduction [ibid].

4.1.5 High production costs

PV prices have dropped consistently over the past 30 years, with an 18% price reduction for each doubling of sales [IEA-PVPS, 2000/2] and PV electricity can now be generated at less than USD 0.6 per kWh, which is cost competitive in many off-grid applications. However, it remains higher than central grid supplies. Hence, PV is locked in a critical "chicken-and-egg" situation between price and economy of volume. The prices are too high to generate a substantial market and a market is needed to generate economy of scale [IEA-PVPS, 1999].

While financing is important, PV system costs must continue to fall, if PV is to enter mainstream electricity markets. Cost reductions will depend largely on research and innovation, increased markets and production levels and increased experience with system design & installation.

Production cost for PV cells and systems are dictated by the technology and materials used, as well as by the production process. Over 80% of PV production is currently based on crystalline silicon cells, using silicon wafers of around 350 microns thickness. These wafers remain the most significant cost component of the PV cell. In addition, much of the existing PV capacity around the world is based on relatively small plant (5-20 MW), with low levels of automation. Hence there are opportunities for cost reductions by reducing wafer thickness, removing the wafer stage and ultimately moving to thin films (< 50 microns) of semi-conductor material, by increasing the scale of production and, for production in developed countries, by increasing automation. Studies by Bruton *et al*, 1997, found that it was feasible for the production lines of crystalline silicon cells to be scaled up to 500 MW per annum and that production costs would be reduced to below USD 1.25 per Wp. Similarly, for thin films [Woodcock *et al*, 1997] this cost could be reached at production levels of 60 MW per annum. It is difficult to generalize current costs of production, due to the different technologies, plant ages and financing arrangements, however current PV module prices have been quoted as averaging USD 6.25-6.5 per Wp for crystalline product and USD 5.5 for amorphous silicon [IEA-PVPS, 2000/3]. Long-term or bulk purchases (say 20 to 100kWp), combined with government or utility subsidies, can achieve prices of USD 3 per Wp.

Even though PV module costs have been decreasing consistently over the past 3 decades, total system costs have not necessarily fallen at the same rate. These "balance of system" or BOS costs can include construction and grid interconnect permits, system design, mounting frames, inverters, batteries, wiring, lightning protection, labour and transport for installation and on-going maintenance costs. They typically account for 50% or more of the total system cost, but can be less than 50% for grid-connected systems, if products and procedures are streamlined.

4.1.6 Lack of integrated PV systems and products

Most PV systems are still designed individually and constructed on site. This means there is a limit to the cost reductions possible through standardized systems and specifically designed products. The first generation of building integrated PV systems has relied on conventional PV modules and used a variety of support structures to facilitate installation onto the building. For the end user, however, innovative PV products, designed to replace standard building components and to meet specific building needs are required. To open up potentially large new PV markets, products must improve on current performance, reduce installation costs and be both attractive and desirable. Hence innovation is needed at several stages: PV cell development and production, module design and production, system design and integration and end-use marketing.

4.1.7 Poor service delivery

The PV market is developing rapidly, with the demand for product overtaking the available pool of trained system designers and installers. In addition, for the non-utility market in particular, there is a severe lack of basic infrastructure, such as supplier networks and maintenance facilities, as well as the support structures such as regulations and standards which would ensure industry credibility and build customer confidence [IEA-PVPS, 1999]. Hence a significant problem for PV is to increase sales without sacrificing the quality of products, installation and back-up. Many of the field problems reported for PV systems are associated with a failure in service delivery, rather than intrinsic technical problems [Lloyd *et al*,2000, Fraunhofer Institute, 1997]. Adequate service delivery would include:

- appropriate customer advice at the outset concerning the cost, the likely performance and the maintenance requirements of a system;
- proper design, component and material selection to ensure customer needs are met and that problems such as corroding connectors are avoided;
- correct installation to avoid shading, maximize PV output at the required time and facilitate ready access for maintenance;
- customer education on basic system operation and maintenance;
- service back-up for general inquiries, routine and emergency maintenance and spare parts.

4.2 Electricity Industry Issues

4.2.1 Impacts of industry restructuring

Many countries are now restructuring their electricity industries, usually with the stated objectives of introducing competition into the market and allowing greater customer choice, although there are often other objectives as well, such as obtaining government revenue through privatization and achieving changes in conditions of employment. For developing countries, energy sector restructuring can play a key role in alleviating poverty and improving health and education outcomes, particularly for the rural sector, where current energy supply systems have not proven to be effective. Restructuring can be used to introduce much needed regulatory reform, including environmental regulations. It can also allow competitive markets, and perhaps private investment, to improve local participation in decision making and in finding more cost effective and appropriate options for energy supply. PV can play a key role in these markets.

The process of electricity industry restructuring, the introduction of competitive markets and the redefinition of roles and business aims which are often associated with them, cause a high degree of upheaval. In this context, the maintenance or development of initiatives to promote PV and other renewables can easily be overlooked. In addition, some previously successful programmes may no longer be appropriate in the regulatory environment of a competitive market, while changes to expert departments, or the re-allocation of responsibilities which accompanies restructuring, often has a deleterious impact on renewable energy development [IEA-PVPS, 1998]. In addition, when associated with privatization of assets, environmental legislation, such as the imposition of targets or least cost planning mechanisms may be considered by governments to reduce the market value of these assets. Thus a conflict in political objectives may arise.

At least in the early period following the introduction of competition, offering lower electricity prices is regarded by electricity retailers as the key strategy in achieving increased market share. This has been most notable where there is an excess of supply capacity. In the longer-term, however, electricity prices which are too low lead to under-investment in new capacity and hence problems in peak periods. This has been most evident in the US over recent summers. Distributed generation technologies, such as photovoltaics, are recognized as offering a solution [US DoE, 2000], are quick to deploy and are well suited to summer peaking loads. Nevertheless, it is too early to see whether the electricity industry is confident enough in the new technologies to include them in their planning processes or to undertake extensive deployment [California Energy Commission, 2000].

4.2.2 Low conventional electricity prices

As an example of relative prices, solar photovoltaic electricity prices in the US can be as low as USD 0.13 per kWh, with long-term contracts and subsidies [IEA-PVPS, 2000/3]. However, USD 0.25 to 0.30 per kWh for grid-connected photovoltaic power systems and USD 0.5 to 0.75 for stand-alone systems are the more typical situations, while conventional grid electricity prices average USD 0.08 to 0.12 per kWh [ibid]. The high prices of PV electricity are caused by the relative immaturity of the industry and its products, and hence the volume of production, as discussed previously. However, the difference between PV and conventional electricity prices is increased by the large price decreases which have accompanied energy sector restructuring in many countries (although retail electricity prices can also increase dramatically as has occurred in California), as well as an inability to access cross subsidies which are available to the established energy industry. Falling energy prices have kept renewables from becoming cost competitive over the last 2 decades, even though most technologies have met or exceeded projected cost reduction targets [McVeigh *et al*, 1999].

4.2.3 Network price issues

Few developing countries have introduced transparency or competition into their energy markets. An estimated US $100 billion per year is spent on fossil fuel subsidies and monopoly industries are protected, yet only a relatively small portion of the population receives the benefits of adequate energy supply [World Bank, 2000]. However, even in industrialized countries where the electricity industry has been restructured, the market does not yet provide a 'level playing field' with respect to renewable energy.

To illustrate the extent of the cross subsidies provided via uniform tariff regulations, it has been estimated that potential revenue losses from rural residents in the State of Victoria, Australia amount to AUD 30 million per year. This works as an effective barrier to the use of PV or other renewables by artificially maintaining low electricity prices and by removing any locational price signals from the network.

Network costs can account for 50% of a customers' electricity bill, yet renewables are rarely considered as an option which might delay or eliminate the need for conventional line upgrading or extension. In addition, network prices are highly averaged and the values of distributing ancillary services have yet to be recognized. Ancillary services are resources used to maintain quality of supply, in particular voltage, frequency and waveform purity. The present arrangements for ancillary services in many electricity markets focus on large participants, and distributed options for ancillary services do not yet receive equal consideration. Arrangements for ancillary services are important for PV because investment decisions in network augmentation are often taken on the basis of quality of supply considerations. Excessive investment in network capacity can result when distributed ancillary service options, such as PV, are not given appropriate consideration. At present, pricing arrangements tend to favour incumbent large generators [Australian Cogeneration Association, 2000], with PV and other distributed generators facing problems caused by:

- Transmission cost savings resulting from the operation of a distributed generator not able to be captured by the generator. This puts the distributed generator at a competitive cost disadvantage compared with distant generators.
- Highly averaged distribution loss factors that do not reward distributed generators for the losses they save by producing power that is consumed locally. In addition, there are often restrictions placed on how distributed generators can sell their power.
- Inefficient maximum demand charges that do not reflect the actual time of maximum demand, which penalize electricity customers who self-generate.

4.2.4 Network access issues

As previously vertically integrated utilities are split up into functional units, network costs should become more transparent and provide an incentive to examine the cost-benefits of distributed generation, as an alternative to grid augmentation or extension, particularly if decision making is decentralized. However, one of the unresolved aspects of electricity industry restructuring is the extent to which the so-called 'wires businesses' of transmission and distribution can be made contestable, either by other wires businesses or by distributed resources. The experience in countries such as Australia and in sections of the US, where the formal monopoly on wires business has been removed, but not the regulated franchises, is that network prices are still not fully cost-reflective or are highly averaged and are therefore in reality not providing a powerful driver. This has created a number of additional barriers for PV to overcome, which are included in the following list of general barriers that have been identified for all distributed resources [Australian Cogeneration Association, 2000]:

- Without access to planning, load and network constraint information, it is extremely difficult for distributed generation proponents to negotiate efficient connection agreements. It is also extremely difficult for proponents of demand side management and local generation to develop competing proposals to network augmentation.
- Information for new market entrants, including distributed generators, which outlines their rights and obligations when connecting to the network and the options available to them is not easily accessible.
- Market registration provisions are restrictive and participation fees are excessive for smaller generators.
- Costs charged by the network provider for project definition, design approval, site supervision, facility commissioning and connection works for distributed generators can be made prohibitively high.
- The lack of information and effective negotiation frameworks has led to delays and frustration for parties negotiating connection agreements. When a contract has been

negotiated, the supplier of distributed generation has faced higher costs and greater risks than necessary.

- New generators are required to meet more onerous technical standards than existing generators.
- Distributed generators are sometimes expected to pay for deep (firm access) transmission augmentation while transmission connected generators are not.
- The lack of effective separation of electricity network and retail businesses can compound the problems while providing less scope to share the benefits with the retailer and thus makes contracting with distributed generators less attractive to other retailers.

Chivelet [2000] cites many of the above as barriers to PV use in Spain and adds problems due to lack of coordination between government agencies, rigidity in applying subsidies, lack of legislation, regulations and standards for components, installation, grid connection and building integration and limited local government involvement.

Specific regulations covering grid access for distributed PV systems have recently been introduced in the US States of California, Texas and New York, while the interconnection regulations recently introduced in Spain remove legal barriers [Chivelet, 2000], and are important steps in removing access barriers to PV and other distributed resources.

4.2.5 Environmental externalities

Although there has been some progress in industrialized nations, usually via legislation, towards reducing the direct environmental costs associated with fossil fuel use, such as sulphur dioxide, particulates and nitrous oxide emissions, in general environmental costs and benefits are not taken into account by energy market participants and regulators. Hence, the costs of environmental damage caused by fossil fuels and nuclear energy are borne by the community generally and are not reflected in the costs of energy services based on those sources. Until recently, the environmental impacts discussed have been those noticeable at the local or regional level. However, as the evidence increases that global warming is being caused by fossil fuel use, worldwide environmental impacts are beginning to be considered. With no inclusion of these costs in energy markets and decision making, low emission and low environmental impact energy options, such as PV, are not able to be appropriately valued. Clear annunciation of policy aims to support the transition to sustainable energy systems would provide confidence for investors. It would also facilitate the introduction of supportive regulations, such as solar access provisions, which in turn would provide customer confidence in the long-term viability of PV systems.

In addition, electricity customers are poorly informed with regard to the environmental impact or carbon intensity of electricity supply so that, even where choice of electricity retailer is available, customers are not able to make informed decisions about their energy supply, nor to influence government or energy industry planning processes. Provision of information to customers is a prerequisite for an efficiently working market. Utility disclosure to customers of the fuel mixes used to generate electricity is a means of increasing the efficiency of competitive markets. In addition to electricity sources, disclosure of greenhouse emissions and other environmental indices would provide important information in enabling consumer choice.

4.3 Lack of Information, Market Knowledge and Training

The final, but often the most critical barrier to PV at present is a general lack of awareness and information on what is available or where to source it. Access to customers, to the grid, to energy planning information and to investment capital is also more difficult for PV than it is for established fossil fuel industries. There is a widespread misuse of "commercial–in–confidence" provisions within the newly corporatized energy industries, as a means of restricting information on the electricity system which was previously in the public domain. Access to information such as solar energy resource data, network loads, maintenance costs and upgrading plans would save considerable lead time and expense to PV system proponents. For building integrated systems, a US survey of architects indicates that assembling and presenting technical and financial analyses to clients is a major barrier to implementation [Eiffert, 2000]. Some of these issues overlap with barriers cited previously. Others are discussed below.

4.3.1 Lack of certification, standards and guarantees

Some countries have recently introduced guidelines and standards for grid interconnection of PV systems (for instance the IEEE "interconnection standard for utility-intertied photovoltaic systems", IEEE Std 929-2000, the Australian "guidelines for grid connection of energy systems via inverters" and the UK's Engineering Recommendation G77 2000 – "Connection of photovoltaic generation to the distribution network – single phase PV systems up to 5kVA"), while PV modules can be rated against accepted performance standards. Nevertheless, to date there has been a severe lack of basic industry support structures such as regulations and installation standards which would ensure industry credibility, reduce costs and build customer confidence. A lack of standards can result in over engineering, low installer confidence, extensive one-off site testing, commissioning of dangerous technology and hence significant cost increases, eroded user confidence and unreliable systems, prone to failure [Spooner, 2000].

However, with such a rapidly growing industry sector and such a wide range of disciplines involved, the development of PV system standards is difficult and time consuming [ibid]. In addition, for grid-connected systems, connection of large numbers of small distributed generation systems into a network designed for a few large scale central generating plants poses new technical and institutional problems. The priority area for standards development is safety – for the dc wiring and the grid interface [ibid]. Nevertheless, standards for building integration and other aspects of system design and operation are also needed [Chevelet, 2000].

Warranties can provide some level of confidence for the customer, and most PV manufacturers offer module warranties of 10 to 25 years. However, the range of possible applications limit their effectiveness, unless total system warranties can also be given. Other than module over-rating, few of the faults found in the German "1000 Rooftop Programme" were attributable to PV module defects. Most were caused by inverters, unsuitable wiring, fuses or switches, or installation faults, while significant system losses were also caused by shading and soiling of the panels [Laukamp et al, 2000]. Hence testing and certification of components used in PV systems is required, as is certification of system installers.

While standards will undoubtedly assist the implementation of PV, it is important to remember that that this is a new and rapidly evolving industry and that stringent standards could stifle innovation and technology development. Hence for some issues, it may be appropriate to develop and use a series of guidelines, which can be readily updated, before progressing to formal standards. The IEA-PVPS Task 5 has summarized grid interconnection guidelines and standards applying around the world [IEA-PVPS Task 5-2-01, 1997].

4.3.2 Lack of expertise and demonstrations

With such a rapidly growing industry and one developing from such a small and technically specialized base, it is not surprising that it has been difficult to keep up with training requirements at all levels from manufacturing through system design, installation and maintenance. When ranked against all factors considered important in the success of PV system introduction [Groenendaal et al, 2000], the status of specialist knowledge was lowest in all areas. Lack of expertise is an important component of reliable and cost effective system design, with poor installation practices and inadequate training for ongoing system maintenance being routinely cited as reasons for system breakdown or poor performance.

The availability of and access to a variety of installed systems is an important element of education and training. Worldwide there are fine examples of building integrated PV, sometimes with actual costs and monitored performance data available. However, for most individuals, architects or developers potentially interested in using PV in a building, there are few local examples to view. Even where they exist, systems installed by utilities or private companies are not always accessible, nor are costs or performance published. Before BIPV can become accepted and desirable for clients, there must be a range of accessible demonstration systems available which illustrate different applications, styles and possibilities.

Demonstration systems are also required in developing countries, especially for promotion of PV use in agricultural applications and cottage industries [FAO, 2000]. Demonstration projects should include all stakeholders and results should be made public [ibid].

4.4 Summary of Key Barriers

In summary the key barriers facing the increased use of photovoltaic power systems include:

- High production costs and electricity prices relative to conventional energy sources
- Lack of familiarity with and procedures for financial analyses, compounded by limited financing options
- Lack of procedures for project assessment, approvals and installation, leading to delays and higher costs
- Lack of standard designs and optimized PV products and systems
- Poor back-up service delivery in many areas
- Restructuring in the electricity industry, with impacts on PV programmes, electricity prices and network access
- Lack of consideration of environmental externalities in the energy sector
- Lack of long-term energy policy guidelines regarding the transition to sustainable options, which would provide confidence for investors
- Lack of information for customers and investors
- Lack of standards, training and certification.

5. Overcoming Barriers to the Implementation of Photovoltaic Power Systems

Energy markets are still heavily biased towards centralized supply and existing participants. In order to achieve a level playing field for PV and other distributed resources, there must be co-ordination of energy industry, greenhouse gas and renewables policies and more proactive stances on least cost planning and the availability of system information. Industry policies, taxation, pollution standards and other measures may need to be rewritten to ensure that they do not favour fossil fuels or nuclear options, while market regulations must be seen to avoid discrimination against distributed, small scale or variable resources.

Documentation and quantification of non-energy values of PV can be used to overcome the barriers facing its use in the built environment. The responsibilities for action fall to different spheres of government, utilities, PV manufacturers and the building industry and can be categorized under the general headings of gaining market access, reducing prices, improving technology and increasing market acceptance through information and education. Many of these actions apply to renewable energy deployment generally, some are specific to PV, others to BIPV. They could therefore be useful to groups such as the G8 Renewable Energy Taskforce, government policy advisors, the UN Food and Agriculture Organisation, as well as to the PV and electricity industries.

IEA-PVPS Task 7 is carrying out a detailed evaluation of the market potential, the barriers affecting implementation and the strategies to remove these barriers for photovoltaic power systems in the built environment. An IEA-PVPS Executive Summary report on non-technical barriers incorporating this work will be published in the near future. Following is an introduction to the problem of overcoming the barriers to the implementation of photovoltaic power systems more generally.

5.1 Market Access

The Australian Cogeneration Association [2000] summarized some of the actions it considers are required in order to deliver a level playing field for PV and other distributed generation options. These include providing fair network access and connection arrangements, fair transmission access contributions and ensuring disclosure of planning information by distribution network businesses. Cost reflective network pricing and fair demand charges would also allow the benefits of distributed PV generation to be rewarded, while incorporating environmental sustainability into the objectives of electricity markets and making it mandatory to disclose greenhouse intensity on customer accounts would reward more environmentally sustainable electricity supply options.

For building integrated PV specifically, at least for systems up to a certain size, standard procedures and requirements must be developed for grid connection and incorporation into buildings. This will minimize the costs and time required for project evaluation and approval. These procedures and requirements must be transparent, so that the existing energy industry does not have an unfair market advantage.

Readily accessible databases of regional information should be developed which cover solar resources, nodal electricity prices, trends in load growth, plans for infrastructure developments, finance available and other market information. This will make the process of site selection, project feasibility studies and economic assessment much faster and more reliable, thereby reducing the costs and the risks for new projects. Further, the use of life cycle cost calculations must be encouraged in public sector energy decision making and reflected in funding allocations to capital expenditure and running costs. The use of capital asset pricing, rather than engineering economics models for project evaluation should also be examined, as a means of reflecting the added values of lower risk and flexibility in calculating project viability.

Supply chains need to be established which can provide information, prices and trained personnel for installation and maintenance of PV systems. Customers are used to having this level of support infrastructure for their energy services and without it they will not have the confidence to try new technologies. Industry credibility will also be enhanced by the availability of standards and regulations, although these need to be flexible enough to incorporate new developments.

5.2 Price

Price, particularly initial capital cost, is the most visible barrier to PV. Continued R&D on new technologies and production processes is necessary, including assessments of possible economies of scale in manufacture and use. Options for lower cost products should also be examined, even at some expense to efficiency, if this would enable a market to be developed.

The technologies currently available for the integration of PV into buildings are, in general, too expensive for large scale introduction. Cost reductions are thus still essential. They can be achieved by carefully redesigning the PV support structure, but also by integrating the PV system into known building components, by developing multi-function systems and by standardization and prefabrication so that economies of manufacturing volume can be reached and installation costs reduced.

Government and utility investment can be actively used to provide viable market sizes for PV, while options to pool their purchasing power to achieve cost reductions, which could be passed on to smaller users, should be examined. Governments should continue to examine the need for targeted long-term subsidies for market stimulation in particular areas or for particular products. Standard finance packages for certified systems can also assist purchasers.

Standard net metering guidelines should be available for small scale installations, up to an agreed percentage of electricity sales, to reduce up front costs and boost the economic viability of PV in the short-term. For larger systems, on-cost assistance and standard procedures for feasibility studies, project development and approval processes would lower up front costs and reduce risk.

Emission taxes on fossil fuels would ensure that their prices more correctly reflect true costs, hence reducing price differentials with PV. Regulatory processes can also be used to ensure transparent pricing of energy supplies, with clear indications of cross subsidies, to allow PV to be targeted to those areas where it is most cost effective.

5.3 Quality Enhancement

If PV is to become a well-accepted technology readily available for use by the energy sector, agricultural enterprises, architects, the building industry, property owners, villages and individuals, the total PV system and products must be customer friendly: well designed for the end-use, reasonably priced, reliable, aesthetically pleasing with innovative designs, non-intrusive, easy to install and maintain and demonstrably environmentally friendly.

For BIPV, integration concepts will have to meet regular building quality standards. This can be achieved by fully integrating the PV system into building materials and by integrating the construction process of BIPV systems into the building construction process. On the other hand, the physical characteristics of PV products for integration in buildings must meet architectural requirements of color, size and material type, which will sometimes require PV performance and hence economic compromises. This is a challenge for both the architect and the PV module manufacturer.

5.4 Market Acceptance

Market acceptance of PV is very low at present, despite a high level of community support for its development and use. Significant effort is needed to raise levels of awareness and credibility. Information on PV must be made readily available to the general public, for household applications and for trades, professions, investors, insurers and planning agencies for all applications. Certification procedures and standards must be developed to enhance credibility and performance. For BIPV, enhanced market acceptance would be assisted by a holistic approach to the design of the entire PV building, including overall energy efficiency and sustainability of building materials used.

Market acceptance by property developers, utilities, development and financing agencies is also required. Added values, other than avoided electricity costs, should be made clear to potential customers in these sectors. The operator of the PV system, the financing institution and, for BIPV, the owner of the building, must have long-term confidence in the performance of the PV system, both as an electricity source and, for BIPV, as a building material. For grid-connected systems, if the utility is not the owner of the PV system, long-term agreements for grid-interconnection and buyback tariffs are required. Similarly, standard procedures for project approval, contracts for maintenance and clear guidelines for responsibility and liability are needed to facilitate project development and to encourage investment in PV.

Customers are often surprised by the low level of renewables in existing electricity supplies and have generally been supportive of Green Power and other renewables support schemes when given the choice. Disclosure of fuel mix details on electricity accounts should be mandatory under competitive market electricity sector regulations, to facilitate customer choice. Nevertheless, there is a need for credible and independent information and advice which would allow customers to make informed choices.

Well documented and monitored demonstration of technical and non-technical aspects of PV projects is critically necessary – information on design, installation requirements and procedures, performance, costs or financing arrangements should be published for all publicly funded projects. In many countries, few such examples are available while misinformation on net energy requirements for PV and confusion with solar thermal systems persist. Government investment in and use of PV could provide the basis for demonstration systems, as well as to increase public knowledge and confidence.

Information on general field performance is also needed for all PV applications. Systematic monitoring and standardized reporting formats must be developed, as well as a coordinated system of user feedback. The latter would be particularly useful in the short-term as a means of ensuring that any scale up of production to meet demand growth has taken into account problems with existing systems.

The diversity of PV applications has made it difficult for the different industry groups involved to achieve market presence and to provide adequate product support. Until each sector reaches maturity, there would be benefits in forming partnerships between PV industries, governments, utilities and other industries or groups which can pool resources to provide information, component supplies and installation, operation and maintenance services. This has been successfully achieved in some countries.

The diversity of PV applications also provides for a diversity of opportunities. There is a need to develop a portfolio of products and applications, so that the long-term benefits of complementary use of a diverse mix can be realized. At the current stage of market development, successful implementation of any system has a positive impact on others. Conversely, projects or applications that are perceived as unsuccessful have a negative impact on all.

Generic policy initiatives, such as renewable energy targets or trading schemes will also assist. However, there is a danger that the allocations will be taken up by a few large projects. If the measures are aimed at the development of robust renewable energy industries, as well as greenhouse gas reduction, the regulations should encourage selection of a range of technologies, best suited to local conditions. In general, energy policies at all levels should begin to reflect the need for a transition to sustainable energy systems. This will provide the long-term signals necessary for investor and public confidence.

5.5 Education and Training

A range of educational programmes is necessary, as is targeted promotion and training for trades and decision makers. Education needs range from those aimed at increasing awareness of applications and costs to wider information on environmental impacts of energy use and the added values offered by PV. Such education should begin in schools and be followed through with more detail in trade and professional courses. Certification for designers and installers will improve system performance and cost-effectiveness and reduce the number of faulty or inappropriate installations. In the short-term, bridging or short courses may be needed to retrain practising trade and professional people in the agriculture, electricity and building industries on the characteristics, performance and requirements of PV systems.

For customer products, there is a need for community education generally and the availability of information, advice and trained system designers and installers. This information should be in a form readily understood by the customer. PV has a history of being treated as an electricity supply technology, so that current material is largely technical. Architects need material on PV system operation and use which is presented in a form they can understand and apply. Similarly, material for householders or community groups needs to allow ready understanding of the general concept and requirements, as well as comparison with other options.

Demonstration systems, illustrating a range of PV concepts, are needed for educational purposes, as well as for awareness raising and inspection by potential customers.

6. Summary and Conclusions

Many renewable energy and energy efficiency technologies meet the definition of "distributed resources", which can be strategically located within electricity distribution networks to reduce the need for external energy supplies, while also providing a range of electrical system, environmental, architectural and socio-economic benefits. Photovoltaics is unique amongst the new energy technologies for the wide range of energy and non-energy benefits which can be combined, while the use of PV as an integral part of a building provides the greatest opportunity for exploiting non-energy benefits and for adding value to the PV system.

PV installed on the surfaces of buildings, allows the possibility of combining energy production with other functions of the building envelope, including structural support, weatherproofing, shading or solar thermal collection. Cost savings through these combined functions can be substantial. Additionally, no high-value land is required, no separate support structure is necessary and electricity is generated at the point of use. The latter contributes directly to the building occupant's electricity requirements while also avoiding transmission and distribution losses and reducing capital and maintenance costs for utilities. The integration of PV into the architectural design offers more than cost benefits, however. It also allows the designer to create environmentally benign and energy efficient buildings, without sacrificing comfort, aesthetics or economy, and offers a new and versatile building material.

A number of projects around the world show an emerging market for grid-connected building integrated PV systems, despite the fact that electricity from PV is still more expensive than grid power. The market for grid-connected PV in IEA member countries is therefore growing rapidly and now accounts for more than 50% of installed capacity.

This report has shown that PV can contribute significantly to reductions in greenhouse gas emissions from the electricity sector: Lifetime CO_2 emissions with current PV technologies are 85 to 94% less than those from coal fired power stations and will be 95 to 97% less with new technologies. Solar powered manufacturing plants can operate as "solar breeders" ensuring a sustainable technology in the long-term.

PV can contribute to improvements in air quality. When PV displaces coal fired generation, NOx emissions are typically reduced by 50% and SOx emissions by 90%, making PV use a valuable adjunct to clean air policies. For improving urban air quality, PV can play a role in facilitating the introduction of electric vehicles, either by powering the vehicle directly or by providing power to recharging stations.

PV can assist in securing energy supplies in both the long-term and short-term. With fossil fuel resources expected to be depleted this century, PV provides a means of maintaining electricity supplies in industrialized countries and providing electricity to the developing world without concern for fuel supply security. Dispersed PV generators feeding into electricity distribution networks, or operating independently, can provide more reliable electricity supplies during power outages caused by summer peaks or emergency situations.

PV is a high technology industry which can create new jobs in manufacturing, distribution, installation and maintenance. Dispersed application means that employment is created in regional areas, as well as in industrial centres. Direct employment in the PV industry world-wide is expected to be between 250,000 and 300,000 by 2010.

The modularity of PV provides benefits to electricity utilities by allowing for generation to be expanded, or reduced, to match demand more easily than for large central generation plant. Lead-times are also shorter, exposure to fuel price volatility is reduced and grid augmentation can be avoided. Hence financial costs and risks are reduced. On-site or local generation also reduces transmission and distribution losses. Dispersed generation reduces the likelihood and impact of large scale outages while smoothing output fluctuations from individual systems. It can be especially valuable in dealing with summer peak loads, where the effective load carrying capacity can exceed 80% of the PV rated output.

For customers, PV offers a range of benefits which can significantly increase its value. These include providing aesthetically pleasing, non-intrusive, multi-function building elements, ensuring supply reliability, reducing energy and peak demand charges and contributing to environmental protection. For society as a whole, PV provides a means of delivering more sustainable energy systems for both rural and urban developments.

Nevertheless PV systems face a number of barriers to their entry into the mainstream energy and building markets. These include high capital costs and associated financing problems; immature products and service delivery chains; a lack of information, expertise, standards and demonstration systems; electricity industries that still favour the central generation paradigm; and electricity markets that do not yet account for environmental externalities. Some of these barriers can be overcome by assessing both the energy and non-energy benefits which can accrue from a PV system, thus making PV a cost effective option even with current costs and energy prices.

With the structure, ownership and operation of electricity supply industries changing rapidly around the world, the added values offered by PV ensure that it will be one of the most significant of the new energy technologies deployed over this century. However, to make the transition from existing to new and sustainable energy systems, work must be done to transform existing electricity systems from being reliant on central generation to systems which embrace the range of technologies and energy service delivery options offered by new, distributed resources. Governments and regulators must also ensure that energy markets account for environmental externalities in selecting network structures, technologies and energy sources and that citizens are well informed about the energy choices they make. The PV industry must continue its technology development by improving efficiencies, increasing production levels, reducing costs and providing reliable, easy to install and aesthetically pleasing products. Finally, a range of educational programmes is necessary, aimed at increasing the awareness and understanding of customers, planners, regulators, electricity industry personnel and the building industry. This needs to be complemented by targeted promotion and training for trades, professions and decision makers, as well as by a range of accessible demonstration systems in key market areas.

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第6章　ＮＳＲ　＆　ＩＳＲ

国際エネルギー機関

太陽光発電システムに関する協力プログラム

タスク1

太陽光発電システムに関する情報交換と普及

日本における太陽光発電応用に関する調査報告書

1999年

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1. 概要

日本は1990年以降太陽光発電（PV）システムの普及促進のために、研究開発、普及導入のための実証試験、本格的普及促進のための環境整備などの政策を積極的かつ着実に実行してきた。

1999年における重要な動向として次の事柄が挙げられる。太陽電池モジュールが建材として建設大臣の認定を取得した（4月）。新エネルギー技術戦略が通産省、資源エネルギー庁によって策定された（10月）。超党派国会議員による「自然エネルギー促進議員連盟」が発足した（11月）。総合エネルギー調査会に新エネルギー部会が創設された（12月）。

政府の政策の外、多くの地方自治体が住宅用太陽光発電システムを設置する住民に対する補助金制度、無利子融資制度などを導入している。また、「新エネルギー導入ビジョン」を既に策定した自治体の中には、所有する公共施設に太陽光発電システムを設置し始めた自治体もある。

主な国家計画の1999年度予算は次の通りである。

1) ニューサンシャイン計画（研究開発）：83.6億円
2) エネルギー使用合理化シリコン製造プロセス開発：10億円
3) 住宅用太陽光発電システム導入促進：160.4億円
4) 産業等用太陽光発電フィールドテスト事業：24.1億円
5) 新エネルギーの導入を行う事業者への助成制度：103.4億円
6) 地域新エネルギー等導入促進対策：67.6億円
7) 地域新エネルギービジョン等策定支援：12.4億円

ただし、5)、6)、7)項の予算にはPV以外の新エネルギーも含まれる。

日本における1999年のPVモジュール生産量は対前年比約60%増の約85MWを記録した。PVモジュールの生産量は3年連続で大幅に増大した。多くのPV製造企業は2000年以降の生産能力拡大を計画しているか、既に拡大に着手いている。

日本におけるPV市場は住宅用PVシステムの促進に関する強力な政策によって、年々拡大してきている。住宅メーカーの中にはPVを標準装備した住宅を商業ベースで販売しているメーカーもある。また、学生、生徒に環境問題に関心を持たせる目的の「エコスクール」事業及び「エコキャンパス」事業も拡大している。環境教育を通じた波及効果による将来の成果が大いに期待されている。

PVに対する一般の理解はPV普及導入に関する積極的及び強力な支援施策によって更に深まりつつある。

以上のような積極的かつ強力な政策、導入計画、普及促進のための環境整備計画等に支えられて、太陽電池の生産規模拡大、コスト低減などが進展しつつあり、PV システムの本格的普及の基盤が拡充されてきている。

1.1 太陽光発電導入普及策の推移

1990年 ① 電気事業法関係法令の改正によって500kW未満の太陽光発電システム設置手続きが簡略化される

1991年 ① 電気事業審議会が新エネルギーを中心とする分散型電源の導入推進と余剰電力買電を提案する

② 電力会社が1995年までに2,400kWのPV導入計画を発表する（実績:2,659kW）

1992年 ① 電力会社が販売価格でPV余剰電力を購入する買電制度が発足する

② 公共施設に対するPVフィールドテストが開始される

1993年 ① 逆潮流ありでの系統連系技術ガイドラインが策定される

② ニューサンシャイン計画が発足する

1994年 ① 住宅用太陽光発電システムモニター事業が着手される

② 「新エネルギー導入大綱」が閣議で決定される（PVシステム導入目標量を2000年に400MW、2010年に4,600MWに設定される）

1995年 ① 各省庁でPVシステム導入の検討が始まる

② 地方自治体が地域新エネルギービジョンの策定に着手する

1996年 ① 総合エネルギー調査会がPV市場自立化のためのエネルギー政策追加提案を発表する

② 通産省・経済構造計画「経済構造の変革と創造のためのプログラム」において、新エネルギー分野では太陽光発電産業育成が新規産業創出の対象として位置づけられる

1997年 ① 新エネルギー利用等の促進に関する特別措置法（新エネルギー導入促進法）が制定される

② 住宅用太陽光発電導入基盤整備事業が発足する

③ 新エネルギー導入事業者に対する助成制度が発足する

④ 地域による新エネルギー導入促進事業が発足する

1998年 ① 「長期エネルギー需給見通し」を改定（2010年における太陽光発電システムの導入目標量5,000MW）

② 「地球温暖化対策推進大綱」決定

③ 環境調和型エネルギー供給整備事業実施

④ 産業等用太陽光発電システムフィールドテスト事業スタート

⑤ 「地球温暖化対策推進法」制定

⑥ 「石油代替エネルギーの開発及び導入の促進に関する法律（代エネ法）」の指針を改定（太陽光発電を石油代替エネルギーの1つとして位置付け）

1999年 ① 総合エネルギー調査会に新エネルギー部会を創設

② 新エネルギー技術戦略を策定

③ 太陽電池モジュールが建材としての建設省大臣認定を取得

④ 住宅用太陽光発電導入基盤整備事業の申し込みで15,000件を突破

⑤ 超党派国会議員による「自然エネルギー促進議員連盟」の発足

1.2 太陽電池生産推移

日本における1999年のPVモジュール生産量は対前年比約60%増の約85MWを記録した。1998年のPVモジュール生産量は約53MWであった。PVモジュールの生産量は3年連続で大幅に増大した。生産量85MWは1995年の世界の生産量に匹敵する。1999年には日本は米国を抜いて、世界最大のPV生産国になった。これには住宅用太陽光発電導入基盤整備事業及び産業等用PVフィールドテスト事業がPV市場を先導するのに重要な役割を果たし、PV生産を増大する大きな原動力になっていると考えられる。

単結晶Si型太陽電池は1997年以来低迷し、1998年にはa-Si型に追い抜かれている。多結晶Si太陽電池は過去5年間市場を圧倒的に支配しており、日本の太陽電池市場の増大する需要に対応してきた。a-Si型太陽電池は民生用市場の飽和と新規応用製品市場開拓の遅れ等で1991年以降4年連続して減少していたが、1996年に市場回復の兆しが見えて落ち込みに歯止めがかかり、1997年からは電力用市場への対応が始まり、再び増大に転じている。a-Si型太陽電池の市場は年産10MWの規模に近くなっている。a-Si/sc-Si型を含む結晶Si型太陽電池は、政府の「住宅用太陽光発電導入基盤整備事業」や「産業等用PVフィールドテスト事業」による電力用市場の増大、また電力会社によるPV導入計画などに支えられて、量的に今後も大きく成長していくと予想される。

1.3 政府関係機関の動き

(1) 通産省

太陽光発電システム普及促進事業を強化し、従来事業の予算拡大と、新規事業の創設を図った。1999 年度の住宅用太陽光発電システム導入基盤整備事業予算は 1998 年度の 147 億円から 160.4 億円に増額された。PV 及びその他の新エネルギーを含む予算に関して次の事業では、新エネルギー事業者支援事業が 1998 年度の 53.9 億円から 103.4 億円に、地域における新エネルギー導入促進事業が 51.8 億円から 80 億円にそれぞれ増額された。地域における新エネルギー導入促進事業には地域新エネルギー等導入促進対策及び地域新エネルギービジョン等策定支援事業が含まれる。

新エネルギー技術戦略が通産省、資源エネルギー庁によって策定された。総合エネルギー調査会に新エネルギー部会が創設された。

(2) 建設省

道路空間への太陽光発電システムの導入を継続するとともに、「環境配慮型官庁施設（グリーン庁舎）計画指針」を策定し、「環境共生を目指すグリーン庁舎事業」によって庁舎に PV システムを設置している。また、太陽電池モジュールが建材として建設大臣の認定を取得した。

(3) 文部省

通産省と共同して進めてきたエコスクール整備推進パイロットモデル事業を継続し、新たに国立大学への太陽光発電システム導入を目的にエコキャンパス整備事業を計画した。

(4) 郵政省

1996 年度以来郵便局への太陽光発電システムの導入が継続されている。

(5) 運輸省

環境対策を重視した空港「エコエアポート構想」を発表し、成田国際空港施設に 120kW の太陽光発電システムを設置した。

(6) 総理府

新首相官邸建設計画で PV システムの導入を決定し、目下建設を進めている。

(7) 地方自治体

多くの市町村が通産省の地域新エネルギービジョン策定事業を利用して、新エネルギー導入計画を策定している。また、実際に地域新エネルギー導入促進事業や産業等用太陽光発電システムフィールドテスト事業を活用して、所有あるいは管理する公共施設への PV システム設置を計画している自治体もあり、既に実施している自治体もある。

また、多くの自治体が国の補助に更に上乗せ補助を行う制度を導入している。その他、上乗せ補助の代わりに、融資制度や利子補給制度または無利子融資制度を実施する地方自治体も多くなっている。

1.4 電力会社の動き

各電力会社は自社所有施設内に PV システムを設置する計画を継続して実施している。東京電力は太陽光発電の普及を促進するために、NPO を通じて住宅用 PV システム設置者に対して半額補助する助成金制度及び PV システムの研究開発を補助する目的で新たな助成金制度を継続している。1999 年には、東京電力に追従して、九州電力と中国電力が NPO、大学、研究機関などへの助成制度を導入した。

1998 年末時点で、10 電力会社と電源開発は累積で 272 基の PV システムを導入した。累積設置容量は 4,116kW である。

1.5 一般の PV に対する理解

積極的及び強力な PV 普及導入政策やプログラムによって PV に対する一般の理解は深まりつつある。例えば、住宅用太陽光発電導入基盤整備事業の場合、住宅用太陽光発電システム設置件数は年々増大している。1998 年度には 8,229 件の応募に対して 6,352 件が認可されたが、1999 年度は応募件数が 17,396 件に上った。

2. PV システムの設置

2.1 PV の適用

通産省支援による住宅用 PV システム、公共施設用 PV システム、産業用 PV システム、商業ビ

ル用 PV システムの導入量が拡大している。住宅用 PV システムは 1 軒当たり 3〜5kW を中心に年々増大している。住宅用 PV システム需要は、日本の全需要の 80%以上を占めている。公共施設用 PV システムは全体の 10%弱を占め、学校用、庁舎用、病院用、福祉施設用、公民館用が中心で 10kW〜50kW クラスのシステムが導入されている。産業用 PV システムは工場、倉庫、研究所用に 10kW〜100kW クラスのシステムが屋上や屋根に設置されている。商業ビル用 PV システムは本社ビル、営業所、事業所用に 10kW〜100kW クラスのシステムが屋上、屋根、外壁に設置されている。産業用 PV システム、商業ビル用 PV システム、その他産業施設への PV システムの導入量は、合わせて全体の約 5%である。このほか政府支援の必要のない通信用、道路・交通標識用、観測用、換気扇用、照明用などの独立電源システム分野に PV が利用されている。

2.2 PV システム設置導入量

表 1 に市場分野別の累積導入量を示す。日本の主要な市場は系統連系分散型市場である。非系統住宅用市場は、山小屋、僻地、離島用であるが市場規模は極めて小さい。非系統非住宅用市場は、街路灯、通信用電源、観測用電源、ポンプ、防災用、農業用、道路・交通標識用、換気扇用が中心で、コマーシャル・マーケットをすでに形成している。系統連系集中型市場は、これまで実証用に設置されてきたが、1995 年以来新規システムは設置されていない。系統連系分散型市場は個人住宅、公共施設、産業用施設、商業ビル用が中心で、通産省の支援により、毎年急拡大している。従って PV 市場の開発は 3〜5kW 規模の住宅用太陽光発電システムや 10〜100kW 規模の公共施設あるいは産業用施設、商業ビル用 PV システムが中心となっている。太陽電池メーカーだけでなく住宅メーカー、建材メーカー、ゼネコン、電源メーカーがこれらの分野への参入を始めている。

表1　4市場分野におけるPV累積導入量

分野／用途	92/12/31 kWp	93/12/31 kWp	94/12/31 kWp	95/12/31 kWp	96/12/31 kWp	97/12/31 kWp	98/12/31 kWp	99/12/31 kWp
非系統連系、住宅用	150	200	250	300	350	400	450	500
非系統連系、非住宅用	15,260	19,170	23,260	29,360	35,890	44,900	52,300	56,400
系統連系、分散型	1,220	2,300	5,130	10,820	20,500	43,100	77,750	145,500
系統連系、集中型	2,370	2,600	2,600	2,900	2,900	2,900	2,900	2,900
合計	19,000	24,270	31,240	43,380	59,640	91,300	133,400	205,300

2.3　主なプロジェクト、実証及びフィールドテスト・プログラム

1999年に実施された主なPVシステム普及プログラムは「公共施設等用太陽光発電フィールドテスト」、「住宅用太陽光発電システム導入基盤整備」、「産業等用太陽光発電フィールドテスト」、「地域新エネルギー導入促進事業」、「新エネルギー事業者支援事業」、「環境調和型エネルギー供給施設整備事業」、「エコスクール整備推進パイロットモデル事業」及び「エコキャンパス推進事業」である。

(1) 住宅用太陽光発電システム導入基盤整備事業

住宅用PVシステムモニター事業は、1997年度に更に拡大され、住宅用PVシステム導入基盤整備事業となった。後者はPV普及の規模が拡大され、1997年4月から発足した。

太陽光発電の意義を認識し、住宅の太陽光発電システムを設置しようとする個人に対して、その運転データなどの提供を条件にシステムの設置費の助成を行うことを目的としている。補助対象者は3つのタイプがあり、①一般住宅に太陽光発電システムを設置する個人、②住宅団地供給者などの事業者、③公共住宅に太陽光発電システムを導入する地方公共団体である。補助対象は低圧系統と逆潮流ありで連系する10kW未満のシステムである。1999年度における1kW当たりの補助金額は次の通りである。

① 87.5万円/kW以下のシステム
{(1kW当たりのシステム価格 － 248,000円)／2}× モジュールの最大出力(kW)+ 消費税相当額

② 87.5万円/kWを超え、95万円/kW以下のシステム
32.92万円 × モジュールの最大出力（kW）+ 消費税相当額

③ 95円/kWを超えるシステム
31.27万円 × モジュールの最大出力（kW）+ 消費税相当額

これらの事業により、住宅用PVシステムは1994年度に539件1.9MW、1995年度に1,065件3.9MW、1996年度に1,986件7.5MW、1997年度に5,654件19.5MW、1998年度に6,352件、24.1MWが設置され、1999年度は17,396件が受理された。1998年度時点の累積設置容量は56.9MWに達した。

(2) 公共施設等用太陽光発電フィールドテスト事業

この事業の目標は次の通りである：公共施設にシステムを設置して、PVに対する一般の理解を深めるために基盤を整備すること；設置コストの情報収集、分析を行い、BOS及び工法の類型化を計り、設置コストの低減を推進すること；運転データを収集、分析し、将来の計画に活用できるようにデータを取りまとめること。

1992年度から1997年度の6年間で、学校、病院、診療所、福祉設備、工場、事務所ビルなどの公共施設に総計186基、4,900kWが設置された。

「公共施設等用太陽光発電フィールドテスト」事業によるPVシステムの設置は1997年度に成功裡に終了し、1998年度からはデータ収集と分析のみ継続されている。

(3) 産業等用太陽光発電フィールドテスト事業

産業施設など産業分野への導入促進に有効な新技術などを用いた太陽光発電システムを試験的に設置し、長期運転における実証試験を行い各種データを収集・分析して、太陽光発電の導入の有効性を実証するとともに、本格的普及に向けたシステムの更なる標準化及び多様な導入形態への対応を図ることを目的として 1998 年度にスタートした。補助対象者は、民間企業及び地方公共団体、各種団体で、標準化推進型のシステムと新形態利用型のシステムが補助対象となっている。補助率は、補助対象額の 1/2 である。1998 年度には 73 件、計 1,940kW 設置された。1999 年度には 93 件、計 2,790kW が認可された。

(4) 地域新エネルギー導入促進事業

地方公共団体が策定した地域における新エネルギー導入に係る事業について、支援策を講じることにより、新エネルギー導入の加速的な促進を図ることを目的としている。

補助対象者は地方公共団体で、太陽光発電、風力発電、太陽熱、温度差エネルギー、天然ガスコージェネレーション、燃料電池、廃棄物発電、廃棄物熱利用、廃棄物燃料製造、クリーンエネルギー自動車、省エネルギー普及事業が補助対象である。この中で太陽光発電については、システム出力が100kW以上であることが条件となっている。補助率は、補助対象費用の1/2以内となっている。1998年度は17件の交付が決定し、このうち太陽光発電関係は市庁舎や小学校など4件が設置された。1999年度は37件の交付のうち、19件のPVシステムに補助金が支給された。1998年度から2002年度までに予定している設置目標は累積で2,039kWである。

(5) 新エネルギー事業者支援事業

エネルギーセキュリティーの確保及び地球環境対策の観点から、太陽光発電、風力発電、太陽熱利用、温度差エネルギー利用、天然ガスコージェネレーション、燃料電池、廃棄物発電、廃棄物燃料製造、廃棄物熱利用などの新エネルギー導入事業を行う者に対し支援策を講じ、新エネルギーの加速的な導入促進を図ることを目的としている。

債務保証対象者あるいは補助事業対象者は、新エネルギー導入事業を行おうとする民間事業者などである。補助率は補助対象費用の1/3以内、債務保証は対象債務の90%となっている。1998年度は18件の交付が決定し、このうち太陽光発電は1件、116kWが設置された。1999年度は32件の交付のうち、1件の116kW PVシステムに補助金が支給された。

(6) 環境調和型エネルギー供給施設整備事業

災害時におけるエネルギー供給を確保するとともに、地球環境問題に関する普及・啓発に活用することを目的として、地方公共団体が行う災害時の避難所における新エネルギーを利用したエネルギー供給施設の整備に対して補助を行う。

対象者は地方公共団体で、対象施設は防災対応型のエネルギー施設を整備することにモデル性を有すると考えられる学校、公民館、公園等の避難場所や官庁舎、警察署、消防署とし、補助率は設置費の 1/2 以内である。1998 年度及び 1999 年度に 46 件、計 1,390kW に補助金が支給された。

(7) エコスクール整備推進パイロットモデル事業

この事業は1997年度に通産省と文部省とのパートナーシップで着手された。この事業の目的は環境を考慮した学校を実証し、推進するパイロット・モデル事業を実施すること、児童生徒の環境教育に資すること、及び今後の学校施設の充実を推進することである。

対象事業は(a)PV、太陽熱、風力、地熱、燃料電池を含む新エネルギー活用型、(b)緑化推進型、(c)中水利用型、及び(d)省エネ型である。

文部省は基本計画の調査に定額の補助金を、校舎新築に1/2の補助金を、校舎改築、改修に1/3の補助金を支給する。PVシステム設置に対しては通産省の補助金が適用される。

PVシステムは1997年度には10校（266.5kW）に、1998年度には4校（170kW）に、1999年度には9校（190kW）に設置された。

また、1998年度には、補正予算で「エコキャンパス推進事業」によって国立学校85校に250基のPVシステムが設置された。総設置容量は3,590kWである。

2.4 市場活性化、実証及びR&Dに関する予算

太陽光発電システムに関する予算は研究開発、実証、市場とも国家予算が中心で、地方自治体による予算は市場開拓分野で補助的に準備されている。研究開発予算は、太陽電池用シリコン開発、太陽電池開発、PVシステム開発、高密度系統連系開発に配分されている、実証予算は公共施設用フィールドテストと産業用フィールドテストに配分されているが、産業用フィールドテストに重点が置かれている。市場開発予算は住宅用太陽光発電システムが中心である。この他、地域新エネルギー導入促進事業及び新エネルギー事業者支援事業予算で太陽光発電システムを設置することが可能であるが、これらの予算はPV以外に、その他の新エネルギーを含んでいるので、表3にはこれらの予算を含んでいない。

表3 研究開発、実証プログラム、市場インセンティブの予算

	1996年			1997年			1998年		
	研究開発	実証	市場	研究開発	実証	市場	研究開発	実証	市場
国家（億円）	75.9	13.5	111.1	85.3	25.7	159*1	97.0	25.2	160.4
地方自治体（億円）	-	-	2.1	-	-	*2	-	-	*2

*1 1998年度の市場活性化の予算には住宅用太陽光発電導入基盤整備事業の予算のほかに環境調和型エネルギー供給施設整備（12億円）も含まれている。

*2 市町村が住宅用PVシステムに対する上乗せ補助を実施している。予算額は不明。

3. 産業界と発展

3.1 太陽電池及びモジュールの生産量

わが国における PV セル及びモジュールメーカーの概要を表 4a に示す。1999 年における太陽電池及びモジュールメーカーは京セラ、シャープ、三洋電機、キヤノン、エア・ウオーター（旧大同ほくさん）、鐘淵化学工業、三菱電機の 7 社である。モジュールメーカーは昭和シェル石油、エム・エス・ケイの 2 社である。住友シチックス尼崎及びエムセテックは太陽電池用 Si 基盤のみを生産している。太陽電池の生産量は民生用及び電力用の総計を示している。

表 4b にわが国における PV 製造企業のモジュール生産プロセスを示す。

表 4c にわが国における代表的モジュールとして住宅用及び電力用 PV モジュールの特性を示す。

表 4d に太陽電池 PV モジュールメーカーにおける新開発品、新製品を示す。

表 4e に PV 製造企業のモジュール生産の将来拡張計画を示す。

表 4f に多結晶及び単結晶モジュールの代表的価格を示す。

表4a　1998年におけるモジュール製造企業の生産量、生産能力

モジュール製造企業名	セルの種類	総生産量（MWp）		最大生産能力（MWp）	モジュール関係認証取得状況	工場関係認証取得状況
		セル	ﾓｼﾞｭｰﾙ			
京セラ	多結晶Si	30.2	30.2	36	IEC61215、UL1703	ISO9000
シャープ	単結晶Si 多結晶Si a-Si	8.5 21.3 0.2	8.5 21.3 0.2	10.0 22.0 2.2	ISO9001 UL1703	ISO9001、ISO14000
三洋電機	a-Si a-Si/sc-Si	4.6 5.9	4.6 5.9	5 8		ISO9000
キヤノン	a-Si	1.31	1.31	10	IEC61646（申請中）	ISO9000
昭和シェル石油	単結晶Si	-	1.5	5.0	UL1703	
エア・ウオーター（旧大同ほくさん）	単結晶Si 多結晶Si	0.10 0.01	0.94 0.03	1.0 1.0		
三菱電機	多結晶Si	4.5	4.5	10		ISO14000
鐘淵化学工業	a-Si	3.0	3.0	20		
エム・エス・ケイ	多結晶Si	-	3.0	15.0		ISO9000（BP Solarex）
合計		79.62	84.98	145.2		

※ すべて電力応用

表4b　製造企業12社のPVモジュール生産プロセス（基板製造企業を含む）

モジュール製造企業	生産プロセスの主なステップ
京セラ	原料Si購入 → 多結晶Siセル → モジュール
シャープ	単結晶Si基板購入 → 単結晶Siセル → モジュール 原料Si購入 →多結晶Si基板 → 多結晶Siセル → モジュール 原料購入 → アモルファスSiセル → モジュール
三洋電機	SiH_4ガス及び基板（TCO付）購入 → a-Siセル → モジュール 原料Si購入 →単結晶Si基板 → a-Si／単結晶Siセル → モジュール
キヤノン	スチール基板とSiH_4ガス購入 → a-Siセル → モジュール
昭和シェル石油	単結晶Siセル輸入 → モジュール
エア・ウオーター（旧大同ほくさん）	単結晶Si基板購入 → 単結晶Siセル 多結晶Si基板購入 → 多結晶Siセル
三菱電機	多結晶Si基板購入 → 多結晶Siセル → モジュール
鐘淵化学工業	SiH_4ガス及び基板（TCO付）購入 → a-Siセル → モジュール
エム・エス・ケイ	多結晶Siセル購入 → モジュール 多結晶Siモジュール購入
住友シチックス尼崎	Siスクラップ自社調達&購入 →多結晶Si基板
エムセテック	Siスクラップ購入 → CZインゴット → 単結晶Si基板

表4c　住宅用、電力用PVモジュール

モジュール製造企業	代表的住宅用モジュール							住宅用	電力用
	セル材料	巾×長さ×厚さ (mm)	重量 (kg)	P_{max} (W)	V_{op} (V)	I_{op} (A)			
京セラ	多結晶Si	971×1,120×36	13.8	145	19.9	7.29		○	○
シャープ	単結晶Si	802×1,200×46	12.5	140	27.5	5.10		○	○
	単結晶/多結晶Si	1,500×2,000×16	31/m^2	310	—	—		×	○
	多結晶Si	802×1,200×46	12.5	136	26.7	5.09		○	○
	多結晶Si	837×1,196×35	12.5	130	26.7	4.86		○	×
	a-Si	1,500×2,000×18	40/m^2	106	—	—		×	○
	a-Si	460×657×—	—	15	—	—		×	○
三洋電機	a-Si／単結晶Si	1,320×895×35	15	180	50.7	3.55		○	○
	a-Si／単結晶Si	1,320×895×35	15	167	48.6	3.44		○	○
	a-Si／単結晶Si	1,403×345×36	6.8	45	12.7	3.55		○	×
昭和シェル石油	単結晶Si	1,200×527×34	7.6	75	17.0	4.4		○	○
	単結晶Si	982×897×35	11.0	114	35.1	3.25		○	×
	単結晶Si	982×869×35	11.0	112	34.8	3.21		×	○
	単結晶Si	1,293×329×34	5.5	55	17.4	3.15		×	○
	単結晶Si	977×440×35	5.5	55	17.3	3.16		×	○
エア・ウオーター(旧大同ほくさん)	単結晶Si	1,185×530×35	8.6	86.0	18.0	4.78		×	○
	単結晶Si	1,185×435×35	6.8	74.0	22.0	3.36		×	○
	単結晶Si	985×445×30	5.8	55.0	17.2	3.20		×	×
鐘淵化学工業	a-Si	910×455×4	5.5	30	41	1.0		○	○
エム・エス・ケイ	多結晶Si	903×930×33	10.5	86	23.0	3.74		○	×
	多結晶Si	1,113×991×50	14.0	126	34.0	3.71		○	○
	多結晶Si	1,113×660×50	9.5	88	17.0	5.18		○	○
	多結晶Si	1,113×502×50	7.2	68	17.5	3.89		○	○
	多結晶Si	1,461×502×50	9.5	88	17.0	5.18		×	○
	単結晶Si	1,183×525×43	7.2	75	17.0	4.45		×	○
	単結晶Si	1,183×525×43	7.2	80	17.0	4.7		×	○
三菱電機	多結晶Si	1,275×850×19	13.0	126	19.2	6.56		○	○
	多結晶Si	1,271×827×37	13.0	132	19.4	6.81		○	○
	多結晶Si	1,271×827×37	13.0	140	11.6	7.15		○	○
	多結晶Si	1.340×540×40	8.5	75	11.4	6.56		○	×
キヤノン	a-Si	219×2,000×—	2.6	25	15	—		○	×

表4d　製造企業の新開発及び新製品（1999年）

モジュール製造企業	新開発製品と新製品
京セラ	・住宅用軽量薄膜型パワーコンディショナ ・太陽電池屋根材「エコノルーフ」
シャープ	・多結晶太陽電池として業界最高のセル変換効率16.0%を達成（2000年4月現在） ・太陽電池モジュールの多様なレイアウトに対応できる「マルチパワーコンディショナ」を開発 ・建材としての太陽電池の新しい可能性を拓く、建築デザイン性を重視した採光型太陽電池モジュールを開発。受注対応として、結晶系合わせガラス、結晶系複層ガラス、薄膜系合わせガラス、薄膜複層ガラスの4タイプをラインアップ
三洋電機	・両面入射型結晶系モジュール ・屋根建材一体型モジュール ・量産型で世界最高変換効率18.3%の結晶系セル ・量産タイプ試作セルで世界最高変換効率20.1%の結晶系セル
昭和シェル石油	・寄棟屋根に対応できる三角／四角モジュールを組み合わせることができる住宅用の専用モジュールRP114,RP044を開発 ・ビル壁用モジュールの試作販売（注文生産）
三菱電機	・屋根材型太陽電池モジュール販売 ・高効率太陽電池モジュール（セル変換効率15.5%）販売
鐘淵化学工業	・20 MWアモルファス生産工場稼働 ・建材一体型・瓦型モジュール防火認定取得
エム・エス・ケイ	・新築住宅向瓦葺き屋根材併用型システム（瓦に太陽電池を組み込んだ屋根建材） ・遮熱（サーマルガード）機能を組み合わせ更に施工を簡単にした陸屋根設置システム
エア・ウオーター（旧大同ほくさn）	・屋根一体型太陽電池 ・結晶系透光型太陽電池
川崎製鉄	・金属屋根一体型太陽光発電システムの商品化 ・水面浮揚体一体型太陽光発電システムの開発 ・壁面設置型太陽光発電システムの商品化

表 4e　モジュール生産の将来の拡張計画

モジュール製造企業	1999 年 生産能力 (MW)	2000 年 生産能力 (MW)	2000 年以降の 生産能力 (MW)	モジュール技術
京セラ	36	60	100（〜2002 年）	多結晶 Si
シャープ	10.0 22.0 2.2	10.0 44.0 2.2	250（2003〜5 年） 5.8（2003〜5 年）	単結晶 Si 多結晶 Si a-Si
三洋電機	5 8	5 11	120（〜2005 年）	a-Si a-Si/単結晶 Si
鐘淵化学工業	20	20	40（〜2001 年）	a-Si
三菱電機	10	15	20（〜2001 年）	多結晶 Si
昭和シェル石油	5	6	検討中	単結晶 Si （セルは輸入）
エム・エス・ケイ	10 3 2	15 8 5	25 10 10	ms-Si sc-Si a-Si

表 4f　多結晶 Si 及び単結晶 Si モジュールの代表的価格

モジュール技術	モジュール価格（円/W）	
	少量注文	大量注文
多結晶 Si 及び単結晶 Si モジュール	430〜900	390〜690

3.2 その他の部品の製造企業及び供給業者

表5に系統連系用インバータの価格を示す。日本にはPV用インバータ・メーカーが26社あり、家電メーカー、電源メーカー、電子部品メーカー、総合電気メーカーから参入している。これらのインバータメーカーのうち数社は住宅用向けに3～5kWのインバータを標準化し、量産している。住宅用のインバータの生産台数は年々拡大し、低コスト化も進んでいる。更に商品化に当たって、小型化、軽量化インバータの開発も進んでいる。この他、公共施設用や産業施設用に10～20kWのインバータも生産している。産業用PVフィールドテスト事業の実施で、産業用、公共施設用に10 kWを1ユニットとする標準化を進めていることから、10 kWインバータの生産台数も増えつつある。わが国の市場は系統連系用が中心なので、太陽光発電用バッテリーや、独立型用インバータはあまり生産されていない。

表5　系統連系PV用インバータの平均価格

インバータのサイズ	1998年 kVA当たりの平均価格（円）	1999年 kVA当たりの平均価格（円）
＜1kVA	－	－
1-10kVA	150,000	130,000*[1]
10-100kVA	200,000	200,000*[2]
＞100kVA	－	200,000

*[1] 住宅用単相3～5 kWの場合

*[2] 10～100 kW、100 kVA 以上は三相 10 kW ユニットを使用の場合

3.3 PV システム価格

表6はカテゴリー別代表応用とシステム推定価格を示す。住宅用システム以外は標準化が進んでいないので、システム価格はケースバイケースとなる。

表6　代表的用途の価格

カテゴリー／範囲	代表的用途	価格（円／Wp）
非系統連系 [1] 1kW以下	遠距離通信、照明、道路・交通標識、換気扇、ポンプ、観測、航路・港湾標識、時計塔	ケースによる
非系統連系 1kWを超える	農業用、通信施設、防災施設、山小屋、公園用施設、遠隔地住宅、灯台	ケースによる
系統連系 10kW以下	住宅用、公園用、小型公共施設用	950 円／W
系統連系 10kWを超える	工場用、倉庫用、商業ビルディング、大型公共施設用、道路施設用	1,200 円／W～

1　価格は設置後のバッテリー交換、保守などの費用は含まない

4. 普及への枠組（非技術的要素）

4.1 新イニシアティブ

(1) 普及イニシアチブ

普及イニシアチブとしてエネルギー需給構造改革投資促進税制とローカルエネルギー税制がある。前者は個人及び民間企業に対して太陽光発電システムの取得価格の 7%相当額の税額控除または、初年度 30%の特別償却の選択適用が認められる。後者は個人及び民間企業に対して、3年間固定資産税の課税標準額が 5/6 に減額される。

金融機関の中には、太陽光発電住宅あるいは住宅用太陽光発電システムの購入者に対して、ローン金利を優遇し、金融面からの支援を実施している。

(2) 電力会社の PV に対する理解

1992 年より電力会社は太陽光発電による余剰電力を売電価格で購入している。グリーン価格制度やレートベースインセンティブといった考え方は検討されていない。

電力会社は早くから PV システムに関心を持っており、毎年、自社施設に PV システムを導入している。

東京電力は 1997 年に PV システムに関する研究開発を支援する新しい助成金制度と PV システム導入を促進するために、NPO を通じて住宅用 PV システム設置に対して半額補助する助成金制度を設け、継続している。1999 年には、東京電力は助成研究の成果を報告する「太陽光発電技術シンポジウム」を開催した。

1999 年に東京電力に追従して、九州電力と中国電力が NPO、大学、研究機関などへの助成制度を導入した。

1998 年末時点で、10 電力会社と電源開発は累積で 272 基の PV システムを導入した。累積設置容量は 4,116kW である。

1999 年に東京電力と中部電力が温暖化ガス削減を目的にした世界銀行の「炭素基金」に参加した。

(3) 一般の PV に対する理解

日本における一般の PV に対する理解は野心的及び強力な施策、PV 導入普及プログラムによって深まりつつある。例えば、住宅用 PV システム導入基盤整備事業の場合、1998 年度は 6,352 件の認可に対して、8,229 件の応募があったが、1999 年度は 17,396 件の応募があった。この事業の予算は PV に対する一般の関心の高まりに対応すべく、1994 年度予算の開始以来毎年増額されている。

また、NPO は東京電力、九州電力、中国電力からの支援を受けて、一般市民への住宅用太陽光発電システムの普及を進めている。

(4) その他

住宅メーカー、建材メーカー、ゼネコンが太陽光発電システムを導入した商品開発に乗り出し、太陽光発電システムの普及拡大に貢献し始めている。

4.2 間接的政策

1994 年に新エネルギー導入大綱を策定し、太陽光発電システムの導入目標量を 2000 年に 400MW、2010 年に 4,600MW と定めたが、1998 年に日本のエネルギー長期需給見通しの改定が行われ、新たな太陽光発電システムの導入目標量は 2010 年 5,000MW に上方修正された。また、1997 年には新エネルギー法を制定し、政府、地方自治体、エネルギー使用者、エネルギー供給事業者、太陽光発電システム製造事業者の基本的な取り組み体制を明確化している。

1998 年には、地球温暖化対策推進大綱が決定し、政府は新エネルギーの導入を強力に推進し、CO_2 排出量の削減に努めることになった。さらに、地球温暖化対策推進法を制定した。建設省は、環境配慮型官庁（グリーン庁舎）施設計画指針を策定し、この中で、太陽光発電システムなどの自然エネルギー導入を示した。文部省もまた太陽光発電システムの利用など環境を考慮した学校施設（エコスクール、エコキャンパス）の整備を進めている。

1999 年における重要な動向として次の事柄が挙げられる。太陽電池モジュールが建材として建設大臣の認定を取得した（4 月）。新エネルギー技術戦略が通産省、資源エネルギー庁によって策定された（10 月）。超党派国会議員による「自然エネルギー促進議員連盟」が発足した（11 月）。総合エネルギー調査会に新エネルギー部会が創設された（12 月）。

更に、新エネルギー・産業技術総合開発機構（NEDO）は 1993 年から太陽光発電システム国際共同実証研究を実施いている。ベトナムでは 1997 年から太陽光発電マイクロ水力ハイブリッド・システム実証研究を実施している。1999 年にタイとミャンマーで電源系統の有効運転を調査するために太陽光発電系統連系システム実証研究に着手した。また、NEDO は国際共同研究助成事業で CdTe 型太陽電池の研究開発の推進を採択した。国際協力事業団（JICA）もシリア、モンゴル、ラオス、ソロモン、ボリビアおよびセネガルと PV または再生可能エネルギーによる地方電化計画基礎調査を実施している。

4.3 規格と規準

1999 年度には新たに公刊された規格、規準及びガイドラインはない。

表 7、8 に日本における PV に関する規格、基準、ガイドラインを示す。PV に関する日本工業規格（JIS）は太陽電池及びモジュールに関する技術要件、太陽電池及びモジュールの特性に関する測定法、PV 用バッテリー及びパワーコンディショナーの試験法、太陽電池アレイ及び独立型 PV システムの関する通則等を網羅している。30 以上の PV に関する JIS 規格が公刊されている。

系統連系技術要件ガイドラインが通産省資源エネルギー庁公益事業部技術課によって作成された。このガイドラインは電力品質（電圧変動、力率、高調波、EMI）、保護協調（内部故障、直流分流法、配電線事故、単独運転）、運転の安全性、系統連系システムの区分、保護継電器などの技術要件が網羅されている。

表7　太陽光発電に関するに関する日本工業規格（JIS）一覧表

規格番号	規格名
JIS C 8905	独立形太陽光発電システム通則
JIS C 8906	太陽光発電システム運転特性の測定方法
JIS C 8911	二次基準結晶系太陽電池セル
JIS C 8912	結晶系太陽電池測定用ソーラシミュレータ
JIS C 8913	結晶系太陽電池セル出力測定方法
JIS C 8914	結晶系太陽電池モジュール出力測定方法
JIS C 8915	結晶系太陽電池分光感度特性測定方法
JIS C 8916	結晶系太陽電池セル・モジュールの出力電圧・出力電流の温度係数測定方法
JIS C 8917	結晶系太陽電池モジュールの環境試験方法及び耐久性試験方法
JIS C 8918	結晶系太陽電池モジュール
JIS C 8919	結晶系太陽電池セル・モジュール屋外出力測定方法
JIS C 8931	二次基準アモルファス太陽電池セル
JIS C 8932	二次基準アモルファス太陽電池サブモジュール
JIS C 8933	アモルファス太陽電池測定用ソーラシミュレータ
JIS C 8934	アモルファス太陽電池セル出力測定方法
JIS C 8935	アモルファス太陽電池モジュール出力測定方法
JIS C 8936	アモルファス太陽電池分光感度・特性測定方法
JIS C 8937	アモルファス太陽電池出力電圧・出力電流の温度係数測定方法
JIS C 8938	アモルファス太陽電池モジュールの環境試験方法及び耐久性試験方法
JIS C 8939	アモルファス太陽電池モジュール
JIS C 8940	アモルファス太陽電池セル・モジュール屋外出力測定方法
JIS C 8951	太陽電池アレイ通則
JIS C 8952	太陽電池アレイの表示方法
JIS C 8953	太陽電池アレイ出力のオンサイト測定方法
JIS C 8960	太陽光発電用語
JIS C 8961	太陽光発電用パワーコンディショナの効率測定方法
JIS C 8962	小出力太陽光発電用パワーコンディショナの試験方法
JIS C 8971	太陽光発電用鉛蓄電池の残存容量測定方法
JIS C 8972	太陽光発電用長時間率鉛蓄電池の試験方法
JIS C 8980	小出力太陽光発電用パワーコンディショナ

表8　太陽光発電に関するガイドラインと基準

（1）	電気事業法
（2）	電気工作物技術基準
（3）	系統連系技術要件ガイドライン

5　将来動向

日本は 1990 年以降、PV システムの普及促進のために研究開発、普及導入のための実証試験、本格的普及促進のための環境整備などの政策を積極的かつ着実に実行してきた。

意欲的かつ強力な政策、導入計画、普及促進のための環境整備計画等に支えられて、太陽電池の生産規模拡大、コスト低減などが進展しつつあり、PV システムの本格的普及の基盤が拡充されてきた。

日本の太陽電池及びモジュール製造企業は年々生産設備を拡充してきている。1999年の最大生産能力は1998年の約104MWに対し、約132MWであった。また2000年には、京セラは60MWに、シャープは57.2MWに、三洋電機は16MWに、鐘淵化学工業は20MWに、三菱電機は15MWに、昭和シェル石油は6MWに、エム・エス・ケイは28MWにそれぞれ生産能力を拡大する計画である。多くのPV製造企業は2000年以降の生産能力拡大を計画しているか、既に拡大に着手いている。

太陽電池モジュールが建材として建設大臣から認可されたことから住宅メーカーも標準仕様としてPV装備住宅の売り込みにますます積極的になると思われる。

日本における PV 市場は、住宅用、産業用、公共施設用の系統連系分散型 PV システムを中心に普及・展開すると思われる。太陽電池モジュールメーカーを始め、住宅メーカー、電源メーカー、建材メーカー、ゼネコンが建材一体型 PV システム市場に参入している。金融機関の中には住宅用 PV システムの購入者あるいは、PV システム装備住宅の購入者に低金利ローンなどの優遇ローンを提供しているところもある。

付録A　為替レート

1 米ドル＝107 円（2000 年 5 月の平均）

付録B　データ収集方法及びデータの精度

この報告書は太陽電池モジュールメーカー、BOS コンポーネントメーカー、住宅メーカー、PV 事業を推進する政府機関の協力のもとに作成された。

独立型分野に関して、システムの中には 40Wp 未満の容量の PV モジュールを使用しているシステムもある。これらの応用タイプや定格電圧を識別するのは非常に難しいので、本報告書には 40Wp 未満のシステムも含まれている。

累積 PV 設置量、生産量、生産能力に関するデータの精度は±10%である。

表2 主な実証およびフィールドテスト事業の概要（その1）

プロジェクト名	技術データ／経済データ	目標	1999年末までの成果／問題、得られた知見	資金	プログラム管理者	備考
住宅用PVシステム導入基盤整備事業（1994年度～）	・系統連系、10kW未満の住宅用PVシステム ・補助金：注）3.参照	・PVに関する認識度向上 ・PVの普及 ・PVの運転データの収集	・1994年度から1997年度間で、9,244軒に住宅用PVシステムが設置された（32.8 MW） ・1998年度に6,352軒が認可された（24.1 MW） ・1999年度は17,396件の応募が受理された（64.3 MW） ・すべての目標を十分達成した ・PVに対する理解が深まった ・住宅用PVシステムのコストが大幅に下がった	・ANRE・MITI [1] ・予算 1994年度 20億3000万円 1995年度 33億1000万円 1996年度 40億5600万円 1997年度 111億1000万円 1998年度 147億円 1999年度 160億4000万円	NEF [2]	・住宅用PVシステム補助金申請者が年々増加している ・1994年度から1999年度までの予算合計は512億4600万円である ・「住宅用PVシステムモニター事業」は1997年度に名称を変更し、「住宅用PVシステム導入基盤整備事業」となった

注）1. 通産省、資源エネルギー庁
2. 新エネルギー財団
3. 1999年度の補助金
(1) 87.5万円/kW以下のシステム
{(1 kW当たりのシステム価格－248,000円）／2} Xモジュールの最大出力（kW）＋消費税相当額
(2) 87.5万円/kWを超え、95万円/kW以下のシステム
32.92万円 Xモジュールの最大出力（kW）＋消費税相当額
(3) 95万円/kWを超えるシステム
31.27万円 Xモジュールの最大出力（kW）＋消費税相当額

表2　主な実証およびフィールドテスト事業の概要（その2）

プロジェクト名	技術データ／経済データ	目標	1999年末までの成果／問題、得られた知見	資金	ﾌﾟログラム管理者	備考
公共施設等PVフィールドテスト事業（1992年度～97年度） モニタリング（1998年度～）	・系統連系、公共施設 ・補助金：システムのコストの50%、但し防災型は67%	・応用形態に依存するPVシステム設置コストの収集 ・部品、設置方法のコスト低減と改善 ・PV運転データの収集 ・PVに対する理解	・1992年度から1998年度間で186基、4,900kWのPVシステムが種々の公共施設に設置された ・地方自治体、市町村等のPVに対する理解が深まった ・PVシステムが災害時の非常電源に適していることが分かった ・公共用PVシステムのコストが下がった	・ANRE・MITI ・予算 1992年度　8億4000万円 1993年度　12億2000万円 1994年度　10億3000万円 1995年度　17億円 1996年度　19億2000万円 1997年度　13億5300万円 1998年度　1億7000万円 1999年度　1億1000万円	NEDO	・この事業は1992年度に開始されたが、毎年、新PV応用分野が開発され、1997年度に新規設置は終了 ・1992年度から1999年度までの予算合計は83億4300万円である ・1998年度以降は、データの収集と分析のみ継続
産業等用PVフィールドテスト事業（1997年度～）	・10kW以上の系統連系型システム ・工場、倉庫、商用ビルディング等の産業施設 ・補助金：設置費用の1/2 ・対象となるシステム ①標準化推進型 10kW単位の標準ユニットを組み合わせたシステム ②新形態利用型 薄膜太陽電池を利用したシステムや建材一体型システム	・産業用PVシステムの運転データの収集と普及 ・産業用PVシステムコストの低減 ・産業用PVシステムの標準化	・標準化推進型144件 4,160kW、新形態利用型22件 570kWのPVシステムが工場、倉庫、研究所、商業ビルディング、学校等に設置された －1998年度：73件、1,940kW －1999年度：93件、2,790kW ・産業サイドからのPV導入の理解が始まった	・ANRE・MITI ・予算 1998年度　24億円 1999年度　24億1000万円	NEDO	

表2　主な実証およびフィールドテスト事業の概要(その3)

プロジェクト名	技術データ／経済データ	目標	1999年末までの成果／問題、得られた知見	資金	プログラム管理者	備考
地域新エネルギー導入促進事業 (1997年度～)	・新エネルギー全般 ・太陽光発電システムは100kW以上の系統連系型システム ・補助金：設置費用の1/2 ・補助対象は地方自治体	・公共施設への新エネルギーの導入促進の強化 ・地域住民への新エネルギーの普及啓蒙	・1997年度はPVは0件 ・1998年度は17件のうちPVは4件 ・1999年度は37件のうちPVは19件 ・1998～2002年度までに計2039 kWのPVシステムが設置される予定	・ANRE・MITI ・予算 1997年度　24億2800万円 1998年度　43億7900万円 1999年度　67億6000万円	NEDO	
新エネルギー事業者支援事業 (1997年度～)	・新エネルギー全般 ・太陽光発電システムは100kW以上の系統連系型システム ・補助金：設置費用の1/3あるいは債務保証	・新エネルギーの導入促進を行う民間企業に対する支援 ・民間企業による新エネルギー導入促進	・1997年度はPVは0件 ・1998年度は18件のうち1件が116 kW PVで、商業用ビルディング設置された ・1999年度は32件のうち1件が100 kW PVで、新配送センターの建物に設置された	・ANRE・MITI ・予算 1997年度　11億2300万円 1998年度　53億9300万円 1999年度　103億4000万円	NEDO	
環境調和型エネルギー供給施設整備事業 (1998年度～)	・災害時対応型システム ・バッテリーのバックアップ ・対象エネルギーは太陽光発電システム、風力発電、燃料電池、コージェネレーション ・補助金：設置費用の1/2 ・補助対象は地方自治体	・災害時における避難所のエネルギー供給の確保 ・地球環境問題に関する普及・啓発	・1998～99年度に46件、計1,390kWのPVシステムが設置された	・ANRE・MITI ・予算 1998年度及び1999年度：12億円	ANRE	

表2 主な実証およびフィールドテスト事業の概要（その4）

プロジェクト名	技術データ／経済データ	目標	1999年末までの成果／問題、得られた知見	資金	プログラム管理者	備考
エコスクール整備推進に関するパイロット・モデル事業 (1997年度～)	・対象事業 新エネルギー(PV、太陽熱など)活用学校、省エネ学校など ・対象エネルギー PVを含むすべての新エネルギー ・補助金 基本計画調査研究経費： 定額（文部省補助） （PVシステム設置費用は通産省の補助金を利用できる） ・補助対象者：都道府県または市町村	・環境を考慮した学校施設の実証及び推進 ・児童生徒等の環境教育	・1997年度： 12校のうち10校にPVシステムが設置された(266.5 kW) ・1998年度： 11校のうち4校にPVシステムが設置された(170 kW) ・1999年度： 11校のうち9校にPVシステムが設置された(190 kW)	・文部省 基本計画調査研究経費： 1998年度　2800万円 1999年度　2800万円	・文部省 ・ANRE	・1998年度補正予算で国立学校85校の250ヶ所にPVシステムが設置された（エコキャンパス・プロジェクト）。総設置容量は3,590 kW

IEA 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 Japan 1999

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National Survey Report on PV Power Applications in Japan

i Forward

The international Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organization 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 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 overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual Tasks (research projects / activity areas) is responsibility of Operating Agents. Currently eight Tasks have been established.

The twenty member 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.

ii Introduction

The objective of Task 1 of the IEA Photocoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic and environmental aspects of photovoltaic power systems for application by utilities and other users. An important deliverable of Task 1 is the annual International Survey Report on PV power applications, and is based on the information provided in the National Survey reports which are produced annually by each Task 1 Participant. The guidelines given in this document are intended to assist national experts and other participants of Task1 in the preparation of their annual PVPS National Survey Reports.

As the International Survey Report is based on the National Survey Reports it is important that experts follow these guidelines when preparing their national reports. The International Survey Report is an external publication of the IEA-PVPS Implementing Agreement so it must not contain confidential information. In contrast the National Survey Reports are classified as internal reports and are not published within the IEA-PVPS Implementing Agreement. When preparing National Survey Reports, experts should make their own arrangements with their sources on how to treat confidential information (e.g. by restricting circulation or ensuring anonymity of the data).

iii Definitions, symbols and abbreviations

For the purposes of this report, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications

PV system: Modules, inverters, batteries and all installation and control components

Module manufacturer: An organization carrying out the encapsulation in the process of the production of PV modules

Off-grid domestic: PV systems installed in households and villages which are not connected to the utility grid

Off-grid non-domestic: PV systems used for a variety of applications such as water pumping, remote communications, safety and protection devices, etc. which are not connected to the utility grid

On-grid distributed: A PV 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.

On-grid centralized: PV systems used for support of the utility distribution grid performing the function of a centralized power station.

Turn-key price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid system, the prices associated with battery maintenance/replacement should be excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be 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 to the general public and 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. They may be implemented by government, the financing industry, utilities etc.

NC: National Currency

Final annual yield is defined as the total energy delivered to the load during the year per kWp installed.

Performance ratio is defined as the ratio of the final yield to the reference yield, where the reference yield is the theoretically available energy per year per kWp installed.

1 Executive summary

Japan has carried out actively and steadily the policies on R&D programme, demonstration projects for promotion, paving the way programme for full scale introduction and the like since 1990 to develop and promote photovoltaic power (PV) systems.

The followings will be noted as the important trend in 1999; PV module was approved as building material by the Minister of Construction (April); the Strategy on New Energy Technology was developed by the Agency of Natural Resources and Energy (ANRE), the Ministry of International Trade and Industry (MITI) (October); Nonpartisan Diet Members' Alliance for Natural Energy was organized (November); New Energy Subcommittee was established under MITI's Advisory Committee for Energy (December).

In addition to the Government' policy, many local governments have been introducing the subsidy systems, no-interest loan systems and so on for people of the district who install PV system to their own houses. Some municipals that have established "New Energy Introduction Vision" started to introduce PV systems to their own facilities.

The budgets for FY1999 of major National Programmes are as follows;
1) New Sunshine Project (PV R&D): 8 360 MJPY
2) SOG Silicon Production Technology Development: 1 000 MJPY
3) Residential PV System Dissemination Programmes: 16 040 MJPY
4) Field Test PV Programmes for Industrial Use: 2 410 MJPY
5) Financial Support for Industries Introducing New Energy: 10 340 MJPY
6) Introduction and Promotion of New Energy at the Regional Level: 6 760 MJPY
7) Support for Local Efforts to Introduce New Energy Resources: 1 240 MJPY

The budgets for items 5, 6 and 7 include other new energies as well as PV.

The 1999 production of PV module in Japan recorded about 85 MW with increase of about 60% over last year. The production of PV module recorded the substantial increase for three consecutive years. Many PV manufacturers plan to expand or are expanding their production capacity from 2000 onwards.

PV market in Japan has been expanding year by year under strong policy for promotion of residential PV system. Some housing manufacturers start selling the houses equipped with PV system on a commercial basis. Also "Eco-school" project and "Eco-campus" project that aim at get students to be interested in environmental issues are expanding. The ripple effect through environmental education is greatly expected in the future.
Public perception to PV in Japan is getting more and more positive through ambitious and strong supporting measures on PV introduction and promotion.

Ambitious and strong policies, introduction projects and dissemination projects for PV promotion have contributed significantly to make progress in reducing cost and boosting production capacity of PV cells, and result in expanding the bases for full-scale introduction.

1.1 Progress of policies, programmes and projects on PV promotion

1990 (1) Procedure to installation of PV systems less than 500 kW was simplified by the amendment of "the Electricity Utility Industry Law"

1991 (1) The Electricity Utility Industry Council made the suggestion that the buy-back system of surplus power by new energy should be introduced, and the introduction and promotion of the dispersed-type power sources should be mainly focused on the new energy.
(2) Electric Power Companies announced "PV introduction project" that PV systems were going to be installed 2 400 kW by 1995 (Results: 2 659 kW).

1992 (1) Buy-back system, which electric power companies should buy back the surplus power by PV from their customers at the selling price, has been implemented.
(2) "PV Field Test Project for Public Facilities" started.

1993 (1) "Guideline of the Technical Requirements for Grid-interconnection" was prepared.
(2) MITI (Ministry of International Trade and Industry) started "New Sunshine Project".

1994 (1) "Residential PV System Monitor Programme" started.
(2) "Basic Guidelines for New Energy Introduction" came to a decision at the Cabinet meeting. The target capacity for PV introduction was set 400MW by 2000 and 4 600MW by 2010.

1995 (1) Government agencies started to study the introduction and applications of PV systems.
(2) Local governments got their own planning on "Vision for Regional New Energy" started.

1996 (1) Advisory Committee for Energy made the additional suggestion to "Energy Policy for PV Market Self-sustaining."
(2) In MITI's Economic Structure Plan " Program for Reform and Creation of Economic Structure ", the target of new industry in the field of new energy was focused on fostering PV industry.

1997 (1) "Law on Special Measures for Promotion of New Energy Utilization (Law for New Energy Promotion Introduction)" was enacted.
(2) "Residential PV System Dissemination Programme (former Residential PV System Monitor Programme)" started to deploy residential PV system on a large scale.
(3) Subsidy system for industrialists who plan to introduce new energy was established.
(4) "Regional New Energy Introduction Projects" started.

1998 (1) "Long-term Energy Supply and Demand Outlook" was revised. The target capacity for PV introduction was set 5 000MW by 2010.
(2) "Basic Guideline for Promotion Measures to Arrest Global Warming" was settled.
(3) "Environmentally-Harmonized Energy Supply Promotion Project" was initiated.
(4) "PV Field Test Project for Industrial Use" was initiated.
(5) "Law Concerning Promotion Measures to Arrest Global Warming" was enacted.
(6) Guideline of "Law Concerning the Promotion of Development and Introduction of Oil Alternative Energy" was revised. PV was regarded as one of oil alternative energies.

1999 (1) New Energy Subcommittee under MITI's Advisory Committee for Energy was established.
(2) Strategy on New Energy Technology was developed
(3) PV module was approved as building material by Minister of Construction
(4) Over 15,000 applicants for Residential PV System Dissemination Program were entered.
(5) Prefabricated housing manufacturers started promoting sale for housing with PV system as standard model.
(6) Nonpartisan Diet Members' Alliance for Natural Energy started.

1.2 Transition of PV cell production

The production of PV module in Japan in 1999 recorded about 85 MW, about 60% increase to the year before. The production of PV module in 1998 was about 53 MW. The production recorded the substantial increase for three consecutive years. The figure 85 MW is equivalent to the amount of world production in 1995. In 1999 Japan became the largest PV production country in the world, overtaking USA. It will be considered that "Residential PV System Dissemination Program" and "PV Field Test Project for Industrial Use" have paid a significant role in leading PV market and served as strong driving force to increase PV production.

Single crystalline silicon solar cell has been staying to lower level since 1997 and the production of sc-Si cell in 1998 was outstripped by a-Si cell. Multicrystalline silicon solar cell has overwhelmingly dominated over the market in Japan for the last 5 years and keeps up with the increasing demand of solar cell market in Japan. Amorphous silicon solar cell had continued to decrease for four consecutive years since 1991 because of the saturation of commercial market, the time lag of market development for new applications and so on. However, in 1996 the market for a-Si cell recovered and the market turned to grow again from 1997 because amorphous silicon solar cells began to be used for electric power application. The market for a-Si solar cell requires annual production of 10 MW. Crystalline silicon solar cell, including a-Si/sc-Si has been significantly growing in quantity, in step with expanding of electric power market due to the Government's "Residential PV System Dissemination Program" and "PV Field Test Project for Industrial Use", and the PV introduction scheme by electric power companies and so on.

1.3 Activities of Government Agencies

(1) MITI

PV System Dissemination Projects were enhanced, the budgets of the current projects were increased and new promotion projects for PV system were established. FY1999 budget for "Residential PV Systems Dissemination Programme" was increased 16 040 MJPY from 14 700 MJPY in FY1998. And regarding the budgets including other new energies as well as PV, there are the following three programmes. The budget for "Subsidy Programme for New Energy Industrialists" was increased 10 340 MJPY from 5 390 MJPY in FY1998. The budget for "Regional New Energy Introduction Project" was increased 8 000 MJPY from 5 180 MJPY in FY1998. "Regional New Energy Introduction Project" includes "Introduction and Promotion of New Energy at the Regional Level" project and "Support for Local Efforts to introduce New Energy Resources" project.

The Strategy on New Energy Technology was developed by the Agency of Natural Resources and Energy, MITI. New Energy Subcommittee was organized under MITI's Advisory Committee for Energy.

(2) Ministry of Construction

PV installation to sound barriers and other facilities of freeways has been gone on with as before. "Guideline for Planning Environmentally-Friendly Government Facilities (Green Government Office Building)" was established, and PV systems have been installed to the buildings of the agencies under "Green Government Office Building Project Aiming at Environmental Co-existence". PV module was approved as building material by the Minister of Construction

(3) Ministry of Education

"Eco-school Promotion Pilot Model Project" in partnership with MITI has been continued to promote and install PV systems to schools in all over Japan. In addition, "Eco-campus Promotion Project" was newly established to introduce PV system to national universities and colleges.

(4) Ministry of Posts and Telecommunications

PV installation to post offices' facilities has been implemented since FY1996.

(5) Ministry of Transport

"Eco-airport Plan" oriented environmental protection was announced and 120 kW PV system was installed to Narita International Airport's facilities.

(6) Prime Minister's Office

The Office decided to install PV system to the new building of the Prime Minister's Official Residence and the construction work is now under way.

(7) Local governments and municipals

Many local governments and municipals start actively grappling with the environmental issues and developing " New Energy Introduction Vision". Actually many municipals have been planning and implementing the introduction of PV systems to their own facilities or public buildings under their management for the possible use of MITI's Regional New Energy Introduction Project and " PV Field Test Project for Industrial Use".

In addition, many local governments have been introducing the subsidy system that can be added to the Government's subsidy. In stead of the added subsidy system, some municipals introduce financing support, interest compensation system, or no-interest loan system.

1.4 Activities of Power Companies

Power companies have implemented their plan to install PV systems to their own facilities.
Tokyo Electric Power Co., Inc. (TEPCO) continues to implement new subsidy system to support R&D on PV system and the subsidy system for their customers which subsidizes a half of residential PV system installation cost through NPO to promote PV system introduction within their district. In 1999 Kyushu Electric Power Co., Inc. and Chugoku Electric Power Co., Inc., following TEPCO, introduced the similar subsidy system for NPO, universities, research institutes and so on. As of the end of 1998, 10 Electric Power Cos., Inc. and Power Resources Development Co., Inc. introduced PV systems of 272. The accumulated capacity installed was 4 116 kW.

1.5 Public perception

Public perception to PV in Japan is getting positive through ambitious and strong policies and programmes on PV introduction and promotion. For example, in case of "Residential PV System Dissemination Programme", the number of applicants has been growing year by year. In FY 1999, 17 396 applicants were accepted, though 8 229 applicants were accepted and 6 352 monitors were qualified in FY1998.

2 The Implementation of PV systems

2.1 Applications for photovoltaics

The installed amount of PV systems has been increasing year after year by developing the market in the sector of PV systems for private houses, public facilities, industrial facilities and commercial buildings by financial support of MITI. Residential PV systems are increasing year by year mainly in range of 3-5 kW per house. The demand of residential PV system is accounted for 80% or more of total PV demand in Japan. PV systems for public facilities are accounted for 10% or less. 10-50 kW PV systems are installed mainly to schools, governmental offices, hospitals, welfare facilities, public halls. 10-100 kW PV systems for industrial use are installed to roof-tops and roofs of factories, warehouses, laboratories and so on. 10-100 kW PV systems for commercial buildings are installed to roof-tops, roofs and exterior walls of head offices, business offices, branch offices. Installation of PV system for industrial buildings, commercial buildings and other industrial facilities is about 5% in total. Besides, off-grid non-domestic PV systems without governmental support are utilized as power supplies for telecommunication, traffic sign, remote measurement, ventilating fan, lighting and the like.

2.2 Total photovoltaic power installed

Table 1 shows the cumulative installed PV power in 4 sub-markets. On-grid distributed PV application dominates over the PV market in Japan. As off-grid domestic market, there are PV application for mountain cottages, remote area and island, but the market scale is very small. Main PV applications in off-grid non-domestic market include power supplies for streetlight, telecommunication, pumping, remote measurement emergency measure for disaster, agriculture, traffic sign, ventilating fan and the like. Off-grid non-domestic market has already been built up as the commercial market in Japan. PV systems for demonstration have been installed so far to promote on-grid centralized market, but no PV system has been installed since 1995. On-grid distributed market has remarkably expanded year after year mainly because PV system installations to private houses, public utilities, industrial facilities, commercial buildings have increased by financial support of the Government. Therefore, the development of PV market has been focused on 3-5 kW residential PV systems and 10-100 kW PV systems for public facilities, industrial facilities, commercial buildings. Housing manufacturers, battery manufacturers, building material manufactures and construction companies as well as PV cell manufacturers have been entering this market.

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

Sub-market/ application	31/12/92 kWp	31/12/93 kWp	31/12/94 kWp	31/12/95 kWp	31/12/96 kWp	31/12/97 kWp	31/12/98 kWp	31/12/99 kWp
off-grid domestic	150	200	250	300	350	400	450	500
off-grid non-domestic	15 260	19 170	23 260	29 360	35 890	44 900	52 300	56 400
on-grid distributed	1 220	2 300	5 130	10 820	20 500	43 100	77 750	145 500
on-grid centralized	2 370	2 600	2 600	2 900	2 900	2 900	2 900	2 900
TOTAL	19 000	24 270	31 240	43 380	59 640	91 300	133 400	205 300

2.3 Major projects, demonstration and field test programmes

Main demonstration programmes that were implemented in FY1999 were "PV Field Test for Public Facilities", "Residential PV System Dissemination Programme", "PV Field Test for Industrial Use", "Regional New Energy Introduction Project", "Subsidy Programme for New Energy Industrialists", "Environmentally-Harmonized Energy Supply Project", "Eco-school Promotion Pilot Model Project" and "Eco-campus Promotion Project".

(1) Residential PV System Dissemination Programme

"Residential PV System Monitor Programme" developed into "Residential PV System Dissemination Programme" in FY1997. The latter programme started on April, 1997 to enlarge further the scale of PV promotion.

"Residential PV System Dissemination Programme" aims to subsidize the PV installation cost for individuals on the condition that they perceive the significance of PV and provide the operation data of their PV system. The subsidy is given three categories, (i) an individual who is going to install PV system to his own house, (ii) housing supplier of housing development complex and (iii) local public organization who is going to introduce PV system to public house. Less than 10 kW PV system with reverse power flow connected to low voltage line is subsidized. Subsidy per 1 kW in FY1999 is provided as follows;

1) in case of 875 thousand JPY/kW or less system:
   {(system cost per kW – 248 thousand JPY)/2} × maximum module output (kW) + sales tax
2) in case of more than 875 thousand JPY/kW to 950 thousand JPY/kW or less system:
   329,2 thousand JPY × maximum module output (kW) + sales tax
3) in case more than 950 thousand JPY/kW system:
   312,7thousand JPY × maximum module output (kW)+ sales tax

Residential PV systems have been installed to 6 352 houses, 24,1 MW in FY1998; to 5 654 houses, 19,5 MW in FY1997; to 1 986 houses, 7,5 MW in FY1996; to 1 065 houses, 3,9 MW in FY1995 and to 539 houses, 1,9 MW in FY1994. In FY1999, 17 396 houses (64,3 MW) were accepted. The accumulated capacity installed was 56,9 MW as of FY1998.

(2) PV Field Tests for Public Facilities

The objectives of this programme are: to pave the way for promotion of public perception to PV by installing the system to public facilities; to collect and analyze the installation cost, categorize the BOS components and installation methods and reduce the installation cost of PV system; to accumulate and analyze the operation data and arrange the data to be available for the future plan.

During FY1992 to FY1997, 186 PV systems in total 4 900 kW have installed to public facilities, such as schools, hospitals, clinics, welfare facilities, manufacturing plants and office buildings.

"PV Field Test for Public Facilities" programme has successfully completed in FY1997 and then the data collection and analysis of PV systems installed under the Programme have been carried since FY1998.

(3) PV Field Test for Industrial Use

This programme started in FY1998. The aim is; (i) to install in trial PV system using new technology effective to introduce to industrial sector, such as industrial facilities, (ii) to demonstrate availability for introduction of PV system by collecting data and analyzing a long-term operation under demonstration test and (iii) further standardization and diversified introduction applications toward full scale deployment of PV system. Eligibles for subsidy are private company, local public organizations and other organizations, who are going to install modular type PV system and novel application of PV system. Half of PV installation cost is subsidized. In FY1998, 73 PV systems, 1 940 kW were installed, and in FY1999, 93 PV systems, 2 790 kW were qualified.

(4) Regional New Energy Introduction Project

This project aims at accelerating new energy introduction by supporting the regional projects that governments established for new energy.

Eligibles for subsidy are local public organizations who are going to introduce and promote PV, wind power, solar heat, differential temperature energy, natural gas co-generation, fuel cell, wastes generation, use of waste heat, production of wastes fuel, clean energy car, energy saving measurements. PV system is subsidized to 100 kW output and over. Half of system installation cost is subsidized. 17 systems in total were subsidized in FY1998, and 4 systems out of them were PV systems installed to elementary schools and city halls. In FY1999, 19 PV systems out of 37 qualified systems were subsidized. The accumulated capacity installed in FY 1998 to 2002 will be 2 039 kW.

(5) Subsidy Programme for New Energy Industrialists

This programme aims at accelerating new energy introduction by supporting the industrialists who set about introducing new energy, such as PV, wind power, solar heat, differential temperature energy, natural gas co-generation, fuel cell, wastes generation, use of waste heat, production of wastes fuel, from a viewpoint of energy security and global environmental protection.

Eligibles for guaranteed debt or subsidy are private industrialists who set about new energy business. A third of system installation cost is subsidized and guaranteed debt is 90% of a debt. In FY1998, 116 kW PV system out of 18 qualified systems and in FY1999 100 kW PV system out of 32 systems were subsidized.

(6) Environmentally-Harmonized Energy Supply Project

This project aims at securing energy supply in disaster, and educating global environmental issues. Subsidy is provided paving the way for infrastructure of energy supply facilities using new energy at safe shelters where local public organizations earmark for.

Eligibles for subsidy are local public organizations. Targeted facilities are government office buildings, police stations, fire stations and safe shelters, such as schools, public halls, parks where are considered suitable for installation of energy supply system against disaster. Half of system installation cost is subsidized. Total 1 390 kW of 46 systems was subsidized in FY 1998 and 1999.

(7) Eco-school Infrastructure Promotion Pilot Project

This Project initiated in FY1997 with the partnership of MITI and Ministry of Education. The project aims at implementing pilot model project to demonstrate and promote environmental-friendly schools, providing students with environmental education, and further improving school facilities.

Eligible projects are (a) new energy utilization, including PV, solar thermal, wind power, geothermal and fuel cell, (b) tree planting promotion (c) gray water utilization, and (d) energy efficiency.

The Ministry of Education provides the subsidy of fixed cost with investigation for fundamental planning, the subsidy of half of cost with new school building and one-thirds of cost with rebuilding and retrofitting. MITI's subsidy is available for PV system installation.

PV systems were installed to 10 schools (266,5 kW) in FY1997, 4 schools (170 kW) in FY1998 and

9 schools (190 kW) in FY1999.

In FY1998, 250 PV systems were introduced to 85 national universities under "Eco-campus project" through FY1998 supplementary budget. Total installation capacity was 3 590 kW.

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

Project Data plant start up	Technical data/ Economic data	Objectives	Main accomplishments until the end of 1999/ problems and lessons learned	Funding	Project Manage -ment	Remarks
Residential PV System Dissemination Programme (FY1994~)	- Grid connected, residential (<10kW) - Subsidy: see NOTE 3	- Perception to PV - Dissemination of PV - Collection of PV operation data	- 9 244 residential PV systems have been installed in total during FY1994 to FY1997 (32.8 MW). - 6 352 houses were qualified in FY1998 (24,1 MW). - 17 396 houses were accepted in FY1999 (64,3 MW). - All objectives have been achieved successfully. - Better understanding to PV has been promoted. - Cost of system reduced substantially.	- ANRE[1], MITI - Budget: FY1994 2 030 MJPY FY1995 3 310 MJPY FY1996 4 056 MJPY FY1997 11 110 MJPY FY1998 14 700 MJPY FY1999 16 040 MJPY	- NEF[2]	- Applications for residential PV system subsidy have been increased year by year. - Total budget FY1994 to FY1999 was 51 246 MJPY. - Title of "Residential PV System Monitor Programme" changed to" Residential PV System Dissemination Programme" in FY1997.

NOTE)

1. ANRE: Agency of Natural Resources and Energy
2. NEF: New Energy Foundation
3. Subsidy for FY1999
   (1) in case of 875 thousand JPY/kW or less system:
   {(system cost per kW – 248 thousand JPY)/2} × maximum module output (kW) + sales tax
   (2) in case of more than 875 thousand JPY/kW to 950 thousand JPY/kW or less system:
   329,2 thousand JPY × maximum module output (kW) + sales tax
   (3) in case more than 950 thousand JPY/kW system:
   312,7thousand JPY × maximum module output (kW) + sales tax

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

Project Data plant start up	Technical data/ Economic data	Objectives	Main accomplishments until the end of 1999/ problems and lessons learned	Funding	Project Manage -ment	Remarks
PV Field Tests for Public Facilities (FY1992~'97) Monitoring (FY1998~)	- Grid connected, public facilities - Subsidy: 50% of system cost, but 67% for disaster prevention	- Collection of PV system installation cost depending on applications - Improvement and cost-reduction of components and installation method of PV system - Collection of PV operation data - Perception to PV	- PV systems have been installed as various applications to public facilities, 186 units, 4 900 kW in total, from FY1992 to FY1998. - Better understanding to PV by local governments, municipalities and the like has been promoted. - PV systems are suitable for emergency power sources. - Cost of system reduced.	- ANRE, MITI - Budget: FY1992 840 MJPY FY1993 1 220 MJPY FY1994 1 030 MJPY FY1995 1 700 MJPY FY1996 1 920 MJPY FY1997 1 353 MJPY FY1998 170 MJPY FY1999 110 MJPY	- NEDO	- This project has been started from FY1992, but every year new PV applications have been developed and completed in FY1997. Collection of data and analysis have been carried out since FY1998. - Total budget FY1992 to FY1999 was 8 343 MJPY.

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

Project Data plant start up	Technical data/ Economic data	Objectives	Main accomplishments until the end of 1999/ problems and lessons learned	Funding	Project Manage-ment	Remarks
PV Field Tests for Industrial Use (FY1998~)	- Grid connected, residential (≧10 kW) - Industrial facilities, such as factory, warehouse, commercial building - Subsidy: 50% of installation cost - Eligible system · Modular type: combined system with 10 kW PV unit · Novel application type: system with thin film solar cell, building integrated PV system.	- Collection and dissemination of operational data - Cost reduction - Standardization of PV system	- 4 160 kW of 144 modular type PV systems and 570 kW of 22 novel application types were installed to factories, warehouses, laboratories, commercial buildings, schools and so on. FY1998; 73 cases (1 940 kW) FY1999; 93 cases (2 790 kW) - Perception of industries are being spread.	- ANRE, MITI - Budget: FY1998 2 400 MJPY FY1999 2 410 MJPY	- NEDO	
Regional New Energy Introduction Project (FY1997~)	- New energy in general - Eligible PV system: grid-connected (≧100 kW) - Subsidy: 50% of installation cost - Eligible: Local governments	- Enhancement of promotion of new energy to public facilities - Education and promotion of new energy to local inhabitants	- No PV system was installed in FY 1997. - 4 systems out of 17 systems were PV in FY1998. - 19 PV systems out of 37 systems were installed in FY1999 - 2 039 kW of PV systems will be installed during FY1998~2002.	- ANRE, MITI - Budget: FY1997 2 430 MJPY FY1998 4 380 MJPY FY1999 6 760 MJPY	- NEDO	

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

Project Data plant start up	Technical data/ Economic data	Objectives	Main accomplishments until the end of 1999/ problems and lessons learned	Funding	Project Manage-ment	Remarks
Subsidy Programme for New Energy Industrialists (FY1997~)	- New energy in general - Eligible PV system: grid-connected (≧100 kW) - Subsidy: a third of installation cost or guaranteed debt	- Support of private industries who introduce new energy - Encouragement of introduction of new energy by private industries	- No PV system was installed in FY1997 - One 116 kW PV system out of 18 systems was installed to a commercial building in FY1998. - One 100 kW PV system out of 32 systems was installed to a new distribution center building.	- ANRE, MITI - Budget: FY1997 1 120 MJPY FY1998 5 390 MJPY FY1999 10 340 MJPY	- NEDO	
Environmentally – Harmonized Energy Supply Project (FY1998~)	- System against disaster prevention - Back-up by battery - Eligible energy: PV, wind power, fuel cell, co-generation - Subsidy: 50% of installation cost - Eligible: Local governments	- Energy security of safe shelter in disaster - Enlightenment about global environmental issue	- 1 390 kW of 46 PV systems was installed in FY1998 and FY1999	- ANRE, MITI - Budget: FY1998 & FY1999 1 200 MJPY	- ANRE	

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

Project Data plant start up	Technical data/ Economic data	Objectives	Main accomplishments until the end of 1999/ problems and lessons learned	Funding	Project Manage-ment	Remarks
Eco-school Infrastructure Promotion Pilot Project (FY1997~)	- New energy use school (PV, solar thermal, etc.) energy efficient school etc. - Eligible Energy: New energy including PV - Subsidy: Investigation; fixed cost (MITI's subsidy is available for PV system installation) - Eligible: Local government	- Demonstration and promotion of environment-friendly school - Environmental education to students	- FY1997: PV systems were installed to 10 out of 12 schools (266,5 kW) - FY1998: PV systems were installed to 4 out of 11 schools (170 kW) - FY1999: PV systems were installed to 9 out of 11 schools (190 kW)	- Ministry of Education - Budget for investigation: FY1998 28 MJPY FY1999 28 MJPY	- Ministry of Education - ANRE	- 250 PV systems were introduced to 85 national schools through FY1998 supplementary budget (Eco-campus project). Total installation capacity was 3 590 kW.

2.4 Budgets for market stimulation, demonstration and R&D

The national budgets for PV system are focused on R&D, demonstration programmes and market incentives. The budgets by local governments are complementarily appropriated for market incentives. The budget for R&D is allocated for R&D on solar grade silicon, on solar cell, on PV system and on high-density grid-interconnection. The budget for demonstration is allocated for mainly PV Field Test Project for Industrial Use and PV Field Test Project for Public Facilities as well. The budget for market initiatives is put emphasis on residential PV system. Moreover, PV systems can be installed using the budgets of New Energy Introduction Project and Subsidy Programme for New Energy Industrialists. However, as these budgets include other new energies than PV, they are not included in Table 3.

Table 3: Budgets (in National Currency) for R&D, demonstration programmes and market incentives.

	R&D FY1997	Demo FY1997	Market FY1997	R&D FY1998	Demo FY1998	Market FY1998	R&D FY1999	Demo FY1999	Market FY1999
National/ federal (billion JPY)	7,59	1,35	11,11	8,53	2,57	15,9*[1]	9,70	2,52	16,04
State/ regional (billion JPY)	-	-	0,21	-	-	*[2]	-	-	*[2]

*[1] The budget for market initiatives in FY1998 included the budget for Environmentally–harmonised Energy Supply Project (1 200 MJPY), besides the budget for Residential PV System Dissemination Programme.

*[2] Some municipals are enforcing additional subsidy programme on residential PV system, but the amount of subsidy is unknown.

3 Industry and growth

3.1 Production of photovoltaic cells and modules

Tables 4a shows the outline of PV cell and module manufacturers. In 1999, PV cell and module manufacturers are 7, i.e. Kyocera, Sharp, Sanyo Electric, Canon, Air Water (former Daido Hoxan), Kaneka and Mitsubishi Electric. Showa Shell Sekiyu and MSK are manufacturing only PV modules. Sumitomo Sitix Amagasaki and M.SETEC are manufacturing only Si substrate for solar cell. Total production of PV cell includes production for both consumer and power use.

Table 4b shows PV module production processes of the manufacturers in Japan.

Table 4c shows technical data of typical module for residential and power uses.

Table4dshowstypical new developments and products of PV cell and module manufacturers in Japan.

Table 4e shows plan for future expansion in module production capacity.

Table 4f shows typical prices of ms-Si and sc-Si modules.

Table 4a: Production and production capacity information for each module manufacturer in 1999.

Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MWp)		Maximum production capacity (MWp)	Certification of Modules	Certification of Plant
		Cell	Module			
Kyocera	mc-Si	30,2	30,2	36	IEC 61215, UL 1703	ISO 9000,
Sharp	sc-Si mc-Si a-Si	8,5 21,3 0,2	8,5 21,3 0,2	10,0 22,0 2,2	ISO 9001 UL 1703	ISO 9001, ISO 14001
Sanyo Electric	a-Si a-Si/sc-Si	4,6 5,9	4,6 5,9	5 8		ISO 9000
Canon	a-Si	1,31	1,31	10	IEC 61646 (application)	ISO 9000
Showa Shell Sekiyu	sc-Si	–	1,5	5,0	UL 1703	
Air Water (former Daido Hoxan)	sc-Si mc-Si	0,10 0,01	0,94 0,03	1,0 1,0		
Mitsubishi Electric	mc-Si	4,5	4,5	10		ISO 14000
Kaneka	a-Si	3,0	3,0	20		
MSK	mc-Si	–	3,0	15		ISO 9000 (BP Solarex)
TOTALS		79.62	84.98	145.2		

- mc: multicrystalline, sc: single crystalline

Table 4b: PV module production processes of manufacturers (including substrate manufacturers)

Module manufacturer	Description of main steps in production process
Kyocera	- Purchase of Si scraps → mc-Si substrate → mc-Si cell → Module
Sharp	- Purchase of sc-Si substrate → sc-Si cell → Module - Purchase of Si scraps → mc-Si substrate → mc-Si cell → Module - Purchase of feedstock → a-Si cell → Module
Sanyo Electric	- Purchase of SiH_4 gas & substrate (with TCO) → a-Si cell → Module - Purchase of Si scraps → sc-Si substrate → a-Si/sc-Si cell → a-Si/sc-Si Module
Canon	- Purchase of steel substrate & SiH_4 gas → a-Si cell → Module
Showa Shell Sekiyu	- Import of sc-Si cell → Module
Air Water (former Daido Hoxan)	- Purchase of sc-Si substrate → sc-Si cell - Purchase of mc-Si substrate → mc-Si cell
Mitsubishi Electric	- Purchase of mc-Si substrate → mc-Si cell → module
Kaneka	- Purchase of SiH_4 gas & substrate (with TCO) → a-Si cell → Module
MSK	- Purchase of mc-Si cell → Module - Purchase of mc-Si Module
Sumitomo Sitix Amagasaki	- Own Si scrap and purchase of Si scrap → mc-Si substrate
M.SETEC	- Purchase of Si scrap → CZ ingot → sc-Si substrate

- mc: multicrystalline, sc: single crystalline

Table 4c: PV module for residences and utilities (1999)

Module Manufacturer	Typical module data						Residential use	Power use
	cell technology	W x L x D (mm)	Weight (kg)	P_{max} (W)	V_{op} (V)	I_{op} (A)		
Kyocera	mc-Si	971×1120×36	13,8	145	19,9	7,29	O	O
Sharp	sc-Si	802×1200×46	12,5	140	27,5	5,10	O	O
	sc/mc-Si	1500×2000×16	31/m^2	310	–	–	x	O
	mc-Si	802×1200×46	12,5	136	26,7	5,09	O	O
	mc-Si	837×1196×35	12,5	130	26,7	4,86	O	x
	a-Si	1500×2000×18	40/m^2	106	–	–	x	O
	a-Si	460×657×–	–	15	–	–	x	O
Sanyo Electric	a-Si/ sc-Si	1320×895×35	15	180	50,7	3,55	O	O
	a-Si/ sc-Si	1320×895×35	15	167	48,6	3,44	O	O
	a-Si/ sc-Si	1403×345×36	6,8	45	12,7	3,55	O	x
Showa Shell Sekiyu	sc-Si	1200×527×34	7,6	75	17,0	4,4	O	O
	sc-Si	982×897×35	11,0	114	35,1	3,25	O	x
	sc-Si	982×869×35	11,0	112	34,8	3,21	x	O
	sc-Si	1293×329×34	5,5	55	17,4	3,15	x	O
	sc-Si	977×440×35	5,5	55	17,3	3,16	x	O
Air Water (former Daido Hoxan)	sc-Si	1185×530×35	8,6	86,0	18,0	4,78	x	O
	sc-Si	1185×435×35	6,8	74,0	22,0	3,36	x	O
	sc-Si	985×445×30	5,8	55,0	17,2	3,20	x	x
Kaneka	a-Si	910×455×4	5,5	30	41	1,0	O	O
MSK	mc-Si	903×930×33	10,5	86	23,0	3,74	O	x
	mc-Si	1113×991×50	14,0	126	34,0	3,71	O	O
	mc-Si	1113×660×50	9,5	88	17,0	5,18	O	O
	mc-Si	1113×502×50	7,2	68	17,5	3,89	O	O
	mc-Si	1461×502×50	9,5	88	17,0	5,18	x	O
	sc-Si	1183×525×43	7,2	75	17,0	4,45	x	O
	sc-Si	1183×525×43	7,2	80	17,0	4,7	x	O
Mitsubishi Electric	mc-Si	1275×850×19	13,0	126	19,2	6,56	O	O
	mc-Si	1271×827×37	13,0	132	19,4	6,81	O	O
	mc-Si	1271×827×37	13,0	140	11,6	7,15	O	O
	mc-Si	1340×540×40	8,5	75	11,4	6,56	O	x
Canon	a-Si	219×2000×–	2,6	25	15	–	O	x

- mc: multicrystalline, sc: single crystalline

Table 4d: New developments and new products of manufacturers (1999)

Module manufacturer	New developments an new products
Kyocera	- Development of light and thin type power conditioner for residential use - Commercialization of roofing–integrated PV module "ECONOROOF"
Sharp	- Development of mc-Si cell with efficiency 16,0% (as of April, 2000) - Development on "Multi-power conditioner" which can meet diverse layout of solar cell - Development of lighting type solar cell as building material which focuses on building design (double glass type crystalline cell, multi-layered glass type crystalline cell, double glass type thin film cell, multi-layered glass type thin film cell)
Sanyo Electric	- Commercialization of roofing–integrated PV module - Commercialization of a-Si / sc-Si bifacial PV module - Development of crystalline cell with efficiency 18,3% at the mass-production base (world record) - Development of prototype a-Si / sc-Si cell with efficiency 20,1% at the mass-production base (world record)
Showa Shell Sekiyu	- Development of module only for residential use "RP114" and "RP044" which can be used on a hip roof with combination of triangle module and square module - Sale of custom-made module for building wall use
Mitsubishi Electric	- Sale of roofing type PV module - Sale of high efficient PV module (cell efficiency 15,5%)
Kaneka	- Operation of 20 MW a-Si manufacturing plant - Certificate of fire proof, roof tile module integrated into building material
MSK	- Commercialization of roof tile PV system for new housing use - Commercialization of PV system with thermal guard function, easily mounted on flat roof
Air Water (former Daido Hoxan)	- Commercialization of roofing-integrated solar module - Commercialization of lighting type sc-Si module
Kawasaki Steel	- Commercialization of metal roofing-integrated PV system - Commercialization of wall-mounted PV system - Development of floater-integrated PV system

- mc: multicrystalline, sc: single crystalline

Table 4e: Plans for future expansion in module production capacity

Module Manufacturer	Production capacity in 1999 (MW)	Production capacity in 2000 (MW)	Production capacity from 2000 onwards (MW)	Module technology
Kyocera	36	60	100(~2002)	mc-Si
Sharp	10,0 22,0 2,2	10,0 44,0 2,2	250(2003~2005) 5,8(2003~2005)	sc-Si mc-Si a-Si
Sanyo Electric	5 8	5 11	120(~2005)	a-Si a-Si/sc-Si
Kaneka	20	20	40(~2001)	a-Si/polySi thin film
Mitsubishi Electric	10	15	20(~2001)	mc-Si
Showa Shell Sekiyu	5	6	Under consideration	sc-Si (import of sc-Si cell)
MKS	10 3 2	15 8 5	25 10 10	ms-Si sc-Si a-Si

- ms: multicrystalline, sc: single crystalline

Table 4f: Typical prices of ms-Si and sc-Si modules

Module Technology	Price of module (JPY/W)	
	Small Quantity	Large Quantity
mc-Si/sc-Si	430 ~ 900	390 ~ 690

- ms: multicrystalline, sc: single crystalline

3.2 Manufacturers and supplies of other components

Table 5 shows the price of inverter sold for on-grid PV application. There are 26 inverter manufacturers for PV use in Japan, who are divisions or affiliates of electric appliance manufacturers, power supply manufacturers, electric component manufacturers and general electric machinery manufacturers. These manufacturers are mainly producing 3-5 kW inverters for residential use. Some of these manufacturers standardize their own inverter and are mass-producing. The production amount of inverters has been increasing year by year and the cost has been reducing. Furthermore, on commercializing inverter, development of compact and lightweight inverter is under way. 10-20 kW inverters for public facilities and industrial uses are also manufactured. As a result of implementation of PV Field tests for Public Facilities and PV Field Tests for Industrial Use programmes, the standardization of 10 kW unit for public facilities and industrial uses is been developing and the production of inverter is increasing. In Japan, batteries for PV use and inverters for stand-alone system use are not manufactured so many, because most of PV applications are connected to utilities grid.

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

SIZE OF INVERTER	AVERAGE PRICE PER kVA	AVERAGE PRICE PER kVA

	IN 1998 (JPY)	IN 1999 (JPY)
<1 kVA	–	–
1-10 kVA	150 000	130 000 *1
10-100 kVA	200 000	200 000 *2
>100 kVA	–	200 000

Note) *1: single phase, 3~5 kW for residential use
*2: 10~100 kW. In case of > 100 kVA, three phase 10 kW unit is used.

3.3 System prices

Table 6 shows the typical application by category and the estimated system price. As other applications except residential application are not standardized, the system prices are determined case by case.

Table 6: Prices of typical applications (1999)

Category / Size	Typical applications and brief details	Price per Wp IN JPY
OFF-GRID[1] Up to 1 k Wp	telecommunications, lighting, traffic and road signs, pumps, ventilating fans, remote measurements, navigation signs, clock towers, etc.	Depending on case
OFF-GRID >1 kWp	agricultural facilities, communication facilities, disaster prevention facilities, mountain cottages, park facilities, remote area housing, lighthouses, etc.	Depending on case
ON-GRID Up to 10 kWp	residences, park facilities, small public facilities, etc.	950/Wp
ON-GRID >10 kWp	plants, warehouses, commercial buildings, larger public facilities, road buildings, etc.	1 200/Wp ~

1. Prices should not include recurring charges after installation such as battery replacement or operation and maintenance

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

(1) Promotion initiatives

There are the system of local energy taxation and the taxation system of promotion of investment for energy supply and demand structure reformation as promotion initiatives. The former stipulates that the taxable amount of fixed property for individuals and private companies should be reduced to 5/6 for three years. The latter stipulates that individuals and private companies can choose either tax credit of 7% of acquisition value of PV system or 30% depreciation of acquisition value for the first year.

Some financing institutions provide preferential loans with purchasers of residential PV system and a house with PV system as financial support.

(2) Utility perceptions to PV

The electric power companies adopted net metering system and have bought back the surplus power by PV from their customers at the selling price since 1992. Other initiatives, such as green pricing, rate-based incentives have not been studies in Japan.

Electric power companies have been interested in PV systems earlier, and introduce PV systems to their own facilities every year.

In 1997, the Tokyo Electric Power Co., Inc. (TEPCO) established new subsidy system to support R&D on PV system and the subsidy system for their customers which subsidizes a half of residential PV system installation cost through NPO to promote PV introduction within their district. These subsidy systems have been continued. In 1999, TEPCO organized "Symposium on Photovoltaics Technology" to report the results of subsidized R&D.

In 1999 Kyushu Electric Power Co., Inc. and Chugoku Electric Power Co., Inc., following TEPCO, introduced the similar subsidy system for NPO, universities, research institutes and so on.

As of the end of 1998, 10 Electric Power Cos., Inc. and Power Resources Development Co., Inc. introduced PV systems of 272. The accumulated capacity installed was 4 116 kW.

In 1999, TEPCO and Chubu Electric Company participated the World Bank's "Carbon Fund" to reduce greenhouse effect gas.

(3) Public perceptions to PV

Public perception to PV in Japan is getting positive through ambitious and strong policies and programmes on PV introduction and promotion. For example, in case of Residential PV System Dissemination Programme, In FY 1999, 17 396 applicants were accepted, though 8 229 applicants were accepted and 6 352 monitors were qualified in FY1998. The budget for this programme has been increased since the year FY1994 of the start of this programme to correspond to increasing public perception to PV.

In addition, NPO is promoting residential PV system for the general public under support from TEPCO, Kyushu Electric Power Co., Inc. and Chugoku Electric Power Co., Inc..

(4) Others

Housing manufacturers, building material manufacturers and construction companies set about developing houses and components with PV system, and are playing a role of PV promotion.

4.2 Indirect policy issues

The target capacity for PV introduction was set 400 MW by the year 2000 and 4 600 MW by the year 2010 by the Basic Guidelines for New Energy Introduction. However, the target capacity by 2010 was amended upward to 5 000 MW by revision of "Long-term Energy Supply and Demand Outlook" in FY1998. The Law for New Energy Promotion Introduction was enacted in 1997 and defined the fundamental framework of the Government, local governments, energy users, energy suppliers and PV system manufacturers.

In FY1998, "Basic Guideline for Promotion Measures to Arrest Global Warming" was settled, and Government came to make an effort to promote strongly the introduction of new energy and to reduce CO_2 emission. Furthermore, "Law Concerning Promotion Measures to Arrest Global Warming" was enacted. The Ministry of Construction established "Guideline for Planning Environmentally-friendly Government Facilities (Green Government Office Building)" and announced the introduction of natural energy, such as PV system. The Ministry of Education is proceeding with preparation of infrastructure for environmentally–friendly school (Eco-school, Eco-campus) using new energy, such as PV system.

The important trends in 1999 are as follows; PV module was approved as building material by the Minister of Construction (April); the Strategy on New Energy Technology was developed by the Agency of Natural Resources and Energy (ANRE), the Ministry of International Trade and Industry (MITI) (October); Nonpartisan Diet Members' Alliance for Natural Energy was organized (November); New Energy Subcommittee was established under MITI's Advisory Committee for Energy (December).

Furthermore, New Energy and International Technology Development organization (NEDO) has carried out International Demonstrative Research on Photovoltaic Power Generation Systems since 1993. Demonstrative Research on a Hybrid System of Photovoltaic Power Generation and Micro Hydropower Generation has been implemented in Vietnam since 1997. In 1999, NEDO initiated Demonstrative Research on a Grid-connected Photovoltaic Power Generation Systems in Myanmar and Thailand to study effective operation of power source system. Also NEDO decided to promote R&D on CdTe solar cell through International Cooperative Research Grand Project. And Japan International Cooperation Agency (JICA) implements the fundamental survey on rural electrification by PV and renewable energies in Syria, Mongol, Laos, Solomon, Bolivia and Senegal.

4.3 Standards and codes

In FY1999, new standards, code and guideline were not published.

Tables 7 and 8 show standards, code and guideline on PV ever published in Japan. Japanese Industrial Standards (JIS) on PV have been prepared to cover the technical requirements on PV and are of much help to the persons concerned. The guideline for the technical requirements for grid-connection is effectively used for on-grid PV application. This guideline covers power quality (voltage regulation, power factor, harmonics, EMI), protection coordination (internal fault, DC injection, distribution line fault, islanding), stability of operation, classification of grid-interconnected system, protective relay and so on.

Table 7: List of Japanese Industrial Standard (JIS) on photovoltaics

Standard No.	Subject
JIS C 8905	General Rules for Stand-alone Photovoltaic Power Generating System
JIS C 8906	Measuring Procedure of Photovoltaic system Performance
JIS C 8911	Secondary Reference Crystalline Solar Cells
JIS C 8912	Solar Simulators in Measuring Crystalline Solar Cells and Modules
JIS C 8913	Measuring Method of Output Power for Crystalline Solar Cells
JIS C 8914	Measuring Method of Output Power for Crystalline Solar Cell Modules
JIS C 8915	Measuring Method of Spectral Response for Crystalline Solar Cells
JIS C 8916	Temperature Coefficient Measuring Method for Crystalline Solar Cells and Modules
JIS C 8917	Environment and Endurance Test Method for Crystalline Solar Cell Modules
JIS C 8918	Crystalline Solar Cell Modules
JIS C 8919	Outdoor Measuring Method of Output Power for Amorphous Solar Cells and Modules
JIS C 8931	Secondary Reference Amorphous Solar Cells
JIS C 8932	Secondary Reference Amorphous Solar Submodules
JIS C 8933	Solar Simulators for Amorphous Solar Cells and Modules
JIS C 8934	Measuring Method of Output Power for Amorphous Solar Cells
JIS C 8935	Measuring Method of Output Power for Amorphous Solar Modules
JIS C 8936	Measuring Methods of Spectral Response for Amorphous Solar Cells and Modules
JIS C 8937	Temperature Coefficient Measuring Methods of Output Voltage and Output Current for Amorphous Solar Cells and Modules
JIS C 8938	Environmental and Endurance Test Methods for Amorphous Solar Cell Modules
JIS C 8939	Amorphous Solar PV Modules
JIS C 8940	Outdoor Measuring Method of Output Power for Amorphous Solar Cells and Modules
JIS C 8951	General Rules for Photovoltaic Array
JIS C 8952	Indication of Photovoltaic Array Performance
JIS C 8953	On-site Measurements of Photovoltaic Array I-V Characteristics (Based on IEC/ TC82/ S43)
JIS C 8960	Glossary of Terms for Photovoltaic Power Generation
JIS C 8961	Measuring Procedure of Power Conditioner Efficiency for Photovoltaic Systems
JIS C 8962	Testing Procedure of Power Conditioner for Small Photovoltaic Power Generating Systems
JIS C 8971	Measuring Procedure of Residual Capacity for Lead Acid Battery in Photovoltaic Systems
JIS C 8972	Testing Procedure of Long Discharge Rate Lead-acid Batteries for Photovoltaic Systems
JIS C 8980	Power Conditioner for Small Photovoltaic Power Generating System

Table 8: Guideline and code on photovoltaics

(1) The Electricity Utility Industry Law
(2) Japanese National Electric Code
(3) Guideline of the technical requirements for grid-interconnection

5 Future trends

Japan has carried out actively and steadily the policies on R&D programmes, demonstration projects, paving the way programmes for full-scale introduction and the like since 1990 to develop and promote PV systems.

Ambitions and strong policies, introduction projects and dissemination projects for PV promotions have contributed significantly to make progress in reducing cost and boosting production capacity of PV cell and module, and results in expanding the bases for full-scale introduction.

PV cell and module manufacturers in Japan have been expanding their product facilities year by year. The maximum production capacity in 1999 increased about 132 MW from 104 MW in 1998. In addition, in 2000, Kyocera is planning to increase production capacity to 60 MW, Sharp to 57,2 MW, Sanyo Electric to 16 MW, Kaneka to 20 MW, Mitsubishi Electric to 15 MW, Showa Shell Sekiyu to 6 MW and MSK to 28 MW. Moreover, many PV manufacturers plan to expand or are expanding their production capacity from 2000 onwards.

Housing manufacturers are also positively promoting the sale of housing with PV system as a standard specification because PV module was approved as building material by Minister of Construction.

The PV market in Japan will continue to grow and deploy in the sector of on-grid distributed PV systems for residential, industrial and public uses. Housing manufacturers, battery manufacturers, building material manufacturers and construction companies as well as PV cell and module manufacturers have been entering this building-integrated PV market. Some of financing institutions provide preferential loans such as low interest loan with residential PV system or a house with PV system.

Annex A: Exchange Rate

1 USD = 107 JPY (Average of May, 2000)

Annex B: Method and accuracy of data

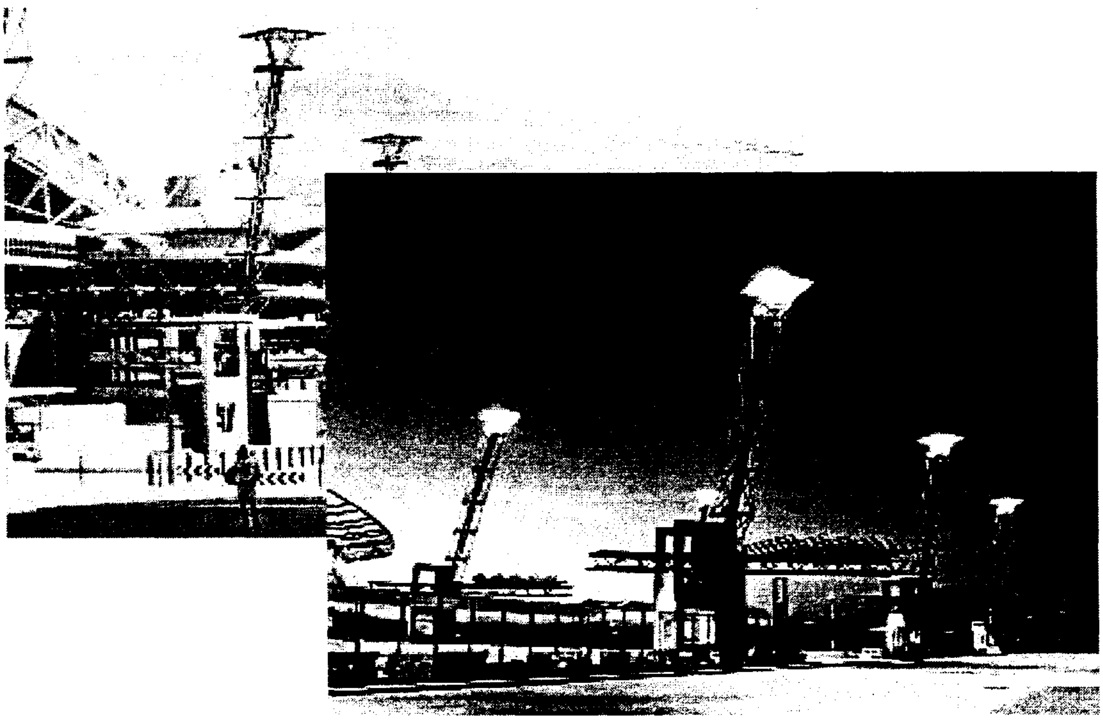
The work was performed in collaboration with PV module and BOS components manufactures, housing manufacturers, government agents running PV programmes / projects.

As regards off-grid sector, some of these systems implement PV modules that have a capacity lower than 40 Wp. In this report they are included because it is very difficult to distinguish the application types and rated voltages.

The accuracy of data is ±10% for cumulative installed PV power, production and production capacity.

IEA INTERNATIONAL ENERGY AGENCY

Trends in Photovoltaic Applications in Selected IEA Countries between 1992 and 1999



PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Report IEA-PVPS T1-08:2000

Cover photographs: Each of the lighting pylons lining the Olympic Boulevard at Australia's Sydney Olympic site carries 6.8 kW_p of PV. Photographs courtesy of Energy Australia.

Contents

This report has been prepared under the supervision of Task 1 by John Knight of Halcrow Gilbert (GBR) on the basis of National Survey reports prepared by Task 1 experts and their assistants (see annex A). The report has been funded by the IEA-PVPS Common Fund and has been approved by the IEA-PVPS Executive Committee.

To obtain additional copies of this report or information on other IEA-PVPS publications contact the IEA-PVPS website:- http://www.iea-pvps.org

September 2000

Foreword

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

The Photovoltaic Power Systems Programme (PVPS) is one of the collaborative R&D agreements within the IEA and was established in 1993. The mission of the Programme is 'to enhance the international collaboration efforts through which photovoltaic solar energy becomes a significant renewable energy source in the near future.' The underlying assumption is that the market for PV systems will gradually expand from the present niche markets of remote applications and consumer products, to the utility market, through building-integrated and other diffused and centralised PV generation systems.

In order to achieve this, the 20 countries participating in the Programme and the European Commission have undertaken a variety of joint research projects in applications of PV power systems. The Programme is organised into nine Tasks. This report has been prepared under Task 1, which facilitates the exchange and dissemination of information arising from the PVPS Programme.

"The International Survey Reports published by the IEA-PVPS agreement have gradually become an important reference document, being a reliable source of useful information in the rapidly growing field of solar PV applications. Although the report can be downloaded from our website (www.iea-pvps.org) we know how much a 'real' document is appreciated by many readers. I trust that this fifth issue will find a large audience, also outside the PV community."

Erik Lysen
Chairman IEA-PVPS Programme

Chapter 1 Introduction

1.1 Survey report scope and objective

As part of the Photovoltaic Power Systems Programme, annual surveys of PV power applications and markets in the 20 participating countries[1] are carried out. The objective of the survey reports is to present and interpret trends in both PV systems and components being used in the PV power systems market, as well as changing applications within that market, in the context of business situations, policies and relevant non-technical factors in the reporting countries. The survey report is not intended to serve as an introduction to PV, nor as a policy document. It is prepared to assist those responsible for developing the business strategies of PV companies and to aid the development of medium term plans for electricity utilities and other providers of energy services. It also provides guidance to government officials responsible for setting energy policy and preparing national energy plans.

This report presents the results of the Fifth International Survey. It provides an overview of PV power systems applications and markets in the reporting countries at the end of 1999 and analyses trends in the implementation of PV power systems between 1992 and 1999.

1.2 Survey method

Data were drawn from national survey reports[2], which were supplied by representatives from each of the participating countries. A list of the national representatives is given in annex A.

The scope of the reports is limited to PV applications with a peak rating of 40 W_p or more. Most national data supplied were accurate to ±10 %, although data on production levels and system prices vary depending on the willingness of the national PV industry to provide data for the survey.

The data were collated and this report prepared by the Technical Writer. The report has been reviewed by the national representatives to ensure the accuracy of the data used and approved by the IEA-PVPS Executive Committee.

1.3 Definitions, symbols and abbreviations

For the purposes of this report, the following definitions apply:

Demonstration programme: a programme to demonstrate the operation of PV systems to the general public and potential users/owners.

Market deployment initiatives: activities to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. They may be implemented by government, the financing industry, utilities etc.

MUSD: million U.S. Dollars (see USD).

PV system: a system including photovoltaic modules, inverters, batteries and all associated installation and control components. When calculating installed photovoltaic capacity only systems with a capacity of 40 W_p or more have been included.

USD: U.S. Dollars: the currency used throughout the report. Exchange rates are given in annex B.

Watt peak (W_p): the peak power of a PV module or system under standard test conditions of 1 000 Wm^{-2} irradiance, 25 °C junction temperature and solar reference spectrum AM 1.5.

[1] *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), the United States of America (USA)*

[2] *A survey report was not available from Portugal and so 1997 data were used where appropriate.*

Chapter 2 Implementation of PV systems

2.1 Applications for photovoltaics

For the purposes of this survey, three primary applications for PV power systems were identified.

Off-grid installations were the first economic application for terrestrial PV systems. Off-grid systems provide electricity to isolated households in remote areas and have been installed worldwide but particularly in developing countries, where they are often the most appropriate technology to meet the energy demands of rural communities. Off-grid PV systems generally offer an economic alternative to extension of the utility grid at distances of more than 1 or 2 kilometres from existing lines. Off-grid PV systems are also used to provide electricity for a wide range of equipment, such as telecommunications, water pumps, vaccine refrigeration, safety, control and protection devices and navigational aids. In these applications small amounts of power have a high value and PV is cost competitive.

On-grid distributed PV systems are a relatively recent application where a PV system is installed to supply power to a building or other load that is connected to the utility grid. The systems usually feed electricity back into the utility grid when electricity generated exceeds the building loads. These systems are increasingly being integrated into the built environment and are likely in the future to become commonplace. They are used to supply electricity to residential homes, commercial and industrial buildings, and are typically between 1 kW_p and 50 kW_p in size. There are a number of perceived advantages for these systems: distribution losses are reduced because the systems are installed at the point of use, no extra land is required for the PV systems, costs for mounting systems can be reduced, and the PV array itself can be used as a cladding or roofing material. Compared to an off-grid system costs are saved because energy storage is not required which also improves system efficiency.

On-grid centralised systems have been installed for two main purposes: as an alternative to centralised power generation from fossil fuels or nuclear, or for strengthening of the utility distribution-grid. Utilities in a number of countries were interested in investigating the feasibility of these types of power plants. Demonstration plants have been set up in Germany, Italy, Japan, Spain, Switzerland and the USA, generating reliable power for utility grids and providing experience in the construction, operation and performance of such systems. However, utility interest is now tending to focus on distributed PV plants and few centralised plants have been started since 1996.

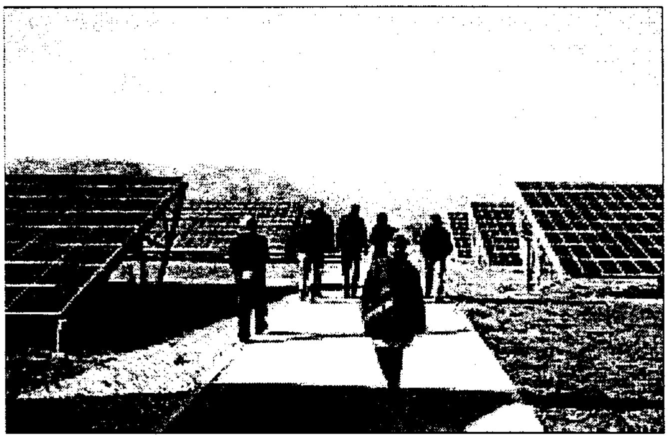


Table 2.1: Cumulative installed PV power as of the end of 1999

Country	Off-grid (kW_p)	On-grid distributed (kW_p)	On-grid centralised (kW_p)	Total (kW_p)	Total installed per capita (W_p/capita)	Power installed in 1999 (kW_p)
AUS	23 180	1 490	650	**25 320**	1.34	2 800
AUT	1 413	2 119	140	**3 672**	0.45	811
CAN	5 529	287	10	**5 826**	0.19	1 356
CHE	2 500	9 420	1 480	**13 400**	1.89	1 900
DNK	190	880	0	**1 070**	0.20	565
DEU	11 500	49 100	8 900	**69 500**	0.85	15 600
ESP[1]	7 000	600	1 480	**9 080**	0.23	1 080
FIN	2 255	17	30	**2 302**	0.45	132
FRA	8 772	349	0	**9 121**	0.16	1 490
GBR	395	736	0	**1 131**	0.02	441
ISR	381	6	14	**401**	0.07	93
ITA	10 860	905	6 710	**18 475**	0.32	795
JPN	56 900	145 500	2 900	**205 300**	1.63	71 900
KOR	3 171	288	0	**3 459**	0.07	477
MEX	12 920	2	0	**12 922**	0.13	900
NLD	3 886	5 309	0	**9 195**	0.59	2 715
NOR	5 670	0	0	**5 670**	1.28	320
PRT[2]	486	17	0	**503**	0.05	0
SWE	2 460	124	0	**2 584**	0.29	214
USA	84 200	21 100	12 000	**117 300**	0.43	17 200
Totals	**243 668**	**238 249**	**34 314**	**516 231**	**0.54**	**120 789**

[1] *Approximate*

[2] *No data available for 1999 or 1998, installed capacity as at 31 December 1997*

Table 2.2: Cumulative installed PV power (kW_p): historical perspective

Country	1992	1993	1994	1995	1996	1997	1998	1999
AUS	7 300	8 900	10 700	12 700	15 700	18 700	22 520	25 320
AUT	524	768	1 062	1 360	1 739	2 208	2 861	3 672
CAN	960	1 240	1 510	1 860	2 560	3 380	4 470	5 826
CHE	4 710	5 775	6 692	7 483	8 392	9 724	11 500	13 400
DNK[1]	0	85	100	140	245	422	505	1 070
DEU	5 619	8 900	12 440	17 790	27 890	41 890	53 900	69 500
ESP[2]	3 950	4 649	5 660	6 547	6 933	7 100	8 000	9 080
FIN	914	1 034	1 156	1 288	1 511	2 042	2 170	2 302
FRA[3]	1 751	2 051	2 437	2 940	4 392	6 118	7 631	9 121
GBR	173	266	338	368	423	589	690	1 131
ISR	100	120	150	180	210	265	308	401
ITA	8 480	12 080	14 090	15 795	16 008	16 709	17 680	18 475
JPN	19 000	24 270	31 240	43 380	59 640	91 300	133 400	205 300
KOR	1 471	1 631	1 681	1 769	2 113	2 475	2 982	3 459
MEX[3]	5 400	7 100	8 820	9 220	10 020	11 022	12 022	12 922
NLD	1 270	1 641	1 963	2 400	3 257	4 036	6 480	9 195
NOR[3]	3 750	4 050	4 350	4 600	4 850	5 100	5 350	5 670
PRT[4]	47	97	135	204	289	503	503	503
SWE	800	1 040	1 337	1 620	1 849	2 127	2 370	2 584
USA	43 500	50 300	57 800	66 800	77 200	88 200	100 100	117 300
Totals	**109 719**	**135 997**	**163 661**	**198 444**	**245 221**	**313 910**	**395 442**	**516 231**

[1] *No data available for 1992*

[2] *Approximate capacity for 1999*

[3] *Revision to data in 4th International Survey Report*

[4] *No data available for 1999 or 1998, installed capacity as at 31 December 1997*

fund (Fonds d'Amortissement des Charges d'Electrification), usually devoted to grid extension/reinforcement in rural areas, was used to support off-grid PV. Between 1995 and 1999, 871 kW_p (1 156 systems) were installed under this programme. The 5 year programme avoided 105 MUSD of line extensions.

In Australia, state government support is provided for conversion of remote area power supplies from diesel to renewable energy sources. In two states, Queensland and Western Australia, about 130 kW_p of PV were installed under these schemes in1999.

A number of the recent major off-grid projects are PV hybrid systems. For example, the Wilpena Pound Solar Power Station in Australia (a 100 kW_p ground-mounted array in configuration with 440 kW diesel and 400 kWh battery storage), the San Juanico plant in Mexico (PV/wind/diesel generator) and a PV/diesel hybrid system installed for a mountain house in Korea. Other projects seek to demonstrate the use of PV in particular locations or applications. The Nunavut Arctic College, Canada, demonstrates that PV can operate reliably at high latitudes and was the first distributed PV system linked to a remote diesel grid.

In contrast to off-grid applications, a number of countries have initiated very large programmes to promote on-grid PV, in particular Japan, Germany and the USA. These are mainly market introduction programmes, aiming to reduce costs through the sheer scale of the programme and to raise public awareness.

In Japan there are several large PV demonstration programmes. The objective of the 'Residential PV System Dissemination Programme' is to subsidise the installation costs for individuals on the condition that they perceive the significance of PV and provide the operational data of their system. Between 1994 and 1998, PV systems were installed on 15 596 houses with a further 17 396 houses accepted in 1999 under this programme. When these are installed, the total capacity will be 121.2 MW_p. Residential PV systems are typically 3-5 kW_p and account for over 80 % of the demand for PV in Japan. The PV Field Test for Public Facilities was completed in 1997 and resulted in a total of 4.9 MW_p installed in public buildings such as schools, hospitals, clinics and offices. This was followed by a PV Field Test for industrial use, which had achieved 4.7 MW_p of PV on warehouses, factories and commercial buildings by the end of 1999. Other programmes provide subsidies for local public organisations and private industrialists who are establishing new energy businesses.

The German 100 000 Roofs Solar Power Programme was launched on 1 January 1999 as a market introduction programme. This provides loans at low interest rates (see Table 4.1 for conditions). By the end of 1999, 3 576 applications (equivalent to 9 MW_p) had been accepted, although this was only half of the anticipated installed capacity. The Renewable Energy Law (which was passed in April 2000) should accelerate the PV market dramatically.

In the USA, a 10 year plan to deploy one million 'solar' roofs was issued early in 1998 (this covers both solar thermal and PV systems). Although the tax credit has not yet been approved by Congress, the initiative has moved forward in 1999 with the formation of state and local partnerships, financing for PV systems, net metering in 30 states and PV for federal buildings. Other programmes include the Sacramento Municipal District (SMUD) Pioneer programme, which equipped 400 homes with utility-owned and maintained PV systems. Pioneer II was initiated in 1998 with the objective of installing 5 MW_p by the year 2005. The aim of the programme is to evaluate the performance of the components and system and to test the impact of 10 years of bulk purchasing on the installed cost. In California the Emerging Renewables Buydown Programme, led to 2.2 MW_p of PV being installed in 1999 on both commercial and residential buildings.

Apart from national or regional demonstration programmes there are a number of high profile, building-integrated PV projects worldwide. PV features prominently in the Sydney 2000 Olympics with a 70 kW_p array on the Superdome, innovative PV streetlights and 629 kW_p installed on houses in the Newington (athletes') village. In 1999, the Nieuwland project in Amersfoort (the Netherlands) was completed. A total of 1.3 MW_p has been installed on the new housing development, providing a role model for future urban expansion. Projects such as the Newington village and Nieuwland are also being used to investigate network issues involved with such a high density of small, embedded generators. In Germany, the world's largest building-integrated PV array began operation in 1999 at the Academy Mont-Cenis Herne: a 1 MW_p PV system was integrated into the enormous glass envelope (with a roof area of 12 000 m^2) to provide shading, daylighting and electricity production. This was one of 20 PV plants selected as 'Expo 2000' projects at the world exhibition in Hannover. In connection with the movement of the German Government and Parliament from Bonn to Berlin, 14 PV plants with a total installed power of 760 kW_p have been included in the new building work. These have been installed in prominent positions such as the German Parliament, Chancellor's building and Ministry of Economy and Technology. BP Amoco are also installing PV on petrol stations: 400 kW_p were installed in the UK in 1999 as part of the global 'Sunflower' project, providing a very visible signal of the future shift from a fossil fuel to a renewable based society.

Increasingly evident is the emphasis on education in PV demonstration projects. For example, the new Earth Centre in the UK, the Kortright Centre for Conservation and the British Columbia Institute of Technology in Canada and the 'Nordic Ark' in Sweden all incorporate PV as a key feature in the design. Many countries are also installing PV systems on schools: for example the UK 'Scolar' programme (20 systems installed by the end of 1999), the 'Sun at School' programme in Germany (total installed power about 2 MW_p) and the Eco-School Infrastructure Promotion Project in Japan (systems installed on 23 schools and 85 universities by the end of 1999). In Israel five educational solar 'villages' have been established where PV generated electricity is used to operate

Table 3.1 - PV cell and module production in 1999 by region

Region	Cell production (MW_p)	Module production (MW_p)				Module production capacity (MW_p)
		Crystalline	Amorphous	Other	Total	
USA	60.80	34.40	5.00	4.20	43.60	94.10
Japan	79.62	69.97	15.01	0.00	84.98	145.20
Europe	23.94	29.32	2.40	0.00	31.72	73.33
Rest	7.00	7.50	0.00	0.00	7.50	12.50
Totals	**171.36**	**141.19**	**22.41**	**4.20**	**167.80**	**325.13**

60 % is multicrystalline and 40 % is single crystalline. However, amorphous silicon production more than doubled between 1998 and 1999. Traditionally used only for consumer products (< 40 W_p), amorphous silicon is now emerging as a viable alternative in the PV power market. Kaneka's 20 MW_p a-Si plant began production in Japan in 1999 and Sanyo Electric have commercialised an a-Si /sc-Si bifacial module with a record efficiency of 20.1 %. 'Other' technologies that are beginning to be commercially produced are cadmium telluride (CdTe) and copper indium diselenide (CIS). Regarding CdTe: Antec Solar announced a 10 MW_p plant (due to be completed by 2001) in Germany and First Solar should complete the first stage of a 100 MW_p cell and module production line in the USA in 2000. Regarding CIS: Würth Solar plan to start pilot production in Germany in 2000 and modules are being produced on a pilot basis in the USA by Siemens Solar. AstroPower produced over 1 MW_p of their new silicon film in 1999 and several companies in Australia are also developing thin film products.

Table 3.2 lists the module manufacturers in each of the reporting countries. The manufacturers can be divided into two broad categories: firstly, those who purchase ready made cells and assemble them into modules; secondly, vertically integrated manufacturers who manufacture their own cells and modules. Amorphous silicon manufacturers are always vertically integrated because the cell and module are built in the same process.

In Germany module production increased from 6.4 MW_p in 1998 to 8.8 MW_p in 1999. Targets for the 100 000 Roofs Solar Power Programme led to the foundation of new companies and realisation of planned production capacity extensions. It is planned to extend the 27 MW_p capacity to 34 MW_p by the end of 2000 and 70 MW_p in 2001. A number of new companies in Australia and the USA are either in pilot production or planning to enter production. There is currently no manufacturing capacity in Austria, Finland, Israel, Mexico or Norway; although one Israeli company is due to begin production in 2000 and there are plans to start production of cells in Norway.

A number of countries that have little, or no, module manufacturing capacity, are active in other areas. For example, Isovolta/Werndorf (Austria) produce and export approximately 50 % of the world demand for tedlar for PV modules. Crystalox (UK) and ScanWafer (Norway) are major exporters of multicrystalline silicon ingots and wafers and Automated Tooling Systems (Canada) have developed and marketed automated photovoltaic cell and custom manufacturing module lines.

3.2 Balance of system component manufacturers and suppliers

A large industry exists manufacturing balance of system components such as inverters, batteries and battery charge controllers, d.c. switchgear and array support structures. The *PV Technology Note* provides a brief technical description of these components.

The price of grid-connect inverters remains similar to 1998: typically between 0.8 - 1.0 USD/VA for inverters in the range of 1 - 10 kVA, although prices below 0.7 USD/VA are reported in the USA and Germany. Prices are generally lower for larger inverters and can be as low as 0.35 USD/VA for inverters above 100 kVA. Stand-alone inverters also tend to be cheaper since they do not need the additional control and protection functions required for grid-connection and are not, generally, required to produce a pure sine wave output.

In the absence of an international standard for grid-connection, the choice of inverters is largely determined by those manufacturers that comply with the requirements for connection pertinent to a particular country. Manufacturers in the USA and the Netherlands are now offering small inverters (~100 VA) for a.c. modules and one manufacturer is currently developing a micro-inverter designed to be plugged directly into a standard wall socket. Many inverters now include a digital output display and data acquisition system connection as standard. Manufacturers in the USA and Germany have developed dual inverters (with a few days storage) so that grid-connect systems can also be used as a back up for the grid. Fears concerning Year 2000 compliance (the 'millennium bug') created a new image for PV as a residential UPS (uninterruptible power supply).

Over 100 000 charge controllers were sold by US suppliers alone in 1999 (80 % exported). Manufacturers in France and Germany offer charge regulators with prepayment function and integrated battery, providing a portable, easy-to-use system. In France computer software has been developed to enable data analysis and remote control of off-grid PV systems through satellite or telephone networks.

3.3 System prices

For off-grid systems, prices vary widely depending on the application and the climate in which it is installed. For example, in the US sunbelt, d.c. systems can be installed with 4 to 5 days storage. In such a 'bare bones' system with PV arrays purchased from a distributor, mounting hardware, charge controller and lead-acid deep-cycle battery bank, a local installer can profitably install the system for 12 - 14 USD/W_p (d.c.). In a moderate climate an a.c. system with

PV technology note

The key components of a photovoltaic system are the **photovoltaic cells** (interconnected and encapsulated to form a **module**), the **inverter**, the **battery** and **charge controller** (for off-grid systems) and the **mounting structure**.

Cells

At present the vast majority of photovoltaic cells are made from silicon. In general, cells are classified as either crystalline (sliced from ingots or castings or grown ribbons) or thin film (deposited in thin layers on a low cost backing).

Crystalline silicon

Single crystal silicon cells are usually manufactured from a single crystal ingot, most commonly grown by the Czochralski method. PV cells made from multicrystalline silicon have now become popular as they are less expensive to produce, although slightly less efficient. Multicrystalline cell manufacture usually begins with a casting process in which molten silicon is poured in a rectangular block. This produces a block of multicrystalline silicon that is then sliced into wafers that are used to make the cells. One way of eliminating the sawing step is to grow ribbons of multicrystalline silicon that are already wafer thin and the correct width for use as PV cells.

The maximum recorded cell efficiency for crystalline silicon is 24.7 %[7]. Cell efficiencies greater than 25 % have been recorded for cells made from III-V semiconductor material (for example gallium arsenide (GaAs)). However, these materials are reserved for concentrator systems and for space applications because of their high cost.

Thin film

Thin film modules are constructed by depositing extremely thin layers of photovoltaic materials on a low cost backing such as glass, stainless steel or plastic. Individual 'cells' are formed by then scribing through the layers with a laser. Thin film cells offer the potential for cost reductions. Firstly, material costs are lower because much less semiconductor material is required and, secondly, labour costs are reduced because the films are produced as large, complete modules and not as individual cells that have to be mounted in frames and wired together.

The most fully developed thin film technology is hydrogenated amorphous silicon. This is the material normally used in consumer applications, although it is used, but less frequently, in power modules. The efficiency of commercial amorphous silicon modules has improved from around 3.5 % in the early 1980s to over 7 % currently. The most efficient modules are made with multiple layers of photovoltaic material, for instance three layer amorphous silicon modules with germanium added to two of the layers (a-Si/a-SiGe/a-SiGe) which have a record cell efficiency of 13.5 %[7]. Other types of thin films can be made using polycrystalline silicon, cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS).

Typical and maximum module and cell conversion efficiencies (at Standard Test Conditions, i.e., 1 000 Wm^{-2}, 25 °C, solar spectrum AM 1.5) are given in the table below for some of the commercially available PV technologies.

Type	Typical module efficiency (%)	Maximum recorded module efficiency[7] (%)	Maximum recorded laboratory cell efficiency[7] (%)
Single crystalline silicon	12-15	22.7	24.7
Multicrystalline silicon	11-14	15.3	19.8
Amorphous silicon	5-7	-	12.7[9]
Cadmium telluride	-	10.5	16.0
CIGS	-	12.1[8]	18.2

[7] Solar Cell Efficiency Tables, Version 15, M.A.Green, K. Emery, D.L. King, S. Igari, Progress in Photovoltaics: Research and Applications, 8, 187-195 (2000)
[8] Alloy with sulphur
[9] Unstabilised results

Module

For crystalline silicon cells, after testing and sorting to match the current and voltage, the cells are interconnected and encapsulated between a transparent front, usually glass, and a backing material. This 'module' is then typically mounted in an aluminium frame. Modules are normally rated between 50 and 200 W_p, although several manufacturers now offer modules above 200 W_p.

Inverter

An inverter is used to convert the d.c. source (from the module or battery) to a.c. The efficiency of inverters is generally greater than 90 %, when the inverter is operating above 10 % of its rated output, and can peak as high as 96 %. Inverters connected directly to the module (as opposed to through a battery) incorporate a Maximum Power Point Tracker (MPPT), which continuously adjusts the load impedance such that the generator is always extracting the maximum power from the system.

Inverters fall into two-main categories: self-commutated and line-synchronised. The first can operate independently, being activated solely by the input power source; the line-synchronised inverters are triggered directly from the grid. Utilities require that inverters connected to the grid must contain suitable control and protection to ensure that systems are installed safely and do not adversely affect the power quality.

Traditionally, one inverter was used for the whole array. Now separate inverters may be used to connect each 'string' of modules or even mounted on the back of individual modules ('a.c. modules'). String inverters and a.c modules are likely to be increasingly used in the building-integrated PV market because they permit easy system expansion, independent operation and easier installation.

Battery

For off-grid systems a battery is used to provide energy storage. Nearly all batteries used for PV systems are of the lead-acid type (with a small quantity of antimony to reduce self-discharge). Nickel-cadmium batteries are also suitable and have the advantage that they cannot be overcharged or discharged, but are considerably more expensive.

All PV batteries are deep-cycle i.e. designed to be discharged down to 50 % or more without damage so that they can supply power over a long period of time (in contrast to a car battery, for example, which is usually only discharged down to 3 to 5 %). The lifetime of a battery varies depending on factors such as how it is used, how it is maintained and charged, and temperature, but is typically 5 -10 years.

Charge controller

The primary function of a charge controller (or regulator) is to maintain the battery at the highest possible State Of Charge (SOC) and provide the user with the required quantity of electricity, while protecting the battery from deep discharge (by the loads) or extended overcharge (by the PV array). Most charge controllers operate via voltage regulation set points. However, as voltage is not representative of the true SOC, new algorithms are being developed to evaluate the state of the battery, based on Ah or combined VAh monitoring.

Additional features such as battery temperature or wire compensation, meters and alarms can enhance the ability of the charge controller to meet the load demand and extend battery lifetime. Other functions such as MPPT, d.c/d.c. conversion, anti-theft protection, load management, pre-payment and data logging can also now be built into the charge controller.

Mounting structure

With the rapid growth of on-grid distributed systems, a wide range of products have been developed for installing PV modules on buildings. These include mounting structures for PV facades, roof profiles, flat roofs and even 'PV tiles' that can be used to replace conventional roof tiles. New products are addressing the need for ease of integration into the building envelope and aesthetic appeal.

Table 3.2: Module manufacturers in the reporting countries

Country	Company	Cell Production (MW_p)	Module Production (MW_p)	Production Capacity (MW_p)	Module Type	Additional Information
AUS	BP Solar Australia	5.0	5.0	6.0	sc-Si	Merger will see new joint cell production in Sydney. Module production will remain at Solarex plant in Sydney - module production expected to reach 20 MW_p by 2001.
	Solarex	2.0	2.0	5.0	mc-Si	
CAN	Canrom Photovoltaic[1]				sc-Si	Now manufactures own cells; produces a standard line of 12, 30, 40 and 50 W_p modules.
CHE	Star Unity	0.0	0.02	0.1	sc-Si	Import cells and integrate them into roof tiles ('Sunny Tile')
	Atlantis Solar Systems	0.0	0.4	1.2	sc-Si	Produce custom laminates using imported cells and 'Sunny Tile' roofing shingles. Also have production facilities in Germany and USA of 1 MW_p capacity.
DNK	Gaia Solar	0.0	0.075	0.33	mc-Si, sc-Si	Produce modules (27 - 150 W_p) from imported cells. Production more than doubled in 1999.
DEU	>20 companies[1]	4.1	8.8	27.0	mc-Si, sc-Si EFG, a-Si	See text
ESP	Atersa	0.0	1.0	1.5	sc-Si	No change in production.
	BP Solar España	4.4	4.6	10.0	sc-Si	
	Isofoton	0.643	3.37	5.0	sc-Si	
FRA	Photowatt International	8.5	3.0	10.0	mc-Si	Manufacturing PV cells and modules since 1978. Installed a new automated cell manufacturing line in 1999. Innovation: 'POLIX' directional solidification ingot casting and wire-sawing of thin wafers.
	Free Energy Europe	0.4	0.4	1.0	a-Si	The Dutch company purchased the a-Si plant from Naps-France in May 1998. Produce modules of 12 W_p for small power applications (up to 100 W_p).
GBR	Intersolar	1.5	1.5	2.5	a-Si	Production capacity has increased from 1.6 MW_p per annum (1998). Further increase to 3 MW_p planned for 2000.
ITA	Eurosolare	0.4 1.1	0.4 1.1	2.5	sc-Si mc-Si	sc-Si wafers are bought on the international market; mc-Si wafers are home made. Production of mc-Si modules has decreased from 1.8 MW_p in 1998.
	Helios Technology	2.1	2.05	2.2	sc-Si	Fabricate single crystal silicon cells and modules, and design and supply turnkey PV systems.
JPN	Kyocera	30.2	30.2	36	mc-Si	Module production has increased from 24.5 MW_p (1998). Production capacity increase to 60 MW_p planned for 2000. Have commercialised solar cell roofing material 'ECONOROOF'.
	Sharp	8.5 21.3 0.2	8.5 21.3 0.2	10.0 22.0 2.2	sc-Si mc-Si a-Si	Production of modules has increased dramatically, from 14.0 MW_p (1998). Plan to double capacity of mc-Si production capacity to 44 MW_p in 2000. New developments: mc-Si cell with efficiency of 16.0 %.
	Sanyo Electric	4.6 5.9	4.6 5.9	5.0 8.0	a-Si a-Si/sc-Si	In 1998 module production was only 3.5 MW_p. Has commercialised a-Si/sc-Si bifacial module and plan to increase production capacity from 8 to 11 MW_p in 2000.
	Canon	1.31	1.31	10.0	a-Si	Module production decreased from 2 MW_p (1998)

Country	Company	Cell Production (MW_p)	Module Production (MW_p)	Production Capacity (MW_p)	Module Type	Additional Information
	Showa Shell Sekiyo	0.0	1.5	5.0	sc-Si	Production capacity has increased but actual production decreased (compared to 1998). Have developed combination of triangle module and square module for residential buildings.
	Air Water (former Daido Hoxan)	0.1 0.01	0.94 0.03	1.0 1.0	sc-Si mc-Si	No change in production.
	Mitsubishi Electric	4.5	4.5	10	mc-Si	Began production in 1999. Plan to increase production capacity to 15 MW_p in 2000.
	Kaneka	3.0	3.0	20.0	a-Si	Largest a-Si manufacturing plant in the world, began production in 1998.
	MSK	0.0 0.0 0.0	3.0 0.0 0.0	10.0 3.0 2.0	mc-Si sc-Si a-Si	Commisssioned sc-Si and a-Si plant and increased capacity of mc-Si plant from 3 MW_p. Plan to increase total production capacity to 28 MW_p in 2000.
KOR	LG Industrial Systems	0.0	0.2	1.0	sc-Si	Unlikely to increase production capacity since local market size is significantly less than current capacity.
	Samsung Electronics	0.0	0.3	0.5	mc-Si	
NLD	Shell Solar Energy	0.8	4.0	6.0	mc-Si	No change in production in the Netherlands. The standard 95 W_p product can be delivered as an 'AC module' containing a mini-inverter that has been approved for installation in the Netherlands.
SWE	GPV	0.0 0.0	0.5 0.5	2.0 2.0	mc-Si sc-Si	Until 1998, produced only sc-Si modules; production of mc-Si modules decreased by 1 MW_p in 1999. Plan to enlarge capacity up to 10 MW_p during 2000.
USA	Siemens Solar Industries	22.2 0.0	17.0 0.0	25.0 4.0	sc-Si CIS	Pilot production of CIS product began in 1998; large-area modules with efficiencies > 12 % have been produced.
	BP Solarex	16.0 2.0	12.0 2.0	20.0 5	mc-Si a-Si	Offers modules from 33-200 W_p. Production of mc-Si modules increased from 10 MW_p in 1998 to 12 MW_p and 2 MW_p of a-Si modules were shipped in1999.
	AstroPower	11.0 1.0	4.0 0.0	20.0 5.0	sc-Si Si film	sc-Si cell and module production increased dramatically from 6.1 MW_p and 2 MW_p respectively in 1998. 1 MW_p of the new thin film on low-cost substrate product was produced in 1999; full production (of the 9 MW_p plant) is expected in 2000.
	Solec International	0.6	0.6	0.6	sc-Si	sc-Si cell and module production almost terminated in 1999 in order to produce 5 MW_p of n-type slices for their owners Sanyo.
	ASE Americas	4.0	4.0	5.0	EFG-Si	Completed a major expansion of their plant in 1998. Produce large (200-300 MW_p) as standard.
	United Solar Systems Corp (USSC)	3.0	3.0	4.5	a-Si	Production of 5 MW_p triple-junction a-Si plant began in 1997. In addition to standard power modules, produce two building-integrated products.
	Other	1.0	1.0	5.0		Other companies nearing production: Evergreen Solar, Ebara Solar, First Solar, Energy Photovoltaics, plus companies specialising in concentrator cells.
Totals		**171.36**	**167.80**	**325.13**		

[1] *Data not available for publishing. Note: for a-Si, the cell and module are manufactured in the same process.*

Key: sc-Si = single crystal silicon. mc-Si = multicrystalline silicon. EFG = edge fed growth silicon. a-Si = amorphous silicon.
CIS = copper indium diselenide. CdTe = cadmium telluride.

10 days storage, a stand-alone inverter and ground-mounted hardware, can be installed for 14 - 18 USD/W_p. High reliability systems in moderate climates with 20 days of storage, all weather mounts, battery enclosures, system controllers etc. can cost at least 24 USD/W_p. A similar range is seen in the other reporting countries, although systems in the Netherlands, Australia and France can be up to 30 USD/W_p. Prices have not altered significantly since 1998.

On-grid systems are generally cheaper because no batteries and associated components are necessary. For on-grid, building integrated systems of 1 - 3 kW_p, system prices[10] are below 6 USD/W_p in Denmark and Germany and below 7 USD/W_p in Australia and France. In the USA, systems installed by Sacramento Municipal Utilities District (SMUD) range between 5 - 6 USD/W_p but according to SMUD suppliers, the module suppliers and system installers made little or no profit. Systems offered, with profit, outside the SMUD programme sell for 8 - 12 USD/W_p. Between 1998 and 1999, the price of on-grid systems below 10 kW_p decreased in France (by 16 %), Italy (by 6 %) and Japan (by 5 %). System prices actually increased in Finland and Switzerland although, for systems over 10 kW_p, system prices in Switzerland decreased by 5 %. This is because 'solar stock exchange' schemes have led to a market for larger systems. In general, the price of systems above 10 kW_p is substantially lower in many countries and can be as low as 4.8 USD/W_p in Australia.

Chapter 4 Framework for deployment

Deployment of PV systems is governed by local, national and international policies and the perception of the general public and utilities; it is also influenced by the availability of suitable standards and codes.

4.1 New initiatives in photovoltaic power systems

As Figure 2.3 showed, increasing emphasis is being placed on market deployment initiatives as opposed to R&D or demonstration programmes. The key initiatives in each of the reporting countries are summarised in Table 4.1.

A wide range of fiscal instruments are being used to support or promote PV (and other renewables) including: reduced interest rates, tax credits, accelerated depreciation, government or regional grants, preferential tariffs and 'green electricity' schemes. The prevalence of green electricity schemes in the reporting countries demonstrates that a significant, and growing, number of customers are concerned about the environment and prepared to pay more for electricity generated from environmentally-benign sources. Public opinion appears to be generally supportive of PV, although lack of awareness and access to information is a barrier in some countries. Utilities are also increasingly supportive of PV: many offer 'net metering' and some are investing in PV (either to give the company a 'green' image, as in Germany, or to avoid the costs of grid extension in rural areas, as in France and Mexico). The value of other network benefits attributed to PV does not, though, appear to be recognised.

4.2 Indirect policy issues and their effect on the PV market

There are two key issues with an indirect, but important, influence on the PV market: namely, the Kyoto Protocol and deregulation of the electricity industry.

As a consequence of the international Framework Convention on Climate Change and the Kyoto Protocol, countries such as Finland, Germany, Sweden and the UK have introduced, or are planning to introduce, taxes on forms of electricity generation that contribute to CO_2 emissions. These taxes are too small to noticeably affect the economics of PV and in the USA some analysts calculated that PV credits would be less than 0.01 USD/kWh if there were serious efforts to credit PV for mitigation of CO_2. However, in the UK, the money raised from the carbon tax will be used as an additional source of funds for the national renewable energy programme. Perhaps more significantly, the Kyoto Protocol has stimulated a reappraisal of renewable energy policy and the setting of national targets for PV deployment. For example, in Japan a law concerning 'Promotion Measures to Arrest Global Warming' was passed and in Australia a range of new renewable energy programmes, including mandated purchase of renewable energy by electricity retailers, have been introduced as part of the national Greenhouse Strategy. As shown in Table 4.1, Germany, Finland, France, Italy, Japan, the Netherlands and the USA have all set targets for increasing PV deployment dramatically. In addition the European Commission are currently preparing a Directive on renewable energy support, including targets, which is likely to influence PV deployment in its' member countries to some extent.

Since an increasing proportion of PV systems are grid-connected, restructuring of the electricity industry is an important factor. Deregulation has been achieved, or is currently underway, in Australia, Canada, Denmark, Finland, Germany, the Netherlands, Switzerland, the UK and the USA. The impact on PV is uncertain. The increase in green power schemes and net metering is one outcome, as many utilities are expanding customer services and choice in the face of increased competition. Deregulation has also opened up access to the grid. Accompanied by simplified connection procedures and requirements, this has permitted a dramatic growth in embedded generation (such as PV). However, market-led schemes promote the cheapest option and so do not necessarily lead to more PV installations. For example, in Australia, PV accounts for less than 0.1 % of the total green power produced and the New Electricity Trading Arrangements in the UK replace existing subsidies for renewables with an obligation on suppliers to obtain a percentage of their electricity from renewable sources. (Electricity suppliers will therefore select the cheapest renewable technologies). Also, the primary aim of liberalisation in the electricity supply industry is to drive down costs to the consumer. Thus, as electricity prices fall, the price differential separating PV from conventional electricity generation will increase.

[10] *Note: these prices are turnkey prices that exclude VAT/TVA/sales taxes, operation and maintenance costs but include installation costs.*

Table 4.1: New initiatives in the reporting countries

Country	Promotional Initiatives	Utility and Public Perceptions	Major New Initiatives and Planned Development
AUS	A number of utilities offer net metering for domestic PV systems. Utility Green Power programmes grew rapidly during 1999 with over 58 000 customers nationwide, although to date PV only accounts for 0.1 % of the total Green Power produced. As part of Green Power schemes, one utility offers 0.17 USD/kWh for electricity exported from PV and another utility uses customer donations, via rounding up of electricity bills, for the installation of PV systems on schools.	Public support for PV and other renewables continues. However, grid-connected customers in particular lack access to information on availability, cost and performance of PV systems and have a limited understanding of the potential role of renewables in the electricity supply network.	Several new renewable energy programmes are planned for 2000 and 2001. The Australian Greenhouse Office will provide support for up to 50 % of the cost of domestic building integrated PV systems and up to 50 % of the cost of conversion of diesel-based off-grid electricity generation to renewable energy technologies. The Renewable Energy Industry Development programme and Renewable Energy Equity Fund will also benefit PV.
AUT	Preferential tariffs ranging between 0.32 to 0.80 USD/kWh. Some regional governments subsidise PV; in Upper Austria subsidies up to 50 % of the total installed cost are available.	Most utility companies have installed PV systems for demonstration purposes or to supply isolated areas. In Upper Austria 23 % of the customers who contributed to the green electricity programmes decided to subsidise PV.	Decisions concerning funding of renewables have been delayed until the effect of the new electricity trading rules is evident.
CAN	Accelerated depreciation for the cost of PV systems greater than 3 kW_p resulting in Sales Tax reduction and, in Ontario, two utilities accept net metering for PV. 1999 saw a marked increase in on-grid PV systems as a result of the Greenpeace Solar Pioneers programme.	PV is attractive to the public for vacation cottages/cabins and recreational vehicles but the general perception is still that PV is too expensive. It is expected that deregulation of the electricity market will allow an increasing number of customers to support solar energy for environmental reasons and green electricity options are being implemented in some regions.	The Government, in collaboration with the Canadian Solar Industries Association, is planning a marketing and promotional initiative to raise awareness of PV.
CHE	The 'solar stock exchange' plays a major role in providing a market for building integrated PV systems. The utilities act as a 'stock exchange' for trading between independent PV generators and customers who are willing to pay a premium for solar energy.	The Government's 'Energy 2000' programme and the Swiss Utilities Association are working to ensure that all customers have access to the 'solar stock exchange'. In 1999, 1.2 % of the 1.8 million households able to purchase 'green electricity' did so.	In September 2000 there will be a public referendum on the introduction of a levy on non-renewable energy and a longer-term ecological tax reform. In the city of Basle new legislation has been introduced which will help fund 300 kW_p of additional PV power per year over a six year period, resulting in an average of 8.5 W_p per resident in the city.
DNK	Subsidy of up to 36 % for PV applications in the commercial sector, funded by the CO_2 tax on electricity (little use has been made of this so far). Net metering for privately owned PV systems was established in mid 1998 for a trial period of 4 years.	Polls reveal a high consumer interest in PV and a willingness to pay more for 'green electricity'. A new law deregulating the electricity sector is likely to influence PV deployment.	A 300 roof top project was launched in 1998; about half of the systems had been installed by the end of 1999. In late 1999 the Danish Parliament allocated 3.9 MUSD for a 3 year programme to promote the use of PV on buildings and to foster the development of appropriate building-integrated PV products.
DEU	The 100 000 Roofs Solar Power Programme, launched on 1 January 1999, provides loans with low interest rates (0 % in 1999) for 10 years. The loan is to be repaid in 8 installments (12.5 %) from years 3 to 10, whereas the last installment is not due for repayment if the PV plant is still in operation. In addition to the Government subsidies, 10 of the 16 Federal states are supporting PV installations, particularly Nordrhein-Westfalen.	Public opinion concerning renewable energy remains very positive. By the end of 1999 more than 50 suppliers were offering green power, compared to 11 suppliers by the end of 1998, and the number continues to increase. Utilities are participating in the green power market and this has resulted in a growing number of 'green-power' plants - a combination of different renewable energy plants, including PV.	The initial response to the 100 000 Roofs Solar Power Programme was disappointing with applications for 9 MW_p instead of the expected 18 MW_p. However, the Law for the Priority of Renewable Energies, which will come into force in 2000 should accelerate the market dramatically. The Law replaces the Renewable Energies Feed-in Tariff Law of 1991 and sets a buy back rate of 0.51 USD/kWh for PV generated electricity. The target capacity for the Programme is 300 MW_p by 2003.
ESP	Regional programmes to support PV provide subsidies of over 25 % of the installation cost. Electricity generated from PV receives a preferential tariff of 0.4 USD/kWh (for systems less than 5 kW) and 0.2 USD/kWh (for systems greater than 5 kW).	Public perception of PV is positive, particularly due to the low visual impact. Several Spanish utilities have invested substantially in grid-connected PV systems.	The Energy Saving and Efficiency Programme (PAEE) ended in 1999, but grants to PV will continue under the new programme for renewable energy (2000-2006), which is currently awaiting approval.
FIN	Investment subsidies of up to 30 % are available for companies installing PV systems. Preliminary interest has been shown in an ESCO type financing approach for PV installations on private homes.	'Green electricity' schemes have been introduced and utilities are increasingly interested in demonstrating building integrated PV systems as part of their environmentally friendly image.	The Ministry of Trade and Industry launched an Action Plan for Renewable Energy Sources in 1999. This set a target of 40 MW_p of installed capacity by 2010 which represents an increase in PV electricity production by 40 fold compared with the base year 1995.
FRA	Up to 95 % of the cost of an off-grid domestic PV system is subsidised (70 % from the Fonds d'Amortissement des Charges d'Electrification (FACE) fund, 15 % from the Finance Ministry and 10 % from ADEME). Between 35-80 % of the cost of on-grid systems can be funded through the PHEBUS initiative, a demonstration programme of the EC (ends in 2000).	EDF (the main electricity utility) and ADEME continue to promote the use of PV (and wind) for isolated houses, where grid extension is a more expensive option, through the FACE programme.	A new demonstration programme for on-grid building integrated systems was initiated in 1999 partly funded by the EC. The aim is to install 500 kW_p in the next 3 years with a targeted installation cost of 5 USD/W_p. Due to a Government decision (in 1998) to reinforce the public budget for the development and promotion of renewables, ADEME has tripled its budget for PV dissemination and aims to install 1 500 kW_p of off-grid systems per year.

Country	Promotional Initiatives	Utility and Public Perceptions	Major New Initiatives and Planned Development
GBR	Government funding is restricted to R&D. Marketing of PV is left to organisations such as Solar Century.	The utility perception of PV is improving but in general utilities are more concerned with the connection of other small embedded generators such as micro-CHP Stirling engines which are viewed as more likely to take-off in the UK. The PV industry continues to lobby for net metering and policy changes.	The large increase in installed capacity in 1999 is largely due to the ongoing BP Amoco 'Sunflower' project. A number of large building integrated PV projects are planned for 2000 when the Government's 100 roofs domestic field trial will also begin. VAT on PV systems will be reduced from 17.5 % to 5 % with effect from April 2000 and the Climate Change Levy will be used to support renewables in general.
ISR	The Government provides support for PV grid-connected demonstration projects but the support is conditional on bringing the proposed project to a state of being 'cost effective'. To date no one has taken advantage of this offer.	Public perception of PV is increasingly positive as a result of greater awareness of environmental issues in general. However, the industry is hampered by continuing thefts of modules and systems increasing installation costs (extra shielding) and maintenance (guard duty) for some isolated applications.	Three major new projects are being developed. In Yeruham, a number of solar projects to provide social and educational benefits. In Nitzana, building a Solar Demonstration Park and establishing a new solar energy curriculum for pupils. In Kibbutz Samar, plans to expand an existing PV power station from 4.5 kW_p to 200 kW_p capacity.
ITA	Tax reductions of 36 % of the investment cost of a PV system are available and a VAT reduction from 20 % to 10 %. Electricity generated from PV receives a preferential tariff of 0.18 USD/kWh for plant commissioned within the year 2000.	The utilities have demonstrated their support for the national roof-top programme by co-operating with ENEA to address technical issues relating to grid connection and some utilities are starting their own demonstration programmes. There is also widespread interest from the general public.	The 10 000 roof top programme has been delayed further but is expected to start in 2000. The target capacity is 50 MW_p.
JPN	The taxable amount of fixed property is reduced to 5/6 for 3 years if PV is installed. Owners can also choose either a tax credit of 7 % of the acquisition value of the PV system or 30 % depreciation for the first year. Some financing institutions offer preferential loans to homebuyers for PV systems. Net metering has been available since 1992.	Several utilities have established a subsidy to support R&D on PV systems and a subsidy of half the cost of residential PV installations. Public support for PV is growing and this is evident in a doubling in the number of applications for the Residential PV System Dissemination Programme in 1999.	The existing demonstration and field test programmes expanded dramatically in 1999, making steady progress towards a target of 5 000 MW_p of installed PV capacity by 2010.
KOR	The Government supports demonstration and field tests of various renewable energy sources; PV remains a 'high priority' sector.		
MEX	Government grants are available to isolated and poor communities for rural electrification.	During 1998-99 the national utility sponsored a study to evaluate the effectiveness of the PV Rural Electrification Programme.	A large programme is to be launched in 2000 by the Agricultural and Hydraulic Resources Ministry to support PV applications in agriculture e.g. water pumps for irrigation, cattle watering and electric fencing.
NLD	Apart from government subsidy through the national PV programme, a wide range of support mechanisms are used to finance PV including: low interest rates for 'green projects', accelerated depreciation on environmental investments, a 'green mortgage' for energy efficient and sustainable buildings and green electricity schemes. A generic subsidy for PV is currently being prepared in order to speed up market deployment.	Utilities are active in project development and subsidising of PV. For many companies, like utilities and the building industry, investing in PV is seen as a strategic choice expected to create new business opportunities. According to a market survey conducted by Greenpeace, many customers would be willing to purchase a small PV system and PV is widely regarded as the most promising renewable energy option for the Netherlands in the long run.	The Government has set targets of 250 MW_p of installed PV capacity by the year 2010 and 1500 MW_p (equivalent to about one million roof top systems) by the year 2020. A new PV Covenant (a treaty signed by 28 parties - industry, utilities, R&D sector, government) is being prepared for the period 2001-2007. Key issues are financing and facilitating market development. Participants in the PV Covenant have also discussed the possibility of raising the target for installed power to 500 MW_p by 2007.
NOR		Growing interest from utilities to include PV in future programmes.	Production of multicrystalline silicon wafers due to increase from 6 MW_p to 30 MW_p in next three years; plan to begin production of PV cells.
SWE	There are no general subsidies for PV. However, government funding of up to 50 % can be obtained for a demonstration project.	The general view of PV as a long-term sustainable renewable energy technology is positive.	Until recently the main activity in the national programme has been to identify and develop niche applications where PV will be cost effective as a stand-alone system. In the last couple of years the programme focus has shifted towards evaluating the application of PV in the built environment as a longer-term option.
USA	The key initiatives in the on-grid distributed sector are: the Million Solar Roofs Initiative, the Sacramento Municipal Utility District (SMUD) Pioneer programme, the California PV Subsidy programme and the PV for Schools programme. By the end of 1999, 12 states had enacted restructuring legislation including such options as net metering, green pricing and set-asides for environmentally benign renewables.	Concerns regarding Year 2000 compliance created a new image for grid-connected PV and led to a surge of sales of PV as a back up power system. The Utility Photovoltaic Group (UPVG) supports net metering as a mechanism for expanding PV markets and has installed nearly 6 MW_p of utility-owned or endorsed PV systems.	In 1998 the Department of Energy issued a 10 year plan to stimulate the deployment of one million 'solar' (PV and solar thermal) roofs. The tax credit for the initiative is still awaiting approval from Congress but progress has been made through a series of public meetings and building partnerships with agencies, states and local entities.

4.3 Standards and codes

The International Electrotechnical Commission (IEC) established a Committee (TC 82) in 1981 to prepare international performance and safety standards for PV. The IEC have published 26 International Standards addressing PV cells, modules and stand-alone PV systems.

Currently, IEC standards development is most active in the grid-connect sector and a number of countries have developed, or are developing, guidelines/standards for connecting small PV systems to the electricity network. Both the USA and the UK have recently published guidelines for connecting PV systems to the distribution network. It is interesting to compare the different approach of these two countries. The Institute of Electrical and Electronic Engineers based in the USA has published a Recommended Practice for Utility Interface of PV Systems (IEEE 929) rated 10 kW or less. This standard requires certification from an *independent and accredited laboratory* (using the associated test standard UL1741). The UK guidelines are, in general, less prescriptive and, in line with European industry practices that allows *self-certification by manufacturers* to an approved type test procedure. The approach for the use of a.c. modules is also different. In the USA, a.c. modules can be installed in accordance with the national electrical code if they have been independently certified to the UL1741 standard and meet the requirements of IEEE 929. However, the connection of a.c. modules is not permitted in the UK because of concerns regarding solid-state (as opposed to mechanical) disconnection from the network. This is a major barrier to market expansion and has raised fears that systems may be illegally connected in the UK. With the objective of harmonising the test requirements of PV products internationally, manufacturers and safety test laboratories are currently working together to develop international safety standards for inverters (IEC 62109) and modules (IEC 61730).

Attention is being turned to addressing the d.c. side of the grid connection. Installation guidelines have been published in the Netherlands and are being developed in the UK, Germany, Canada and Australia. The IEC also have a committee (TC 64) which is seeking to extend the existing Wiring Regulations (IEC 60364) to encompass PV installations. Guidelines are urgently required for the electrical contracting industry to address the safety issues unique to PV installations and facilitate training and certification of installers. Co-operation is also required between the building industry and PV industry to include joint development of guidelines and standards.

A major initiative, the Global Approval Programme (PV GAP) was launched in 1997 to promote and maintain quality standards and certification, focusing primarily on stand-alone systems in developing countries and driven by quality concerns of donor programs and the World Bank. PV GAP and IEC technical experts have collaborated on an important project to prepare a new international standard for small PV stand-alone systems.

Chapter 5 Summary of trends

There is great diversity between the countries participating in the IEA Photovoltaic Power Systems Programme and, although this survey does not capture the whole PV market, it provides an indication of global trends. The key trends in PV applications and markets are summarised below and in Table 5.1. Care must be taken in interpreting the statistics due to the very large PV programme in Japan, which is influencing trends in the participating countries to an increasing degree.

- The market for PV power applications continues to expand rapidly: between 1998 and 1999 the total installed capacity in the reporting countries grew by 31 %, reaching 516 MW_p. Of the 121 MW_p installed during 1999, 60 % was installed in Japan alone. Minus Japan, the installed capacity grew by 19 % between 1998 and 1999 (similar to the previous year).

- Off-grid applications account for over 90 % of the total installed capacity in Australia, Canada, Finland, France, Israel, Mexico, Norway, Portugal and Sweden. However, overall, the trend is for an increase in the proportion of PV power that is grid-connected. Between 1992 and 1999, the installed grid-connected PV increased from 29 % to 53 % of the total capacity in the reporting countries. This is due to the large, government-subsidised programmes, especially in Japan and Germany, which focus on PV in the urban environment (on-grid distributed systems).

- Awareness of PV power systems is growing with a number of high profile projects such as the PV installations associated with the Sydney 2000 Olympics, the Amersfoort Nieuwland project in the Netherlands, Expo 2000 projects and new governmental buildings in Germany and PV on petrol stations. Education is increasingly being recognised as a key aspect of national programmes and a number of countries, including Japan, Germany, Israel and the UK have programmes to install PV systems on schools.

- The total budget allocated by government bodies to support the PV industry in the reporting countries has increased from 287 MUSD in 1994 to 479 MUSD in 1999. Over half of the total budget for 1999 was for Japan although other countries, in particular France, saw significant increases in the PV budget. An increasing proportion of the budget is spent on initiatives to encourage the market deployment of PV, as opposed to research, development and demonstration.

- Between 1993 and 1999, module production tripled: from 52 MW_p to 168 MW_p per annum. Japanese production increased by 67 % between 1998 and 1999 and as a result over half of all the modules in the reporting countries were produced in Japan in 1999; largely to feed the increase in demand in the home market. A number of new companies are planning to

Table 5.1 Installed PV power and module production in the reporting countries

Year	Cumulative installed power and percentage increase						Power installed per year	Module production in year
	Off-grid		On-grid		Total			
	MW_p	%	MW_p	%	MW_p	%	MW_p	MW_p
1992	78		32		110			
1993	94	21	42	32	136	24	26	52
1994	112	19	51	24	164	20	28	
1995	132	18	66	29	198	21	35	56
1996	157	19	88	33	245	24	47	
1997	187	19	127	44	314	28	69	100
1998	216	15	180	42	395	26	82	126
1999	244	13	273	52	516	31	121	168

enter production in 2000 in Australia, the USA, Norway and Israel and many companies are planning to enlarge existing production lines. Overall, production remains well below capacity (52 %): this reflects the rapid expansion of the industry with large plants being built but not, yet, fully operational.

- The vast majority of modules produced (84 %) are still crystalline silicon, of which approximately 60 % are multicrystalline and 40 % are single crystalline (a similar split to 1998). However, amorphous silicon production more than doubled between 1998 and 1999 and is now emerging as a viable alternative in the PV power market. CdTe and CIS manufacturing plants are either planned or operational in Japan, Germany and the USA. These will provide a market test for new, lower manufacturing cost, module options. The first stage of a giant 100 MW CdTe cell and module production line should be completed in 2000.

- In general the price of systems has not altered significantly since 1998, although cost reductions were seen in France, Italy and Japan. On-grid building integrated systems of 1 - 3 kW_p are typically between 6 - 12 USD/W_p (installed) although prices below 6 USD/W_p were reported in Denmark and Germany. The new on-grid demonstration programme in France aims to achieve an installed cost of 5 USD/W_p within 3 years. Off-grid systems remain competitive in many applications such as remote houses, telecommunications, water pumping and traffic signals.

- Utilities are increasingly supportive of PV: many now offer net metering or preferential tariffs for PV and some, as in the USA, Spain and the Netherlands, are actively involved in project development. Deregulation in the electricity industry is likely to have an impact on PV deployment and further measures may be necessary to increase the attractiveness of PV. As an example of such 'measures': a dual inverter, coupled with storage, has been introduced to make PV a grid-connected UPS system. Concerns regarding Year 2000 compliance caused a surge of sales during 1999, providing a real, grid-connect market (without subsidies) for such systems.

- Many countries (Germany, Finland, France, Italy, Japan, the Netherlands and the USA) have set targets to increase PV deployment dramatically in the near/medium term; this can be attributed in part to the Kyoto Protocol of 1997.

Annex A IEA - PVPS Task I

Experts

Australia	Greg Watt, Australian PVPS Consortium
Austria	Georg Baier, Verbund
Canada	Raye Thomas, representing the Canadian Solar Industries Association (CanSIA)
Denmark	Peter Ahm, PA Energy A/S
Finland	Leena Grandell, Motiva
France	André Claverie, ADEME
Germany	Peter Sprau, WIP
Israel	Yona Siderer, The Ben Gurion National Solar Energy Centre
Italy	Salvatore Guastella, CESI - ENEL
Japan	Masao Kando, NEDO
Korea	Kyung-Hoon Yoon, KIER
Mexico	Jaime Agredano Diaz, Electrical Research Institute
Netherlands	Astrid de Ruiter, NOVEM
Norway	Bruno Ceccaroli, SCATEC AS
Portugal	Gina Pedro, DGE
Spain	Jesus Garcia Martin, Iberdrola
Sweden	Lars Stolt, Uppsala University
Switzerland	Pius Hüsser, Nova Energie GmbH
United Kingdom	John Stones, EA Technology Ltd
United States of America	Charles Linderman, Edison Electric Institute

In some cases, the Task I expert was assisted by one or more experts from their respective countries.
These experts are listed below.

Australia	Muriel Watt, University of NSW
Austria	Gerd Schauer, Verbund
Canada	Lisa Dignard-Bailey, Natural Resources Canada - CEDRL
Denmark	Bent Sørensen, Roskilde University
Germany	Ingrid Weiß, WIP
Israel	Shoshona Dann, The Ben Gurion National Solar Energy Centre
Italy	Salvatore Castello and Anna De Lillo, ENEA
Japan	Eiichi Waki, NEDO Shuji Yamamoto, PVTEC
Korea	Jinsoo Song, KIER
Mexico	Jorge Huacuz Villamar, Electrical Research Institute
Netherlands	Leendert Verhoef, VSEC
Sweden	Karin Granath and Olle Lundberg, Uppsala University
Switzerland	Alan C. Hawkins, A.C.Hawkins Consulting & Services
United States of America	Ward Bower, Sandia National Laboratories: Paul Maycock, PV Energy Systems

Technical writer:
The International Survey Report was written by John Knight: Halcrow Gilbert, Burderop Park, Swindon, SN4 0QD, UK.

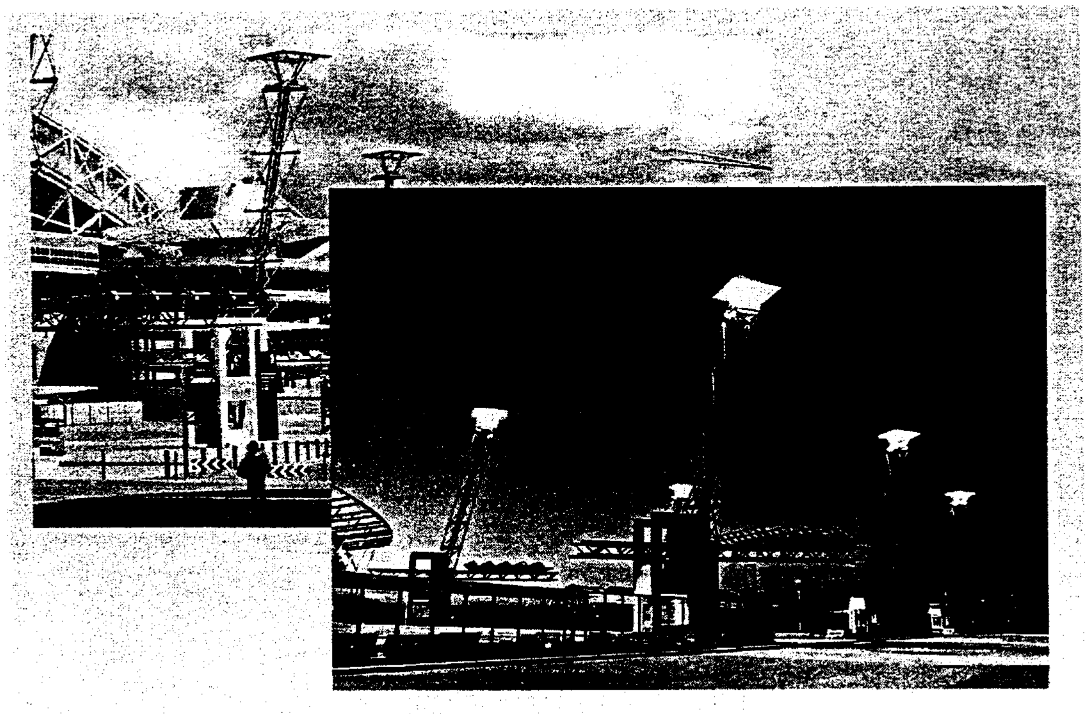
Annex B Exchange rates

The table below lists the participating countries, corresponding ISO country and currency codes, and the exchange rates used to convert national currencies. 1999 exchange rates are generally used. For Israel all financial information was provided in USD, which is the currency used locally, by industry, for statistical purposes. No financial information was available for Portugal and Spain.

Country	ISO country code	Currency and ISO code	Exchange rate (1 USD =)
Australia	AUS	Dollar (AUD)	1.67
Austria	AUT	Schilling (ATS)	12.5
Canada	CAN	Dollar (CAD)	1.486
Denmark	DNK	Krone (DKK)	7.6
Finland	FIN	Markka (FIM)	5.92
France	FRA	Franc (FRF)	6.56
Germany	DEU	Mark (DEM)	2.1
Israel	ISR	New Israeli Shekel (NIS)	(see above)
Italy	ITA	Lira (ITL)	2 000
Japan	JPN	Yen (JPY)	107
Korea	KOR	Won (KRW)	1 188
Mexico	MEX	Peso (MXP)	9.44
Netherlands	NLD	Guilder (NLG)	1.27
Norway	NOR	Krone (NOK)	8.75
Portugal	PRT	Escudo (PTE)	
Spain	ESP	Peseta (ESP)	
Sweden	SWE	Krona (SEK)	8.267
Switzerland	CHE	Franc (CHF)	1.5
United Kingdom	GBR	Sterling (GBP)	0.625
United States	USA	Dollar (USD)	1
European Union		Euro (EUR)	1

IEA　国際エネルギー機関

IEA 参加諸国における 1992 年～1999 年間の太陽光発電応用の動向



太陽光発電システム・プログラム

報告 IEA-PVPS T1-08：2000

表紙写真：オーストラリア、シドニー・オリンピック競技場のオリンピック並木に立ち並ぶ各照明灯電柱に設置された 6.8 kWp PV、写真提供：Energy Austraria 社

目次

本報告書はタスクＩの専門家および補助者が作成した自国の調査報告書に基づいてタスクＩの監修のもとに Halcrow Gilbert 社（英国）の John Knight によって作成された。本報告書は IEA-PVPS 共同資金の提供を受け、IEA-PVPS 執行委員会から承認された。

本報告書のコピーまたはその他の IEA-PVPS 出版物に関する情報を入手するには、IEA ウエブサイト：- http://www.iea.orgにアクセスされたい。

2000 年 9 月

はじめに

1974 年に設立された国際エネルギー機関（IEA）は経済協力開発機構（OECD）の枠組みの中での独立組織体である。IEA は会員国 23 ヶ国間で包括的エネルギー協力プログラムを実行している。欧州委員会も本機関の活動に参加している。

太陽光発電システム・プログラム（PVPS）は IEA 内の研究開発協力協定のひとつで、1993 年に制定された。このプログラムの使命は「国際協力によって太陽光エネルギーが将来の重要な再生可能エネルギーの選択肢になるように推進すること」である。太陽光発電（PV）システムの市場は遠隔地応用や消費財応用などの現在のニッチ市場から建物一体型システムや分散配置型および集中配置型 PV 発電システムの普及を経て電力市場へと徐々に拡大していくものと推測されている。

このプログラムの目的を達成するために参加国 20 ヶ国と欧州委員会は PV システムの応用に関する種々の共同プロジェクトを実施してきた。このプログラムは 9 つのタスクに分かれている。本報告書は、PVPS プログラムで得られた太陽光発電システムに関する情報の交換と普及を促進するために、タスクⅠによって作成された。

IEA-PVPS 協定によって公刊された国際調査報告書は重要な参考文書になってきており、急速に成長する PV 応用分野において有用な、信頼性のある情報源となっている。報告書はインターネット（www.iea-pvps.org）でダウンロードできるが、本文書も多くの読者から非常に評価されていることは周知の通りである。本国際調査報告書第 5 報が更に多くの読者の興味を引き、また PV コミュニティー以外の関係者の興味をも引くものと確信している。

Erik Lysen
PVPS プログラム議長

緒言

1.1 調査報告の範囲と目的

太陽光発電システム・プログラムの一環として、IEA は参加国 20 ヶ国[1]における PV 発電システム応用と市場の調査が毎年実施されている。本調査報告書の目的は PV 発電システム市場で使用されている PV システムおよびコンポーネントの動向はもちろん、報告国における事業状況、政策および非技術的要因に関連した PV 市場内での応用の変化についても紹介し、説明することである。本調査報告書は PV の導入に役立てたり、政策文書の作成に役立てることを意図したものではない。本調査報告書は PV 企業の事業戦略を策定する責任者を支援し、また電力会社やその

[1] オーストラリア(AUS)、オーストリア(AUT)、カナダ(CAN)、デンマーク(DNK)、フィンランド(FIN)、フランス(FRA)、ドイツ(DEU)、イスラエル(ISR)、イタリア(ITA)、日本(JPN)、韓国(KOR)、メキシコ(MEX)、オランダ(NLD)、ノルウェー(NOR)、ポルトガル(PRT)、スペイン(ESP)、スウェーデン(SWE)、スイス(CHE)、英国(GBR)、米国(USA)

他のエネルギー供給業者の中期計画策定を支援する意図で作成されている。また、国のエネルギー政策を策定し、国のエネルギー計画を作成する立場にある政府役人にとっても指針となるはずである。

本調査報告書は国際調査報告書第 5 報である。本調査報告書は 1999 年末時点における報告国のPV 発電システムの応用と市場を概観し、1992 年から 1999 年における PV システムの実施動向を分析したものである。

1.2 調査方法

データは各参加国の代表から提出された各国の調査報告書[2]の中から引用している。報告国の代表者のリストは付属書 A に示した。

本報告書の範囲は 40 Wp 以上の PV 応用に限定されている。提供された多くの国のデータは±10%の精度であるが、生産能力レベルおよびシステム価格に関するデータは精度にバラツキがあった。これはその国の PV 産業界が調査のためのデータを提供する協力度に左右されたためである。

データは順序正しく整理され、テクニカル・ライターによって本報告書が作成された。本報告書は使用するデータの正確さを期すために、各国の代表者によって再検討され、PVPS プログラム執行委員会から承認された。

1.3 定義、記号および略語

本報告書を作成するに当たって、つぎの定義を適用している。
実証プログラム：一般大衆や潜在的ユーザー／所有者に PV システムの運転を実証するプログラムを言う

市場展開イニシアチブ：グリーン・プライス制度、レート・ベース・インセンティブなどの市場開発手段を用いて PV の市場展開を活性化するための活動を指す。この活動は政府、金融業界、電力会社等によって実施されている

MUSD：百万米ドル（USD 参照）

PV システム：PV モジュール、インバータ、蓄電池、付属装置および制御コンポーネントを含むシステムを指す。PV 設置容量を計算する場合には 40 Wp 以上の容量を有するシステムのみが対象となっている

USD：米ドル。本報告書で使用された通貨を指す。為替レートは付録 B に記載した

ワット・ピーク（Wp）：日射強度 1000W/m²、接続部温度 25℃、基準太陽スペクトル AM1.5 の標準試験条件での PV モジュールあるいはシステムが発電するピーク電力を言う

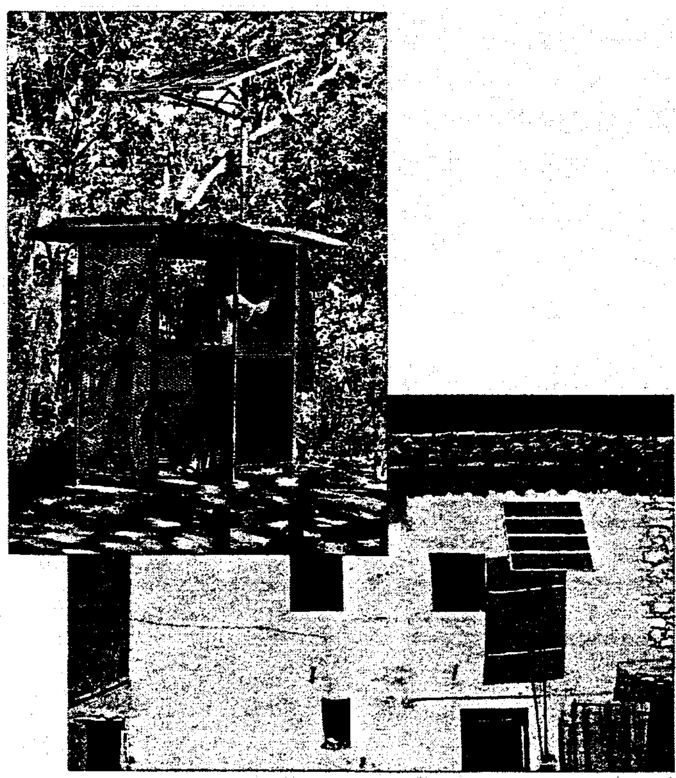
[2] 調査報告書をポルトガルから入手できなかったので、1997 年のデータを利用した

2章　PVシステムの実施

2.1　太陽光発電の応用

本調査報告書では、PV発電システムをつぎの3つの基本的応用に分類している。

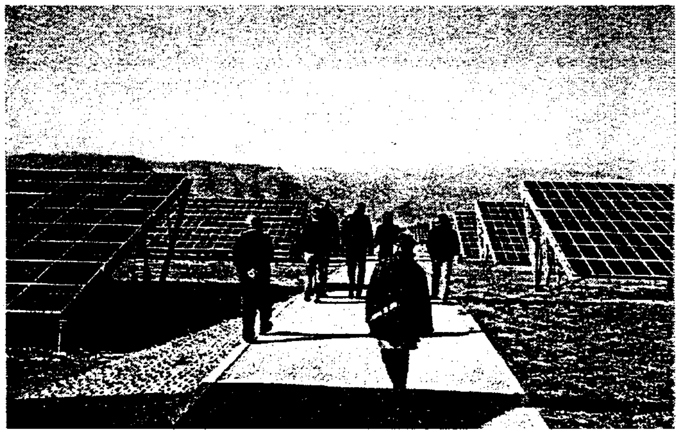
独立形システムは地上に設置されるPVシステムに関する最初の経済的応用であった。独立形システムは遠隔地における孤立家庭に電気を供給するシステムとして世界中で設置されているが、特に発展途上国において農村地域のエネルギー需要に合致した最適技術であることが多い。独立形PVシステムは既存の電線路から1～2km以上離れた地点への電力会社の系統延長に対する経済的な代案として通常よく使用されている。また、独立形PVシステムは遠距離通信、揚水ポンプ、ワクチン保存用冷蔵庫、安全・制御・保護装置、航行補助装置などの電源としても使用されている。これらの応用は小電力負荷の電源として価値が高く、PVもコスト競争力がある。



分散配置系統連系形システムは比較的最近の応用で、電力会社の系統に連系される建物その他の負荷に電力を供給するために設置されるPVシステムである。このシステムは発電電力量が建物の負荷を超過した場合には、通常電力会社の系統に逆潮流を行うこができる。建物やその他の建造物に一体化することが増加しているこのシステムは将来一般的になると推測されている。システムは電気を住宅、商業ビル、産業ビルに供給するために使用され、サイズは1 kWp～50 kWpが代表的である。このシステムにはよく知られている数多くの利点がある。すなわち、システムが使用場所に設置されるので配電損失が減少すること、PVシステムに余分な土地も必要としないこと、システム取り付けコストを削減できること、PVそのものを屋根材として利用できることなど

である。独立形システムに比較して、蓄電池を必要としないのでコストも削減できるし、またシステム効率も向上する。

集中配置系統連系形システムの設置には 2 つの大きな目的がある。ひとつは化石燃料または原子力による集中配置型発電所の代替としてのシステム、もうひとつは電力会社の配電網の補強用としてのシステムである。多くの国の電力会社はこのタイプの発電所の実行可能性調査に関心を持っている。PV 実証システムがドイツ、イタリア、日本、スペイン、スイスおよび米国において今までに設置され、電力会社の系統に信頼性のある電力を供給したり、システムの設置、運転、性能に関する経験を蓄積してきた。しかし電力会社の関心は、現在では、分散配置型 PV 発電システムに重点を置く傾向にあり、従って 1996 年以降に着手された集中配置型発電所はほとんどない。



2.2 太陽光発電設置容量

1999 年末時点で報告国において 516 MWp が設置された。3 分野の PV システム応用別の 1992 年から 1999 年までの PV 設置容量の増加を図 2.1 に示す。世界の設置容量は報告国における設置容量よりはるかに大きいが、この図は世界的動向を示唆している。

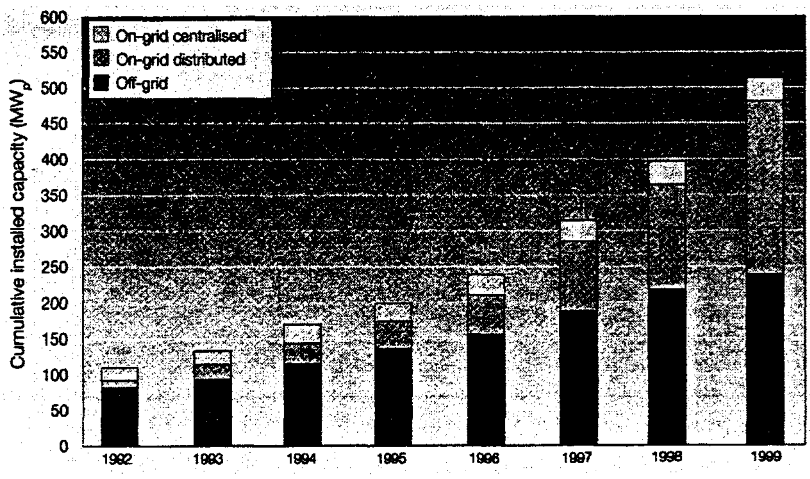


図 2.1：報告国における応用別累積 PV 設置容量

1992 年から 1998 年にかけての累積 PV 設置容量は年 20～28%の割合で増加している。1998 年から 1999 年にかけての設置容量増加率は 31%である。しかし表 2.1 および表 2.2 を参照すると、この上昇は日本における著しい増加によることが分かる。日本を除外した場合、1998 年から 1999 年にかけての報告国の設置容量増加率は 19%である（前年と同じ）。実際に 1999 年に設置された 121 MWp のうち 60%は日本で設置されていることが表 2.1 から分かる。総合的に日本、米国およびドイツが 1999 年に設置された 121 MWp のうちの 87%を占めているが、人口あたりの設置容量では依然としてスイスが最高である。

図 2.1 に示すように、従来多くの PV 発電システムは独立形応用であった。このことは大多数の報告国に現在でも当てはまり、オーストラリア、カナダ、フィンランド、フランス、イスラエル、韓国、メキシコ、ノルウェー、ポルトガルおよびスウェーデンでは総設置容量の 90%以上が独立形応用である。独立形応用の範囲は広い。カナダ、フィンランド、ノルウェーおよびスウェーデンでは大部分の独立形 PV システムは別荘や遠隔地の小屋に使用されている。フランス、イスラエル[3]およびメキシコでは PV は農村電化の手段として使用されている。オーストラリア、韓国および日本では多くの独立形 PV システムは非住宅用で、ポンプ、農業、交通信号、特に遠距離通信などの電源に使用されている。遠隔地域では PV システムはディーゼルおよび集中配置型系統電源の商業用代案として使用されている。

しかし図 2.1 および図 2.2 に示すように全体の動向として系統連系形応用の割合が急激に増加している。1992 年では系統連系形応用の設置容量はわずか 29%であったが、1999 年末時点では 53%に達した。この現象は分散配置系統連系形システムの増加に起因している。1999 年に大容量の集中配置系統連系形 PV システムを設置した国はドイツのみである（1.5 MWp)。

分散配置系統連系形応用の急激な増加は日本、ドイツ、米国、オランダおよびスイスにおける政府の大型補助金プログラムによって主に促進されたもので、プログラムは都市部における PV システム設置に重点を置いている。絶対値ではさほど重要ではないが、デンマークや英国（比較的

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3 これは主にパレスチナ当局が係わっている

PV 市場が小規模の国)、および従来 PV が独立形応用に使用されてきたオーストラリアやフランスで分散配置系統連系形応用が非常に増加していることは特記に値する。

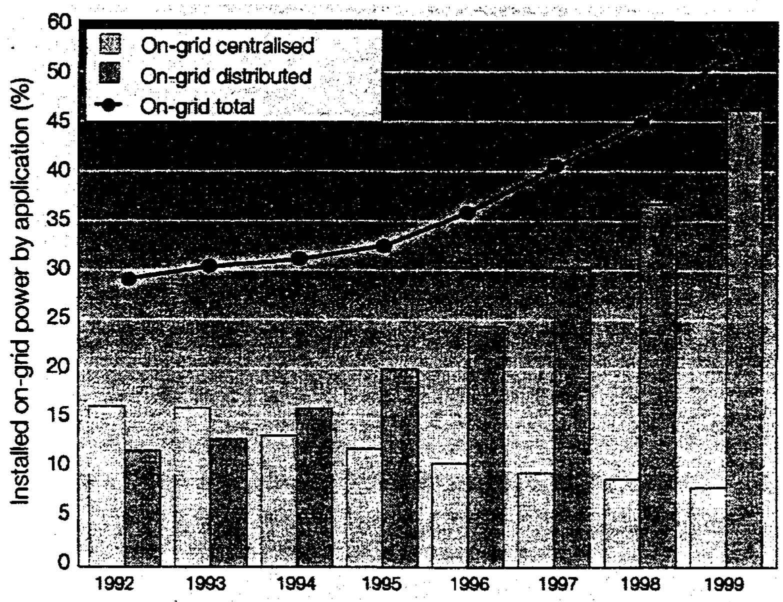

図 2.2 報告国における系統連系 PV 設置容量の比率（集中配置型および分散配置型）

表 2.1：1999 年末現在報告国で設置された PV 容量の累積量

国	独立形 (kWp)	分散配置 系統連系形 (kWp)	集中配置 系統連系形 (kWp)	総設置容量 (kWp)	人口当たり 総設置容量 (kWp)	1999 年の 設置容量 (kWp)
オーストラリア	23,180	1,490	650	25,320	1.34	2,800
オーストリア	1,413	2,119	140	3,672	0.45	811
カナダ	5,529	287	10	5,826	0.19	1,356
スイス	2,500	9,420	1,480	13,400	1.89	1,900
デンマーク	190	880	0	1,070	0.20	565
ドイツ	11,500	49,100	8,900	69,500	0.85	15,600
スペイン [1]	7,000	600	1,480	9,080	0.23	1,080
フィンランド	2,225	17	30	2,302	0.45	132
フランス	8,772	349	0	9,121	0.16	1,490
英国	395	736	0	1,131	0.02	441
イスラエル	381	6	14	401	0.07	93
イタリア	10,860	905	6,710	18,475	0.32	795
日本	56,900	145,500	2,900	205,300	1.63	71,900
韓国	3,171	288	0	3,459	0.07	477
メキシコ	12,920	2	0	12,922	0.13	900
オランダ	3,886	5,309	0	9,195	0.59	2,715
ノルウェー	5,670	0	0	5,670	1.28	320
ポルトガル [2]	486	17	0	503	0.05	0
スウェーデン	2,460	124	0	2,584	0.29	214
米国	84,200	21,100	12,000	117,300	0.43	17,200
合計	243,668	238,249	34,314	516,231	0.54	120,789

[1] 概算値

[2] 1999 年および 1998 年のデータ不明、1997 年 12 月 31 日現在の設置容量

表 2.2：報告国で設置された PV 容量の累積量の推移(kWp)

国	1992	1993	1994	1995	1996	1997	1998	1999
オーストラリア	7,300	8,900	10,700	12,700	15,700	18,700	22,520	25,320
オーストリア	524	768	1,062	1,360	1,739	2,208	2,861	3,672
カナダ	960	1,240	1,510	1,860	2,560	3,380	4,470	5,826
スイス	4,710	5,775	6,692	7,483	8,392	9,724	11,500	13,400
デンマーク [1]	0	85	100	140	245	422	505	1,070
ドイツ	5,619	8,900	12,440	17,790	27,890	41,890	53,900	69,500
スペイン [2]	3,950	4,649	5,660	6,547	6,933	7,100	8,000	9,080
フィンランド	914	1,034	1,156	1,288	1,511	2,042	2,170	2,302
フランス [3]	1,751	2,051	2,437	2,940	4,392	6,118	7,631	9,121
英国	173	266	338	368	423	589	690	1,131
イスラエル	100	120	150	180	210	265	308	401
イタリア	8,480	12,080	14,090	15,795	16,008	16,709	17,680	18,475
日本	19,000	24,270	31,240	43,380	59,640	91,300	133,400	205,300
韓国	1,471	1,631	1,681	1,769	2,113	2,475	2,982	3,459
メキシコ [3]	5,400	7,100	8,820	9,220	10,020	11,022	12,022	12,922
オランダ	1,270	1,641	1,963	2,400	3,257	4,036	6,480	9,195
ノルウェー [3]	3,750	4,050	4,350	4,600	4,850	5,100	5,350	5,670
ポルトガル [4]	47	97	135	204	289	503	503	503
スウェーデン	800	1,040	1,337	1,620	1,849	2,127	2,370	2,584
米国	43,500	50,300	57,800	66,800	77,200	88,200	100,100	117,300
合計	109,719	135,997	163,661	198,444	245,221	313,910	395,442	516,231

[1] 1992 年のデータ不明
[2] 1999 年の数値は概算値
[3] 第 4 回国際調査報告書のデータ修正
[4] 1998 年および 1999 年のデータ不明、1997 年 12 月 31 日現在の設置容量

2.3 主なプロジェクト、実証およびフィールド・テスト・プログラム

多くの国において総設置容量の大部分は独立形 PV 応用が占めているが、独立形応用に関する主なプロジェクトまたは実証プログラムはほとんどない。これは独立形市場が報告国では比較的良好に確立されていること、および独立形システムが本質的に小規模で遠隔地に設置されることのためである。

独立形住宅用 PV システムを推進する最大規模のプログラムのひとつはフランスのプログラムである。1993 年に ADEME とフランス電力会社 EDF は電力系統延長が再生可能エネルギーを使用するよりも高価につく孤立家屋に PV（および風力）の利用を推進する協定に署名した。通常農村地域における電力系統延長／補強のために使用されていた FACE 基金（電気料金償却基金）が独立形PV システムの支援にも利用できるようになった。1995 年から 1999 年にかけて 871 kWp（1,156 システム）がこのプログラムで設置された。5 年間で 105 MUSD（112 億 3500 万円）相当の電力

系統延長費用が節約できた。

オーストラリアでは遠隔地域電力供給をディーゼルから再生可能エネルギーに変換するプログラムが州政府の支援で実施されている。1999年にこのスキームによってクイーンズランド州およびウェスターンオーストラリア州でPVシステム合計130 kWpが設置された。

独立形応用とは対照的に、特に日本、ドイツ、米国を中心に多くの国で系統連系形 PV を促進する政府の補助金による大型プログラムが着手されている。このプログラムの目的は一般大衆のPVに対する認知の向上およびプログラムの実施によるコスト低減にある。

日本では種々の大型 PV 実証プログラムが実施されている。「住宅用太陽光発電導入基盤整備事業」ではPVシステムを設置した個人がPVの意義を理解し、システムの運転データを提供する条件で設置コストに対する補助金が支給されている。1994年から1998年の5年間で15,596基のPVシステムが住宅に設置され、1999年は更に17,396件の応募が受理された。1999年の受理された件数を含めると総設置容量は121.2 MWpに達する見込みである。住宅用PVシステムの代表的規模は3～5 kWpで、日本における住宅用PV需要の80%以上に相当する。「公共施設等用太陽光発電フィールドテスト事業」は1997年に終了し、学校、病院、診療所、事務所などの公共施設に総計4.9 MWpのPVシステムが設置された。このプログラムに続いて、「産業等用太陽光発電フィールドテスト事業」が発足し、1999年末時点で倉庫、工場、商業ビルなどに4.7 MWpのPVシステムが設置された。その他に、新エネルギー事業に参入する地方自治体や民間事業者に対する補助金プログラムも実施されている。

ドイツの100,000ルーフPVプログラムが市場導入プログラムとして1999年1月1日から開始された。このプログラムでは低金利のローンを提供している（条件については表4.1を参照)。1999年末時点で3,576件（9 MWp相当）の応募が受理された。応募件数は目標設置容量の50%に過ぎないが、(2000年4月に可決された）再生可能エネルギー法によってPV市場は急激に加速されるものと期待されている。

米国ではソーラー・ルーフ（太陽熱とPVシステム）を100万基設置する10年計画が1998年初めに開始された。税額控除はまだ議会で承認されていないが、州および地方自治体のパートナーシップの成立、PVに対する融資、30州におけるネット・メタリングの実施、連邦建物へのPVシステムの設置などがイニシアチブによって1999年に既に進行している。その他にサクラメント地区電力公社（SMUD）のPV Pioneerプログラムがあり、電力会社がPVシステムを所有し保守する方式で400戸の住宅にPVシステムが設置されている。1998年に着手されたPV PioneerⅡプログラムは2005年までに合計5 MWpのPVシステムを設置する目標である。プログラムの目的はコンポーネントおよびシステムの性能を評価すること、および設置コストに及ぼす大量購入の10年間の影響を検証することである。カリフォルニア州のEmerging Renewables Buydownプログラムでは1999年に商業ビルおよび住宅用建物に2.2 MWpのPVシステムが設置された。

国家または地域実証プログラムとは別に、世界中で多くの注目すべき建物一体型 PV プロジェク

トが実施されている。2000 年シドニー・オリンピック大会では PV は際だった重要な役割を果たしていて、スーパードームに設置された 70 kWp システム、斬新な PV 街灯システム、Newington（選手）村の住宅に設置された 629 kWp の PV システムがある。1999 年に Amersfoort（オランダ）の Nieuland プロジェクトは完了した。新築住宅に合計 1.3 MWp が設置され、将来の都市部拡張モデルの役割を果たしている。Newington 村や Nieuland などのプロジェクトは高密度に小型 PV 発電機が連系された電力系統の問題を調査することにも利用されている。ドイツでは Academy Mont-Cenis Herne に設置された世界最大の建物一体型 PV アレイが 1999 年に運転を開始した。1 MWp PV システムは巨大なガラス屋根（屋根面積 12,000m^2）に一体化され、日よけ、昼光採光および発電の機能を果たしている。このシステムはハノーバー世界万博で「Expo 2000」プロジェクトとして選ばれた 20 基の PV システムのひとつである。ドイツ政府および国会のボンからベルリンへの移転に関連した新建設工事に PV システム 14 基、総設置容量 760 kWp の設置も含まれている。ドイツ国会、首相官邸および経済・技術省庁舎などに優先的に PV システムが設置された。BP Amoco 社もガソリン・スタンドに PV を設置している。1999 年には「Sunflower」プロジェクトによって 400 kWp が設置され、化石燃料社会から再生可能エネルギー社会への将来の転換を可視的に明確に理解させる役目も果たしている。

PV 実証プロジェクトで教育を強調するプロジェクトが明らかに増加している。例えば、英国の新 Earth Centre、カナダの Kortright Centre for Conservation およびブリティッシュコロンビア工科大学、スウェーデンの「Nordic Ark」の建物は設計の重要要素として PV を一体化している。また多くの国で学校に PV システムを設置している。例えば、英国の「ソーラー」プログラム（1999 年末時点で 20 システム設置）、ドイツの「Sun at School」、日本のエコスクール整備推進パイロットモデル事業（1999 年末時点で 23 校、85 大学に PV システム設置）がある。イスラエルでは教育用ソーラー村が 5 ヶ所設立され、PV 発電電力は遊び道具、教材、泉水などの電力に利用されている。教材 50 セットが学校に配給された。これらのプロジェクトの目的は若い世代を目標にした PV に対する認識の向上であり、認識の向上によって将来の PV 技術の応用も拡大される。場合によっては性能データの情報交換の手段としてインターネットも利用されている。

2.4 市場活性化、実証および R&D に関する予算

図 2.3 に報告国における PV に関する国家総予算額を示す。1999 年の総予算額は 1998 年対比 4% 増で、479 MUSD（512.5 億円）[4] であった。R&D 予算額は変動しているが、明確な動向がなく、1994 年の配分額とほぼ同じである。実証プロジェクト予算額は 1994 年の 2 倍になったが、総予算額に占める割合は依然として小さい。従って予算額の増加は PV の市場開発を活性化するイニシアチブに配分される予算額の着実な増加によるもので、設置容量の増大に反映されている（図 2.1 参照）。

表 2.3 に報告国の 1999 年予算額を示す。日本の莫大な PV 予算額が報告国の総予算額の 50%以上

[4] 1999 年の予算にはスペインおよびポルトガルのデータは含まれていない。スペインの予算額はかなり大きいので、実際には 1999 年の予算総額は 1998 年に比較して 4%以上の増加となっている

も占めている。絶対値では比較的小さいが、フランス、オランダ、英国、オーストラリアなど多くの国でPV予算額が著しく増大した。特にフランスは70%も予算額が増大した。

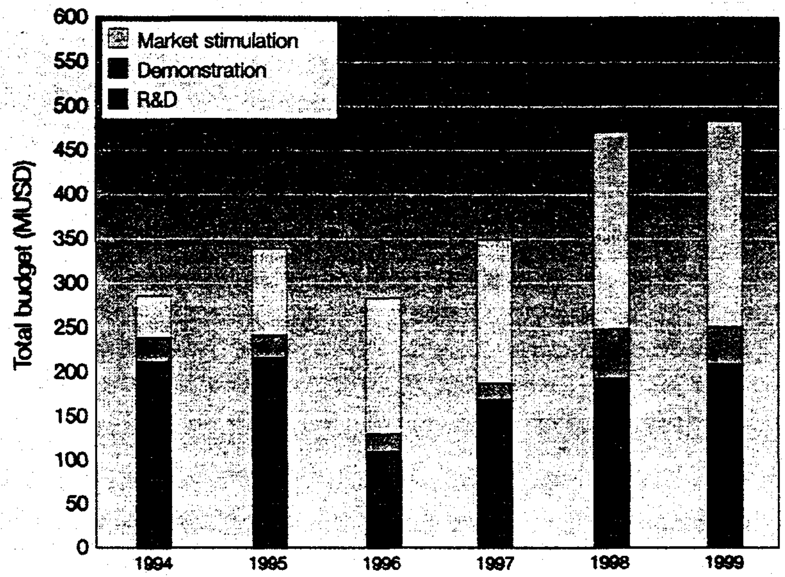

図2.3　1994年から1999年までの市場活性化、実証、R&Dの予算内訳

2.3　報告国における1999年のR&D、実証、市場活性化に関する予算

単位：MUSD（億円：参考値）

国	R&D	実　証	市場活性化	合　計
オーストラリア	1.68 (1.8)	2.34 (2.5)	0.90 (1.0)	4.92 (5.3)
オーストリア	1.92 (2.1)	0.00	0.00	1.92 (2.1)
カナダ	0.47 (0.5)	0.13 (0.1)	0.29 (0.3)	0.89 (1.0)
スイス	8.33 (8.9)	2.13 (2.3)	3.53 (3.8)	14.00 (15.0)
デンマーク	0.46 (0.5)	0.86 (0.9)	0.00	1.32 (1.4)
ドイツ	26.86 (27.8)	0.62 (0.7)	18.71 (20.0)	46.19 (49.4)
フィンランド	0.76 (0.8)	0.01 (0)	0.00	0.77 (0.8)
フランス	7.60 (8.1)	0.00	8.70 (9.3)	16.30 (17.4)
英国	3.84 (4.1)	0.00	0.00	3.84 (4.1)
イスラエル	0.19 (0.2)	0.00	0.00	0.19 (0.2)
イタリア	5.00 (5.4)	0.50 (0.5)	0.00	5.50 (5.9)
日本	90.65 (97)	23.55 (25.2)	149.91 (160.4)	264.11 (282.6)
韓国	1.16 (1.2)	0.38 (0.4)	0.00	1.55 (1.7)
メキシコ	0.59 (0.6)	0.00	0.00	0.59 (0.6)
オランダ	29.13 (31.2)	11.02 (11.8)	7.09 (7.6)	47.24 (50.5)
ノルウェー	0.46 (0.5)	0.00	0.00	0.46 (0.5)
スウェーデン	2.47 (2.6)	0.00	0.00	2.47 (2.6)
米国	35.00 (37.5)	0.00	31.50 (33.7)	66.50 (71.2)

注：　円換算レート　1 USD＝107円（小数点2桁を四捨五入）

PV 技術ノート

太陽光発電システムの主なコンポーネントは太陽電池（各電池が接続され、封止されてモジュールに形成される)、インバータ、蓄電池、チャージ・コントローラ（独立形システム用）および取付架台である。

太陽電池

現在、ほとんどの太陽電池はシリコンで出来ている。一般に太陽電池は結晶（インゴットまたは鋳造物から切断、またはリボン状)、薄膜（低コスト基板上に薄膜を堆積）のいずれかに分類される。

結晶シリコン

単結晶シリコン・セルは通常引上法によって成長させた単結晶インゴットから形成される。多結晶シリコン・セルが現在一般的になってきた。これは多少変換効率は落ちるが、その生産コストが低廉であるためである。多結晶 PV セルの製造は、通常溶融シリコンを立方体のブロックに入れて鋳造する工程から始まる。こうして多結晶シリコン・ブロックを作り、セルを作るためのウエハに切断する。切断工程を除く 1 つの方法は、すでに薄いウエハ状にし、セルに使用される正確な幅の多結晶のリボンを成長させることである。

結晶シリコンの最高変換効率は 24.7%[7] である。変換効率 25%以上はⅢ－Ⅴ族半導体（例えば GaAs)。しかしこの材料はコスト高のため、集光型システムや宇宙用にセルに主に使用されている。

薄膜

薄膜モジュールは、ガラス、ステンレス鋼、プラスチックなど安価な基板の上に非常に薄い感光材を堆積することによって作製される。個々の‘セル’がレーザーによるスクライビイング加工で順次形成される。薄膜セルはコスト低減の可能性がある。半導体材料の使用量が非常に少なくてすむため、材料コストが非常に安くなる。次に薄膜の製造サイズが大きく、完全なモジュールとなっており、個々のセルをフレームに取り付け、互いに電線で接続する必要がないので、ハンドリングに係わる人件費も少なくてすむ。

開発が最も進んでいる薄膜技術は水素添加アモルファス・シリコンである。この材料は通常消費財応用に使用されているが、電力用にもまれには使用される。商用アモルファス・シリコン・モジュールの変換効率は 1980 年代初期には約 3.5%であったものが、現在では約 7%以上に改善されている。最も変換効率の高いモジュールは多層の PV 材料から構成されたもので、例えば、アモルファスに 2 層のゲルマニウムを積層した（a-Si/a-SiGe/a-SiGe）モジュールではセルで 13.5%[7] の変換効率を記録した。多結晶シリコン、GaAs、CdTe、CIGS を用いて、その他のタイプの薄膜を作ることができる。

次表に、種々の PV 技術について代表的なモジュールおよびセルの最高変換効率を示す（標準試験条件は 1000 W/m²、25℃、太陽光スペクトル AM1.5)。

タ　イ　プ	代表的モジュールの変換効率(%)	モジュール変換効率の最高記録[7] (%)	実験室でのセル変換効率の最高記録[7](%)
単結晶シリコン	12 - 15	22.7	24.7
多結晶シリコン	11 - 14	15.3	19.8
アモルファス・シリコン	5 - 7		12.7[9]
カドミウム・テルル	—	10.5	16.0
CIGS	—	12.1[8]	18.2

7 「ソーラー・セル変換効率表、15 版」M.A. Green, K. Emery, K. Bucher, D. L. King, S. Igari, Progress in Photovoltaics: Research and Applications, 8, 187-195 (2000)
8 硫黄を含む合金
9 安定化前の結果

モジュール
電圧、電流の調整試験後、結晶シリコン・セルではセルを接続し、通常ガラスを使用した上部透明材と裏面材でエンキャプされる。モジュールは一般にはアルミ枠に取り付けられる。モジュールの定格は通常 50～200 Wp であるが、定格 200 Wp 以上のモジュールを提供している製造企業も数社ある。

インバータ
インバータは（モジュールまたは蓄電池からの）直流を交流に変換するのに使用される。インバータの効率は一般には 90%以上で、インバータが定格出力の 10%以上で運転した場合、96%にもなる。モジュールに直接接続されたインバータは最適動作点追尾装置（MPPT）を装備している。この装置はシステムが常に最大電力を発電するように連続的に負荷インピーダンスを調整する。

インバータは自励式と他励式に分類される。自励式は入力電力のみによって独立に動作する。他励式は系統から他励転流で動作する。電力会社は系統に連系するインバータは系統の安全性を確保し、電力品質に悪影響を及ぼさないことを保証する適切な制御保護機能を具備することを義務づけている。

伝統的にインバータはアレイ全体に対して 1 基が設置されていたが、最近はモジュールの「ストリング」ごとにインバータを設置することもあり、また個々のモジュールに取り付ける（ac モジュール）場合もある。ストリング・インバータや ac モジュールはシステムの拡張が容易であること、独立運転であること、および設置が容易であることなどから建物一体型 PV 市場での利用が増加していく傾向にある。

蓄電池
独立形システムでは蓄電池がエネルギー貯蔵に利用される。PV システムに使用されるほとんどの蓄電池は（自己放電を抑止するために少量のアンチモンを含有した）鉛蓄電池である。ニッケル・カドミウム電池も適していて、過放電、過充電しない利点を持っているが、非常に高価である。

PV 用蓄電池はすべて 50%まで放電しても損傷しないように設計したディープ・サイクル型であるため、長時間給電できる（例えば、自動車用バッテリーは 3～5%しか通常放電できない）。蓄電池の寿命は使用法、保守および充電方法、温度などの要因に左右されるが、通常 5～10 年である。

チャージ・コントローラ
チャージ・コントローラ（または通常のコントローラ）の主な機能は出来る限りの高い充電状態（SOC）に蓄電池を保持し、要求される品質の電力をユーザーに供給すること、および（負荷による）ディープ放電または（PV アレイによる）過充電から蓄電池を保護することである。多くのチャージ・コントローラは設定制限電圧で作動する。しかし電圧が真の SOC に対応していないので、Ah または Ah と VAh を組み合わせたモニタリング方式で蓄電池の状態を評価する新アルゴリズムが開発中である。

蓄電池温度補償、計器類および警報装置などの追加的機能はチャージ・コントローラの能力を向上し、負荷需要を満たし、蓄電池寿命を延ばす役割を果たす。MPPT、dc/ac 変換装置、盗難防止装置、負荷管理装置、プリペイド装置、データロガーなどの機能も現在ではチャージ・コントローラに付帯できる。

取付架台
分散配置系統連系形システムが急成長するにつれて、建物に PV モジュールを設置する例が増加し、その製品が多く開発されている。これらの製品には PV ファサード、傾斜屋根、陸屋根、従来の屋根タイルの変わりに使用できる「PV タイル」に対する取付架台が含まれる。新製品では建物に容易に一体化できる機能および美的訴求力も取り上げている。

3 章　産業と発展

3.1 太陽電池とモジュールの生産量

報告国における 1999 年のモジュール生産量の総計は 168 MWp である。図 3.1 に PV モジュール生産量の動向を示す。表 3.1 は世界の地域毎の 1999 年における PV 生産量を示す。

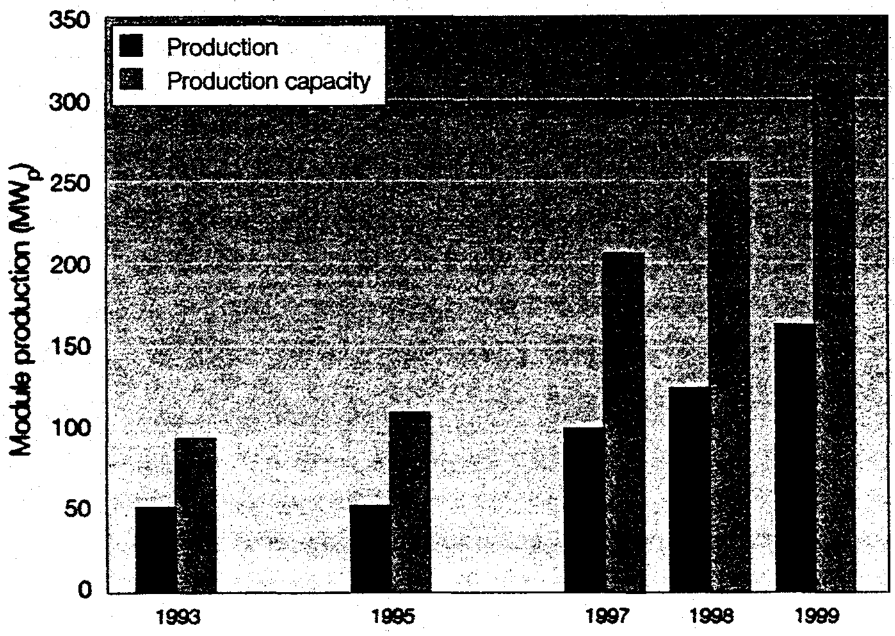

図 3.1　1993 年から 1999 年における PV モジュールの生産量と生産能力

表 3.1　IEA 報告国における 1999 年の PV 生産量

地　域	セル生産量 (MWp)	モジュール生産量 (MWp)				モジュール生産能力 (MWp)
		結　晶	アモルファス	その他	合　計	
米　国	60.80	34.40	5.00	4.20	43.60	94.10
日　本	79.62	69.97	15.01	0.00	84.98	145.20
ヨーロッパ	23.94	29.32	2.40	0.00	31.72	73.33
その他	7.00	7.50	0.00	0.00	7.50	12.50
合　計	171.36	141.19	22.41	4.20	167.80	325.13

1999 年のモジュール総生産量は 1998 年に比べて 34%増加した[5]。この増加は主として日本および米国の増産によるものである[6]。日本における 1999 年のモジュール生産量は 1998 年対比 67%増で、10 MWp 以上生産した企業が 3 社あった（京セラ、シャープおよび三洋電機）。1999 年における報

[5] 1998 年における米国のモジュール生産量が第 4 回国際調査報告書の 53.9 MWp から 36.8 MWp に修正された。従って 1998 年におけるモジュール総生産量は 125.6 MWp に修正された

[6] 二重計上を避けるために、モジュールは、エンキャプスレーションがその国で行われる場合のみその国で製造されたとみなしている

告国の全モジュール生産量の51%が日本で生産された。この生産能力拡大は2000年に200 MWp以上の生産能力を達成する計画の一環と見られる。米国のセル生産量は報告国の全生産量の35%を占めているが、セルの大部分を輸出しているので、モジュール生産量は26%に過ぎない。オーストラリアのモジュール生産量は一時的にBP社とAmoco社の合併の影響を受けた。

図3.1に生産設備利用率を示すが、依然として低調である（52%）。韓国など国によっては市場需要より過剰な生産能力になっている国もある。しかし低生産設備利用率は大型生産工場建設中の産業の急激な拡大を反映したもので、まだ本格稼働に入っていないためである。

モジュールの生産量は相変わらず結晶シリコン（sc-Si）が圧倒的な量を占めている（84%）。結晶シリコンの内訳は多結晶が約60%、単結晶が約40%である。しかしアモルファス・シリコン（a-Si）の1999年の生産量は1998年の2倍以上になった。伝統的にa-Siは消費財（40 Wp以下）用に使用されてきたが、現在PV電力市場で実用できる代替技術として市場に出ている。日本では1999年に鐘淵化学工業の20 MWp a-Si工場が生産を開始した。また三洋電機がa-Si/ sc-Siバイフェイシアル・モジュールを商業化し、変換効率 20.1%の記録を達成した。商業生産が始まったその他の技術はテルリ化カドミウム（CdTe）および銅・インジウム・セレン（CIS）である。CdTeに関しては、ドイツではAntec Solar社から10 MWp工場計画（2001年までに完成）が発表され、また米国のFirst Solar社の100 MWpセルおよびモジュール生産ラインが2000年に第1次建設段階を完了する予定である。CISに関しては、Siemens Solar社が米国でパイロット・ベースでモジュールの生産を開始し、ドイツの Würth Solar 社が 2000 年にパイロット生産を開始する計画である。AstroPower社は1999年に新シリコン薄膜を1 MWp以上生産した。またオーストラリアの企業数社も薄膜製品を開発中である。

表3.2に報告国各国のモジュール製造企業の一覧表を示す。モジュール製造企業は2つの大きなカテゴリーに分けられる。ひとつは既製のセルを購入し、モジュールを形成するモジュール化企業、もうひとつはセルもモジュールも製造する一貫生産企業である。a-Si 製造企業はセルとモジュールは同一工程で生産されるので、通常一貫生産を行っている。

ドイツにおけるモジュール製造企業の1999年生産量は1998年の6.4 MWpから8.8 MWpに増加した。これは100,000ルーフPVプログラムの目標が新企業設立の動機になり、また計画していた生産能力拡充着手の動機にもなったためである。2000年末時点で27 MWpから34 MWpに、2001年に70 MWpに生産能力が拡充される計画である。オーストラリアや米国では多くの新企業がパイロット生産を開始したり、生産計画を立案している。オーストリア、フィンランド、イスラエル、メキシコ、ノルウェーには現在製造企業はない。しかしイスラエルでは1社が2000年に生産を開始する予定であり、ノルウェーではセル生産を開始する計画がある。

モジュールの生産能力が小さいか、全くない国で、その他の分野で積極的に活動している国も多い。例えば、Isovolta/Wedorf社（オーストリア）はPVモジュール用テドラーの世界需要の約50%を生産し、輸出している。Crystalox社（英国）およびScanWafer社（ノルウェー）は多結晶シリコン・インゴットとウエハの主な輸出業者であり、Automated Tooling Systems社（カナダ）はセル

および注文生産モジュールの自動化生産ラインを開発し、市場に出している。

表 3.2 報告国におけるモジュール製造企業

国	製造企業	セル生産量 (MWp)	モジュール生産量 (MWp)	生産能力 (MWp)	モジュールタイプ	追加情報
オーストラリア	BP Solar Australia	5.0	5.0	6.0	sc-Si	シドニーに新しい合弁セル生産設備が建設される予定。シドニーの Solarex 工場でモジュールを生産する予定 - モジュール生産量は 2001 年時点で 20 MW に増大される予定
	Solarex	2.0	2.0	5.0	mc-Si	
カナダ	Canrom Photovoltaic[1]				sc-Si	セルを自社生産。標準仕様の 12,30,40 および 50 Wp のモジュールを製造
スイス	Star Unity	0.0	0.02	0.1	sc-Si	セルを輸入して、屋根タイルに一体化する (Sunny Tile)
	Atlantis Solar Systems	0.0	0.4	1.2	sc-Si	輸入セルと'Sunslates'屋根板を使用して、顧客注文のラミネート・システムを製造。米国とドイツに 1 MWp 生産設備を所有
デンマーク	Gaia Solar	0.0	0.075	0.33	mc-Si sc-Si	輸入セルでモジュール (27~150 Wp) を生産。1999 年の生産量は倍増
ドイツ	20 社以上[1]	4.1	8.8	27.0	sc-Si mc-Si EFG セル a-Si	
スペイン	Atersa	0.0	1.0	1.5	sc-Si	生産能力に変化なし
	BP Solar スペイン	4.4	4.6	10.0	sc-Si	
	Isofoton	0.643	3.37	5.0	sc-Si	
フランス	Photowatt International	8.5	3.0	10.0	mc-Si	1978 年から PV セルおよびモジュールを生産。1999 年に新しい自動化セル生産ラインを設置。インゴット鋳造法、POLIX および薄型ウエハのワイヤ・ソーイングを開発
	Free Energy Europe	0.4	0.4	1.0	a-Si	1998 年 5 月にオランダ企業が Naps-France の a-Si 工場を買収。小電力用モジュール (12~100 Wp) を生産
英国	Intersolar	1.5	1.5	2.5	a-Si	生産能力が 1.6 MWp/年 (1998 年) から増大。2000 年に 3 MWp に拡張する計画
イタリア	Eurosolare	0.4 1.1	0.4 1.1	2.5	sc-Si mc-Si	sc-Si ウエハは国際市場から購入。mc-Si ウエハは自社製。mc-Si モジュールの生産は 1998 年の 1.8 MWp 以下に減少
	Helios Technology	2.1	2.05	2.2	sc-Si	
日本	京セラ	30.2	30.2	36	mc-Si	モジュール生産量は 24.5 MWp (1998 年) から増大。生産能力を 2000 年に 60 MWp に増大する計画。PV 屋根材 ECONOROOF を商業化
	シャープ	8.5 21.3 0.2	8.5 21.3 0.2	10.0 22.0 2.2	sc-Si mc-Si a-Si	モジュール生産量は 14.0 MWp (1998 年) から著しく増大。2000 年に mc-Si 生産応力を 2 倍にし 44 MWp に増大する計画。変換効率 16.0%の mc-Si セルを開発
	三洋電機	4.6 5.9	4.6 5.9	5.0 8.0	a- Si a-Si/ sc-Si	1998 年のモジュール生産量は 3.5 MWp。a-Si/sc-Si バイフェイシアル PV モジュールを商業化。また 2000 年に生産能力を 8 MWp から 11 MWp に増大する計画
	キャノン	1.31	1.31	10.0	a-Si	モジュール生産量は 2 MWp (1998 年) から減少

1 利用できるデータは未公開

国	製造企業	セル生産量 (MWp)	モジュール生産量 (MWp)	生産能力 (MWp)	モジュールタイプ	追加情報
日本	昭和シェル	0.0	1.5	5.0	sc-Si	生産能力は増大したが、実際の生産量は 1998 年に比較して減少。住宅用に組み合わせて使用できる三角／四角モジュールを開発
	エアー・ウオーター（旧大同ほくさん）	0.1 0.01	0.94 0.03	1.0 1.0	sc-Si mc-Si	生産能力に変化なし
	三菱電機	4.5	4.5	10	mc-Si	1999 年に製造開始。2000 年に生産能力を 15 MWp に増大する計画
	鐘淵化学工業	3.0	3.0	20.0	a-Si	世界最大の a-Si 工場が 1999 年に稼働
	MSK	0.0 0.0 0.0	3.0 0.0 0.0	10.0 3.0 2.0	mc-Si sc-Si a-Si	sc-Si および a-Si 工場が稼働。mc-Si 工場の生産能力が 3 MWp から増大。全生産能力を 2000 年に 28 MWp に増大する計画
韓国	LG Industrial System	0.0	0.2	1.0	sc-Si	国内の市場規模が現状の生産能力より著しく小さいため、生産能力の増大予定はない
	Samsung Electronics	0.0	0.3	0.5	mc-Si	
オランダ	Shell Solar Energy	0.8	4.0	6.0	mc-Si	生産能力に変化なし。ミニ・インバータを装備した標準型 95 Wp AC モジュールがオランダにおける認定品として使用
スウェーデン	GPV	0.0 0.0	0.5 0.5	2.0 2.0	sc-Si mc-Si	1998 年までは sc-Si モジュールのみ生産。mc-Si モジュールの生産量は 1999 年に 1 MWp に減少。2000 年中に生産能力を 10 MWp に増大する計画
米国	Siemens Solar	22.2 0.0	17.0 0.0	25.0 4.0	sc-Si CIS	1998 年に CIS のパイロット生産を開始。変換効率 12%以上の大面積モジュールを製造
	BP Solarex	16.0 2.0	12.0 2.0	20.0 5	mc-Si a-Si	33～200 Mp のモジュールを製造。mc-Si モジュール生産能力を 10 MWp から 12 MWp に、a-Si モジュールの生産能力を 2 MWp に増大
	AstroPower	11.0 1.0	4.0 0.0	20.0 5.0	sc-Si 薄膜 Si	1998 年に sc-Si セルおよびモジュールの生産能力をそれぞれ 6.1 MWp、2 MWp から増大。1999 年に低コスト基板薄膜製品を 1 MWp 生産。2000 年には 9 MWp 工場がフル稼働予定
	Solec International	0.6	0.6	0.6	sc-Si	親会社三洋電機に n 型スライスを 5 MWp 供給するためセルおよびモジュール生産を 1999 年に中止
	ASE Americas	4.0	4.0	5.0	EFG-Si	1998 年に工場拡張完了。標準型として 200-300Wp の大面積モジュールを生産
	United Solar Systems (USSC)	3.0	3.0	4.5	a-Si	5 MWp 三接合型 a-Si 工場が 1997 年に稼働。標準型電力用モジュールの他に、建物一体型製品を製造
	その他	1.0	1.0	5.0		生産開始が近い企業：Evergreen Solar、Ebara Solar、First Solar、Energy Photovoltaics、および集光型セルに専従する企業
合計		171.36	167.80	325.13		

注：a-Si に関してはセルもモジュールも同一工程で製造されている

記号：

sc-Si ：	単結晶シリコン	a-Si ：	アモルファス・シリコン
mc-Si ：	多結晶シリコン	CIS ：	銅・インジウム・ジセレン化合物
EFG ：	Edge fed growth ribbon	CdTe ：	テルル化カドミウム

3.2 周辺装置製造企業と供給業者

インバータ、蓄電池とバッテリー・チャージ・コントローラ、直流開閉装置、アレイ支持架台などの周辺装置コンポーネントを製造している大企業が 1 社存在する。これらのコンポーネントについて簡単な技術的説明を *PV 技術ノート*に記述してある。

系統連系形用インバータの価格は 1998 年とほぼ同じで、1～10 kVA のインバータの代表的価格は 0.8～1.0 USD (86～107 円) /VA であるが、米国およびドイツは 0.7 USD (75 円) /VA 以下である。価格は通常大型インバータのほうが割安で、100 kVA 以上のインバータでは 0.35 USD (38 円) /VA である。独立形用インバータは系統連系形に要求される制御・保護機能を必要とせず、また通常厳密な正弦波出力を要求されないので、価格は系統連系形用インバータよりも安くなる傾向にある。

系統連系に関する国際的標準がないために、各国の製造企業は各国独自の系統連系要件に適合するインバータを製造している。米国およびオランダのインバータ製造企業は現在 a.c.モジュール用小型インバータ（～100 VA）を提供している。また壁に取り付けた標準コンセントに直接差し込めるマイクロ・インバータを開発している企業が 1 社ある。多くのインバータは標準装備としてデジタル出力表示装置とデータ収集システムを内蔵している。米国およびドイツのインバータ製造企業は系統連系形システムを系統のバックアップとしても利用できるデュアル・インバータ（数日間の蓄電）を開発した。2000 年問題に関する懸念（いわゆる millennium bug）は住宅用無停電電源（UPS）として PV に対する新しいイメージを生み出した。

1999 年に米国企業がチャージ・コントローラを 100,000 台以上販売した（80%は輸出）。フランスおよびドイツの製造企業がプリペイド機能を備えた蓄電池内蔵の、携帯用で使い勝手の良いチャージ・コントローラを提供している。フランスでは衛星または電話回線を利用して独立形 PV システムのデータ分析および遠隔制御ができるコンピュータ・ソフトが開発された。

3.3 システム価格

独立形 PV システムの価格は設置形態および設置環境に大きく左右される。例えば、米国のサンベルト地帯では、蓄電容量は 4～5 日間を考慮すれば、d.c.システムは設置することができる。配給業者から購入した PV アレイ、取付装置、チャージ・コントローラおよびディープ・サイクル鉛蓄電池を装備した「骨子だけ (bare bones)」のシステムでは、地元の設置業者は 12～14 USD (1,284～1,498 円) /Wp (d.c.) の価格でシステムを設置でき、妥当な収益も挙げることができる。温和な気候の場所に設置される、10 日間の蓄電容量、独立形用インバータおよび地上設置装置を装備した a.c.システムでは価格は 14～18 USD (1,498～1,926 円) /Wp である。温和な気候の場所に設置される、20 日間の蓄電容量、耐候性取付装置、蓄電池室、システム制御装置などを装備した高信頼性システムでは価格は 24 USD (2,568 円) /Wp 以上となる。オランダ、オーストラリア、フランスにおけるシステムの価格は 30 USD (3,210 円) /Wp 以下であるが、その他の報告国では上述の価格範囲である。1998 年以降価格に大きな変動はない。

系統連系形システムは蓄電池や付帯コンポーネントが必要ないので、通常独立形よりも低廉である。1～3 kWp の系統連系形建物一体型システムではシステム価格[10]はデンマーク、ドイツで 6 USD（642 円）/Wp 以下、オーストラリア、フランスで 7 USD（749 円）/Wp 以下である。米国ではサクラメント地区電力公社（SMUD）が設置したシステムは 5～6 USD（535～642 円）/Wp の価格範囲であるが、SMUD への供給業者によればモジュール供給業者もシステム設置業者もほとんど利益が出ないか収益がないとのことである。SMUD プログラム以外の収益のあるシステムは 8～12 USD（856～1,284 円）/Wp の価格で販売されている。1998 年から 1999 年にかけて 10 kWp 以下の系統連系形システムの価格はフランス（16%）、イタリア（6%）、日本（5%）で低下した。フィンランドおよびスイスではシステム価格は上昇したが、10 kWp を超えるシステム価格はスイスで 5%低下した。これは「ソーラー株式取引所」スキームによって大型システムが市場に導入されたためである。一般に 10 kWp を超えるシステム価格は多くの国で著しく低下していて、オーストラリアでは 4.8 USD（514 円）/Wp まで低下した。

4 章　市場展開の枠組み

PV システムの市場展開は地方自治体、国家および国際的政策ならびに一般大衆および電力会社の PV に関する認識に係わっている。また適切な標準および規準の有無も PV システムの市場展開に影響を及ぼす。

4.1　太陽光発電システムに関する新しいイニシアチブ

図 2.3 に示すように R&D または実証プログラムに対して重点が置かれなくなってきている反面、市場展開イニシアチブがますます強調されている。表 4.1 に報告国の重要なイニシアチブの概要を示す。

PV（およびその他の再生可能エネルギー）の支援または促進に利用される財政手段は範囲が広い。例えば、金利優遇、税額控除、加速度償却、国家政府または地方自治体の補助金、特恵関税、「グリーン電力」スキームなどがある。報告国におけるグリーン電力の普及は環境に関心を持ち、環境に優しい資源から発電される電力に割増料金を支払っても良いとする顧客が非常に増加していることを実証している。PV に関する認識および情報が欠如している国もあるが、一般的に世論は PV を支持していると思われる。電力会社の PV 支援も増加している。多くの電力会社が「ネット・メタリング」を提供しいる。また（ドイツのように企業の「グリーン」イメージを印象づける目的で、またはフランスやメキシコのように農村地帯への系統延長を回避する目的で）PV に投資している電力会社もある。しかしその他の系統に対する PV による付加価値については認識されていないようである。

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[10] 価格は VAT/TVA/売上税、運転・保守コストを除いたターンキー価格である。ただし設置費用は含まれる

表 4.1　報告国における普及イニシアチブ

国	普及イニシアチブ	電力会社および一般の認知	主な新イニシアチブおよび計画
オーストラリア	多くの電力会社が住宅用PVシステムに対するネット・メタリングを提供している 電力会社のグリーン電力・プログラムに参加する顧客は1999年に急激に増加し全国で58,000となったが、PVは全グリーン電力発電量の0.1%に過ぎない グリーン電力スキームの一環として、逆潮流PV電力を0.17 USD（18.2円）/kWhで買い戻している電力会社が1社あり、また電気料金請求の切り上げ分に相当する顧客の寄付を利用して、学校にPVシステムを設置している電力会社がもう1社ある。	PVおよび再生可能エネルギーに対する公的支援は継続されている。しかし系統連系形システムを利用している顧客にとってPVシステムの有効性、コストおよび性能に関する情報のアクセスが欠如しており、また電力給電系統における再生可能エネルギーの潜在的役割に対する認識に欠けるところがある	各種の再生可能エネルギー・プログラムが2000年、2001年に計画されている Australian Greenhouse 局は住宅用建物一体型PVシステムの費用、および独立形ディーゼル発電を再生可能エネルギー技術に転換する費用を50%を上限にして資金援助を提供する予定である 再生可能エネルギー産業開発プログラムおよび再生可能エネルギー・エクィティ基金もPVを援助する計画である
オーストリア	優遇電気料金は 0.32～0.80 USD（34.2～85.6 円）/kWh の範囲である 地方自治体によってはPVに対して補助金を支給している：オーバーエーステライヒ州では設置コストの 50%まで補助金が適用される	ほとんどの電力会社が実証用あるいは孤立地域への電力供給用としてPVシステムを設置している オーバーエーステライヒ州ではグリーン電力プログラムを支援している顧客の23%がPVに補助金を支給することを採決した	再生可能エネルギーの資金援助に関する決定は新電気取引法が有効になるまで延期された
カ　ナ　ダ	3 kWp 以上の PV システムのコストに対する加速度償却は結果的に売上税控除になっている オンタリオ州では PV に対するネット・メタリングを受け入れている電力会社が2社ある 1999 年に Greenpeace Solar Pioneers プログラムによって系統連系形 PV システムが著しく増加した	PV は別荘／山小屋、キャンピング・カー応用に一般大衆の関心を引いているが、PV は非常に高価であるとまだ一般的に認識されている 電力市場の規制緩和によって環境保護のために太陽エネルギーを支援する顧客が増加し、地域によってはグリーン電力が導入されると期待されている	カナダ PV 産業協会と協力して、政府は PV に対する認識を向上させるマーケティングおよび普及イニシアチブを計画している
ス　イ　ス	「ソーラー株式取引所」は建物一体型 PV 市場を推進する重要な役割を果たしている。電力会社は独立発電業者と PV 電力に割増金を支払う顧客との取引に関する「株式取引所」の役割を果たしている	政府の「エネルギー2000」プログラムとスイス電力事業協会はすべての顧客が「ソーラー株式取引所」スキーム参加できるように努力している。1999 年に「グリーン電力」を購入できる顧客は 180 万戸の 1.2%に達した	2000 年 9 月に非再生可能エネルギーに対する課税および長期環境保護税改革の導入に関する国民投票が行われる Basle 市では年 300 kWp の割合で 6 年間 PV 電力に資金を援助する新制度が導入された。この導入量は Basle 市民 1 人当たり平均 8.5 Wp に相当する

国	普及イニシアチブ	電力会社および一般の認知	主な新イニシアチブおよび計画
デンマーク	商業分野の PV 応用に対し36%まで補助金が支給される。この原資は電気に対する CO_2税から徴収される(この補助金はこれまでほとんど利用されなかった) 個人所有の PV システムに対するネット・メタリングが1998 年年央に制定され、4年間試行される	世論調査では、消費者の PV に対する関心は高く、グリーン電力に自発的に割増金を支払う意向のあることが分かった 電力分野の規制緩和に関する新法は PV 普及に影響を及ぼすものと期待される	1998 年に 300 軒ルーフトップ・プログラムが開始された。1999 年末時点で約 50%が設置された 1999 年末にデンマーク国会は建物一体型 PV システムを推進し、建物一体型 PV システム製品の開発を促進する 3ヶ年プログラムに対して 3.9 MUSD(4 億 1700 万円)を配分した
ドイツ	1999 年 1 月 1 日に開始された 100,000 ルーフ・プログラムは 10 年間の低金利ローンを提供している(1999 年は0%)。ローンは 3 年目から 8年間かけて毎年 12.5%づつ返済する。ただし 10 年目もPV システムが稼働中であれば 10 年目のローンは返済しなくて良い 政府補助金の他に、16 連邦州のうちノルトライン-ヴェストファーレン州を中心に10州がPV設置に対して資金を援助している	再生可能エネルギーに関する世論は非常に積極的である。 グリーン電力を提供する供給業者が 1998 年末には 11 社であったが、1999 年末は50 社を超えた。 電力会社もグリーン電力市場に参入しており、この結果PV を含む多種多様な再生可能エネルギーを組み合わせたグリーン電力発電所の数が増加している	100,000 ルーフ・プログラムの当初の結果は期待はずれで、目標の 18 MWp に対して9 MWp の申し込みであった。しかし 2000 年に施行される再生可能エネルギー優先法(Law for the Priority of Renewable Energies)によって市場は急激に加速されるものと予想される。この法律は 1991 年に制定された再生可能エネルギー逆潮流料金法(Renewable Energies Feed-in Tariff Law)に替わる法律で、PV 発電電力に対して 0.51 USD(54.6 円)/kWh の買い戻し料金が設定されている。このプログラムの目標は 2003 年までに 300 MWp が設置することである
スペイン	地方プログラムによって PV を支援するため設置コストの 25%以上の補助金を提供している。PV 発電電力は 5 kWp 以下の PV システムに対しては 0.4 USD(42.8 円)/kWp、5 kWp を超える PV システムに対しては 0.2 USD(21.1 円)/kWp の優遇料金が設定されている	PV は環境に及ぼす影響が小さいことから一般の認知は好意的である 電力会社の数社は系統連系形 PV プロジェクトに大きな投資をしている	省エネ・プログラム(PAEE, Energy Saving and Efficiency Programme)は1999 年に終了したが、PV は再生可能エネルギー新計画(2000~2006)によって継続して支援される予定で、現在認可待ちである
フィンランド	PV システムを設置する企業に上限 30%までの投資補助金が適用される。個人住宅に関する PV 設置に対する融資は予告金利が ESCO(訳注:略語の内容不明)で表示される	「グリーン電力」の導入に伴って、電力会社は建物一体形 PV システムの実証に大きな関心を示している	1999 年に通商産業省が再生可能エネルギー源行動計画に着手した。この行動計画は2010年までに1995年レベルの設置容量の 40 倍に相当する 40 MWp を設置することを目標にしている

国	普及イニシアチブ	電力会社および一般の認知	主な新イニシアチブおよび計画
フランス	独立形 PV システムに関して補助金はコストに対して最大 95%提供される（FACE 基金から 70%、経済省から 15%、ADEME から 10%） 系統連系形 PV システムに関して補助金はコストに対して 35 ～ 80% の資金が PHEBUS イニシアチブ、EC の実証プログラム（2000 年で終了）から提供される	国営電力会社 EDF および ADEME は FACE プログラムによって系統延長が独立形 PV システムの設置よりも高価になる孤立家屋における PV（および風力）の利用を継続して推進している	1999 年に系統連系形建物一体型システムに関する実証プログラムが部分的に EC の資金援助を受けて着手された。目標は 5 USD（535 円）/Wp のコストで 3 年間に 500 kWp 設置することである。 再生可能エネルギー源の普及と開発に関する予算を強化する 1998 年のフランス政府の決定によって、ADEME は PV 普及予算を 3 倍にし、独立形システムを年 1,500 kWp 設置する計画である
英国	政府の融資は R&D に限定されている PV のマーケティングは Solar Century などの組織団体に任されている	PV に関する電力会社の認識は改善されつつあるが、一般的には電力会社は英国で立ち上がりつつあるマイクロ CHP スターリング・エンジンなどの小型発電機の系統連系に対する関心が強い PV 産業はネット・メタリング導入および政策転換に関するロビー活動を継続している	BP Amoco の「Sunflower」プロジェクトによって 1999 年の設置容量は大きく増大した 政府の 100 ルーフ・フィールド・テストが再開される予定のため多くの大型建物一体型ＰＶシステム・プロジェクトが 2000 年に計画されている PV システムに対する VAT が 2000 年 4 月以降 17.5%から 5%に下げられる。また気候変動課税は通常再生可能エネルギー支援に利用される
イスラエル	政府は系統連系形 PV システムの実証プロジェクトを支援しているが、この支援は提案プロジェクトが「費用効果性がある」ことが条件である	環境問題の認識が高まった結果、PV に対する一般の認識は向上している。しかしモジュールの盗難が頻発しているために、独立形応用では設置コストの上昇（追加保護）や保守費の上昇（監視費）でコスト高になっているシステムもある	新しいプロジェクト 3 件が発足した。Yeruham プロジェクトは社会的・教育的な目的で実施される。Nitzana プロジェクトはソーラー実証公園の建設と生徒に対する太陽エネルギー教程の設定を目的にしている。Kibbutz Samar プロジェクトは現存の 4.5 kWp PV 発電所を 200 kWp に拡張する計画である
イタリア	PV の投資コストに対する税額控除が 36%適用され、VAT が 20%から 10%に低減される PV 発電電力は 2000 年内に稼働する PV システムに対して 0.18 USD（19.3 円）/kWp の優遇料金が適用される	系統連系に関する技術的問題を取り上げるために、電力会社は ENEA と協力して国家ルーフトップ・プログラムを支援している。また自社の実証プログラムに着手した電力会社もある。 PV に対する一般の関心は広がりつつある	10,000 ルーフトップ・プログラムの開始は更に遅れて、2000 年になる予定である。設置容量の目標は 50 MWp である

国	普及イニシアチブ	電力会社および一般の認知	主な新イニシアチブおよび計画
日本	PV システムを設置した場合3年間固定資産税の課税標準額が5/6に減額される PV システム所有者はシステム取得価格の7%相当額の税額控除、または初年度30%償却の適用の選択が認められている 一部の金融機関は住宅用 PV システムの購入者に対して優遇ローンを提供している 1992 年からネット・メタリングが適用されている	一部の電力会社は PV に関する R&D を支援する助成金制度と住宅用 PV システム設置コストの半額を補助する助成金制度を制定している 住宅用 PV システム導入基盤整備事業で申し込みが倍増したように、PV に対する一般の支援は増加している	2010 年時点で PV の導入目標量5,000 MWの達成を目指して、現行の実証およびフィールド・テストの予算が1999 年に大幅に増額された
韓国	政府は各種再生可能エネルギー源に関する実証およびフィールド・テストを支援している。PV は高い優先度を与えられている	—	—
メキシコ	農村電化を目的にしている財政的に苦しい遠隔コミュニティーに政府の助成金が適用される	1998年から1999年にかけて国有電力会社は PV 農村電化プログラムの有効性を評価する研究を支援した	潅漑用および畜牛用飲料水揚水ポンプ、電気フェンスなどの農業における PV 応用を推進するために、農業・水資源省が 2000 年に大型プログラムを開始する
オランダ	国家 PV プログラムによる政府の補助金のほかに、広範囲の支援スキームが PV に対する融資に利用されている。例えば、「グリーン・プロジェクト」に対する低金利、環境投資に対する加速度償却、省エネ建物に対する「グリーン・モーゲージ」、グリーン電力スキームなどがある 市場展開を加速するために PV に関する包括補助金が現在準備されている	電力会社は PV 開発プロジェクトに積極的で、補助金も提供している。電力会社や建築産業など多くの企業にとって、PV に投資することは新しい事業機会を創出できる戦略として期待されている グリーンピースが行った市場調査によれば、多くの顧客が小型 PV システムを進んで購入する意向を示している。また PV は長期的にオランダにおける最も有望な再生可能エネルギーのひとつと広く見られている	政府は PV を 2010 年までに 250 MWp、2020 年までに 1,500 MWp（ルーフトップ・システムで約 100 万基相当）設置する目標を設定している 新しい PV 協定（産業、電力会社、R&D 機関、政府など 28 団体が連署した協定）が 2001 年から 2007 年まで実施する予定で現在準備中である。重要課題は市場開発に関する融資と促進である。また PV 協定の参加団体は 2007 年までの設置容量目標を 500 MWp 積み上げの可能性を検討している
ノルウェー	—	PV に対する電力会社の関心が高まり、将来のプログラムに PV を組み込む	今後3年間で mc-Si ウエハの生産量を 6 MWp から 30 MWp に増産する 太陽電池の生産を計画している

国	普及イニシアチブ	電力会社および一般の認知	主な新イニシアチブおよび計画
スウェーデン	PV に対する通常の補助金はない。しかし政府は実証プロジェクトに対して最大 50%の融資を提供している	長期的持続可能再生可能エネルギー技術として PV は一般から好意的に認められている	最近まで国家プログラムの主な活動は PV が独立形システムとして費用効果のあるニッチ市場応用を開発することであった。過去 2 年間でプログラムの焦点は長期的選択肢として建物一体型 PV を評価する方向に転換された
米国	系統連系形 PV システムに関する重要なイニシアチブにつぎのプログラムがある。すなわち 100 万ソーラー・ルーフ・イニシアチブ、サクラメント地区電力公社（SMUD）の Pioneer プログラム、カリフォルニア州 PV 補助金プログラム、学校向け PV プログラムである 1999 年末時点で 12 州でネット・メタリング、グリーン・プライシング、環境に優しい再生可能エネルギーに対する優遇などの選択肢を含む規制の再構築が実施された	2000 年問題に関する関心が系統連系形 PV の新しいイメージを創り出し、バックアップ電源システムとして PV の売上げが伸びた 電気事業用太陽光発電普及促進協議会（UPVG）は PV 市場拡大のメカニズムとしてネット・メタリングを支援し、電力会社所有の PV システムを約 6 MWp 設置した	1998 年にエネルギー省（DOE）が 100 万ソーラー・ルーフ（PV および太陽熱温水システム）の開発を奨励する 10 年計画を開始した。このイニシアチブに関する税額控除はまだ議会の承認待ちであるが、政府機関、州機関および地方自治体との公式の会合やパートナーシップの組織作りは進行している

4.2 間接的政策問題と PV 市場への影響

PV 市場に間接的であるが重要な影響を及ぼす問題が 2 件ある。すなわち京都会議議定書と電力産業規制緩和である。

気候変動枠組条約締結国国際会議および京都会議議定書の結果として、カナダ、フィンランド、ドイツ、スウェーデン、英国などの諸国は CO_2 を排出する電力に対する課税を既に導入したり、導入を計画している。この課税は少なすぎて PV の経済に顕著な影響を及ぼしていない。米国では CO_2 の排出緩和に対する PV の貢献は 0.01 USD/kWh 以下であると算定しているアナリストもいる。しかし英国は炭素税から徴収した税金を国家再生可能エネルギー・プログラムの追加資金源として利用する予定である。非常に重要なことは京都会議議定書が再生可能エネルギー政策の再評価と PV 普及の国家目標の設定を刺激したことである。例えば、日本では、「地球温暖化対策推進大綱」が制定された。オーストラリアでは電気小売業者による再生可能エネルギーの購入義務づけを含む広範囲の再生可能エネルギー・プログラムが国家グリーンハウス戦略の一環として導入された。表 4.1 に示すように、ドイツ、フィンランド、フランス、イタリア、日本、オランダおよび米国は PV 普及を大規模に展開する目標を設定している。更に EC は EU メンバー国の PV 普及にある程度影響を及ぼすと思われる再生可能エネルギー支援の目標も含めた指令を現在作成中である。

系統連系形 PV システムが占める割合が増加してきたので、電力産業の再構築が重要な要素となっている。オーストラリア、カナダ、デンマーク、フィンランド、ドイツ、オランダ、スイス、英国および米国では、電力産業規制緩和は既に実施されているか、現在進行中である。PV に及ぼす影響は不明である。グリーン電力スキームおよびネット・メタリングの増加は激化する競争に直面した多くの電力会社が顧客サービスおよび電力の選択を拡大している結果である。また規制緩和は系統へのアクセスを開放する結果にもなっている。系統連系手続きおよび要件の簡略化に伴って、PV など系統に連系する発電機が非常に増加することになる。しかし市場主導型スキームは価格が最低の選択肢を推進することになり、必ずしも PV の設置が増加するとは限らない。例えば、オーストラリアでは PV はグリーン電力発電量総計の 0.1%以下に過ぎないし、英国の新電気取引協定によって再生可能エネルギー源による発電電力をある量だけ購入することを供給業者に義務づけた現行の補助金制度が変更された（電力供給業者は最も低廉な再生可能エネルギーを選択することができる）。また、電気供給産業における自由化の当初の目的は顧客に対するコスト低減を促進することにある。その結果、電気料金が下がるにつれて、PV 発電電力と従来の発電電力の価格差が広がっていく。

4.3　規格および基準

国際電気標準会議（IEC）は PV の性能および安全に関する国際規格を作成する委員会（TC 82）を 1981 年に設立した。爾来 IEC は太陽電池、モジュールおよび独立形システムを中心に多くの規格を公刊してきた。

現在、系統連系形システムに関する規格が積極的に検討されていて、多くの国で電力系統網への小型 PV システムの連系に関するガイドラインや規格が既に作成されていたり、または作成中である。米国および英国は最近配電網に連系される小型 PV システムに関するガイドラインを公刊した。興味を引くのは米国および英国の内容に相違があることである。米国の電気電子技術者学会は定格 10 kW 以下の PV システムに関する系統連系実施勧告（IEEE 929）を公刊した。この規格は（関連試験規格 UL 1741 に準拠した）独立認定研究所の認証を必要としている。英国のガイドラインは一般的に規定事項が少なく、欧州産業界の実践法をふまえて型式試験についてインバータ製造企業の自社証明書の発行を認めている。a.c.モジュールの使用法にも相違がある。米国では a.c.モジュールが UL 1741 の承認を取得していて、IEEE 929 の要件に合格すれば、国家電気規準に従って a.c.モジュールを使用することができる。しかし英国では系統の解列が機械的に操作できない懸念から、a.c.モジュールの連系は許可されていない。このことは市場拡大の主な障壁にもなり、英国ではシステムが非合法的に連系される懸念も出ている PV 製品に関する試験要件を国際的に調和させる目的で、企業および安全試験研究所は現在協力してインバータに関する国際安全規格（IEC 62109）およびモジュール関する国際安全規格（IEC 61730）を作成中である。

現在関心は系統連系の直流側の問題に移っている。オランダでは設備に関するガイドラインが既に公刊されている。また英国、ドイツ、カナダおよびオーストラリアでは検討中である。また IEC は現行の配線規準（IEC 60364）を拡大して PV 設備まで含めることを検討するため委員会（TC 64）

を設けている。PV 設備に独特な安全問題を取り上げ、また設置業者の教育および認定を促進するガイドラインが電気工事契約企業にとって緊急に必要とされている。建築産業と PV 産業との協力もガイドラインや規格の共同作成も含めて必要とされる。

独立形システムを重点にした品質規格と認定を促進し、維持するために 1997 年に PV Global Approval Programme（PV GAP）が開始された。このイニシアチブは供与プログラムおよび世界銀行の品質に関する関心から発足した。小型独立形システムに関する国際規格を作成する重要なプロジェクトに PV GAP および IEC の技術専門家が協力している。

5章　結論

IEA の太陽光発電システム・プログラムの参加諸国には多種多様性があるので、本調査報告書は PV 市場全体を把握していないが、世界的動向は示唆されている。PV 応用および市場の主な動向は表 5.1 および以下に要約されている。統計を見るときに留意しなくてはならないことは日本における非常に大規模な PV プログラムが参加国の動向に大きな影響を及ぼしていることである。

表 5.1　報告国における PV 設置発電容量とモジュールの生産量

年	独立形設置累積容量と増加率		系統連系形設置累積容量と増加率		PV 設置総容量と増加率		年間 PV 設置容量と増加率	モジュール生産量
	MWp	%	MWp	%	MWp	%	MWp	MWp
1992	78		32		110			
1993	94	21	42	32	136	24	26	52
1994	112	19	51	24	164	20	28	
1995	132	18	66	29	198	21	35	56
1996	157	19	88	33	245	24	47	
1997	187	19	127	44	314	28	69	100
1998	216	15	180	42	395	26	82	126
1999	244	13	273	52	516	31	121	169

・PV 電力応用は引き続き急速に成長している。1998 年に比較して 1999 年は IEA 報告国における累積 PV 設置容量は 31%増で、516 MWp に達した。1999 年に設置された設置容量 121 MWp のうち 60%が日本に設置された容量である。日本を除くと、1998 年に比較して累積 PV 設置容量は 19%増である（前年と同じ)。

・独立形応用についてはオーストラリア、カナダ、フィンランド、フランス、イスラエル、メキシコ、ノルウェー、ポルトガルおよびスウェーデンが設置容量総計の 90%以上を占めている。総体的に系統連系形 PV システムの割合が増加する傾向を見せている。1992 年から 1999 年の 8 年間で報告国における系統連系形 PV の累積設置容量は総設置容量の 29%から 53%に増加している。これは日本、ドイツを中心に、都市部への（系統連系形）PV システムの設置を重点にし

た大型の政府支援補助金プログラムに起因している。

・2000年シドニー・オリンピック大会に関連したPV施設、オランダにおけるAmersfoort Nieuwlandプロジェクト、ドイツにおけるExpo 2000プロジェクトや新庁舎、給油所のPVシステムなど多くの際だったプロジェクトによってPVシステムに対する認識も向上している。教育も国家プログラムとって重要であるとの認識が大きくなり、日本、ドイツ、イスラエルおよび英国など多くの国が校舎にPVシステムを設置するプログラムを実施している。

・報告国におけるPV産業の支援に政府機関が配分した1999年の予算総額は1994年の287 MUSD（307.1億円）から479 MUSD（512.5億円）に増加した。このうちの50%以上が日本の予算であるが、その他の国、特にフランスはPVの予算が大幅に増加している。予算の増加分はPVの市場普及を活性化するイニシアチブに費やされ、反対に研究・開発・実証の予算は増加していない。

・1993年から1999年の7年間でモジュールの生産量は3倍になり、年産52 MWpから169 MWpになった。日本の1999年の生産量は1998年に比べて70%増で、報告国の1999年総モジュール生産量の50%以上を占めている。この増加の大部分は住宅市場の需要増加に対応したものである。オーストラリア、米国、ノルウェーおよびイスラエルでは多くの新企業が2000年に生産開始することを計画している。また多くの企業が既存の生産ラインを拡張する計画を立てている。総体的に生産量は生産能力を大きく下回っている（52%）。これは企業が増産のために建設している大型工場がまだ本格的稼働に入っていないことを反映している。

・生産されたモジュールの大部分（84%）は相変わらず結晶シリコンが占め、そのうち約60%は多結晶シリコンで、約40%が単結晶シリコンである（1998年と同じ）。しかしアモルファス・シリコンの1999年の生産量は1998年の2倍以上になり、現在PV電力市場で実用できる代替技術として市場に出ている。CdTeおよびCIS製造工場は日本、ドイツおよび米国で既に稼働している工場もあり、計画中の工場もある。これらの工場は低製造コストの新しいモジュール選択肢に対する市場の試金石である。100 MW CdTeセルおよびモジュール生産ラインの第1次建設段階が2000年に完了する予定である。

・PVシステムの価格は全般的に1998年以降大きな変動はないが、フランス、イタリアおよび日本ではコストの低下が見られる。1～3 kWpの系統連系形建物一体型システムの代表的価格は6～12 USD（642～1,284円）/Wp（設置も含む）であるが、デンマークおよびドイツは6 USD（642円）/Wp以下と報告している。フランスにおける新しい系統連系形システム実証プログラムは3年以内に設置を含むシステム・コストを5 USD（536円）/Wpにすることを目標にしている。独立形システムの価格は遠隔地家屋、遠距離通信、揚水ポンプ、交通信号など多くの応用ではまだ競争力がある。

・PVを支援する電力会社も増加している。現在多くの電力会社がネット・メタリングまたはPVに対する優遇料金を提供している。また米国、スペイン、オランダにおけるようにプロジェク

ト開発に積極的に参画している電力会社もある。電力産業の規制緩和は PV 普及に影響を及ぼすものと予想されるが、更なる対策が PV の魅力を向上させるために必要とされる。対策の例として、蓄電池を装備したデュアル・インバータが PV を系統連系形 UPS システムにするために既に導入されている。2000 年問題に関連した懸念から 1999 年に PV の販売量が急増した。これはこのようなシステムに対する（補助金なしの）真の系統連系形市場が形成された例と言える。

・短・中期に PV 普及を急速に促進する目標を設定している国も多い（ドイツ、フィンランド、フランス、イタリア、日本、オランダ、米国）。これを実施することによって 1997 年の京都会議議定書に部分的に寄与することができる。

付属書　A　IEA PVPS タスク I

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場合によっては、タスクＩの専門家は自国の専門家の支援を受けた。これらの専門家を以下に挙げる。

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付属書B　為替レート

下表は参加国、ISO 対応国名コードと通貨コード、およびその国の通貨を換算するときに使用した為替レートを一覧表にしたものである。為替レートは一般的には 1999 年のレートである。イスラエルに関しては財政的情報はすべて統計上の便宜のために産業ごとに使用されている USD で提供された。ポルトガルおよびスペインに関しては為替レートの情報は報告がなかった。

国	ISO 国名コード	通貨と ISO コード	為替レート（1 米ドル＝）
オーストラリア	AUS	ドル（AUD）	1.67
オーストリア	AUT	シリング（ATS）	12.5
カナダ	CAN	ドル（CAD）	1.486
デンマーク	DNK	クローネ（DKK）	7.6
フィンランド	FIN	マルッカ（FIM）	5.92
フランス	FRA	フラン（FRF）	6.56
ドイツ	DEU	マルク（DEM）	2.1
イスラエル	ISR	ニューシェケル（ILS）	（上記）
イタリア	ITA	リラ（ITL）	2,000
日本	JPN	円（JPY）	107
韓国	KOR	ウォン（KRW）	1,188
メキシコ	MEX	ペソ（MXP）	9.44
オランダ	NLD	ギルダー（NLG）	1.27
ノルウェー	NOR	クローネ（NOK）	8.75
ポルトガル	PRT	エスクード（PTE）	
スペイン	ESP	ペセタ（ESP）	
スウェーデン	SWE	クローナ（SEK）	8.267
スイス	CHE	フラン（CHF）	1.5
英国	GBR	スターリング（GBP）	0.625
米国	USA	ドル（USD）	1
欧州連合		ユーロ（EUR）	1

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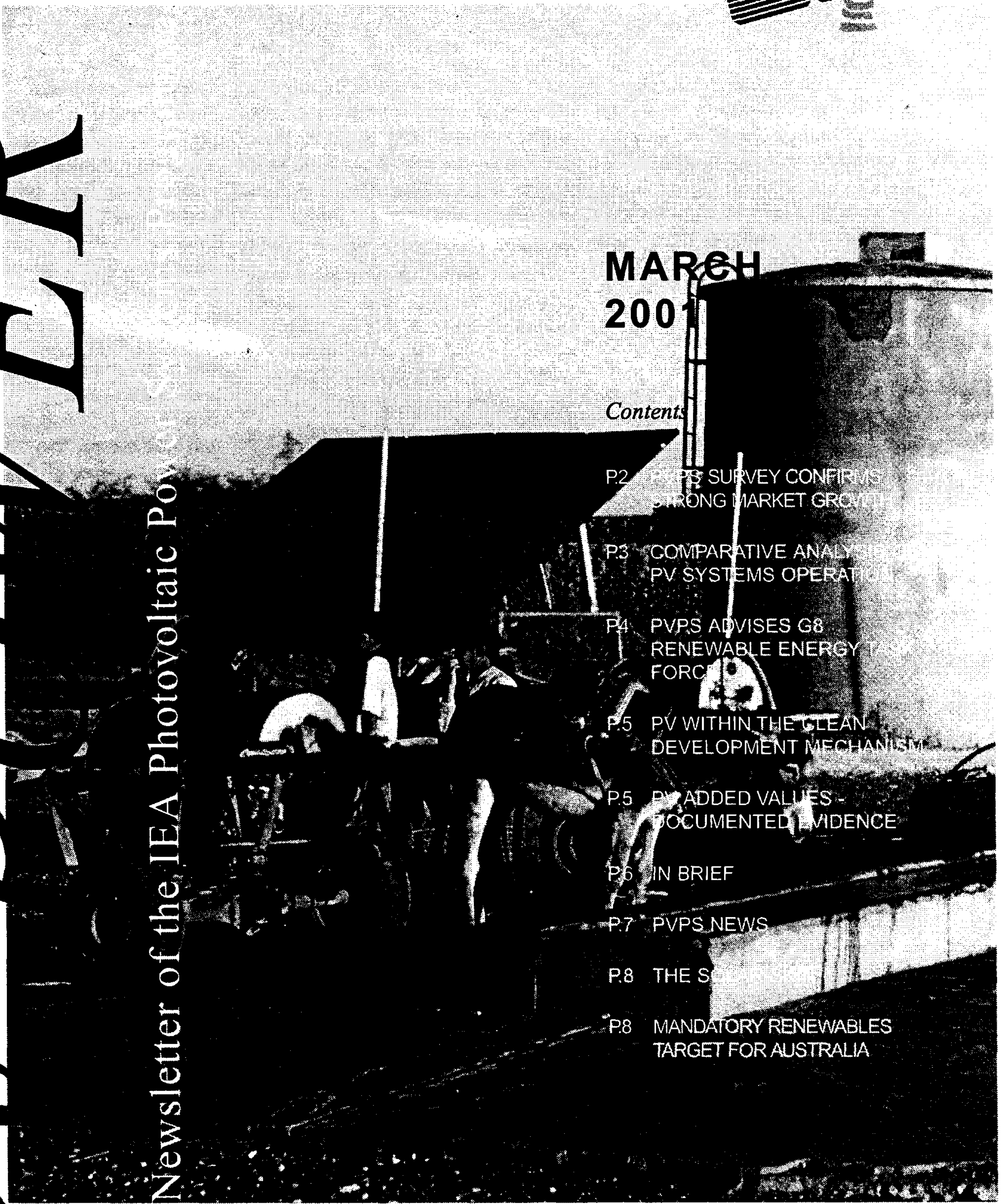
IEA INTERNATIONAL ENERGY AGENCY 14

PV POWER

Newsletter of the IEA Photovoltaic Po



MARCH 2001

Contents

Caption

PVPS SURVEY CONFIRMS STRONG MARKET GROWTH

The latest update of the PVPS Annual international Survey Report "Trends in Photovoltaic Applications" covering the period 1992-1999 is now available.

The report gives an overview of installed generation capacity, application segmentation, manufacturing capabilities and the business and political environments for PV in the 20 countries participating in PVPS as at the end of 1999. Market development trends over the preceeding 8 years are also analysed.

Market Expansion

The market for PV power continues to grow rapidly: between 1998 and 1999 the total installed capacity grew by 31 %, to reach 516 MWp. Japan's New Sunshine Programme, which commenced in 1995 is now exerting a major influence on the trends in participating countries (see box). Of the 121 MWp installed during 1999, 60 % was installed in Japan alone. If Japan is excluded from the analysis, installed capacity grew by 19 % in the remaining countries - similar to the previous year. Collectively Japan, USA and Germany accounted for 87 % of the PV installed in 1999

Applications

In the most recent report the market is divided into three sectors (a change from previous reports): off-grid applications, distributed on-grid and centralised on-grid applications.

Overall the trend is for an increase in the proportion of grid connected systems. In 1992 only 29 % of the installed capacity was connected to the grid; this had increased to 53 % by the end of 1999. Again, this is largely due to significant government-subsidised programmes in Japan, the USA and Germany, which have a predominant on-grid focus.

Nevertheless, off-grid applications - for seasonal/recreational buildings, rural electrification, pumping, agricultural uses, traffic signals and telecommunications for instance - are still very important in many countries. Indeed 90 % of the combined capacity in Australia, Canada, Finland, France, Israel, Mexico, Norway, Portugal and Sweden is off grid.

Fiscal Support

The total budget allocated by government bodies to support the PV industry increased by 4 % between 1998 and 1999, to MUSD 479 . Over 50 % of the 1999 funding was allocated by Japan. Spending trends show an increasing proportion of the budget is for initiatives to encourage market deployment as opposed to research, development and demonstration.

The ISR summarises key initiatives in the reporting countries and shows that a range of fiscal instruments are being used to support and promote PV, including: reduced interest rates, tax credits, accelerated depreciation, grants, and preferential tariffs. Utilities are seen to be increasingly supportive of PV with initiatives such as net metering and investments in PV.

Nurturing the Market

Education is increasingly being recognised as a key aspect of national programmes. A number of countries, including Germany, Japan, Israel and the UK have programmes to install PV systems on schools and universities.

Many countries have set targets to increase PV deployment significantly in the near/medium term (Germany, Finland, France, Italy, Japan, the Netherlands and the USA) which can be attributed to the Kyoto Protocol. Another major influence is energy market deregulation.

Public opinion appears to be generally supportive of PV although lack of awareness and access to information remains a barrier in some countries.

Production and prices

The report also summarises information on cell and module production, technology preferences and trends in system prices. Total module production increased by 34 % between 1998 and 1999 to 168 MWp a year, primarily in Japan and the USA. Japanese production alone increased by 67 %, largely to meet the increased demand in the home market. However overall production remains well below capacity (52 %) in all producing countries.

In terms of the technology used, 84 % of the modules produced in 1999 were crystalline silicon, of which 60 % was multi-crystalline and 40 % was single crystalline. Amorphous crystalline is emerging as a viable alternative in the PV market, with production more than doubling between 1998 and 1999. In addition, CdTe and CIS manufacturing plants are planned or operational in Japan, Germany and the USA.

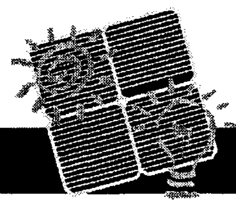
Generally the price of systems has not changed significantly since 1998, although reductions were seen in France,

BEHIND THE SCENES: JAPANESE PV PROGRAMME INFLUENCES WORLD WIDE TRENDS

Japan has several large PV demonstration and field test programmes, which expanded dramatically in 1999, moving towards the target of 5 000 MWp of installed PV capacity by 2010. Residential PV systems, of typically 3-5 kWp, are subsidised on the condition that the individuals provide operational data on their system. Between 1994 and 1998 15 596 PV systems were installed on dwellings and a further 17 396 houses were accepted under this programme in 1999. Other programmes provide subsidies for local public organisations and private industrialists who are establishing new energy businesses. Net metering has been available in Japan since 1992.

PVPS SURVEY CONFIRMS STRONG MARKET GROWTH

Italy and Japan. On-grid building integrated systems of 1-3 kWp are typically between 6-12 USD/Wp installed, though prices below 6 USD/Wp were reported in Denmark and Germany. Off-grid systems remain competitive in many applications.
The report also includes the latest news on standards and codes in the reporting countries and a PV technology note on balance of system components, prices manufacturers and suppliers.
To order copies of the report (IEA-PVPS T1-08:2000) contact your national newsletter representative (contact details on page 8) or visit the PVPS website: www.iea-pvps.org



COMPARATIVE ANALYSIS OF PV SYSTEMS OPERATION

Data from over 260 PV systems have been analysed and compiled onto an IEA-PVPS database

A new report "Analysis of Photovoltaic Systems" has been produced under PVPS Task 2. The study summarises the operational performance, reliability and costs of 266 PV systems installed in the 7 participating IEA member countries (Austria, France, Germany, Israel, Italy, Japan and The Netherlands, plus EU) as contained in the Task 2 database (see PV Power #12).
Based on the experiences and lessons learnt from the sampled systems, the report sets out to identify how the performance of PV systems in general may be optimised.
Detailed operational results for each of the systems are included, illustrated with graphical representations of key data. A normalisation methodology has been adopted to allow performance analysis comparisons to be made between typical PV systems in different countries under different climatic conditions and different load patterns.
The results include; an analysis of the annual yields, which show only slight fluctuation from one year to the next; annual performance ratios, which differ from plant to plant, but range between 0.25 and 0.9 with an average of 0.66; and analysis of loss factors.
Potential optimisation measures identified in the report include: avoiding diode, wiring and mismatch losses; improving efficiencies of components through the selection of high efficiency modules and inverters; and avoiding high module temperatures by integrating modules into the building during installation.
The report also describes the project background data sources and the use of the database, and gives an overview of the evaluation procedures developed to enable system comparisons.
Copies of the report IEA-PVPS T2-01:2000, priced 75 USD, are available from the Task 2 Operating Agent, or can be downloaded from the PVPS website: www.iea-pvps.org.
Contact: Reinhard Dahl, Forschungszentrum Juelich GmbH, PT BEO 21, D-52425 Juelich, Germany
email r.dahl@fz-juelich.de

PVPS ADVISES G8 RENEWABLE ENERGY TASK FORCE

At the Okinawa Summit in July 2000, G8 leaders announced the formation of a Renewable Energy Task Force (RETF). The Task Force's primary mission is to identify the main barriers preventing significantly increased use of renewable energy for sustainable development world-wide, and to recommend key actions which G8 governments can take to remove these barriers.

The work of the RETF is complementary to that of PVPS Task 9, whose primary objective is to increase the overall rate of successful deployment of PV systems in developing countries. Following the 3rd Experts Meeting of Task 9 in Marrakech in September 2000, a formal submission presenting PVPS recommendations for G8 action was delivered to the RETF. The document was also submitted to the IEA's Renewable Energy Unit whose personnel are drafting the RETF's report that will be presented to the G8 ministers when they next meet in Genoa in June.
Although Task 9 is mandated to focus on photovoltaic technologies, the submission recognises that other renewable energy technologies can also satisfy energy needs of rural communities in developing countries. Many of the recommendations proposed by Task 9 are also applicable to these other technologies.

The six key recommendations proposed are summarised in the box above. The full text of the submission can be downloaded by visiting task 9 on the PVPS website. www.iea-pvps.org

RECOMMENDATIONS TO THE G8 RENEWABLE ENERGY TASK FORCE

1. G8/OECD development aid organisations should set a target of electrifying 1 billion people within the next 10 years. In order to achieve this, aid budget allocation to renewable energy should be immediately doubled then increased progressively. A renewable energy component should be included in conventional energy projects. Investments should be targeted at the development of sustainable infrastructures rather than purely at product subsidies.
2. Renewable energy expertise should be incorporated into all G8 development aid organisations and capacity built in the country offices and sector teams.
3. Energy supply options should be chosen on the basis of a least cost analysis in multi-lateral and bilateral development projects. The least cost analysis should be based on a life cycle cost analysis and, where possible include externalities.
4. The OECD should allocate funds to South-South exchanges in order to accelerate the adoption of renewables.
5. The G8 should ensure that the electrification of those without access to electricity services is addressed explicitly in G8/OECD funded bilateral or multilateral programmes for restructuring or privatising power sector utilities in developing countries, which implies that resources must be specifically earmarked to this effect.
6. The G8 should encourage high level planning for rural development and rural electrification through the development, and implementation of appropriate Rural Electrification/Energy Plans.

PV WITHIN THE CLEAN DEVELOPMENT MECHANISM

The Clean Development Mechanism (CDM) is an instrument established under the Kyoto Protocol aimed at achieving sustainable development while contributing to the cost-effective mitigation of climate change.

It allows Parties to the Protocol to meet part of their reduction commitments abroad - notably in developing countries - where specific greenhouse gas (GHG) abatement costs are lower. Simultaneously, this can allow developing countries to attract investments in clean energy technology and assist them in reaching a sustainable development path.
Under the CDM, the GHG emissions that are avoided through the use of clean energy technologies (in comparison to what would have been emitted had polluting energy technologies been adopted) will generate 'certified emission reduction units' (CERs) for the investor. These CERs can then be offset against the investing Party's emission allowance, effectively reducing the emissions reduction measures that need to be implemented domestically.
The CDM should therefore be a suitable vehicle for the implementation of PV projects in developing countries. However, CERs, as the name suggests, require that the amount of avoided emissions needs to be certified. This represents a potential problem for small, distributed energy technologies such as PV solar home

PV WITHIN THE CLEAN DEVELOPMENT MECHANISM

systems (SHS), as monitoring of all such systems would be impractical.

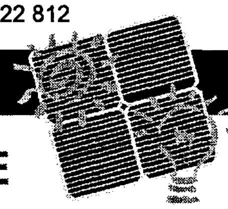
To address this problem, the Dutch PV Export Group, with funding from Novem, has commissioned a study to assess the eligibility of SHS under the CDM and determine a simple reference CER calculation procedure.

Details of eight solar home system projects and field studies in Africa, Asia, and Latin America were evaluated. The case studies show that savings of kerosene for lighting provide the largest contribution to CO_2 displacement. In some cases, savings of candles and battery charging also contribute.

In order to pave the way for PV SHSs in the current CDM negotiations, the study proposes that a global emission value appears to be the most appropriate approach to use. Based on information from the existing case studies and factors such as upstream emissions, the study concludes that an abatement potential of 200 kg CO_2 per 50 Wp SHS per year is a conservative but safe global emission reduction value.

A second phase of work and further consultation with stakeholders is now underway aimed at refinement of the streamlined processes for SHS's in the CDM. Recommendations arising from this work will be presented at the next round of climate talks.

Contact: Jan Cloin, ECN
Fax: +31(0)20 49 22 812



PV ADDED VALUES - DOCUMENTED EVIDENCE

The conclusions of a PVPS special information activity to assess PV 'added values' are to be published as a new report

Following on from the focus workshops held in Sapporo, Japan in 1999, and Glasgow, UK last year, a summary report documenting the 'Added Values of Photovoltaic Power Systems' has been prepared under PVPS Task 1 (Information Dissemination), with support from Task 7 (PV in the Built Environment).

PV is increasingly accepted as an economically viable energy supply technology for a wide variety of - mostly off-grid - applications. Photovoltaics can provide high-value service or amenity wherever low-maintenance, reliability, easy of deployment or relatively small power demand is an issue.

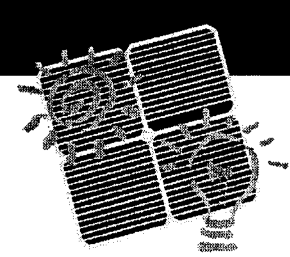
For grid-connected applications in particular, though, viability assessments continue to be made largely on the basis of electricity cost, which despite consistent reductions over the past three decades, typically remain higher than those available from centralised, fossil fuel or nuclear plants.

As the report details, however, even in grid supplied areas, values other than kWh energy cost are important. For utilities these include ancillary services, such as power quality and reliability, and capacity values. For customers and society in general reliability, environmental impact, convenience, supply security and associated employment are important issues. In the built environment, there are other non-energy values to consider, such as avoided land and structure costs, architectural interest and multi-functionality.

Present arrangements for ancillary services and network augmentation or extension continue to focus on the larger participants in the electricity market and distributed options like PV do not yet receive equal consideration. Additionally, electricity industry regulation with respect to climate change is still in its infancy, so that little value is placed on emission-free generation. The study summarises the key barriers which are currently hampering increased PV power system utilisation, and proposes measures to overcome these.

Although the report does not attempt to quantify the values in a form which could be used for cost/benefit analysis, documenting the various added-values is an important first step towards this.

Copies of the report, IEA-PVPS T1-09:2001, are available from Task 1 National contacts (See page 7).



IN BRIEF

EUREC AGENCY PV OUTLOOK & ROADMAP 2000

The European Renewable Energy Centres Agency (EUREC) has prepared a position paper on 'Future Research & Development in Photovoltaics'.

The document provides an introduction and status review of PV technology and applications, and presents short (to 2005) and medium (to 2010) term goals for PV components and system efficiency improvements and cost reductions.

The Agency identifies six main barriers that must be overcome if uptake of PV technology worldwide is to be increased. Key amongst these are the need for System price reductions, resolution of silicon feedstock issues, continued development of thin film technology to improve public image and efficiency, and alleviation of energy storage problems.

EUREC outlines an R&D roadmap to address the problem areas and achieve the cost and efficiency goals. Various fiscal initiatives and improved product marketing measures are also identified to complement the R&D focus.

The PV position paper forms part of the Agency's update of it's publication, *The Future for Renewable Energy : prospects and directions.*

Contact: EUREC
Fax: +32 (0)2 502 92 84

LOW-COST SOLAR-GRADE SILICON CLAIMS

Venture Aims to Accelerate Industry Growth by Removing Raw Material Constraints

US PV manufacturer, Astropower and Elkem of Norway, the world's largest silicon processor, signed a technical cooperation agreement in December 2000 aimed at finalising a low-cost process for manufacturing large-volumes of solar-grade silicon. Both companies have been researching feedstock issues for several years, and have been cooperating since 1998 to develop a solar-grade silicon manufacturing process. The agreement calls for the future establishment of a jointly-owned manufacturing venture, based in Norway and managed by Elkem, that will supply low-cost silicon feedstock to the global solar power industry.

The limited availability and high price of solar-grade silicon feedstock have hampered solar industry growth, noticeably in recent years as electronics industry 'scrap' has become a more valued commodity.

Contact: Astropower
Fax: +1 302 368 6087

GREEN ENERGY CERTIFICATE TEST TRADING

Six European countries are piloting an initiative which enables cross-border trading of the environmental benefits of electricity from renewable energy (RE) sources.

Renewable Energy Certificates (RECs) are issued to electricity producers according to the amount of RE power they generate. The RECs can be bought by energy supply companies to confirm that a proportion of their sales are made up of green electricity. The certification helps ensure that suppliers' green power schemes comply with their claims. They can also serve as an indicator of power companies compliance to national renewables obligations (which exist in Australia, and will be introduced in the UK in October, for instance.)

National RE certificate trading systems are already in operation in the participating countries - Denmark, Greece, Italy, The Netherlands, Norway and Sweden - but their certificate issuing rules have now been harmonised to facilitate international trading.

Contact: RECS Secretariat
Fax: +31 (0)10 280 56 54

NAME-CHANGE FOR UPVG

The US Utility Photovoltaic Group is now known as the Solar Electric Power Association, SEPA.

Contact details are unchanged.
Fax: +1 202 223 5537

INTERNET RESOURCES

US NATIONAL CENTER FOR PHOTOVOLTAICS (NCPV)

The NCPV, which was established by the US Dept. of Energy in 1995, serves to mobilise US resources in photovoltaics by performing world-class research and development, promoting partnering and growth opportunities, and serving as a forum and information source for the photovoltaics community.

The NCPV website provides information about the Centre and the United States' PV programme, as well as a good resource area containing PV-related background information, educational material and news.

www.nrel.gov/ncpv

ISES WIRE

WIRE is the International Solar Energy Society's World-wide Information System for Renewable Energy. The site is a global information exchange tool, giving visitors access to a vast, searchable database of RE-related news, opinion, papers, reports and images. The purpose of this service is to facilitate and accelerate the flow of knowledge among renewable energy professionals worldwide.

Visitors can enter as guests to view the available resources, or can register as a contributor, to enable them to upload text and other data for review and subsequent online presentation.

The WIRE system has been designed and optimised specifically for use by standard web browsers operating at low bandwidth to ensure maximum user accessibility.

wire.ises.org

SOLARINFO

The German Solarinfo site provides a number of useful resources for visitors interested in PV and solar heating. Amongst the tools are product and service locators, information on finance support schemes, exhibition and job listings and a large database of solar projects including many PV examples.

An English language version is available, though some content is not fully translated.

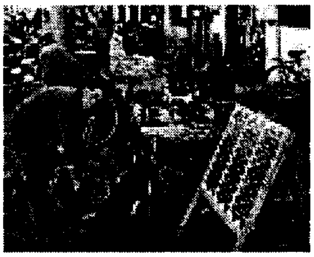
www.solarinfo.de

RENEWABLE ENERGY CERTIFICATE SYSTEMS

The RECS Central Information Exchange contains public information about the pilot RECS scheme operating in Europe, and provides an information exchange for the organisations that are currently working to implement it.

www.recs.org

PVPS NEWS



STANDARDS, GUIDELINES & QA PROCEDURES FOR STAND-ALONE PV SYSTEMS

Quality Assurance (QA) of stand-alone PV systems and components is one of the priority focus areas for PVPS Task 3. A review of existing programmes of standardisation and QA for PV has been undertaken by Task 3 to identify ways in which the group can best contribute to work in this area. The results of the review are now available as an online report, *Survey of National and International Standards, Guidelines & QA Procedures for Stand-alone PV Systems.*

The document in itself provides a useful resource which describes the current status of existing standards and QA programmes, as well as describing the role of international and national standardisation and QA organisations, and the work which they are conducting to provide guidelines for the application of quality stand-alone PV (SAPV) systems. The survey identifies areas where there are insufficient, or no guidelines, and suggests a Task 3 plan of action to address some of these shortcomings.

This report, available for download via the PVPS website, will be regularly updated for the duration of the current Task 3 programme.

www.iea-pvps.org

COOPERATION FOR DEVELOPMENT

The fourth Task 9 meeting will be held in Jakarta, Indonesia in March. Three associated events are planned: a renewable energy promotion seminar with the ASEAN Centre for Energy and SECO; a seminar on Financing SHS in developing countries; and a workshop on Certification and Accreditation of PV Installer Training Programmes.

Contact: Jonathan Bates

Fax: +44 (0)118 973 0820

WORKSHOP ANNOUNCEMENT

Building with PV - New Product Opportunities

Wednesday May 9, 2001 at Amsterdam RAI

The rapidly increasing number of photovoltaic projects around the world demonstrate that PV is becoming a serious market. PV technology is being used in building applications for its energy-efficiency and ecological benefits and its aesthetically-pleasing appearance. Users are purchasing systems to power their homes with independently generated, 'clean' electricity. Large PV plants are installed in ground-mounted arrays, on roofs of large, industrial buildings and along noise barriers to produce green electricity for utilities. To keep up with the demands of these rapidly developing markets, new and innovative building products are required.

The objective of this Task 7 workshop, is to consider opportunities for new products suited to the various emerging markets for PV in the built environment. The workshop will be closely linked to Sustain 2001, providing excellent opportunities to meet industry at the exhibition and join other events at the main conference.

Contact: Frederik Leenders at Ecofys, Fax: +31 30 2808 301

DIARY DATES

Sustain 2001
Amsterdam, Netherlands
08-10 May 2001
☛ Sustain 2001
Fax. +31(0)20 549 1843
www.sustain2001.com

UPEx'01 - PV Experience Conf.
Sacramento, Ca, USA
30 September - 5 October 2001
☛ Julia Judd , SEPA
Fax. +1 202 223 5537
www.upvg.org/upvg/upex2001

IEA Future Building Forum Think Tank
Oslo, Norway
9-11 May 2001
☛ Helen Shawcross, ESSU
E-mail: exco.support@ecbcs.org

17th EPSEC, European PV Conf.
Munich, Germany
22-26 October 2001
☛ Bettina Kaisa, WIP-Munich
Fax. +49 (0)89 720 1291
www.wip-munich.de

12th International Photovoltaic Science and Engineering Conf.
Cheju Island, Korea
11-15 June 2001
☛ PVSEC-12 Secretariat KIER
Fax. +82 (0)42 860 3739
www.solarpv.or.kr/pvsec-12

ISES 2001 Congress - Bringing Solar Down to Earth
Adelaide, Australia
25 November - 02 December 2001
☛ Hartley Management Group
Fax. +61 (0)8 8363 4577
www.unisa.edu.au/ises2001congress

IEA-PVPS NEWSLETTER

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FINLAND Leena Grandell fax. 09 8656 3199	**MEXICO** Jaime Agredano Diaz fax. 73 189 854	**UNITED KINGDOM** Paul Cowley fax. 0118 973 0820
FRANCE André Claverie fax. 04 93 95 79 87	**NETHERLANDS** Astrid de Ruiter fax. 030 231 64 91	**USA** Charles Linderman fax. 202 508 5225

PV POWER

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This newsletter is intended to provide information on the activities of IEA PVPS. It does not necessarily reflect the viewpoints or policies of the IEA, IEA PVPS Member Countries or the participating researchers. Articles may be reproduced without prior permission, provided that the correct reference is given.

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Website: http://www.iea-pvps.org

THE SOLAR-SKIN

CASE STUDY

PROJECT SUMMARY

- Location: Trondheim, Norway
- Installed: June 2000
- Retro-fitted secondary facade
- Total facade area: 465 m²
- BP Solar glass-glass encapsulated cells
- Total array generation capacity: 16 kWp
- PV module area: 192 m²
- PV cell net area: 102 m²
- Cavity width: 0.8 m

Contact: Øyvind Aschehoug, NTNU
Fax: +47 (0)73 59 50 45

BP Solar asked the solar energy research unit at the Norwegian University of Science & Technology (NTNU) to devise a challenging R&D problem project that would also demonstrate the company's activities in PV. NTNU proposed a BIPV double-facade - the 'Solar Skin'.

The solar skin combines two contemporary building concepts; the use of double facades in renovation projects, and building integrated photovoltaics (BIPV).
The double facade is effectively a glass wall attached to the outside of the existing building envelope, separated by an air gap of 0,8 m. Thermal performance is similar to a glazed atrium; the cavity creates a buffer zone which reduces heat loss from the main facade, while harnessing winter solar gains to reduce the building heating load. The cavity can be cooled during summer through ports at the top and bottom of the secondary skin which induce stack-effect ventilation.
The PV cells are encapsulated in clear glass modules, which in turn are installed in the outer wall. The semi-transparent modules enable natural lighting to be taken advantage of, while the air gap between the two skins ensures that the modules are well ventilated to maximise their efficiency.
The facade will be monitored for at least one year to evaluate electrical and thermal performance. The data will be used to optimise simulation models for future double-skin PV systems.

MANDATORY RENEWABLES TARGET FOR AUSTRALIA

From April 1st, 2001, wholesale electricity purchasers in Australia will be legally bound into contributing towards the generation of an additional 9 500 GWh of electricity from renewable energy sources in 2010.

A gradual scale-up of production to meet the 2010 target will be achieved by establishing mandatory RE purchase requirements on electricity retailers and wholesale electricity buyers. Purchasers will be 'proportionately liable for the measure'. In other words, if a party purchases 1% of the country's total electricity production in a given year, they must purchase 1% from the RE target for that year.
The measure will be implemented through the creation of tradeable renewable energy certificates. Each 1 MWh of electricity generated from eligible renewable energy sources will earn 1 certificate for the generator. This can then be sold to a third party for surrender to the Renewable Energy Regulator as evidence of purchase of eligible power. Any shortfall in the obligatory purchase requirement will be penalised at the rate of AUD40/MWh.

In July last year, the Australian government introduced a 4 year, MAUD 31, PV-specific support scheme, the Photovoltaic Rebate Programme. Rebates of up to 50 % of system capital costs are available for rooftop and integrated systems on homes and community use buildings.
Details of both schemes are available from the Australian Greenhouse Office fax: +61(0) 2 6274 1884

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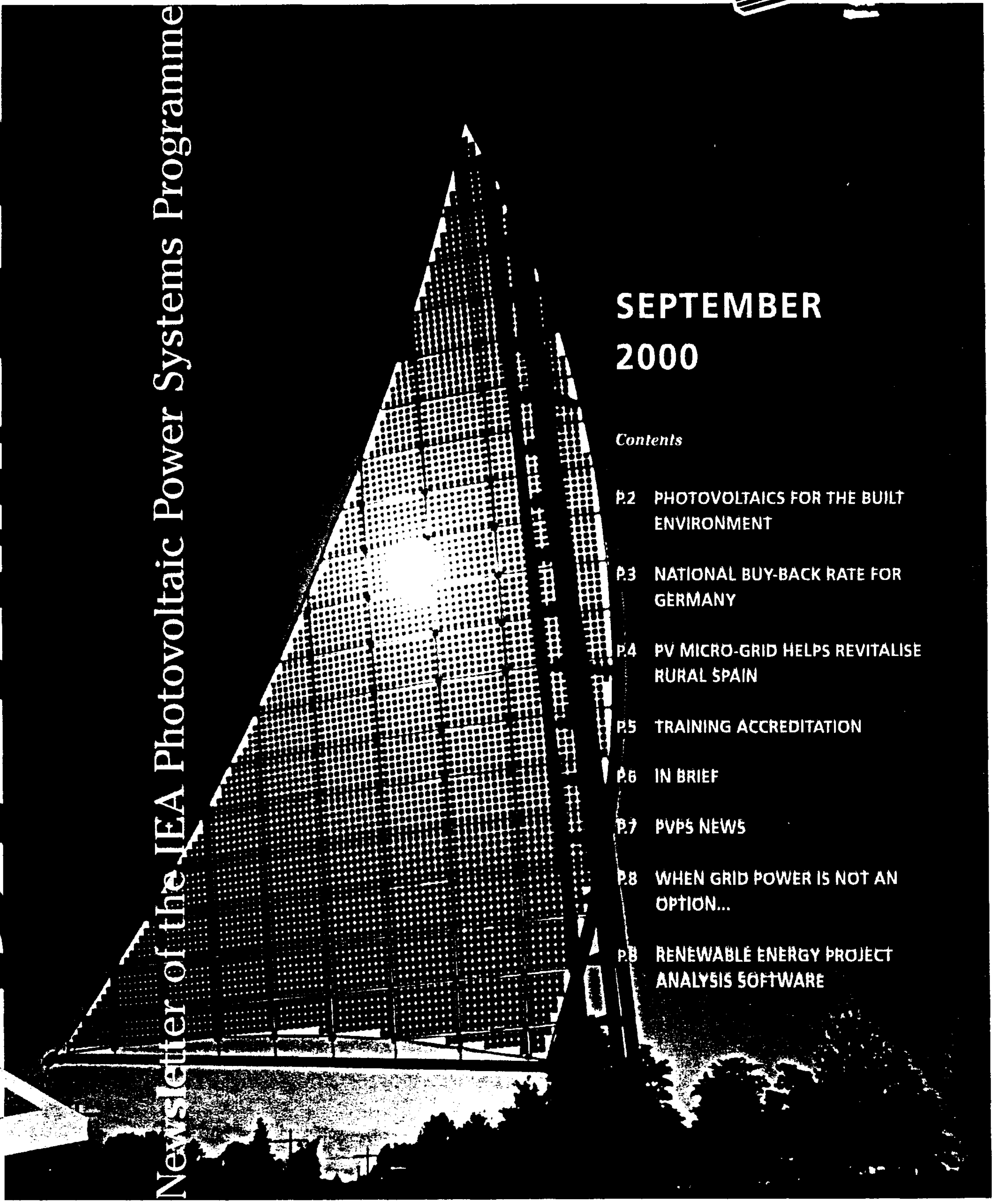
Newsletter of the IEA Photovoltaic Power Systems Programme



SEPTEMBER 2000

Contents

The Swiss-designed 'Solarsail' captured public imagination as an exhibit in the PVPS Task VII BIPV Design competition. See pages 2-3.

PHOTOVOLTAICS FOR THE BUILT ENVIRONMENT

The results of PVPS Task VII's international design competition for PV products for the built environment were announced in May. Prizes totalling 7000 Euros were awarded to five winners in 4 product categories.

Task VII's objectives are strongly oriented towards enhancing the architectural and technical quality of PV systems specifically for use in urban settings. The design competition aimed to encourage attractive, innovative and functional approaches for integrating PV into these environments with products for which there is a clearly identifiable market. The competition entries were assessed primarily on how well they addressed these key criteria, with additional marks being awarded for ease of installation, operation and maintenance, efficiency of performance, practicality and cost-effectiveness of manufacture, design flexibility and regard to environmental considerations.

More than 60 architects, engineers, designers and students registered for the competition. These were narrowed down to 29 entries from 10 countries, with designs grouped into four categories: roofing products, façades, other building products (such as shading devices and building entrances), and PV products recently released into the market.

The overall competition winner, together with the designs judged to be best in each category were announced during the 16th European PV Solar Energy Conference in Glasgow.

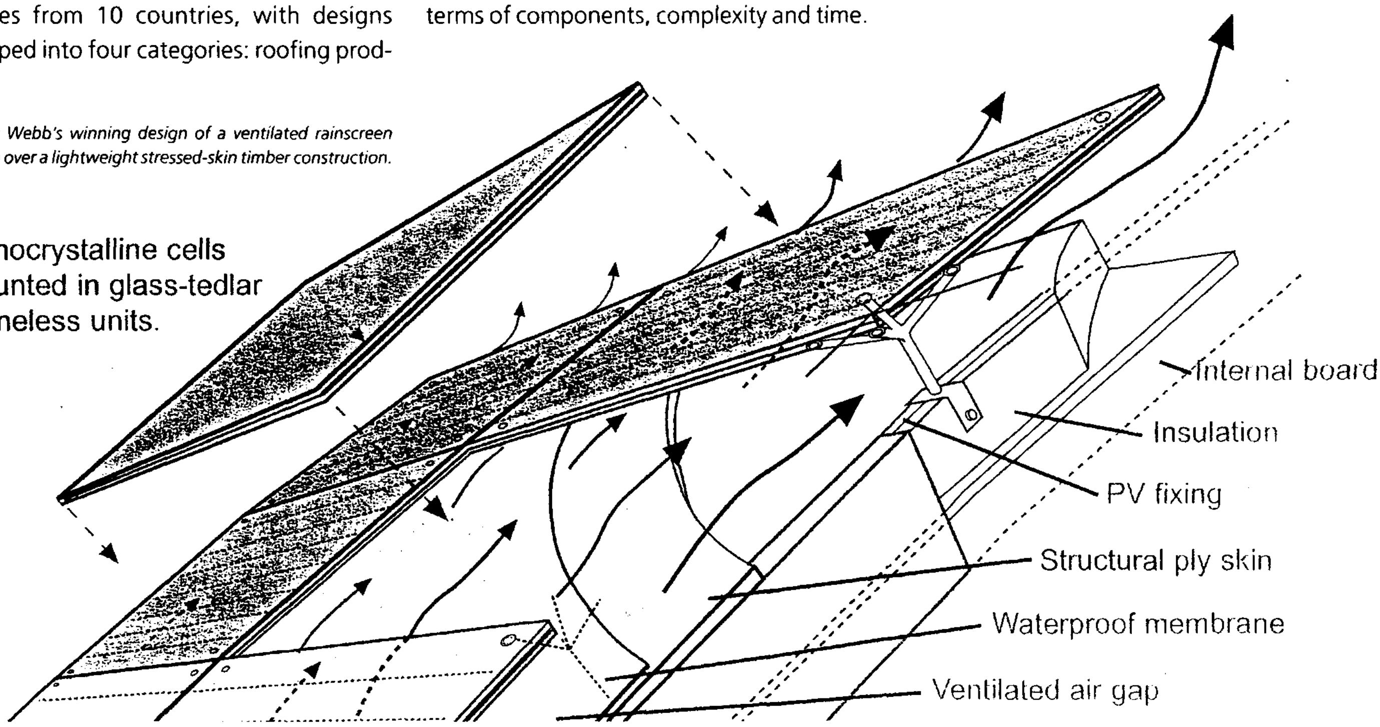
Robert Webb of Robert Webb Associates, UK, won EUR 1 500 as the overall competition winner for his design for PV panels as a ventilated rainscreen system over a lightweight stressed-skin timber construction. The judges admired the overall concept for the building and its consideration for environmental and passive solar issues in addition to electricity generation.

Andrew Weight from Reading University, UK, was the winner of the roofing products category, as well as overall student winner. He was awarded EUR 1 500 for his PhotoFIT design. This design for mounting PV modules to provide a roof or façade covering used an innovative profile system as the module frame. It aims to minimize costs by simplifying installation requirements in terms of components, complexity and time. The judges considered it to be a well-presented and well thought through entry, giving good consideration to the integration of cabling and avoiding the problem of the frame shadowing the module.

The façades category prize of EUR 1 500 was shared between Marcel Ferrier, an architect from Switzerland and a team of three students (S Tomatsuri, K Kondo and T Ohashi) from Hosei University, Japan. Marcel's design was for a PV façade on a circular building that addressed the issue of the sun's movement in an innovative manner. The Japanese design was for a building with a PV roof and façade with water flowing over the module surfaces. The combination of PV and water-cooling systems aims to keep the building and PV installation cool.

A practical and sturdy design for a PV Sunshade system that both optimized solar gain and avoided self-shading won EUR 1 500 for the other building products category. D Hewitt and R Braunstein of Kawneer Co. in the USA submitted the design.

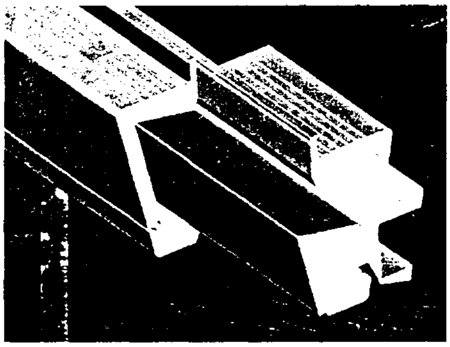
The recently released products short listed were all roofing products, and included sys-



Robert Webb's winning design of a ventilated rainscreen system over a lightweight stressed-skin timber construction.

tems to fit onto sloped roofs, PV roof tile systems and systems for mounting PV modules on flat roofs. They were all well developed designs providing cost effective and practical methods of mounting PV on a wide range of roof types. A team from Econergy International in the Netherlands was the category winner with their INTERSOLE design that allows a range of module types and sizes to be integrated into any type of tiled roof in a weatherproof manner. The judges commented that this was a practical system likely to be good value for money.

In addition to the main category prizes, an award of EUR 1 000 was presented to Halle 58 Architekten, in Switzerland for their Solarsail creation. This prize was awarded on the basis of the number of votes given to the entry by visitors to the exhibition of short listed designs held at the Glasgow conference. All the short listed entries were exhibited at the conference and visitors to the exhibition were invited to vote on their favourite design.



PhotoFIT – simple componentry to keep installation time and costs to a minimum.

For further information, visit Task VII on the PVPS Website, http://www.iea-pvps.org, or download the official final judges report from the Task VII website, http://www.task7.org.

Alternatively, contact Angela McKenna at Halcrow, Fax: +44 (0)1793 815020

IEA

NATIONAL BUY-BACK RATE FOR GERMANY

As of 1 April 2000, a nationwide buy-back tariff of 0,99 DEM/kWh for PV generated electricity has been available in Germany.

The new rates form part of the Renewable Energy Law (REL) which has established buy-back terms for electric power generation from all renewables. The broad objective of the law is to double the contribution of renewables to Germany's power mix from 5% in 1999 to 10% in 2010, and to contribute towards bringing the cost of renewable generation in line with that of conventional methods in the medium to longer term.

For PV the new buy-back rate can be combined with favourable loans available under the 100 000 roofs programme. This stimulated unprecedented interest – and considerable disarray – in the rooftop programme in the run-up to the launch of the REL. Nearly 10 500 applications to the programme were submitted during March – some 6 500 more than during the whole of 1999. This was largely due to the widespread understanding that the ten year zero-interest loan available under the rooftop scheme was to be replaced with somewhat less favourable terms, in order to ensure that the programme remained within budget.

The programme was temporarily halted shortly after the REL launch to prevent further applications being made until the new loan conditions were defined. The rooftop initiative is now in operation again with revised installation targets and modified low-interest loan conditions in place. Whereas the original programme was scheduled for six years (1999-2004), the added benefit of the REL buy-back rate means that the same PV installation target of 300 MWp now seems likely to be achieved by the end of 2003.

Under the REL, acceptance of renewably-generated electricity is obligatory for the local distributors and transmission grid operators. The scheme is funded through a small premium added to the general electricity tariff (equivalent to 0,001 DEM/kWh) payable by every electricity purchaser throughout the country. As of 2002, the buy-back rate payable for new installations will be reduced by 5 % per year in order to encourage cost-convergence with conventional generating technologies.

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PV MICRO-GRID HELPS REVITALISE RURAL SPAIN

The village of San Felices is located at an altitude of 700 m in Aragón, the Spanish Pyrenees. The lack of infrastructure in the region caused a progressive depopulation of such villages during the 20th Century, but rural development projects like the one described below are supporting their revitalisation.

The project utilises a stand-alone PV power plant comprising a 10 kWp array, 180 kWh battery bank and power conditioner (charge regulator and inverter) to generate AC electricity which is distributed via a micro-grid. The system was designed for 15 connections but initially provides energy for 6 houses, a community hall, a church, a hostel/museum and public lighting. Centralizing the PV plant requires fewer modules and batteries than if each house is supplied by an independent PV system. In addition, only one power conditioning unit is needed to supply all the houses which simplifies maintenance.

The 90 m^2 array of 135 x BP 275 (75 Wp) modules is integrated into the roof of a purpose-built building in a way that takes into account the natural and architectural surroundings. The building contains the power conditioning equipment (2 x TApS C-8648 units providing 12 000 Wp MPP-tracking regulator and 7,5 kW inverter), 180 kWh Powerbloc battery storage (providing 7 days autonomy) and a back-up propane gas generator for emergencies. It also houses a community hall.

System reliability is enhanced by the Power Conditioning Rack, which controls all aspects of operation. This unit includes the charge regulator as well as converting direct to alternating current of mains quality (230 V - 50 Hz). Operational performance parameters (state of charge, battery voltage, PV-current etc.) are recorded hourly. Key meteorological data are also registered. These data can be seen in real time on the unit's display, or analysed remotely via modem-link. This facilitates early failure detection and timely maintenance.

The energy service delivered is equivalent to that of the public grid, though attention to load management is more critical. Each house is fitted with an energy-dispenser and meter which limits the amount of energy available for each user in accordance with their predetermined needs and the contracted tariff. The service scheme is managed by SEBA (Servicios Energeticos Basicos Autonomous), which also provides social and technical support for the end users.

Installation of the micro-grid enabled other infrastructure facilities to be introduced to the village at the same time. Pipes for drinking water and waste water were installed in the ditches used to bury the electric cables. In a second phase, water purification and waste water treatment will be completed.

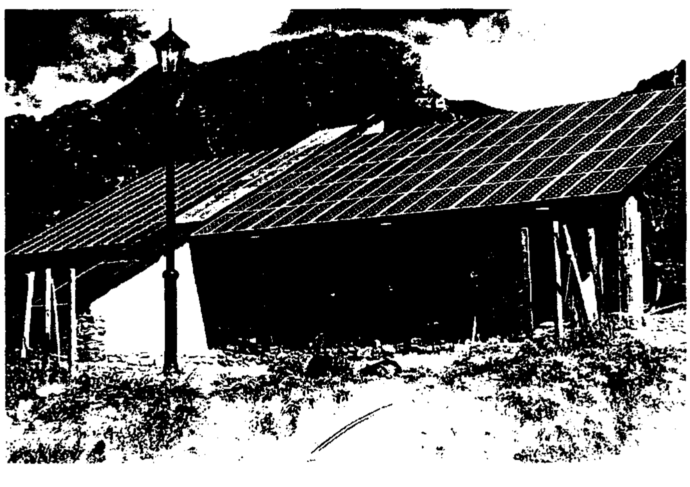
The total cost of the PV plant, distribution, public lighting and water distribution system was just under EUR 221 000 (approx. USD 204 000), co-financed by the European Commission, National, Regional and local governments and the users themselves.

This installation was undertaken as part of SEBA's 'Programa de Energetización Renovable Autónoma (PAERA)', which is now providing energy service to 36 isolated sites in the provinces of Huesca and Zaragoza.

SEBA, a non-profit users group founded in 1989, has promoted nearly 250 PV installations in rural Spain to date. Together with the Fraunhofer Institute for Solar Energy Systems (ISE), Germany, and The Spanish engineering firm Trama TecnoAmbiental, SEBA has recently produced a brochure about Successful User Schemes for Photovoltaic Stand-Alone Systems, which can be downloaded from ISE website: http://www.ise.fhg.de/english/projects/pv-standalone/index.html

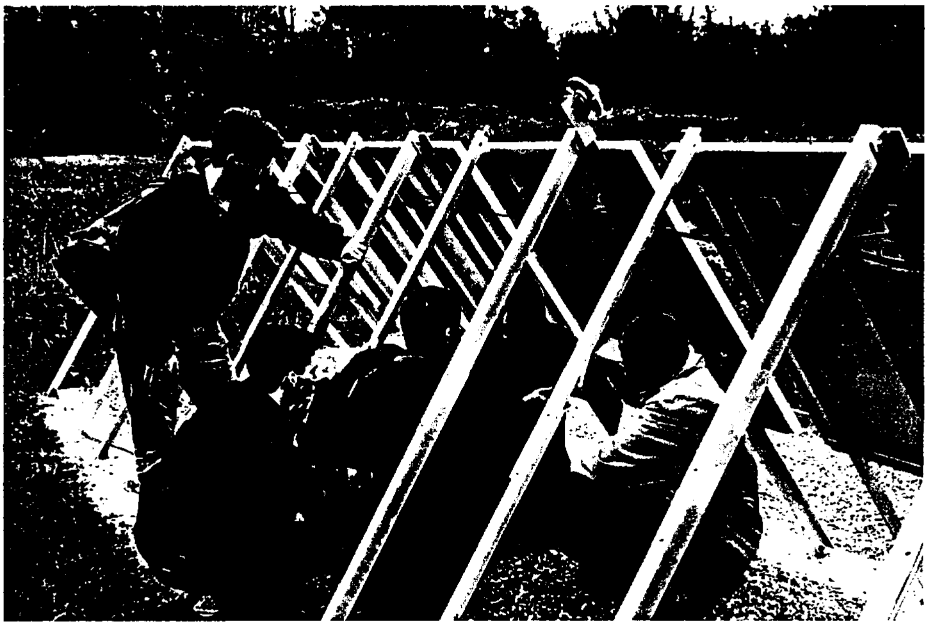
For further information contact Xavier Vallvé, Trama TecnoAmbiental
Fax: +34 93 456 6948

User involvement throughout the installation process – from conception to delivery – is invaluable for ensuring the system meets local needs in the most appropriate way.



TRAINING ACCREDITATION

Since 1996, the non-profit Institute for Sustainable Power, Inc. (ISP), has been working with the PV industry, the finance community, standards and certification professionals, and the education and training community to develop and implement an international PV training accreditation and practitioner certification framework.



Funding organizations and government agencies are very interested in market development of sustainable technologies, but often the infrastructure needed to successfully market, install, and service the technical solutions that they wish to support is inadequate. Training is one component needed for successful market development, and the ISP and its partners are working to define the tasks, knowledge, and skills needed for the successful implementation of dispersed sustainable energy technology. The outcome of this work is a series of certificates for PV professionals (e.g. installation and maintenance practitioners) based on minimum knowledge and skills competency standards, which will provide customers, financial professionals, and employers with an objective indication of professional competency.

ISP is one of four organisations working with The World Bank to develop a series of implementation manuals to address infrastructure needs: Installation and Maintenance Practitioner Certification (ISP); Quality Manufacturing (PV GAP); Testing Laboratories Quality Systems (Florida Solar Energy Centre); and, Quality Component Design (ECN).

The ISP has developed a manual for implementation of a training accreditation and practitioner certification programme at the country level. The project is being piloted in India, Sri Lanka, and China, and supported in South Africa.

The initial pilot of these four infrastructure components was held in Jaipur, India, in October 1999. ISP organised a five-day workshop based on The World Bank implementation manual for four levels of practitioner certification (Solar Home System Maintenance, Solar Home System Installer, Large Stand-Alone System Maintenance, and Large Stand-Alone System Installer). This served to introduce Indian officials and industry to the proposed quality standards framework, and to test the material and presentation in an appropriate setting. PVPS Task III (Stand-alone and Island Systems) also attended to observe proceedings.

Based on the reviews and comments of the attendees, the manual was modified for use in the follow-on implementation workshops in Sri Lanka and South Africa in February 2000, and in China in March 2000.

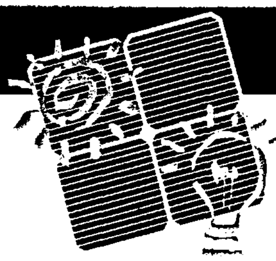
The goals in South Africa were to test the revised materials and to assess the potential for countries to use them without requiring a specially trained instructor.

In the course of the workshop, the participants moved quickly through the material, indicating that they felt that the manual provided sufficient guidance and detail to implement such a program on a national or regional level. In fact the participants decided to move beyond the framework of the manual and work together to establish a pan-Africa working group to coordinate the development of framework standards for training quality and competence.

In Sri Lanka, the participants took part in both classroom education and hands-on skills training, as the first phase of becoming certified as PV trainers for solar home systems installation.

At the end of one week, the participants were evaluated through a knowledge examination and a hands-on skills evaluation. Of the 21 participants, 17 received passing marks and will participate in the second phase of the trainer certification program. In evaluating the four who were unsuccessful, it was determined that having the material presented primarily in English, even with a Sinalese translator available, was insufficient, especially for teaching technology-based subjects. This only emphasises the need for national-level programs to qualify trainers, to avoid having to contract with outside trainers.

For further information Contact Mark Fitzgerald at ISP
Fax: +1 303 470 8239
http://www.ispq.org



IN BRIEF

NEW US GRID CONNECTION STANDARD

The new IEEE Recommended Practice for Utility Interface of Photovoltaic Systems, IEEE Std 929-2000 was published in April.

The extensive revision of the previous 929 was in response to the maturation of the PV industry which requires a comprehensive document giving specific recommendations rather than general guidance. The intent of the new standard is to define the technical requirements of PV system interconnection in a manner that can be readily adopted by utilities. It also includes several annexes for tutorial and clarification of test methods and measurements. The standard applies to utility-interconnected PV systems operating in parallel with the utility and utilising static inverters for conversion of direct current (dc) to alternating current (ac).

The document describes specific recommendations for small systems rated at 10 kW or less. Larger static inverters could also follow the same recommendations.

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Sandia National Laboratories
Tel: +1 505 844 7717

EUROPEAN PV CONFERENCE

Scotland plays host to the world's largest PV meeting

Some 1 300 hundred delegates from nearly 60 countries attended the 16th EPSEC in Glasgow from May 1-5 this year.

As always the technical content of the meeting was high. The main interest surrounded policy and deployment issues, with dramatic news of the impact of the REL on the German PV Programme (see page 3) and a high level of interest in developing country issues, including PV use for small-island states.

Special interest workshops on developing countries (co-organized by World Bank / EU), standards (PV-GAP) and PV added-value (PVPS-Task I) were well-attended.

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JAPAN BEGINS SOLAR-GRADE SILICON PRODUCTION

Rapidly expanding global demand, for PV has raised concerns that silicon scrapped by the semiconductor industry will soon be insufficient to satisfy the solar industry's needs.

Since 1996 SOGA, Japan's Solar-grade silicon Technology Research Association, with assistance from the New Energy and Industrial Technology Development Organisation (NEDO), has been working to avert a silicon shortfall. The main technological problems have now been addressed and production has recently commenced at a 60 ton per year pilot manufacturing facility.

Kawasaki Steel Corp., one of the main partners in the project, will start full-scale production in early 2001, with an initial output of 200 t/year. SOGA has been aiming for a SOG-Si production cost of JPY 2 300 per kg. The new solar-specific material is expected to be very competitive with the current scrap silicon price.

Contact Masao Kando, NEDO
Fax: +81 (0)3 5992 6440

PV BEST PRACTICE STORIES

New booklet summarises some of the better projects initiated under the EC THERMIE programme.

The publication, which is intended to motivate others to consider using PV in future infrastructure investments, provides a synopsis of 34 installations across Europe. Projects are categorised in 7 applications sectors: Noise Barriers, Power Stations, Buildings, Transport, Rural Electrification, Islands and Other Uses.

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NEW ON THE NET

PV PORTAL

Only two clicks away from that missing PV link...

Ekomation SEC has initiated a new tool which aims to help you find the on-line PV information you are looking for within two clicks. PV Portal provides visitors with a host of links to other PV-related websites, using a simple category locator – e.g. manufacturers, project examples or trade places – to identify relevant sites. The portal is dependent on country-specific 'Partners' located around the world who provide details of URLs that should be listed. Partners for some countries are still being sought. Applications can be made on-line.

http://www.pvportal.com

KYOCERA'S SERVICE NET

Kyocera introduces a new on-line technician referral service

PV users can now report system faults to Kyocera's worldwide network of installers via the internet. Within two working days of completion and submission of the on-line service request form, users will be contacted by their nearest available service technician.

Interestingly, the company does not restrict this service only to systems originally purchased through its own network.

The referral service itself is free, though the response may be chargeable depending on the nature of the problem.

http://www.solarelectricrepair.com

PV-WEB

The British Photovoltaic Association (PV-UK) has launched its new on-line presence

In addition to standard information on what PV is, applications, news and events, etc., the remodelled website incorporates two useful tools: the first is a searchable directory of UK suppliers of PV products and services; the second is a database containing descriptive listings of all UK PV in buildings projects.

http://www.pv-uk.org.uk

COULD YOU MAKE THE DIFFERENCE?

BP poses a 'solar challenge'

BP has initiated an internet forum or 'knowledge network for exchange of ideas, creative technical openings and inspiration' on solar energy.

The challenge has two focus areas: the first is to develop inexpensive solar panels that can be integrated into residential and commercial buildings, the second is to develop a '21st Century Solarplant' to accommodate the ten-fold increase in production throughput that the company believes will be needed in the next decade if it is to meet the expected growth in demand.

The company is inviting visitors to their website to become part of the solar knowledge network in order to contribute to achieving these two challenges.

http://www.bp.com/earthday/solar_challenge.asp

PVPS NEWS

NEW REPORTS ON BOS COMPONENTS

Batteries and charge controllers are critical elements of most stand-alone PV systems. Two new publications aimed at improving performance and reliability of these components have been produced under PVPS Task III.

The charge controller performs a vital function in the PV system, ensuring that the battery is not subjected to overcharging or overly deep discharging which could prevent them from delivering their rated capacity or even cause premature failure. 'Recommended Practices for Charge Controllers' is a handbook aimed primarily at users, operators and integrators of autonomous PV systems. It contains advice on how to choose, configure and maintain controllers, as well as information on troubleshooting problems and test procedures used to verify satisfactory functioning.

The complementary booklet is the 'Lead-Acid Battery Guide for Stand-Alone Photovoltaic Systems'. Again the report is directed towards the end customers, with a view to improving knowledge of the construction, characteristics and use of such equipment. The guide provides a useful reference for how to install lead-acid batteries and how to maintain them to ensure continued reliable operation.

Both reports will shortly be available for download via the PVPS main website: http://www.iea-pvps.org

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DEVELOPING COUNTRY SURVEY

The results of the Task III survey of stand-alone applications in developing countries are available from the Task III website.

The survey focused upon past renewable energy programmes: how many there have been; how they were perceived by officials and consumers; what the local and national government policy issues have been; and how the programmes have affected the technical, financial and institutional infrastructure of the country.

Summary reports presenting the key findings in 21 countries are provided as PDF documents.

http://www.task3.pvps.iea.org

TASK-SPECIFIC WEBSITES

Both PVPS Task III (Stand-alone and Island Systems) and Task IX (Technical Cooperation for Market Deployment) now have dedicated internet sites.

The new sites provide additional information on the work being undertaken in each of these areas to that contained on the main PVPS site. In addition, task-specific publications and products can be downloaded directly from these new locations:

Task III: http://www.task3.pvps.iea.org

Task IX: http://www.task9.pvps.iea.org

Both sites are also accessible via the PVPS main homepage:

http://www.iea-pvps.org

ADDED-VALUE

Task I (Information Dissemination) held the second workshop on PV Added-Value in Glasgow in May

The meeting was attended by some 35 delegates aiming to identify and discuss the different added values of grid-connected PV systems for various target groups. Addressing these issues is important for tailoring PV development strategies to influence policy and decision makers.

The results of the Glasgow Workshop and the preceding Sapporro event will be collated and published later in the year.

For further information contact your Task I national representative.

DIARY DATES...

PV Hybrid Power Systems
Aix en Provence, France
7-8 September 2000
☛ Bureau de Congres
Fax: +33 (0)442 161 179
http://www.re.e-technik.uni-kassel.de

UPEX 2000: 5th UPVG Conf.
Baltimore, USA
25 October 2000
☛ Tina Schneider, UPVG
Fax: +1 202 223 5537
http://www.upvg.org/upvg/upex2000

The City – A Solar Power Station
Bonn, Germany
12-15 September 2000
☛ Eurosolar
Fax: +49 (0)228 36 12 79
http://www.eurosolar.org

Solar 2000 (38th ANZSES Conf)
Brisbane, Australia
29 November - 1 December 2000
☛ Conference Secretariat
Fax: +61 (0)7 3844 0909
http://www.icms.com.au/solar2000

28th IEEE PV Specialists Conf.
Anchorage, Alaska, USA
15-22 September 2000
☛ John Brenner, NREL
Fax: +1 303 384 6481
http://ieeepvsc.nrel.gov

IEA Future Building Forum Think Tank
Oslo, Norway
9-11 May 2001
☛ Helen Shawcross, ESSU
E-mail: exco.support@ecbcs.org

IEA-PVPS NEWSLETTER

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PV POWER

PV Power is the newsletter of the IEA PVPS Programme. It is prepared by IT Power, UK, under supervision of PVPS Task I.

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E-mail: pvpower@itpower.co.uk

WHEN GRID POWER IS NOT AN OPTION...

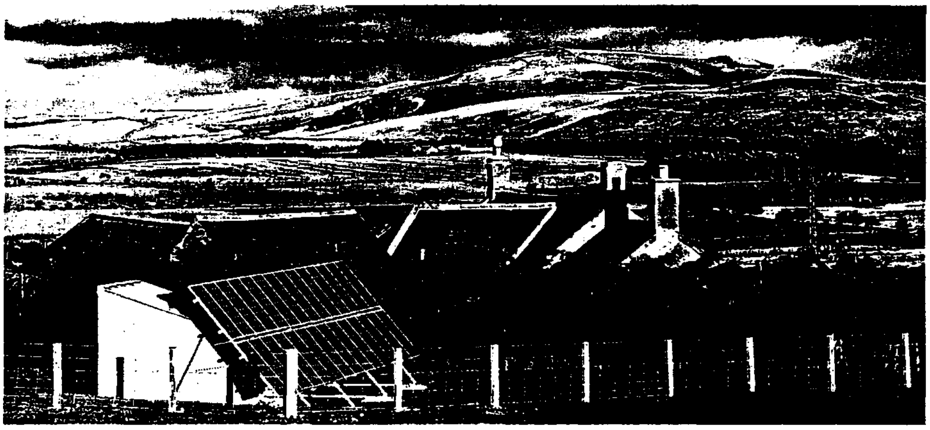
CASE STUDY

PROJECT SUMMARY

- Location: Coldstream, Northumberland, UK
- Isolated PV / diesel / battery hybrid
- 2,1 kWp ground-mounted array
- 28 x Astropower AP7105 mono-crystalline modules
- 450 Ah battery at 48 V
- Trace SW4548E 4,5 kVA modified sinewave inverter
- 11 kVA backup Lister Petter diesel generator
- Typical daily consumption 8 kWh

Contact: Dan Davies, Solar Century
Fax: +44 (0)870 735 8101

When your local electricity company wants to charge GBP 35 000 (over USD 52 000) to lay on mains power you know alternative energy sources have to be investigated.



This was certainly the case for the owner of a refurbished shepherd's house in the idyllic setting of Mindrum Farm in the North of England. A PV-diesel hybrid system now provides an economically and environmentally sound solution to the farm's various power requirements.

The occupier needed a secure power supply with scope for future expansion. The system not only had to meet the demands of typical domestic appliances, but also needed to match occasional surges related to various agricultural activities on the farm.

The turnkey package supplied by Solar Century comprises a ground-mounted 2,1 kWp PV array charging a 450 Ah battery via a charge controller. This feeds power to the main consumer unit via a modified sine-wave inverter with a maximum output of 4,5 kVA. A water cooled diesel generator feeds power to a subsidiary consumer unit to meet occasional and high power loads and for supplementary battery charging.

The diesel set is activated when any of the loads on the subsidiary unit are used, or if the battery is discharged below a pre-set level.

The costs of all the goods and services for the installation of the PV hybrid system amounted to GBP 17 500 (USD 26 000), in other words only half of the cost of connecting to the mains.

IEA

RENEWABLE ENERGY PROJECT ANALYSIS SOFTWARE

RETScreen is a pre-feasibility software package which enables users to assess energy production, costs and financial viability of renewable energy projects anywhere in the world.

The package currently provides for evaluation of eight renewable energy technologies through a series of modules which run within the main Excel-based program. The PV-specific module can assist with technical and economic analyses of grid-connected projects, ranging from centralised plants to smaller-scale distributed applications. The tool can also be used to determine radiation data in the plane of the array based on known horizontal insolation data.

The latest version of the software incorporates a link to NASA's Solar Energy Data Website to allow retrieval of insolation and near-surface air temperature data for any location worldwide. An integrated on-line database of renewable energy products provides information such as product specifications and performance data on equipment that may be used in the project, enabling comparison of alternative components.

The program, which is the work of Canada's CANMET Energy Diversification Research Laboratory (CEDRL) with input from many international renewable energy experts, can be downloaded free of charge from http://retscreen.gc.ca

For further information contact CEDRL:
Fax: +1 450 652 5177