Buy-back rates for grid-connected photovoltaic power systems

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BUY-BACK RATES FOR GRID-CONNECTED PHOTOVOLTAIC POWER SYSTEMS

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FOREWORD

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

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

The twenty members are: Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), European Commission, Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), United Kingdom (GBR), United States (USA).

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in co-operation with experts of the following countries:

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and approved by the PVPS programme Executive Committee.

The report expresses, as nearly as possible, an international consensus of opinion on the subjects dealt with.

SHORT ABSTRACT AND KEYWORDS

The buy-back rate offered by utilities for electrical energy produced by grid-connected photovoltaic power systems has recently been considered as an important parameter for the deployment of such systems. This report summarises the different buy-back rate models implemented in the participating IEA member countries. The report mainly covers the period up to 1995 with additional information up to the end of 1996. The existing buy-back rate schemes for grid-connected photovoltaic power systems are classified and compared with the energy price from conventional energy systems. The situation in the participating countries is described according to the identified buy-back rate schemes. A first analysis is performed on the experiences and the success of the observed schemes. Finally, these rate-based incentives are compared to other types of incentives.

Keywords: buy-back rate, economics, energy production, financing, grid-connection, incentives, independent power producer, non-technical barrier, payment, photovoltaics, promotion, public opinion, tariff, utilities

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1 SUMMARY

This research has been carried out by the TISO staff - in close collaboration with the management of the Swiss Photovoltaic R&D programme - for the International Energy Agency (IEA), Photovoltaic Power Systems Programme (PVPS), Task 1, Exchange and dissemination of information on Photovoltaic Power Systems. Task 1 is divided into 4 activities: this report deals with Activity three ‘Special information activities’.
The main objective was to study and to catalogue the different buy-back rate models of selected IEA member countries. This study was proposed because the buy-back rate is an important issue for grid connected photovoltaic plants and for the short-term diffusion of photovoltaic technology.

In total, 18 countries were invited to participate in this study:

- 11 countries (AUS, AUT, CHE, DEU, ESP, FRA, ITA, JPN, NLD, PRT, GBR) **have experience with** buy-back rate models, i.e. they have considered or implemented these models. This report illustrates the present situation within these countries.
- 3 countries (FIN, TUR, and USA) have not directly participated in this study.[1]
- 4 countries (CAN, DNK, KOR, and SWE) are **without experience** in buy-back rate models, i.e. they have no specific models or no grid-connected photovoltaic systems. These countries have not been fully considered. **Denmark** has long experience with buy-back rate models for wind power, bioenergy and independently produced combined heat and power, but no specific models for photovoltaic power.

The report focuses on the models that are presently in operation and on the results achieved. All countries have described at least 1 model - a total of 13 out of 17 models - which are presently operating, except France and Austria. For those countries with several models only the most important model is described (e.g. Germany). On the other hand, only 4 models (DEU, CHE 2x, ITA) have been successful in developing the number of installed photovoltaic systems, particularly the German one. The payment for photovoltaic energy inserted into the grid (compared to the cost of conventional energy taken from the grid: in this report r = ratio between these 2 prices) varies considerably from country to country. A country classification according to this criteria has been proposed. Not only do Switzerland and Germany apply the highest payments (r = 5 - 6), but they also do it for a longer period than other countries; even the total payment is greater with respect to other countries, since all the energy produced is paid for.
In chapter 3, stress has been placed on the different **types of schemes** that exist. Each scheme and its operating principle has been described with the registered models being placed in the following categories:

a) **very low** buy-back rate schemes, which apply the same conditions as for other producers; consequently, the rates are generally low and the ratio r is <<1.
b) **low** schemes: as a), however, special incentive premiums, (+10 % up to +100 %) are granted on these general buy-back rates. The resulting total energy payment is still low, with r<1.

[1] For the USA, see Appendix B

c) **parity** schemes: the price paid for photovoltaic electricity is equal to that charged by the utility ($r = 1$).
d) **high** schemes with attractive prices ($r>1$, normally $1<r<2$). Restrictions are imposed regarding the length of payment (high payment during n years/further years at reduced payment).
e) **very high** schemes, with the highest tariffs ($r>>1$, normally $5<r<6$), and foreseen strictly for photovoltaics.
f) **other** schemes, where ‘green electricity’ can be bought by users without a photovoltaic-system.

It seems that the most frequently mentioned factors that hinder the different models are of a non-technical nature. They are mainly concerned with financial aspects. Some important obstacles of this type are related to economic feasibility, and exist especially in France and Australia. Other non-technical obstacles of a political and juridical nature have been found, although to a lesser degree. Only Japan and Australia mentioned obstacles of a technical nature.

In addition, other types of incentives based on investment subsidies for the initial capital cost have been considered. Most countries have significant incentives of this type, and only United Kingdom and Australia are without them: the greatest, i.e. 12 906 US dollars/kWp, were reported by Austria (programme no longer in operation). Italy also seems to have very high incentives, where the subsidies can reach 80 %. Other models of this type have been described for Germany and Japan: all these models were successful.

2 INTRODUCTION

2.1 Description of the proposed work

Motivation:
This study has been carried out because the buy-back rate is a fundamental issue for grid connected PV installations and it is very important for the short-term diffusion of PV technology. Rate-based incentives focus consumer attention on total-system energy production, which redirects priorities toward improvements in system efficiency and design. In addition, Switzerland, in charge of this study, has experience with different models and their effect on deployment of PV.

Scope of the study, approach:
First, an analysis has been made to define which IEA PVPS countries are part of the study. The idea is to analyse in detail only a limited number of countries. Countries without experience in buy-back rates models - e.g. countries in which sale to the grid is not allowed, etc. - have not been fully considered. For each country considered, just a few models have been studied with particular emphasis on the ones already in use.
In general, this report explains the situation in IEA PVPS countries (cf. chapter 4), shows existing information about the models, and explains what will be needed for an efficient development of the photovoltaic market. At a more detailed level (cf. chapter 3) the document puts together the most interesting models, and describes each of the existing schemes using a typical example and a list of countries where this scheme is being considered or implemented. The document gives (cf. chapter 5) a presentation that does not only describe the different models, but also considers technical and non-technical facts (incentives and barriers: environmental aspects, policies,...). In particular, with this study, the focus is on the models that are already in use and their success, new models are also mentioned.
Other types of incentives based on investment subsidies have been considered in chapter 6. To make the document more user friendly, some of the tables have been put in the appendix (Appendix A).

Objectives:
The main objectives of this study can be summarised as follows:

- To catalogue the different buy-back models of selected IEA member countries.
- To study the advantages and disadvantages of the different models and their success.
- To objectively study the problems encountered (acceptance, implementation, legal,...).
- To learn from the experience with different models.
- To promote feedback on the buy-back rate models.

Objectives 2, 3 and 4, which are concerned with the production of the results obtained by the various models, have not always been attained, since for certain more recent models, not all the necessary data is available.

Method used to collect information:
The data was gathered through a form sent to every IEA member country. This form allowed the data to be collected in the easiest and fastest way possible (2 to 4 pages for every model). Each participating country was responsible for the identification and collection of interesting models.
The study was carried out taking into account data gathered between December 1995 and May 1996.

2.2 Data collected

This chapter reports on the state of data collection to the end of July 1996.

In total, 18 countries were involved in the study with 15 providing data.

- 11 countries (FRA, DEU, ESP, GBR, JPN, AUT, ITA, AUS, PRT, NLD, CHE) provided the data that is reported and analysed in the next chapters.
- 4 countries (DNK, KOR, SWE and CAN) have no specific models for buy-back rates or no grid-connected PV systems. In fact, Table A1, shows reduced activity in the grid-connected sector for these countries. **Denmark** has long experience with buy-back rate models for wind power, bioenergy and independently produced combined heat and power, but no specific models for photovoltaic power. Denmark, over the past 2 years, has seen an increase in the grid-connected sector, although on a low level. With regards to Canada, the situation is similar: 12,1 % of total PV power is grid-connected, with a corresponding figure of only 222 kWp.

Table 2.1: Participating countries

	Country	Countries which have answered the form	Countries which have not answered the form, but which have described their situation (no models of this kind)
1	Australia	X	
2	Austria	X	
3	Canada		X
4	Denmark		X
5	Finland		
6	France	X	
7	Germany	X	
8	Italy	X	
9	Japan	X	
10	Korea		X
11	Netherlands	X	
12	Portugal	X	
13	Spain	X	
14	Sweden		X
15	Switzerland	X	
16	Turkey		
17	United Kingdom	X	
18	United States[1]		
Total	18	11	4

[1] For the USA, see Appendix B

3 BUY-BACK RATE SCHEMES

In this chapter, stress has been placed on the different types of schemes which exist; all the registered models have been placed in the following categories: 'no', 'very low', 'low', 'parity', 'high', 'very high', 'other' buy-back rate schemes.
Each scheme has been described so that the operating principle, a list of countries using or considering using the scheme, and a typical example have been included.

Definition: "We define r as the ratio between the payment of the PV energy inserted into the grid ($C_{pv\ in}$) and the cost of conventional energy taken from the grid (C_{out}), i.e. $r = C_{pv\ in}/C_{out}$."

> Remark: The energy costs ($C_{pv\ in}$ and C_{out}) and the factor r includes VAT and other fixed expenses, where these have been supplied. Nevertheless, only 5 countries have stated clearly that: prices include VAT and subscriptions (France), 15 % VAT (Germany), metering and fixed charges (Austria), demand charges (Japan), or that taxes are not included (Italy). Not all the other countries specify whether prices are net or not: inaccuracies may therefore occur in determining C and r. However, the **influence of these factors** (VAT and fixed expenses) **is minimal** when compared to price variations (often very different) due to the utility, the season and time of day. **r** is a **'typical average value'** for each model; its aim is to supply an approximate value. Furthermore, the effect of VAT alone on r is nil since $r = C_{pv\ in}/C_{out} = C_{pv\ in}\ \alpha VAT/C_{out}\ \alpha VAT$

In this section, there is no intention of forming a league table of nations based on merit. The lists of countries mentioned in chapters 3.1 to 3.7 are used for exemplification or clarification purposes; various countries appear in more than one chapter.

3.1 No buy-back rate schemes

The present situation in Korea, Sweden, Denmark, and Canada. More details are available in chapter 4.2.

3.2 Very low buy-back rate schemes

These consist of schemes that allow feeding into the grid, and apply the same conditions as for other producers. Consequently, the rates are generally low and the ratio r is <1. Normally these are models which only pay the surplus inserted into the grid for an unlimited period.
These types of models are applied in France (r = 0,31[1]), United Kingdom (r = 0,37), Portugal (r = 0,55), Spain (r = 0,56), Holland (r = 0,68[2]) and in Australia (New South Wales, r = 0,55; Queensland, r = 0,6). In some countries, these rates correspond roughly to the sale price applied to industry (cf. Portugal, the Netherlands).

Example: Portugal
The Decree Law n° 313/95 of 24 November regulates the independent power production of electricity. A first model was created in 1988 by Decree Law 189/88, since modified by a later one. The

[1] Average for other renewable energy sources hydro and wind; for PV the model is still under study, but r ≤ 1 is predicted in any case!
[2] This is a variant of the Dutch model, the others are more profitable.

amount to be billed for the energy supplied by the producer will be charged monthly according to the prices fixed for the high voltage consumers in the grid with the following conditions:

Rate for the power: P = 0,8*TP*p', where:

TP = monthly rate of power for high voltage supplies
p' = minimum of P1 and P2 where: P1 = Ep/Tp and P2 = (Ep+Ec)/(Tp+Tc)
Ep = energy delivered monthly at peak hours ; Ec = energy delivered monthly at off-peak hours
Tp = Monthly peak hours delivered; Tc = Monthly off-peak hours delivered

Rate for the energy: Equal to the monthly rate for the high voltage consumers.

A new, differentiated tariff system for independent power generators from renewable energy sources will be implemented in 1998. Although not yet regulated, this system is likely to favour PV (as well as other renewables), as far as buy-back rates are concerned, leading to an average ratio r closer to 1.

3.3 Low buy-back rate schemes

Like those in 3.2, these consist of models that are based upon the general conditions valid for other producers. However, special incentive premiums, which can range from +10 % to +100 % are granted on these general buy-back rates. The resulting total energy payment is still low, with r<1. Moreover, these models only pay the surplus inserted into the grid. However, a restriction is imposed, where all known models of this type have a payment period that is limited.
These models are applied in Australia and in Austria.
In the States of Western Australia (payment during 7 years) and Victoria (10 years), the buy-back rates are based upon the general buy-back rates plus a 10 % premium for renewable production. In New South Wales, it is possible to increase the payment with an incentive premium of 15 % for projects of particular environmental and/or community benefit.

Example: Austria
The Austrian model (called 'Separate Agreement programme') for private delivery of PV energy into the grid is very simple: since 1993 there exists a separate agreement between the Austrian Utilities and the Federal Government. Within this agreement utilities guarantee to pay double rate of the general tariff (general buy-back rates used for hydropower and other renewables) in the first 3 years of operation of PV plants (also wind and biomass). The model applies to installations with power less than 1 MW. Some utilities also pay these rates for participants in the roof top programme (see incentives, chapter 6). Buy-back rates depend on the time of delivery and on the utility and there also is a differentiation as to whether the total generation or only surplus generation is delivered to the utility. Depending on the utility, the payment of PV energy varies between 0,8 to 1,8 ATS/kWh (r varies between 0,5 to 1,1). Two states have recently introduced a special rate for PV: 10 ATS/kWh duration 10 years.

3.4 Parity buy-back rate schemes

Parity describes the situation where the price paid for PV-generated electricity is equal to the price charged for electricity (r = 1). For these models which only need information on the energy balance a two-way kWh-meter is used (‘net metering’: the meter is allowed to turn backwards). In some cases, two kWh-meters are installed, to monitor both incoming and outgoing energy. In general, this scheme is applicable to other renewable energies (except for the Netherlands, see below). This scheme has different variations relating to the type of energy taken into consideration (total/surplus production); in addition, net production ‘penalties’ could be applied (see also Appendix).
These types of models are applied in Switzerland[1], Germany[2], Japan, the Netherlands and Australia. Below, there are two examples to illustrate the variants.

Example 1: Japan
This very simple model was established and operated by utility companies themselves. Utilities purchase surplus electricity from PV at a price equal to the retail price. This is based on a contract between utility company and electricity consumer. The expiry period of the contract is one year, and it can be extended if both sides agree. The model was set up in 1992 and is still in operation. It is applicable at a national level. Japan is the only country among the four above-mentioned where the scheme is the only payment option for PV energy.

Example 2: Australia, New South Wales, Integral Energy Model
Customers are encouraged to install PV systems on their premises at their own cost. Integral Energy has a commercial business unit, set up to supply and install these systems in a standard range of seven packages, ranging from 150 W to 9 kW. An additional standard energy meter is installed on the customers switchboard to measure total PV generation. Energy measured on this meter is deducted from the customers bi-monthly account at the same rate at which they purchase the energy from Integral (net billing). If the customer becomes a net exporter[3], they will be paid a flat rate of 0,10 AUD for every kWh which is net exported (i.e. if net production r = 0,87). This buy-back rate is guaranteed until 2003; at which time buy-back rates will be renegotiated.
Individual systems are limited to a maximum of 10 kW. This regional model was launched in 1996, therefore it is too early to judge the success.

3.5 High buy-back rate schemes

These are models, which are more complicated than the ones already described but where the prices are much more attractive (r>1, normally 1<r<2). Some important restrictions are imposed regarding length of payment, thereby creating ‘two-stage models’ (high payment during n years/further years at reduced payment).
This model is applied in Italy.

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[1] In Switzerland, the minimum recommended payment corresponds to 80 % of parity, and parity with the retail price is a standard.

[2] Since 1991 in Germany the utilities have been obliged by law to pay for PV and other renewable energies fed into the grid at a rate of 0,172 DEM/kWh corresponding to 90 % of their parity in selling electrical power.

[3] In NLD the net annual production is not paid for, or is paid as described in 3.2 - general tariff for (auto)producers - (in this case r=0,68).

Example: Italy
This model uses two different tariffs depending on whether the energy under consideration is the total production or only surplus production. The model also applies different tariffs according to the insertion hour (peak hours). In case of PV plants built without Law n. 10 incentives, the price of the energy sold to ENEL[1] is fixed by CIP (price regulations for the PV energy delivered to the grid) and has to be set at a level which is attractive for self-producers. The prices fixed at present are reported in table 3.1. This table clearly shows, that during the first 8 operating years the CIP price is substantially higher than the average price of the kWh sold by ENEL to users (about 190 ITL/kWh). After this period, a reduced payment - which is however greater than that described in chapter 3.2 and 3.3 - is applied. The description of the model is reported in table 3.1.

Table 3.1: Principle of the model: ratio r and price paid by ENEL for PV energy (CIP 6/92)

Owner sells **all produced energy**:	First 8 years operation: r = 1,4		Further: r = 0,5	
Prices in ITL/kWh:	270,5		89,9	
Owner sells only **surplus energy**:	First 8 years operation: r up to 2,2		Further: r up to 0,6	
	Peak hours(*)	Others	Peak hour(*)	Others
Prices in ITL/kWh:	377,4+41,4*R(**)	47,9	76,4+41,4*R(**)	47,9

* Peak hours are defined as: hours from 6.30 to 21.30 of each day, except for all Saturdays and Sundays and for all days of August (45/90 CIP act).

** R is a coefficient of regularity that takes into account the time when the energy is delivered to the grid; its value can vary between 0 and 1.

This model is valid at national level, but only in the case of PV plants built without incentives (see Italian law n. 10 on incentives for the construction of PV plants, chapter 6): it has been in operation since 1992.

3.6 Very high buy-back rate schemes

These are models with the highest tariffs ($r>>1$, normally $5<r<6$), and foreseen strictly for PV, which is not normally the case for the models already described. Owing to the high payment, they are limited in power and in time; all these models are only applicable to private installations. All these restrictions are aimed at limiting the economic impact on the utilities.
In this scheme, the utility pays the owner a special buy-back tariff, intended as a subsidy. These rate-based incentives allow utility customers to install PV systems and then recover their investment over time through a per kWh payment for ‘clean energy generation’. The scheme is therefore based on the total production costs: the rate is paid for the total system installation and is intended to pay for both the installation and the capital cost . The rate is paid over a long period, generally equal to the average life of a PV system. After this period, a reduced payment is applied (in general 1:1). Usually the high payment consists of a fixed price. In other cases, after a period of time, for example 1 year, the price of one kWh can be determined again, and the rate may be less than the initial price. Consumers installing a PV system will now get the new price, but they are guaranteed payments over the number of years necessary to recover their investment.
A particularly important aspect is that the payback rate is based on the total energy produced by the

[1] ENEL is the Italian state owned utility

PV system. These kinds of incentives focus consumer attention on real total system power production, which redirects priorities towards improvements in system efficiency and design. Since the amount of the payment depends on the actual total production, the owner is encouraged to make the plant work well.
Advantage: the payment/production connection creates an important stimulus for optimum plant utilisation.
Disadvantage: the owner must take on the financing and the risk that the plant might not reach the expected power and production targets.
This scheme is applied in Switzerland and in Germany. In Germany, the first, and most famous, model of this type was proposed in the town of Aachen (cf. chapter 4.1 and 5.2.1).

Example: Switzerland
A model of this type has been implemented in the town of Burgdorf, where 1 CHF/kWh is paid for the produced energy (r = 5). The model is limited in total installed power (<600 kW) and in time (payment duration 12 years, later at 1:1). It came into force in 1991 and expired 31.12.1996. This model has led to a rapid development of installed power in the service area of that utility. The particular success in Burgdorf was strongly favoured by additional investment subsidies leading to even higher effective buy-back rates. The town of Burgdorf was also the first one to achieve the goals of the action programme ‘Energy 2000’ for photovoltaics. In fact, by the end of 1995, 26 installations with a total power of 211 kW were connected to the grid, and their energy production of 190 000 kWh/year was paid in accordance with this model.

3.7 Other buy-back rate schemes

In general these schemes concern plants belonging to utilities, and are valid only for PV.
The utility invites private parties to buy the PV power that does not come from any particular plant. In certain cases this price for ‘green electricity’ is approximately the cost price, therefore a much higher price (in Switzerland up to 1,6 CHF/kWh, i.e. r = 8!) with respect to the conventional price. In other cases, this price is a few cents higher than the usual price (ex. NLD). The green electricity can also be bought by users without a PV-system. The electricity distributing company guarantees that the money will be used to generate electricity by renewable energy sources.
Advantages: the client can take out a bond of limited duration and with a modest outlay: in this way, a large number of people can become involved. The client is not responsible for the functioning of the plant.
This scheme is applied in Switzerland, Germany (RWE Umwelttarif since 7.96) and in Netherlands (see example 1).
A variant exists, based on a more open market: the ‘solar stock exchange’ to which all market operators can have access. In this case, not only the utilities, but also all market operators can build PV plants and sell the energy produced to the utilities at a price which allows the plant to be re-financed. The utilities role is to market the PV energy at cost price (see example 2).

Example 1: Interlaken in Switzerland
The model implemented in the town of Interlaken, started in 1992, is a typical example. In this case, the energy comes from a specific plant of 9 kWp. The payment of PV energy amounts to 1,60 CHF/kWh; there are no time limits. The model considers the total energy produced. In Switzerland, energy from approximately 85 plants (23 kWp) is paid according to models of this type.
Example 2: Zurich in Switzerland
In response to the customer interest, on November 1995, the Zurich city government approved the

project for a solar power exchange. EWZ, the utility of Zurich, realised the ‘solar stock exchange’ project, itself acting as intermediary between producers and consumers. The utility buys solar power from the producers and sells it at the same price to its customers.

The combined efforts of the Zurich mill and many subscribers have ensured that the EWZ Solar Stock Exchange’s first plant could be built. In fact, in 1996, 130 people subscribed to 13 000 kWh of PV energy at CHF 1,2 per kWh. This price is well above the 0,16 CHF/kWh normally charged for electricity, enabling EWZ to go ahead with the construction of the plant. The plant, installed on the grain silo of the Zurich mill, was connected to the grid in November 1996. It has a capacity of 32 kWp and supplies about 20 000 kWh a year. The plant belongs to 12 private parties.

EWZ aims to provide the entire population of Zurich with an opportunity to obtain solar power on a regular basis by spring 1997. Regular subscribers can decide for themselves how much they wish to contribute: a year’s subscription starts at 21,60 CHF, and there is no upper limit.

4 SITUATION IN IEA PVPS COUNTRIES AND STATISTICS

4.1 Countries with experience in buy back rates models

4.1.1 Main models in these countries

This chapter illustrates the present situation within the countries that have experience of these models, namely:

- **Australia** (AUS)
- **Austria** (AUT)
- **France** (FRA)
- **Germany** (DEU)
- **Italy** (ITA)
- **Japan** (JPN)
- **Netherlands** (NLD)
- **Portugal** (PRT)
- **Spain** (ESP)
- **Switzerland** (CHE)
- **United Kingdom** (GBR)

Table 4.1 gives the number of models described for every country and their status.

Table 4.1: Main buy-back rate models for every country

Country	Number of models	Name of the model or reference	Coming into force-expiry	Status of the model			
				Under study	Planned	In operation	Finished
Australia (AUS)	5	Queensland	95-97			x	
		Victoria	92-02			x	
		Western Australia	92-1.96				x
		New South Wales	91-94				x
		Integral Energy[1]	6.96-03			x	
Austria (AUT)	2	Separate agreement	93-open			x	
		Roof top programme[2]	92-93				x
France (FRA)	1	-	96-open	x			
Germany (DEU)	1	Full-cost rate based models (Aachen)[3]	10.94-open			x	
Italy[4] (ITA)	1	CIP act 6/92	92-open			x	
Japan (JPN)	1	-	92-open			x	
Netherlands[5] (NLD)	1	Ad hoc	90-00			x	
Portugal (PRT)	1	Decree law 313/95	95-open			x	
Spain (ESP)	1	Roy. decree 236694	10.94-open			x	
Switzerland (CHE)	2	Burgdorf model	1.91-12.96			x	
		Interlaken model	92-open			x	
Unit. Kingdom (GBR)	1	-	95-open			x	

[1] Integral Energy is a distribution utility owned by the New South Wales Government
[2] This is an incentive model (cf. chapter 6.2), providing buy-back rates too
[3] The Aachen model is the most important model in Germany on full-cost rates. This model started at first in Freising (Bavaria) on the 1st of August 1993. Besides this model several other cost-oriented models are in operation.
[4] Another model has been described, but it provides only incentives for the construction of PV plants (cf. chapter 6.2)
[5] This model comes in 3 versions.

Total	**17**			**1**	**0**	**13**	**3**

This table focuses on the models that are presently in operation: on the other hand, the results achieved until now are dealt with in 4.1.3. It is noticeable that, except for France, Austria and Australia, all the other countries have described models that have actually been put into operation. In France, the model is still under study. In Austria 1 model has already ended; this model does not particularly concern this chapter, since it was mainly conceived with view to incentives, and here it just receives a mention. In Australia the situation is more varied: while three models have been set up originally 2 models have already ceased. A total of 13 out of 17 models are operational.

4.1.2 Payment and country classification

The exchange rate used in this (and in the next) chapter is given in table A2.
This chapter focuses on how much, after having analysed how (principle) in chapter 3, the PV energy payments are in the different countries. Comparing the payment of PV energy inserted into the grid to the cost of conventional energy taken from the grid, we notice immediately that the ratio r between these 2 prices varies considerably from country to country. In some countries, PV energy inserted into the grid is paid at 5 - 6 times the amount paid for that taken from the grid whereas in others PV energy has been given little ‘value’. There are even countries where PV energy payment is practically non-existent or not contemplated (see chapter 4.2). Table 4.2 below gives an overview.

Table 4.2: Cost of conventional energy taken from the grid and payment of PV energy inserted into the grid. (Duration for the payment: ∞ = unlimited; ? = not decided yet; (1) 1 year, it can be extended every year; (2) Models valid up to the year 2000)

Country and name of the model or reference		Payment Duration years	Cost of energy taken from the grid in 0,01 USD /kWh	Cost of energy inserted into the grid in 0,01 USD /kWh	Ratio r paym. E inserted ÷ cost E taken: **avg.**	min	max	Principle of the model and observations
AUS	Queensland	∞	7,99	4,78	**0,59**	0,34	0,96	General buy-back rates for private generation
	NSW	∞	8,16	4,53	**0,55**	0,28	0,78	General buy-back rates +15 % premium possible
	Western A.	7	10,3	3,35	**0,33**		1,4	General buy-back rates +10 % premium for renewables
	Victoria	10	8,24	4,45	**0,54**	0,28	0,82	General buy-back rates +10 % premium for renewables
	Integral	7	9,47	9,47	**1**	0,87		Parity; if net exportation then r = 0,87
AUT	Separate Agr	3	15,29	12,45	**0,81**	0,5	1,1	2 x general buy-back rates for other renewables (hydro)
	Roof top pr.	∞	15,29	6.22	**0,4**	0,25	0,55	General buy-back rates for other renewables (hydro)
FRA	-	?	17,82	5,5	**0,31**		1	Actual rates for hydro; project for PV: r ≤ 1
DEU	Full-cost rate based models Aachen	10-20	23,46	134,08	**5,7**			Buy-back rates based on total production costs
ITA	CIP act 6/92	8	12,6	17,96	**1,42**	0,47	1,42	If all energy is inserted, after 8 years reduced pay. r = 0,5
	CIP act 6/92	8	12,6	27,81	**1,17**	0,25	2,2	If only surplus inserted, after 8 years reduced pay. r = 0,6
JPN	-	∞(1)	24,2	24,2	**1**			Parity, purchasing price = selling price
NLD	Ad hoc	10(2)	11,4	7,8	**0,68**			General buy-back rates; equal to tariff for industry + 4 cts
		10	11,4	11,4	**1**	0,68		Parity, but the net annual production is paid 7,8 ct, r = 0,68
		10	11,4	11,4	**1**	0		Parity, but the net annual production is not paid
PRT	Dec law 313/95	∞	12,1	7,0	**0,58**	0,41	1,7[1]	General buyback rates; = tariff for high voltage users
ESP	Dec 236694	∞	15,84	8,9	**0,56**			General buy-back rates for private generation
CHE	Burgdorf mod.	12	16,8	80	**4,76**	1	4,76	Based on total production costs. In CH in most cases 1:1
	Interlaken mod	1(1)	16,8	128	**7,62**	4,76	7,62	Based on total production costs (rates paid by users)
GBR	-	∞	12	4,46	**0,37**	0,35	0,39	General buy-back rates for private generation

There are certain countries with similar situations (countries with a similar ‘r’ ratio): Table 4.3 classifies countries according to this criterion. This table highlights two countries where, most probably, there is solid public and hence political support for PV: **Germany** and **Switzerland**. These two countries not only apply the highest payments, but also do it for longer than other countries (Switzerland 12 to 20 years, Germany 10 to 20 years). Even the total payment is greater with respect to other countries, since all the energy produced is bought. Moreover, in both countries, the minimum compulsory payment is very high. In fact, in Germany the utilities are obliged by law to pay

[1] if double-rate metering (peak and off-peak hours) is applied

for PV and other renewable energies fed into the grid at a minimum rate of 0,172 DEM/kWh: this corresponds to 90 % of parity (r = 0,9). In Switzerland, the connection authorities for independent suppliers and the Federal Department of Transportation, Communication and Energy recommend a minimum payment of 0,16 CHF/kWh. This corresponding to 80 % of parity, r = 0,8) for the energy generated in plants operated by independent suppliers using renewable energy sources. Concerning PV energy, most Swiss electricity companies charge rates that range from the above-mentioned minimum to a tariff of 1:1; parity with the retail price of 1 kWh is a standard in Switzerland.

Table 4.3: Countries classified by 'importance' of PV energy compared to conventional energy

'Importance' of PV energy	Ratio r	Country
Very important	≅ 5..6	Germany, Switzerland
⇓	≅ 1..2	Italy
⇓	≅ 1	Japan, Netherlands (CHE and AUS in some cases)
	≅ 0,8	Austria, Germany (by law)
⇓	≅ 0,5..0,7	Australia, Portugal, Spain (NLD in some cases)
⇓	≅ 0,3..0,4	France and United Kingdom
Not important	0 or no models	Korea, Sweden, Denmark, Canada

Germany and Switzerland deserve to be studied more closely in a further study, in which particular facets and the history of the typical models can be shown in detail (the respective models being Aachen for Germany and Burgdorf for Switzerland).

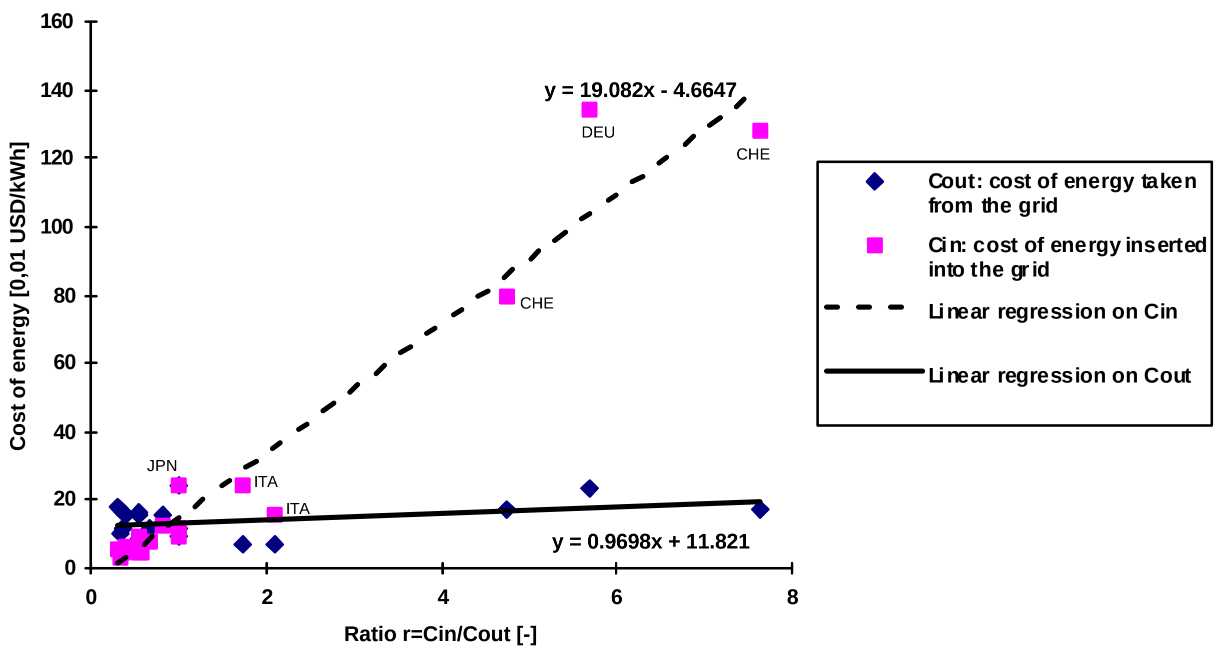

Figure 4.1: Cost of energy taken from the grid and payment of PV energy inserted into the grid as function of r

Figure 4.1 gives the cost of conventional energy taken from the grid (C_{out}) and the payment of PV energy inserted into the grid (C_{in}), as a function of the ratio r. On this scale, the C_{out} differences vary from 0,073 to 0,2346 USD/kWh (C_{max} = 3,21 x C_{min}). The cost of energy taken from the grid is therefore 'similar' - or at least of the same proportion - for the various models (countries) studied. The differences among the various C_{in} are, however, much greater: this value ranges from 0,0335 to 1,3408 USD/kWh (C_{max} = 40 x C_{min}). r is thus almost entirely influenced by C_{in} and only in small measure by C_{out}: **high r** values (DEU, CHE, and ITA) are due to **high PV energy payments** (C_{in}).

4.1.3 Success of the different models

In paragraph 4.1.1 emphasis was laid on existing models that are presently in operation. In this chapter, those models which are really working and for which there are up-to-date results are highlighted. Table 4.4 gives an overview, classifying countries according to the success of the various models.

It is immediately noticeable that the classification based on 'success' coincides almost exactly with that based on the 'price paid' (cf. table 4.3 and 4.4). In other words, the **most recompensed** models (Germany, Switzerland, and Italy) are logically the ones with the **most success**.
In Germany, the model adopted by an ever-increasing number of municipal utilities has been very successful: in 1996 between 6 and 7 MWp were installed, of which 2 to 3 MWp in regions using the Aachen model and variations of full-cost-rate-based and cost-oriented models. This model has developed rapidly in Bavaria: in 7 cities out of ten, growth was over 100 % during the second half of 1996. In one case it reached 360 %. At present a total of 554 kWp has been installed in these ten cities; for 369 kWp (66 %) the energy is paid for in accordance with the model. In the city of Hammelburg, the installed PV power has reached 2,5 Wp per inhabitant.
In Switzerland, the success of the buy-back rate model applied in Burgdorf was not due to the high buy-back rate alone. Additional investment subsidies, together with the buy-back rate, led to particular favourable conditions.

In those countries where the buy-back rates are based on tariffs which are also valid for other producers (cf. chapter 3.2) (ex. Portugal, United Kingdom, Spain, France[1]), the models have been more successful for other renewable energies than for PV.

In countries with very competitive markets, these models have not been very successful. Australia is a typical example. In fact, results, modest with only two plants being set up, have only been obtained for 1 model. No plants have yet been set up for the other models.

- two models finished without going beyond the drawing board
- one model has only been successful until now with other renewable energies
- one model, the most promising, only began in June 1996.

On the other hand, table 4.5 shows how successful the main models based on incentives were (for Japan, Italy and Austria). Other models of this type are described in 6.2. All these models were successful.

[1] In the case of France, the model is still under consideration with low priority. However, though grid connection is not encouraged by EDF and ADEME, some private initiatives (with EC/DG17 support) have allowed to install by the end of 1996 60 PV rooftops. In this case the running of the analogue meter on both sides is allowed.

Table 4.4: Success of the different buy-back rates models (*= no response)

Success	Coun-try	Name of the model	Nbr inst.	Power kW	Towns	Observations
Very good	DEU	Full-cost rate based models (Aachen)[1]	950	2900	18	**Successful**, about 5,2 million potential consumers were reached (1996)
	CHE	Burgdorf model Interlaken model	66 85	274 23	5 7	**Successful** **Successful**
Good	ITA	CIP act 6/92	N/A	5000	N/A	**Successful**
	JPN	Buy-back menu for surplus electric power from PV	1437	6113	N/A	**Successful**
Middling	NLD	Ad hoc	N/A	N/A	N/A	This is an **experimental** (ad hoc) model (no definite models yet)
Low	AUT	Separate agreement	N/A	N/A	N/A	This model does **not work** in the field of **PV**, because the rates are too low.
	AUS	Western Australia New South Wales Victoria Integral Energy model Queensland	0 0 0 0 2	0 0 0 0 N/A	0 0 0 0 N/A	Model **finished** in Jan. 1996 Model **finished** in 1994 In operation since 1992: **no PV at present**, successful for other renewable (25 MW incl. all renewables) Model Launched **June 1996**; success: too early to judge There exist significant **non-technical barriers** to the acceptance of this model, including mind-set
	PRT	Dec. law 313/95	1	2	N/A	General model for independent producer, **successful for** small **hydropower and wind** plants
	GBR	-	1	N/A	N/A	Success: **not relevant**, regional
	DEU	Utility buy-back law since 1/91	N/A	N/A	general	Success: difficult to specify for PV, very successful in the area of wind energy and hydropower plants
	FRA	-	60	80	N/A	The model r = 1 is only a project. It is accepted for a limited number of demonstration projects.
Probably low*	ESP	Roy. decree 2366/94	N/A	N/A	N/A	The model is **not specific for PV,** but a law devoted to increasing the role of renewable energy sources

[1] and variations

Table 4.5: Success of the main investment subsidies models

Success	Country	Name of the model	Nbr inst.	Tot. power kW	Towns	Observations
Very good	JPN	Monitor program of residential PV sys.	577 in 1994 1023 in 1995	5 459 (by 1995)	N/A	**Successful**. PV systems for residential use. Subsiding ratio amounts to 50 % of the total cost.
Very good	JPN	PV field test project for public facilities	N/A	1 760 (end of 1995)	N/A	**Successful**. PV systems are experimentally installed on public buildings and on ground. The subsiding ratio amounts to 2/3 of the total cost.
Very good	NLD	NOZ-PV	N/A	709 (by 1996))	N/A	**Successful**. Subsidies of 40 to 60% available for demonstration projects in the built environment
Very good	AUT	Roof top program	97	200	N/A	**Successful.** Subsidy: 71 %
Good	ITA	Law n. 10/91	Some thousands	N/A	N/A	**Successful.** Subsidy: 30 to 80 %

4.2 Countries without experience in buy-back rate models

The following 4 countries,

- **Korea**
- **Sweden**
- **Denmark**
- **Canada**

are without experience in buy-back rate models; their situation is described below.

Korea: no grid-connected PV systems
At present, Korea does not have a grid-connected PV system, only stand-alone types are in operation. There is no obligation for the Korea Electric Power Corporation to buy electricity generated by such systems. However, Korea is very interested in doing research in this type of PV technology starting in 1996.

Sweden: the model does not concern PV
There are no specific models for buy back rates for grid-connected PV systems in Sweden. There are general recommendations concerning the economic conditions necessary for delivering electric power to the grid from small production units.
The principle applied is that the utility should pay the producer the same price they would otherwise have to pay to have the electricity supplied, usually from a large producer. Since the model does not concern PV or promote renewable energy in any other way, the Swedish recommendations are not interesting for this study.

Denmark: the model is under consideration
In Denmark there are at present no official rules or models for grid-connected PV systems, either economic or technical. However, a national committee has been formed to look into this with representatives from the utilities. These are the Electric Council (safety aspects), the Energy Agency and a Task 1 participant as chairman of the DK national PV Advisory Group to the Energy Agency.

Canada: the model is under consideration
There are no specific models for PV and no incentive programmes to date, but legislation is planned by 2000. This will enable PV and other renewable power to reach the customer directly: Ontario Hydro (OH) will buy back the energy (20 % premium is likely on conventional power).

5 ANALYSIS

It is still too early to make a deeper analysis regarding the development of PV. This chapter consists more of an overview with an attempt at some overall conclusions with respect to technical and non-technical factors.

5.1 Common characteristics and trends

The following is a summary of the main characteristics of the various models, based on the points mentioned in the questionnaire.

Except for two models, all the other classified models are valid at a national level (7) or a regional one (8)[1]. There are therefore few or no geographical limits to the validity of the models. The concept of buy-back rates is recent; in fact, all the classified models came into force from 1990 (cf. table 4.1). In 1992, the greatest number of models came into force, i.e. 6 (see figure A1, Appendix A). No expiry date is foreseen for 9 out of 17 models.
The models not only exist on paper, but also are being or have been put into operation. In fact, out of 17 models 13 are presently operating, three have come to an end and one is still under study. On the other hand, only 4 models (DEU, CHE 2x, and ITA) have been reasonably successful.

Most models have limitations of time (length of payment) and of power, limits[2] that nevertheless vary greatly from model to model. In fact:

- **the length of payment** for the power varies from between 1 to 12 years (20 in certain cases)
- **maximum total power** that can be installed varies from between 2 kW to 200 MW according to the model
- **the size of each installation** where a model can be applied is of no importance for about 1/3 of the cases. In the other cases there are maximum limits, which are, however, very different and vary from 2 kW to 100 MW (factor 50 000). By contrast, only in 2 cases is a minimum power of 1 kW needed .

It is therefore difficult to find a common characteristic regarding these types of restrictions. All the differences concerning length of payment and power limits probably serve to limit the economic impact on the utilities.

The energy taken into consideration is, in the clear majority of cases (12 models), the surplus power inserted into the grid. Only 5 models (CHE 2x, DEU, ITA, AUS) evaluate the total energy produced. The latter models also apply the best prices and are the most successful.
It seems that location is not a factor, since in almost every case (14), the models are applied to plants situated in whatever location is available. Models are applied to any kind of installation (private or public) or only to private plants: no model is uniquely valid for public plants .

[1] Australia alone has five regional models
[2] Whereas there are practically no financial limitations

In almost every case, the plants need certificates. For most models there are no quantitative objectives for the power installed which can be reached by the model itself. Only seven models have an estimate for the time needed to pay off the plant (based on PV energy payment); this ranges from 10 to 50 years.

5.2 Other factors

5.2.1 The customer

The situation is very similar in all countries in that the electricity fed into the grid is paid by the electrical utility; in certain cases it is a state owned distribution utility, for instance in Italy and Australia. Only rarely is the energy bought by other bodies, like, for example, by a bank in Zurich, Switzerland. However in 3 countries - Switzerland, the Netherlands and Germany - there is a special feature: the contributor can even be the ordinary user or a group of them (Betreibergemeinschaft).
In **Switzerland, Germany** and in the **Netherlands** users without a PV system can purchase 'green electricity' from the grid (for more details see chapter 3.7).
In **Germany** the payback is funded through a low surcharge on monthly electric utility bills paid by all[1] utility customers (i.e. the taxpayer is the ordinary user by means of a 'tax'). The limit of this surcharge is still in discussion and varies from state to state between 0,6 % and 1 %. Many observers believe that 1 % will be the accepted rate. If a community wants to protect industry, then industrial customers with special rates may continue to pay the old rates.
These types of rate-based models were first proposed in Germany in Aachen according to Solarenergie-Förderverein. The Aachen model was proposed in 1992 and was implemented on Sept. 1, 1994. The electric utility bill surcharge is limited to 1 %. This will be sufficient to install 1 MWp of PV. If this power were installed in Aachen (city of 250 000 people), the average monthly bill would increase from 40,20 USD to 40,70 USD. Utility ratepayers are essentially being asked to contribute less than half a dollar per month to support clean energy generation and improve the environment.

5.2.2 Structure of utilities and initiatives

An overall conclusion which can be drawn is that, in general, models have more difficulty in establishing themselves in countries which have a centralised structure (like France), than in countries with multi-utility systems (like Germany with more than 1700 utilities and 850 of them with power generation from renewable energies). The exception to the rule is Italy, where the model pays well and has been successful (cf. 3.5 and 4.1.3). The general picture shows that there are rapidly developing systems such as in Australia[2] (utilities in process of being privatised). On a global scale, there is a general tendency towards a liberalisation of the energy market. This liberalisation can produce both negative and positive effects.

[1] Surcharge paid by the public 'rate-base" of the utility
[2] Australia has a state based utility structure, with multiple utilities in most states, and increasing competition both within and between states.

It is also interesting to study who is the initiator of the model; what is noticeable is that a clear distinction can be made between countries and where the initiative comes from:

a) the utilities: the models were established and have been operated by utilities companies themselves (ex. Switzerland, Japan and the Netherlands)
b) national law: a typical example is given by Italy, Spain and Portugal. In certain countries the utilities are put 'under pressure' (cf. Germany), and are obliged by law to pay for PV energy fed into the grid a minimum (but already high) rate.
c) private people organised in promoting associations (Germany)

In some countries it seems that the initiative came from both the utilities and the state: agreement between the Austrian utilities and the Federal Government in Austria; or through the recommendation of the French Ministry of Industry to EDF (Electricité de France, state owned utility).

Only one model emerged through other means, for example through public pressure and private initiative (Aachen model).

5.2.3 Required conditions for access to the grid

In all cases technical regulations are in force. Nevertheless, these consist of general conditions required for linking any kind of PV system to the grid. No special technical conditions necessary for conformity to the model were reported.
These conditions are valid both at the national and regional levels (cf. table A3).

5.2.4 Applicability of the models to other renewable energies

It can be said that in most cases the models are of a general nature designed for independent auto producers. In fact, in 9 countries out of 11 (13 models out of 17), the models can be applied to other renewable energy sources. Among these nine countries, 3 (i.e. France, Germany and United Kingdom), however, apply special tariffs for other forms of energy. The table below sums up the situation:

Table 5.1: Applicability of the models to other renewable energies

Country	**Yes/no**	**Observations**
Australia (5)	Yes	Applicable to wind, hydro, etc.
Austria (1)	Yes	1 model - providing incentives - is not applicable to other renewables
France (2)	Yes	**Specific rates** for wind and for small hydro
Germany (1)	Yes	**Specific rates** for other renewables
Italy (1)	Yes	The model providing incentives is applicable to other renewables too
Japan (1)	Yes	It is also applicable to wind power
Netherlands (0)	**No**	Separate regulation for wind energy producers (see below)
Portugal (1)	Yes	It is a general model for every independent electric power producer
Spain (1)	Yes	It is not specific for PV systems
Switzerland (0)	**No**	Specific models for PV, except Geneva (variation of Burgdorf model)
United Kingdom (1)	Yes	In principle, though can be **specific rates** for other renewables

() = number of models applicable to other renewable energies

Only for 2 countries, Switzerland and Netherlands, are the models described not applicable to other renewables. In Switzerland, this particular situation results from the very high tariffs applied (among the highest, cf. table 4.2 and 4.3), which were developed for models studied ad hoc rather than for those aimed at a general promotion of renewables, as is the case in other countries. One can conclude that, as a rule, models which apply high tariffs are not valid for other domains (CHE, DEU), or that they are but with other tariffs. If we define as ‘low’ those tariffs for which r<1 (cf. table 4.3) the following relationship can be stated:

low (high) tariffs ⇔ (non) valid model for other renewable energies

satisfies all the countries, except for Italy and Japan, which are more permissive.

In the Netherlands, this is notably a consequence of the order of magnitude: 709 kWp grid connected PV plants and 157 000 kW wind power. Notably wind energy producers have a separate regulation for buy-back rates.

5.3 Experience made and needs

5.3.1 Lessons learned

The particularly significant experiences, and lessons - positive and/or negative - learned are very different from country to country. In the following, the main aspects that have emerged are described, making a distinction between those countries that have stressed lack of experience, positive and negative experiences respectively.

No experience

France has no significant experience at this stage, though around 60 houses[1] (by end 1996) have a grid connected PV rooftop (‘THERMIE’ project of EC-DG17). Their status is unclear regarding feeding power into the utility network. **Japan** reports nothing special: the model has been encouraging the dissemination of PV systems, but it is difficult to estimate how much. **United Kingdom** and **Australia** (Integral energy model) have insufficient experience to date (too early to judge).

Positive lessons, satisfaction

In **Spain**, the National Energy Plan (PEN) 1991 - 2000 forecasted a total installed capacity of PV systems of 2,5 MW by 2000. This objective was reached by December 1994 and there are another 500 kW under construction. PEN objectives have been reached six years before the targeted date. Penetration rate of PV system is satisfactory. In **Austria**, the roof top programme was the most attractive one and was a great success with more than 200 proposals. In **Italy**, on the whole, the set of incentives has allowed, during the last few years, an increasing number of projects for the construction of grid-connected PV-plants to be carried out. **Switzerland** and **Germany** have expressed great satisfaction with the success of the respective models (cf. 4.1.3) . In these countries (in particular in Germany), the energy payment has contributed to improving the quality of the installa

[1] Total grid-connected = 80 kWp, corresponding to 4 % of total installed PV power (continent + overseas department)

tions. In Switzerland, the Burgdorf model has led to a rapid development of PV systems in this town, which was also the first one to reach the important quantitative objectives of the action programme 'Energy 2000' for PV.

Negative lessons/ barriers (see also 5.3.2)

In **Austria**, today there are discussions to lengthen the validity of the tariffs (separate agreement model). First experiences indicate that this agreement does not work in the field of PV, because the rates are too low. In **Australia** (State of Queensland), the project identified that significant non-technical barriers exist to the acceptance of this concept. In the State of New South Wales, small-scale investors (renewable energy, cogeneration) are more interested in their avoided costs i.e. the retail price, and would benefit more from technical assistance than incentive premiums. In **the Netherlands,** the tariff structures have only limited effect on the topics mentioned in this study. In most cases, the PV systems are part of demonstration projects in which cost reduction by building integration and system optimisation, etc. is the most important subject of interest.

5.3.2 Problems encountered

The main technical and non-technical factors that hinder the different models are reported in table A4.
It seems that the most frequently repeated factors are of a non-technical nature. They are mainly concerned with financial aspects (related to economic feasibility, the limitations of the tariffs applicable and price fixing etc.). Some important financial obstacles exist, especially in France and Australia. In particular, Australia is developing a competitive, National Electricity market and hence there is currently very little discussion about non-commercial buyback schemes. All new renewables into the grid have to compete in the competitive generation market with other producers, making nearly all renewables (apart from selected mini-hydros) uneconomical. However, the increased focus on customers is causing many Australian utilities to view energy efficiency and renewables from a potential business perspective rather than just a loss of sales. Hence, green pricing is starting to attract some interest.
Other non-technical obstacles of a political (reluctance of utilities, political instability) and juridical nature have been found, although to a lesser degree. In some cases it seems that the models are being blocked by judicial procedures, which are often too slow. For example, it has taken the Aachen model a long time (2 years) to be set up. Only Japan mentioned obstacles of a technical nature (10 % insertion limits) and Australia (questions relating to feasibility and energy quality).

5.3.3 Public opinion

Public opinion could also act as an obstacle to the models. From our research it has emerged, however, that public opinion is generally in favour of PV and the various models are well received.
There were no reports of problems relating to the functioning of the model caused by adverse public feeling. However, in certain cases it is clear that public interest is directed towards other renewables, like wind (Austria). The principle attitudes are mentioned below.
In **France**, the 'THERMIE' projects are technically a success, projected installation costs are met, the users seem satisfied and the press reports positively on the experience. In **Spain**, in general terms, the public is more favourable to PV systems than to other renewable installations (e.g. wind power) due to the lack of environmental impact. In **Austria**, today the discussion about renewables

and subsidies for renewables (incl. buy-back rates) is not focused on PV. Wind power is of much more interest. In **Japan**, the model is welcomed by manufacturers and probably by consumers. Nevertheless, many manufacturers seem to think that the price is still too low to push dissemination of PV. In **Australia**, public reaction has been very positive; the different models have been openly accepted and expected; in certain cases confusion as to the status of the guidelines has been created. In **the Netherlands**, people are generally in favour of renewable energies, and some are even willing to pay more for ‘green’ electricity (say 2 % of Dutch households). In **Switzerland**, public opinion is generally in favour of PV. The different models have been very well accepted. In **Germany**, the proponents of the rate-based incentives see these models as a new and viable path to self-sustaining markets for photovoltaics. In **Italy** public perception of photovoltaic is rather good, but the general environmental concern has not been reinforced by adequate national information programs. The two incentive models which are operational (CIP act 6/92 and Law n. 10/91) are well received by public, but unfortunately the actual funding status of these models is subject to the current uncertainties of the Italian financial situation, so that the subsidies are often revised, both the amount and the time distribution.

5.3.4 Comments and needs

In the preceding chapters, the different existing models of buy back rates have been listed together with recent developments in the financing schemes. An attempt has also been made to quantify the success these different models have met. As the field is rapidly changing, these qualifications represent a momentary picture. The concept of high buy back rates certainly is one method to promote the deployment of grid connected PV systems on a short-term basis. It is however not seen unanimously as the only concept that can reach this goal. Models that are more market oriented or green pricing models are favoured by many utilities. General aspects regarding these financing schemes to promote the deployment of PV systems are summarised below.

In certain countries buy-back rates are based upon avoided costs, e.g. Australia. At present, avoided costs tend to be low as they mainly reflect avoided fuel costs. In view of the relatively high cost of electricity from photovoltaic power system plants, high buy-back rates, and therefore not based on avoided costs, will be required until installed system costs decrease significantly. This situation might change in view of energy taxes in discussion in some countries or the incorporation of external costs into energy prices.

Models based on minimal total production costs optimised for highest energy production can be characterised by the fact that there is no need for further subsidies from governments or from utilities. The resulting energy prices nevertheless remain high at the present time. Therefore, further measures such as investment subsidies, tax credits or assessment of the true added value represented by the application of PV systems will have a beneficial effect.

Optimising with respect to energy production during the life cycle of the system rather than on the investment side will benefit to the actual energy produced by focusing on proper system design, operation and efficiency.

Finally, information and publicity will play a further important role for the deployment of PV systems. It would be a waste of time to set up a model that satisfies all the criteria for success without communicating its existence to the general public. For example, in Germany there is a good publicity campaign. In Australia too, a recently launched model (Integral Energy) has been well publicised. In this campaign particular arguments are used in favour of PV, e.g. as “the PV system will also add value to your home” or “ for every kWh that your system produces, you will be reducing CO2 emissions by around 1,4 kg (based on a comparison of the present methods of electricity generation in NSW)”.

In a period where, in many countries, the liberalisation of the energy sector is advancing very rapidly, these developments will affect the deployment of PV systems. Therefore, not only the identification of the threats but also of the opportunities represented by these general developments in the energy sector will be of primary importance for the development of the different PV market segments. Sustainable solutions regarding the financing of solar electricity will have to be compatible with the general trends in the energy sector.

6 OTHER TYPES OF INCENTIVES

6.1 General remarks

The main types of existing financial incentives can be divided into incentives based on:

a) the **energy** produced: these incentives are the main object of this study
b) the **power** installed: these incentives are mainly in the form of subsidies towards the initial investment (aid in construction) and are described in chapter 6.2. Another form of incentive, which consists of the possibility of deducting construction costs from taxes.

Naturally, there are also other kinds of non-financial and non-individual incentives, not dealt with here that are concerned with the promotion of PV in general. For example, information about users and potential users (regional authorities, etc.), through technical/economical PV brochures and training of electricians are other types of action to increase awareness of PV value, particularly in places where the technique demonstrates its viability.

6.2 Financial incentives

Most countries have significant investment subsidies for the initial capital cost. In addition, in many countries subsidies are available from national and/or state governments. In some cases, additional subsidies are available, such as exemption from property taxes, sales taxes or VAT, etc.
Only **United Kingdom** and **Australia** are **without subsidies** for the construction of PV power systems.
France has the largest subsidy: 90 % of a stand alone PV generator is financed by public funds (FACE fund) - provided that the PV system is cheaper than extension of the grid - and the system is maintained by the utility EDF. However, there is no special incentive for grid-connected PV roof generators.
The greatest financial incentives in USD/kWp (i.e. 12 906 USD/kWp) were reported by **Austria**: these incentives being made available within the framework of the ‘Roof top programme’. This very attractive programme, now over, was a great success exceeding 200 projects. Apart from these subsidies, the plants created within the framework of this programme can sell the energy produced to the grid at a price, which is valid in general for all independent producers. This programme therefore contains an incentive based both on the ‘power installed’ and on the ‘energy produced’.
Other combinations of subsidies and preferential tariffs exist. A recent example is Berlin, which has adopted the Zurich model (see chapter 3.7), whilst maintaining a basic subsidy in the order of 7 000 DEM/kWp.
Italy also seems to have very high incentives: although no absolute values in USD/kWp have been reported, the percentage the subsidies can reach 80 %. Nevertheless, unlike Austria, in Italy the plants set up with the incentives described below do not have the right to payment for the energy produced, and vice versa (i.e. you can take advantage of one of the two buy-back rates/incentives models exclusively!). Nevertheless, the plants which sell energy to the grid and therefore benefit from the prices described in the buy-back rates model (cf. chapter 3 and 4), can receive public financing within the framework of regional or European Community promotion programs. In table 6.1 below, there is a summary of the situation as well as a more detailed description for some

countries.

Table 6.1: Financial incentives in the different countries: summary

	Incentives USD/kWp	%	Max. limit	Total budget	Observations
DEU	4 693	40-70[1] 35-70[2] 10-30[2]	46 928 USD/plant (10 kW)	12,1 MUSD, up to the end of 1998	Additional up to 40 % for off-grid.
ESP	grid-connected: 6 336 stand-alone: 12 672			Tot. 47,5 MUSD 91-00. Of this 23 MUSD public	'PEN' (National Energy Plan) program
AUT	'roof top prog.': 12 906	71		2,58 MUSD, 92-93.	Regional: some utilities 956 USD/kW; some cities (ex Vienna), up to 2 868 USD/plant
JPN	residential use: 8 228 public use: 66 %	50 66	43 560 USD/plant (5 kW)	21,7 MUSD, 93-94	
ITA		30 to 80			For residential, industrial and agricultural applications.
CHE	Grid-connected: 3 888	27-50		Total 94-95: 5,032 MUSD (federal subs. 1,36 MUSD)	Government: 27 % to max. 50 % (pilot and demo programme). 15 - 50 % in some cantons (states) since 1997: 2 400 USD/plant for systems between 1 and 100 kWp
PRT		40	1 MUSD		Plus various tax benefits: low VAT (5 %), individual deductions in income tax credit, etc.
NLD		40-60		Annual budget until year 2000: 16 MUSD	
FRA	Grid-connected: none Stand-alone: yes	- 90			
GBR	**NONE**				
AUS	**NONE**				

Austria:
Within the framework of the 'Austrian roof top programme', (1992 - 1993) Austrian utilities have promoted the creation of 97 private PV-plants (total 200 kW) by investment subsidies. The average construction costs have been 190 000 ATS/kW.

Subsidy (tot. 71 %)	Promoter
60 000 ATS/kW installed	Austrian Ass. of El. Utilities
10 000 ATS/kW installed	Utilities
Connecting works free	Utilities
10 000 ATS/kW installed	Federal Government
up to 50 % of the remaining investment	Regional Government
meters for free	Meas. Instruments Industry

Other subsidies: besides this programme, also regional governments make special promotional programmes. They have paid in the past up to 50 % of total investment costs, but today they have re-

[1] National, respectively states and in cities
[2] status 94/95

duced their subsidies (Vienna: max. 30 000 ATS/PV-plant). In addition, some utilities still promote the construction of private PV with subsidies up to 10 000 ATS/kW.

Germany:
The programmes are different at the governmental, federal state and local community level. On the governmental level, PV-plants are subsidised through the Ministry of Economics. The total volume of the programme is 100 million DEM for all renewable energies, 18 million for PV and it runs up to the end of 1998. The subsidy for every plant is 7 000 DEM/kWp (6000 DEM/kWp since 1997) and the maximum is limited to 70 000 DEM for each project. The minimum size of the plant should be 1 kWp whereas the maximum is unlimited.
Many of the federal states have their own programmes with subsidies for solar energies: in these programmes, 35 % to 70 % of the total cost is subsidised by the states. Nearly all plants realised in the framework of these programmes are of the grid-connected type; there are only a few stand-alone systems.
Examples of federal state subsidies:[1] plants are subsidised at 35 % in Baden-Würtemberg, at 40 % in Hessen, at 50 % in Bavaria, Brandenburg, Niedersachsen, Saarland and Thüringen. In Berlin plants are subsidised at 70 %, at a maximum of 15 400 USD/kWp. In many states, the maximum grant per installation is 20 000 USD.

Japan:
In Japan, there are two major incentives. One is for residential use and the other is for public use.
In the scope of the first programme (called ‘Monitoring program of residential PV Power Systems’), the New Energy Foundation of Japan subsidises the individual installation of a solar system with one half of the installation cost. This is on the condition that the same individual is to take part in the solar photovoltaic power generation monitoring programme and to furnish demanded data. The subsidy amounts to 850 000 JPY/kW (nearly equal 8 500 USD/kW), and the upper limit of subsidy correspond to 5 kW. This program started in 1994 Japanese Fiscal Year (April to March). Installed systems were 552 in 1994 FY. In 1995 FY it was 1 023.
Concerning the incentives for public use, NEDO is supporting field-testing projects for the wider introduction of power generation systems using solar energy, fuel cells and wind power.
PV systems are experimentally installed on public buildings or constructions and on the ground. Installation cost data and various operation data are collected. The subsidising ratio amounts to 2/3 of the total cost (1995 FY). This programme started in 1992 FY, Installed capacities were 235 kW in 1992 FY, 476 kW in 1993 FY, 370 kW in 1994 FY and 679 kW in 1995 FY.

Italy:
In Italy, a national law (the law n. 10 of 9 Jan 1991) provides for incentives to the construction of PV Plants for residential, industrial and agricultural applications. The foreseen government contribution reaches a different ratio of the plant total cost, according the destination of produced energy:
- up to 80 %: electrification of isolated houses (rural or mountain houses, vacation houses) and lighting
- up to 55 %: electrification of farms and related equipment
- up to 50 %: industrial applications, with innovative technical and/or operational characteristics
- up to 30 %: industrial applications

Unfortunately, the actual funding status of law n. 10 is subjected to the current uncertainties of the Italian financial situation, so that subsidies are subjected to revision for both the amount and the time distribution. In addition to the aforementioned incentives, the law n. 47 of 2/3/1993 has reduced the VAT from the 19 % to 9 %, within the frame of harmonisation of this tax in the European Community Countries. Overall, this set of incentives has allowed, during the last few years, an increasing number of projects for the construction of grid-connected PV-plants to be carried out.

[1] status 1994

Netherlands:
The total annual budget for the Netherlands national PV-programme is about 16 MUSD, of which about half is for the support of pilot and demonstration projects of PV in the built environment. The programme is aiming at preparing market and technology for a large scale introduction of PV in the next century.
The height of the subsidy depends on the type of project. For projects which are highly innovative, the subsidy may be 50% or even 60 % in exceptional cases with a high element of R&D. For demonstration projects, the subsidy is 40 % and for projects that are not innovative but are intended to open up the market, the subsidy is 25 %. The subsidies apply to total project costs.
Apart from subsidies, there are various fiscal instruments which may in most cases be applied simultaneously. The advantages of these combined fiscal instruments may be up to 18 % of project costs.
Several utilities also subsidise PV systems with a fixed amount of 1.5 USD/Wp. In most cases, utilities are initiators and investors in PV projects.
The national programme is aiming on large-scale projects, with the involvement of professional market parties.

Portugal:
In Portugal, there is no programme targeted specifically to PV, but a broader incentive mechanism - the programme ENERGIA (1994-1999), formerly SIURE (1990-1994) - aiming at stimulating energy conservation, efficient use of energy and exploitation of indigenous resources (mainly renewables). Under the terms of the scheme for renewable energy applications, incentives are provided on capital and development costs: projects receive soft-loans equivalent to 40 % of the total investment, with a maximum limit of about 1 MUSD. Al renewable technologies for applications up to 10 MVA are eligible. The demonstration scheme of ENERGIA also provides subsidies of 40 % of the project eligible cost, up to a maximum limit of about 860 kUSD per application and, in case of EU demonstration projects, a complimentary subsidy, provided the total incentive does not exceed 49 % of the project cost. However, the programme excludes individual consumers in the domestic sector, which constitutes an important barrier for potential PV users in this sector.

Switzerland:
In addition to existing incentives in the pilot and demonstration programme and the earlier school demonstration programme, since February 1997, PV installations between 1 and 100 kWp are subsidised at 3 000 CHF/kWp (2 400 USD/kWp), corresponding to 25 % of a typical on-grid system.

7 CONCLUSION

High buy-back rates are one possible way among many concepts to increase the market penetration of PV power systems. It is still too early to offer a thorough analysis regarding the development of buy back rates for photovoltaics, since for certain more recent models, not all the necessary data are available. The concept of buy-back rates for photovoltaics is recent, in fact, all the classified models came into force from 1990. In 1992 the greatest number of models came into force (6). This study has clearly shown, however, that the topic needs special attention in view of the great number of models existing within the 11 countries studied so far. In fact, a total of 17 models classifiable in six categories according to their operating principle have been found. Another element of interest will be the evolution of this concept as prices for PV systems will decrease and legislation will further progress towards the liberalisation of energy markets.

The models not only exist on paper: in fact, 13 models are being or have been put into operation. On the other hand, only 4 models have, so far, been reasonably successful regarding the impact on the development of grid-connected photovoltaic systems.
Most models, are based upon general conditions valid for other producers, consequently rates are generally low and paid for an unlimited period: these models e.g. PRT, GBR and ESP have been more successful for other renewable energies. Other models have limitations in duration of payment and maximum power, probably to limit the economic impact on the different utilities. In countries with very competitive markets, the models have not been very successful. Australia is a typical example. In the clear majority of cases, the energy taken into consideration is the surplus power inserted into the grid. Only 5 models consider the total energy produced. The latter models also apply the best prices and are logically the most successful ones. This study highlights in particular 2 countries where high buy-back rates have led to increased deployment of photovoltaics power systems: Germany and Switzerland. These two countries not only apply the highest rates, based on total production costs and allowing investors in photovoltaics to recover their investment over time, but also do it for longer periods than other countries (10 to 20 years). Even the total payment is greater with respect to other countries, since all the energy produced is bought. Moreover, in both countries, the minimum (compulsory in DEU, recommended in CHE) rate generally applied is very high and even higher than those used by other models (GBR, PRT, and ESP).
This report has laid particular emphasis on the models that already exist and the success they have achieved. The basic needs for the concept of increased buy-back rates with respect to the development of photovoltaics are given below. It is necessary that:

- **Models should not be based on avoided costs**, but created specifically for photovoltaics. In certain countries buy-back rates are based upon avoided costs, e.g. AUS. At present, avoided costs tend to be low as they mainly reflect avoided fuel costs. In view of the relatively high cost of electricity from photovoltaic power system plants, high buy-back rates, not based on avoided costs, will be required until installed system costs decrease significantly.

- **Models based on total production** costs will also be necessary; the main attraction of these types of models is that there is no need for subsidies from governments or from utilities. These models are probably a new and viable path to self-sustaining markets for photovoltaics (cf. DEU and CHE).

- **Incentives based on energy** rather than on power are also required. In particular, models that pay the **total energy** inserted into the grid, focus consumer attention on total actual system energy production, and redirect priorities toward improvements in system efficiency and design. This creates an important stimulus to improve the quality of the installations.

- **Multi-utilities structures** generally favour the introduction of models. In general, models have more difficulty in establishing themselves in countries that have a centralised structure (like FRA), than in countries with multi-utility systems (DEU). The exception to the rule is Italy, where the model pays well and has been successful.

- **Publicity and more initiative**. Further advertising for those models that are already operating and a stronger sense of initiative are needed. In fact, a clear distinction can be made between countries where the initiative comes from the utilities or is a consequence of a national law. Except for one case (Aachen, DEU), no model emerged through other means, for example through public pressure, although the public opinion in all countries is in favour of photovoltaics.

APPENDIX A: TABLES

Table A1: Distribution of installed PV Power by the end of 1993 and 1995

Country	On-Grid [%]		On-Grid [MWp]		Off-Grid [%]	
	end of '93	end of '95	end of '93	end of '95	end of '93	end of '95
Australia	**0,1**	**0,4**	**0,005**	0,05	99,9	99,6
Austria	52	46,9	0,345	0,637	48	53,1
Canada	14	12,1	0,195	0,222	86	87,9
Denmark	**6**	**28,6**	**0,0051**	0,04	94	71,4
Finland	3	2,6	0,035	0,035	97	97,4
France	**1**	**1**	**0,005**	0,08	99	99,0
Germany	97	90,5	8,267	16,103	3	9,5
Italy	30	39,2	3,58	6,185	70	60,8
Japan	29	43,8	4,15	11,386	71	56,2
Korea	**0**	**0**	**0**	0	100	100
Netherlands	6	13,7	0,094	0,337	94	86,3
Portugal	**0**	**9,1**	**0**	0,015	100	90,9
Spain	15,8	24,8	0,733	1,621	84,2	75,2
Sweden	**1**	**1,9**	**0,015**	0,031	99	98,1
Switzerland	66	66,9	3,792	5,4	34	33,1
Turkey	**0**	**N/A**	**0**	N/A	100	N/A
United Kingdom	**0**	**16**	**0**	0,059	100	84,0
United States	13,5	18,4	6,94	9,4	86,5	81,6

For **Australia**, **Denmark**, **France, Korea, Portugal, Sweden, Spain, Turkey, and United Kingdom,** grid-connected PV plants, by the end of 1993, represented a low percentage of the total. However, in Portugal, the United Kingdom and Denmark, there has been a significant increase in the grid-connected sector over the past 2 years. There has been little or no penetration of grid-connected PV systems in Australia, France, Korea, Sweden and Finland. In Australia, Canada, Finland, France, Korea, the Netherlands, Portugal, Sweden, the United Kingdom, and the USA over 80 % of the installed PV power, by the end of 1995, was off-grid. This is in contrast to the situation in Germany and in Switzerland, where over 90 % and 66 % respectively of installed power is grid-connected. This application sector is of particular importance in Austria, Japan and Italy too, where the figure is nearly or over 40 %.

Table A2: Exchange rate on 04.06.1996 (NC = National Currency)

	ISO codes		Exchange rate	
Country name	Country	Currency	**1 USD = X NC**	**1 NC = X USD**
Australia	AUS	AUD	1 USD = 1,21 AUD	1 AUD = 0,824 USD
Austria	AUT	ATS	1 USD = 10,46 ATS	1 ATS = 0,0956 USD
France	FRA	FRF	1 USD = 5,03 FRF	1 FRF = 0,198 USD
Germany	DEU	DEM	1 USD = 1,49 DEM	1 DEM = 0,6704 USD
Italy	ITA	ITL	1 USD = 1506,02 ITL	1 ITL = 0,000664 USD
Japan	JPN	JPY	1 USD = 103,31 JPY	1 JPY = 0,00968 USD
Netherlands	NLD	NLG	1 USD = 1,66 NLG	1 NLG = 0,6 USD
Portugal	PRT	PTE	1 USD = 150,60 PTE	1 PTE = 0,00664 USD
Spain	ESP	ESP	1 USD = 126,26 ESP	1 ESP = 0,00792 USD

Switzerland	CHE	CHF	1 USD = 1,25 CHF	1 CHF = 0,8 USD
United Kingdom	GBR	GBP	1 USD = 0,625 GBP	1 GBP = 1,6 USD

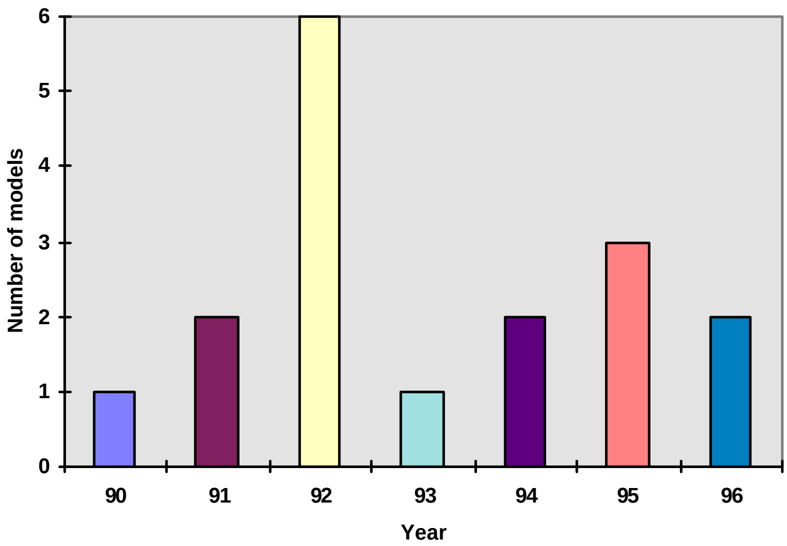

Figure A1: Year of coming into force of the models

Table A3: Provisions and required conditions: additional information for certain countries

Validity	Nation	Required conditions / Provisions
National level	GBR	GBR regulation G59/1
	AUS	The PV installation must comply with the utility installation standards (technical policy on interconnection). In State of New South Wales any additional capital costs caused to the utility through the connection or presence of the private generator to be recovered from that supplier. The 'Integral Energy model' applies only to Integral's (a state utility) 680 000 customers.
	AUT	The facilities (especially converters, meters and safety devices) have to accomplish the Austrian standard (ÖNORM E 2750).
Regional level	JPN	There are not provisions **at national level**. In order to connect grid system, a PV system must meet technical requirements. If a PV system is mainly for self-consumption, it is allowed to deal a contract of surplus electricity power purchasing. Most of the utility companies owe costs for grid connecting such as electricity meters. There are two electricity meters at a grid connected PV system. One is for electricity consumption and the other is for surplus electricity power. Each price is paid each
	NLD	At **national level, no provisions** are available. In most cases, the utility is one way or another involved in the project and authorises the grid connection. **No specific rules or regulations are in practice**. The PV system **has to be certified** (NEN 1010). Costs of grid connection are for the owner of the system. Reinforcement of the grid is out of the question, because of the small scale of the installed system power. Large-scale systems are/will be owned by utilities. Rules for power interchange: nil.
No cond.	FRA	Under consideration with low pricing

Table A4: Main technical and non-technical factors that hinder the models

Kind of factor	Country	Factors which hinder the model
NON technical factors	FRA	The ministry of industry dealing with energy matters in France **doesn't wish to subsidise any project that doesn't show any economic viability within 5 years**. EDF, the electricity utility, tolerates two-way meter in agreement with Ministry of Industry. Today the Ministry, EDF and ADEME have **only a policy for promoting autonomous stand-alone** PV systems to power off-grid sites.
(economic)	AUS	Queensland model: **Restriction on modifications to standard tariffs** Victoria model: All new renewables into the grid have to compete in the **competitive generation market** with other producers, making nearly all **renewables uneconomical**. Western Australia model: Low avoided costs & **high PV costs**. New South Wales model: Only guidelines for establishing maximum buy-back prices, hence **any negotiations** regarding private generation were carried out on a purely commercial basis by the electricity supply industry Integral Energy model: **Reduced return** on network investment
	NLD	The (experimental, ad hoc) models will be influenced by new incentives on **financial structures** for renewables; also, green tariffs may be introduced in buy-back tariffs. If the contribution of this source will become significant, most **definitely new tariff systems will be developed**
	JPN	**Financially** utility companies cannot owe a large amount of cost born by purchasing surplus power
(political)	ITA	**Model based on incentives**: Unfortunately, the actual funding status of law n. 10 is subjected to the current **uncertainties of the Italian financial situation**, so that subsidies are subjected to revision both for the amount and the time distribution.
	GBR	**reluctance of utilities and regulatory regime**
(juridical)	DEU	Juridical procedures too long. For the Aachen model, 2 years were necessary before it came into force. This model starts operation in Freising (8.93) about 2 years earlier than in Aachen.
technical factors	JPN	It will be hard to maintain the model if quantity of surplus power grow large. **Technically** surplus power from PV **cannot be larger than 10 %** of grid scale.
	AUS	Integral Energy model: added risk and public liability; safety (islanding etc.); power quality issues

APPENDIX B: SITUATION IN THE USA

General observations

The United States could not fully participate in the study, that is, it did not supply data with the same format and level of detail as the other countries. It supplied general information due to the large number of utilities without a unified approach to power purchase.

Utility and public perceptions of photovoltaic power systems

Because of many successful demonstration programs and projects, public perception of PV Power systems is generally good in the United States. A survey by the American utility SMUD indicated that 70 % of their residential customers would be prepared to pay a 15 % premium on their electricity bill for the installation of a SMUD owned PV system on their roof.

The perception of PV by a large number of electric utilities in the United States is excellent, as proven by the formation by the utilities of an Organisation called the **U**tility **P**hoto**V**oltaic **G**roup (UPVG). As Of January 1995, eighty-nine utilities have joined the Organisation whose mission is to accelerate the use of cost-effective, small-scale and emerging large-scale applications of photovoltaics for the benefit of the electric utilities and their customers.

Subsidies and incentives

Table B3 gives the main incentives available in the different USA states. In particular, an important tax credit exists, which varies from 10 % (California) to 35 % (Oregon); however, only 6 states employ sales-tax exemption or reduction.

The general situation is summarised in table B1.

Table B1: Subsidies and buy-back rates in the USA: summary

Subsidies	Buy-back rates
10 % of total capital cost plus 0,015 USD/kWh for 10 years, up to 35 % state, plus various tax exemptions; 35 % federal for grid-connected (UPVG)	Avoided costs as defined by each state. 20 states employ net metering (see below)

Buy-back rates

In general, in the United States the utilities usually agree to pay a rate equal to their avoided costs, i.e. the PV energy delivered to the grid is compensated at marginal or avoided costs ranging from 0,01 USD/kWh to 0,05 USD/kWh ('dual metering', two meter required).

However, more recently, utilities, customers, and the PV industry all have an interest in encouraging the development and use of uniform metering and national interconnection standards that adequately address economic, safety, and reliability concerns while encouraging PV commercialisation. These will be applied uniformly to utility and non-utility projects.

In fact, at present 20 states with 4 still pending or interested, employ 'net metering' (see table B2 where. the PV energy delivered to the grid is compensated at retail price. The price varies between 0,06 USD/kWh and 0,21 USD/kWh and in this case only 1 meter is required. This 'preferential tariff' does not concern the net excess generation (i.e. generation exceeds consumption) during the billing period. In fact, for all the 20 states reported in table B2, the same rate (1:1) will be applied for home generation and consumption until the electric bill is cut to zero. If the PV system generates more energy than is consumed, the utility will pay for the excess energy at:

- a lower wholesale rate (avoided cost: 0,01 to 0,05 USD/kWh), in 11 states (AZ, CA, CT, IA, ME, MA, ND, RI, TX, NY, VT)
- retail rate (0,06 to 0,21 USD/kWh) in only 3 states (ID, MN, WI). Vermont applies a special tariff for the net excess generation, but only in the case of residential cogeneration.
- no purchase of excess generation in 3 states (excess is granted to the utility) (IN, NH, OK)

These models all have the following common characteristics (cf. table B2):
- there are few **limits concerning the 'applicability to other energy sources':** only in two states are the models applicable for solar exclusively
- there are few **limits concerning the "customer classes":** only in three states are the models applicable for residential exclusively
- however all the models have important **power[1]or energy limits**

A typical example of a model of this kind is applied in California (see below); this model is applicable only to residential PV systems with power less than 10 kW. It is capped at 0.1 % (50 MW) of total utility peak load (first come, first served basis).

Analysis of net metering impact relative to dual metering: California example

Net metering gain with respect to dual metering, for 1 PV system
The net metering financial impact depends on PV size; the difference between the two metering systems is greater if the size of the PV system is big. In fact, on the basis of the typical Californian climate and retail utility rate, it has been calculated that the financial savings for a PV system <1 kW are the same for both dual and net metering. However, for a 4 kW system, net metering has a significant impact and the gain vs. dual metering (annual basis) ranges from 40 to 80 %. In this case net metering can provide up to 2 USD/W equivalent buy-down.

Some forecasts: net metering impact of a 50 MW program
The effects that a 53 MW net metering program in California would produce, have been calculated; more precisely, using the following input assumptions:

Program size:	53 MW[2] (= 0,1 % state-wide demand)
Average PV system size:	2 kW
Years to reach program cap:	10
Number of systems for program:	26 500
Retail electric rate:	0,10 USD/kWh
Utility avoided generation cost:	0,04 USD/kWh

The impact of this net metering programme, relative to dual metering with avoided cost payment,

[1] Limits on systems size or on overall program size
[2] The existing customer-sited PV capacity in California is, at present, < 3 MW.

over 10 year period is estimated at:

- 18,6 MUSD saved by PV customers, and over 1,7 MUSD by utilities. In particular net metering simplifies PV interconnection: utilities can reduce meter hardware and interconnection costs (2,5 MUSD saved), and meter reading and billing costs (17,8 MUSD saved!!).
- worst case, rates would have to be increased 0,003 %. That's about only 2 pennies per year per customer.

Table B2: 'Net metering' models in the USA

State	Applicable to	Allowable customers	Max. size / other limits	The net excess generation (NEG) purchased at	Enacted
Arizona	renewables & cogeneration	all customer classes	100 kW	avoided cost	1981
California	**solar only**	**residential only**	10 kW	avoided cost	1995
Connecticut	renewables & cogeneration	all customer classes	50 kW for cogeneration. 100 kW for renewables	avoided cost	1990
Idaho	all resource	all customer classes	100 kW	**retail rate**	1986
Indiana	renewables & cogeneration	all customer classes	max. 1000 kWh/month	No purchase of NEG; excess is granted to the utility	1985
Iowa	renewables	all customer classes	105 MW overall limit for all renewable facilities	avoided cost	1983
Maine	renewables & cogeneration	all customer classes	100 kW	avoided cost	1987
Massachusetts	renewables & cogeneration	all customer classes	30 kW	avoided cost	1982
Minnesota	renewables & cogeneration	all customer classes	40 kW	**average retail** utility energy rate	1983
New Hampshire	renewables	**residential only**	25 kW per system 500 kW total for state	No purchase of NEG; excess is granted to the utility	1994
North Dakota	renewables & cogeneration	all customer classes	100 kW	avoided cost	1991
Oklahoma	renewables & cogeneration	all customer classes	100 kW and annual output ≤ 25 MWh	No purchase of NEG; excess is granted to the utility	1990
Pennsylvania	renewables only	all customer classes	50 kW	N/A	N/A
Rhode Island	renewables & cogeneration	all customer classes	25 kW for larger utilities; 15 kW for smaller utilities	avoided cost	1985
Texas	renewables only	all customer classes	50 kW	avoided cost	1986
Wisconsin	all resource	all retail customers	20 kW	**retail rate** for renewables, **avoided cost** for non-renew.	1993
Hawaii (pending)	N/A	N/A	N/A	N/A	N/A
Nevada (pending)	N/A	N/A	N/A	N/A	N/A
New York (pending)	**solar only**	residential only	10 kW	avoided cost	1996
Vermont (pending)	wind, hydro, PV **or** residential cogeneration.	all retail customers	10 kW	avoided cost, **or** special customer-producer tariff for all energy	1993

NOTE: - '**NEG**' refers to the **n**et **e**xcess **g**eneration of electricity by the customer-generator (i.e. generation exceeds consumption) during the billing period.
- Some utilities impose minimum monthly meter charges or minimum monthly bills; in California, for ex., it is recommended that any minimum charges not exceed USD 5,00 per month.

Table B3: Main state incentives for solar technologies in the USA

State	Tax credit	Sales tax exemption	Property tax exemption	Industry recruitment	Loan	Grant	Other
Arizona		x		x	x		
California	**10 %**				x	x	
Hawaii	**35 %**		x	x			
Idaho					x		income tax
Indiana			x				
Iowa			x		x		
Massachusetts	15 %	x	x			x	corporate tax
Minnesota		x	x				accel deprec
Mississippi					x		
Montana			x				
Nevada		x	x				
New Hampshire			x			x	
New Jersey		x				x	permit fee ex
New York			x				
North Carolina	25 %			x			
North Dakota	15 %		x				
Ohio			x				
Oregon	**35 %**		x		x		
Pennsylvania						x	
Puerto Rico					x		
Rhode Island		x					
South Dakota			x		x		
Tennessee					x		
Texas			x			x	accel deprec
Utah	25 %						
Virginia			x	x			
Wisconsin			x			x	
Wyoming						x	
Totals: 28	**7**	**6**	**16**	**4**	**9**	**8**	**5**