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5. REST OF THE WORLD (ROW)

5.1 GENERAL

For simplicity reasons, and in accordance with the specific characteristics of the world PV sector, for the purpose of the present investigation, the world market has been subdivided into four main geographical areas, namely the European Union (including associated countries), USA, Japan and the Rest of the World. Accordingly the here presented geographical area classified under "Rest of the World" (ROW) covers the remaining parts of the globe excluding the EU, USA and Japan.

Obviously this enormous market area, while covering the large majority land territory existing on the globe and more than 80% of the world population, is the most dishomogeneous as compared to the other three, since it comprises countries of extremely different cultural, demographic and economic characteristics, including:

- **Industrialised OECD member countries** such as Australia, Canada etc. are mostly characterised by similar economies as those of the EU, USA and Japan (and present similar electrification levels), but also by vast territories of extremely low population density, where conventional electrification via utility network extensions is mostly not reasonable since anti-economic;
- The **Eastern European countries** which formerly belonged to the COMECON are characterised by previously centrally planned economies presently in a transition phase, by mostly relatively high electrification levels of populations, but where vast rural territories (of lower population density and lower economic development level) are still not electrified.
- **Newly developed countries** such as Taiwan and others, where urban centres present highly developed characteristics, but rural populations still live under depressed conditions and without electrification.
- The two **most populated countries** of the world, namely **China** and **India**: characterised by developed urban centres and enormous numbers of rural population still living under depressed conditions and without electrification.
- **The third (and fourth) World**, presenting a majority of population living under depressed conditions and without electrification.

5.1.1 Non-electrified populations, a primary PV market potential

Unlike the industrialised OECD countries with their electrification networks developed near to saturation, especially in the third world a significant share of population lives in areas without electricity supplies. Of these the majority will probably never be connected to an electric network, since such electric connection will remain, for a predictable future, anti-economic, as for the remotedness and related insurmountable geographical and physical obstacles.

Lack of electricity and related commodities contributes consistently to rural migration and urbanisation tendencies, that is the trend of rural populations to abandon their living in rural areas and to migrate to the cities in the hope to gain access to better living conditions. To counteract such migration phenomena with their known catastrophic consequences to the people, to the development of urban centres and to national economies, there is a recognised need to improve living conditions in rural areas, to stimulate local economic development, and to provide access of rural populations to basic infrastructures such as to safe water, illumination, education, health, sanitary services, communications, safety, etc. At present the only commodity means available to non-electrified rural populations in non-OECD countries are either provided by means of kerosene fuelled devices (lamps and refrigerators), throwaway batteries, or else, in some few more sophisticated circumstances by means of diesel or gasoline fuelled generator sets (gen-sets). On the other hand, especially in small scale applications, presenting a daily power demand of a few kWh's only, the service reliability of gen-sets has proven to be very low, and their operation resulted to be surprisingly expensive, as for the need to provide for their fuelling, for lubricants, spare part supplies and maintenance in general.

Where the solar resource is available (from tropical to moderate climate range), and specifically for micro-scale applications (in range of a few kWh power consumption per day) solar PV systems are to be considered not only a technically viable, but also an economically much more advantageous alternative solution for such power supply problems, and this in spite of their apparently high specific investment cost. This is due to their unequalled simplicity, very high reliability (if adequately sized and designed) and extremely low maintenance requirements.

A main disadvantage of solar PV technology (but same applies also to wind-power) is that today their very little diffusion throughout rural territories in the third world has not yet allowed to create a network of technical support services sufficient to ensure the necessary technical assistance, maintenance, application engineering and installation services. Furthermore, the diffusion of this new technology is suffering the lack of adequate financing services allowing interested rural families to overcome the initially required consistent investment.

In the past, electrification required necessarily the extension of the electric power distribution network to the addressed area, since otherwise the only way to produce electricity locally was to adopt stand-alone (diesel) generator sets for the purpose. This kind of pre-electrification using diesel gen-sets presented (and still today presents) some substantial drawbacks, since the reliability of such stand-alone power supplies is generally low, relevant costs are high and, what is more, a qualified technical assistance structure (and personnel) is required to look after the gen-set system in order to ensure long timfetime and generally its operation.

5.1.2 Economic development potentials of PV technology

The potentials for economic stimulation effects and impact of PV technology on local economies may be examined according to different viewpoints as follows:

- **Creation of local employment** by introducing PV technology, both direct (manpower for manufacturing, distributed local manpower for installation and maintenance services) and indirect, since availability of PV power allows to improve productivity in rural areas and to create a diffused rural economy based on so-called "cottage industries" (typical example an electrically powered loom or sewing machine allows relevant productions (and mostly employed women) to increase highly their productivity);
- The possibility to provide alternative solutions for the problems related to **rural electrification allows to reduce social and political pressure** on decision makers, which otherwise have to decide anti-economic investments in electric power network extensions. But at the same time PV electrification allows to make much more use of financing resources made available by national and international development agencies for rural electrification purposes, by increasing (for the same money) the number of beneficiaries;
- The resulting **improvement in living conditions of rural populations allows to reduce the migration pressure from rural areas towards the urban centres**, resulting thereby in a marked improvement in the overall social, demographic and economic balance of the nation. On the long run, the possibility to provide autonomous electrification means to rural populations may be expected to counteract significantly the present overwhelming trend in developing countries towards urbanisation;
- Apart from the obvious advantages concerning the **avoided pollutant emissions (and noise)** of conventional power generation facilities, the otherwise **uncontrolled disposal of throwaway batteries (toxic waste)** by rural populations presently using such batteries extensively is also avoided.
- The modularity of PV systems allows for their very **smooth and gradual introduction**, i.e. in a distributed way both within the territory as well as in time. Actually, unlike conventional energy systems requiring consistent one-time investments, solar PV applications need no large investments concentrated in a certain region and during a very limited time period of a year or two only. On the contrary, it is possible to dilute the introduction of PV technology over a long time period, offering thereby also **continuity in local employment** required for their gradual installation and maintenance.

5.2 OVERVIEW OVER REST OF THE WORLD PV INDUSTRY

The following tables and graphs provide an overview over the present situation of PV manufacturers located in the geographical areas classified under "Rest Of the World" (ROW).

It is to be recalled here, that capacities, shipments and market shares have been assigned to geographical areas on the basis of manufacturing facility location, and not on the basis of ownerships.

Accordingly, the relevant figures referring for example to BP Solar Australia have been assigned to Australia (ROW) and not to Europe, although the mother company BP-Solar is located in Europe (UK). Same applies also to all SIEMENS SOLAR ownerships in the USA, where relevant capacity and market figures have been assigned to the USA and not to Europe.

Table 5.1 - Number of producers and production lines for PV technology

Technology	*Manufacturing Facilities*	
	number	*capacity*
Crystall. silicon	14	7,0
Ribbon		-
A-Si	3	5,0
CdTe		-
CIS		-
Other		-
TOTAL PRODUCTION LINES	**17**	**12,0**
Only modules assembly	13	1,0
TOTAL PRODUCERS	**30**	

It is to be recalled here, that capacities, shipments and market shares have been assigned to geographical areas on the basis of manufacturing facility location, and not on the basis of ownerships.

Accordingly, the relevant figures referring for example to BP Solar Australia have been assigned to Australia (ROW) and not to Europe, although the mother company BP-Solar is located in Europe (UK). Same applies also to all SIEMENS SOLAR ownerships in the USA, where relevant capacity and market figures have been assigned to the USA and not to Europe.

Figure 5.1 - Distribution of number of ROW PV manufacturers per technology (1994)

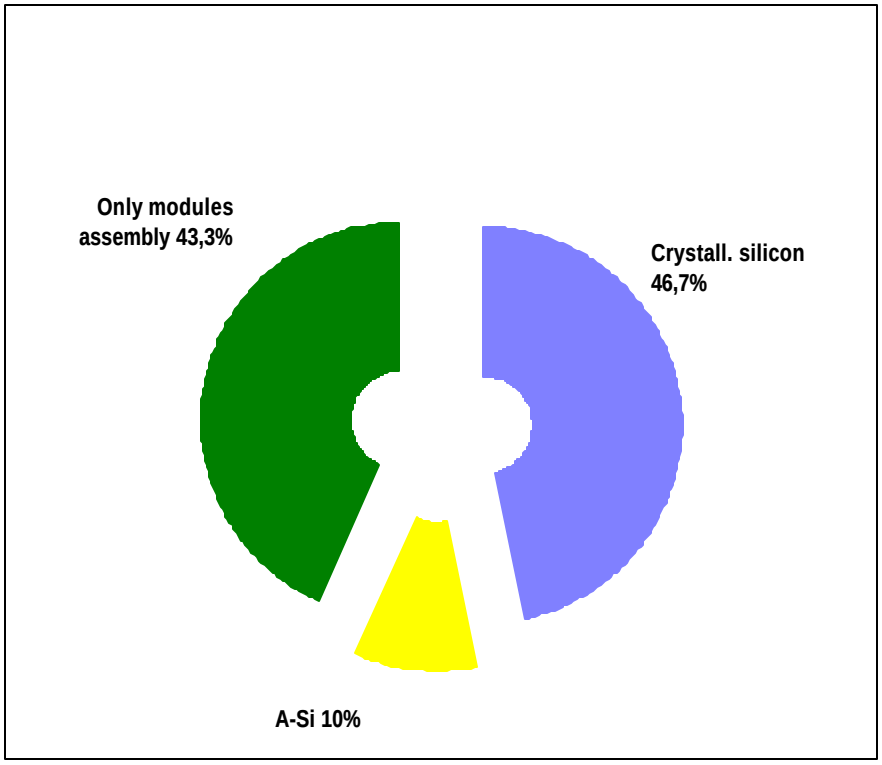


Figure 5.2 - Distribution of production capacity of ROW PV manufacturers per technology (1994)

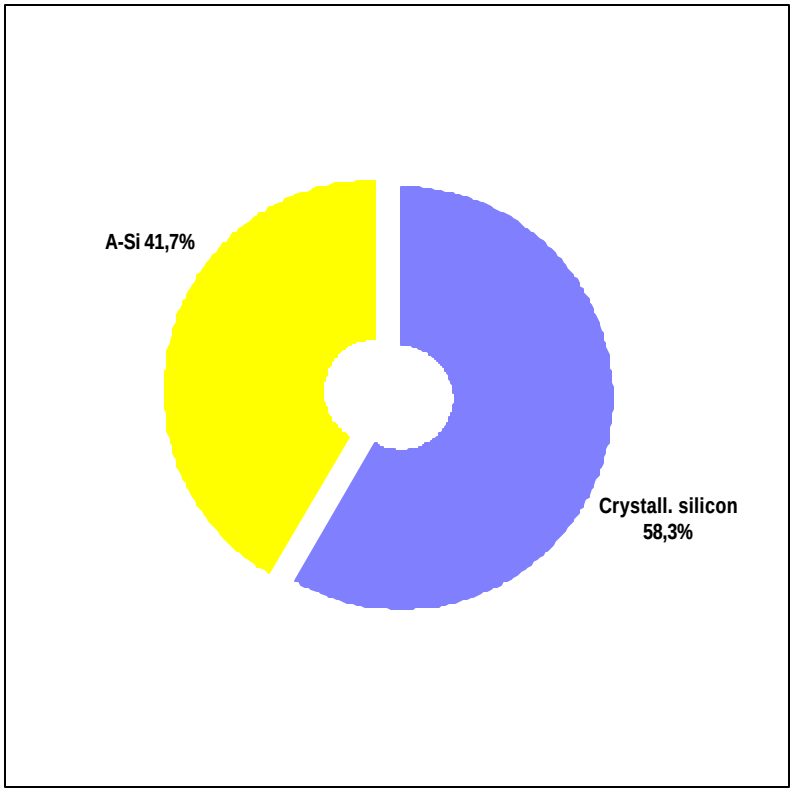


Table 5.2 - Behaviour in time of shipmnets growth and market share for PV ROW industry

PERIOD	*SHIPMENTS*			*MARKET SHARE*
	Total	*Annual growth*		%
	kWp	*kWp*	*%*	
1987	2.906			10,4%
1987- 1988	3.028	122	4,2%	8,8%
1988- 1989	3.461	433	14,3%	8,6%
1989- 1990	4.500	1.039	30,0%	9,4%
1990- 1991	5.700	1.200	26,7%	10,7%
1991- 1992	4.990	-710	-12,5%	8,8%
1992- 1993	5.123	133	2,7%	8,3%
1993- 1994	6.200	1.077	21,0%	8,9%
AVERAGE PERIOD VALUES			**9,3%**	**9,2%**

5.2.1 The PV Manufacturing Industry

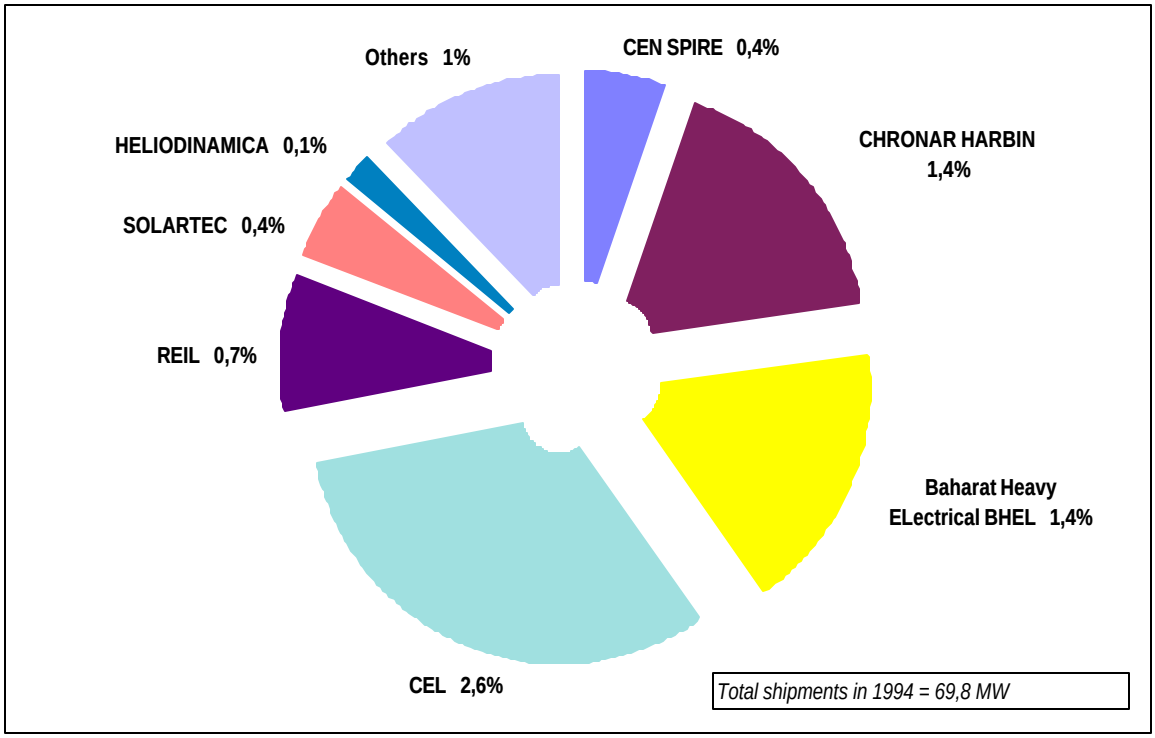
Table 5.3 - Overview of main PV producers per technology in Rest of the World

COUNTRY	PRODUCER	CELLS AND MODULES						Only modules assembly	Capacity 1994
		Crystall. silicon	Ribbon	A-Si	CdTe	CIS	Other		(in MWp/yr)
Algeria	CEN SPIRE							*	
Egypt	EGYCEL							*	
Morocco	PHOEBUS MAROC							*	
Tunisia	UNIVERSITY	*							
China	BAO TUO	*							
China	Beijing General Research	*							
China	CHANGJIANG	*							
China	CHRONAR HARBIN			*					2,0
China	HUA-MEI PV Electr.	*							
China	INNER MONGOLIA							*	
China	KAIFENG	*							
China	NANJING	*							
China	NINGBO	*							3,0
China	SHANGAI 901	*							
China	SHENZEN DAMING	*							
China	YUNAN Plm							*	
India	Baharat Heavy ELectrical BHEL			*					1,0
India	CEL	*							2,0
India	PENTAFOUR HELIOS							*	
India	REIL							*	
India	SURYOVONICS			*					2,0
India	UDHAYA SEMICOND.	*							
Indonesia	PT CENTRONIX							*	
Sri Lanka	SUNTEC							*	
Thailand	SOLARTRON							*	
Iran	OMAN SOLAR SYSTEM							*	
Oman	OPTICAL FIBER FAB. CO.							*	
Argentina	SOLARTEC							*	1,0
Brazil	HELIODINAMICA	*							2,0
Australia	PHILIPS	*							
Australia	SOLAREX PTY	*							1,0
TOTAL		**15**		**3**				**13**	**14,0**

Table 5.4 - Estimated behaviour in time of market share of main PV producers in Rest of the World

COUNTRY	*PRODUCER*	*ESTIMATED MARKET SHARE*								
		1987	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*total*
Algeria	CEN SPIRE			0,7%	0,6%	0,6%	0,5%	0,5%	0,4%	0,5%
China	CHRONAR HARBIN					0,9%	0,9%	0,8%	1,4%	0,6%
India	Baharat Heavy ELectrical	1,4%	1,2%	0,7%	0,6%	0,6%	0,4%	0,5%	1,4%	0,8%
India	CEL	4,3%	3,8%	3,2%	2,9%	2,8%	3,2%	2,5%	2,6%	3,0%
India	PENTAFOUR HELIOS								0,7%	0,1%
India	REIL			1,2%	1,0%	0,9%	0,9%	0,8%	0,7%	0,8%
Argentina	SOLARTEC	0,4%	0,4%	0,4%	0,4%	0,5%	0,5%	0,5%	0,4%	0,4%
Brazil	HELIODINAMICA	1,8%	1,5%	1,2%	1,0%	1,9%	0,5%	0,8%	0,1%	1,0%
Australia	SOLAREX PTY					1,9%	1,9%	1,9%		0,8%
	Others	2,5%	2,1%	1,0%	2,7%	0,7%	0,2%	0,3%	1,0%	1,1%
	TOTAL	**10,4%**	**8,9%**	**8,5%**	**9,4%**	**10,7%**	**8,8%**	**8,4%**	**8,9%**	**9,2%**

Figure 5.3 - Estimated world market shares for major PV suppliers in Rest of the Wolrd (1994)



Note: Given percentages do not sum up to 100% since the world market shares of only ROW (Rest of the World) manufacturers are presented

5.3 MARKET OVERVIEW FOR MAIN APPLICATION SEGMENTS

5.3.1 **Large and medium power plant**

5.3.1.1 Capacity installed 1980-1994

Only the following two medium-large PV plants are presently installed in the geographical areas classified under Rest of the World (ROW = all excluding EU, USA and Japan). Accordingly, at the present stage of PV price developments, this market segment is to be considered near to zero for the majority of ROW countries, especially as regards the third world.

Table 5.5 - PV large-medium power plants installed capacity per year in Rest of the World (1982-1994

PLANT	*COUNTRY*	*INSTALLED PEAK POWER (kWp)*	*YEAR*
PV concentrator field of Riyadh	Saudi Arabia	350	1981
East Oweinat	Egypt	200	1987
TOTAL ROW		**550**	

5.3.1.2 ROW market potentials for large-medium size PV plants

The above presented data on installed capacities of large-medium size PV plants make evident that, at least at the present stage of PV price developments, this market segment is to be considered near to zero for the majority of ROW countries, especially as regards the third world.

An exception to this rule is to be expected mainly from the Arab Petroleum producer countries, as well as from Australia.

Arab Petroleum Producer countries

Arab petroleum producer countries represent definitely a potential for large PV power plants, since they combine an abundant solar resource with the required consistent funding capacity. However, as for their overwhelming petroleum resource, decision makers in these countries (Saudi Arabia, Emirates, etc.) assign little value to energy issues (availability of technical assistance allows them to run easily any conventional energy system) and do not feel, at least for the time being, the need to adopt solar technologies to satisfy their energy needs.

On the other hand, they are also aware to have an abundant solar resource, but the exploitation of this resource is deemed still too expensive, and what is more, of too low power density in order to be able to satisfy the high (concentrated) energy requirements of typical energy demands in these countries. Particularly **water desalination** and **air conditioning** are the most requested applications for energy installations but, as known, they are also the most energy consuming, so that conventional power results to be more cost-effective.

Considering the incredible urban development presently under way in the Arab emirates (e.g. Abu Dhabi has developed from a small military fort in the 1950's to a large city of nearly 1 million inhabitants), PV building integration is instead a strong potential PV application in these areas.

Nevertheless, the fact that one of the world first large PV plants was started up in Saudi Arabia in 1982 is a sign for the interest of the Kingdom to "keep an eye" on the development of any new solar technology. Saudi Arabian decision makers are well aware that, once Petroleum resources will have been depleted, to harness the sun by means of solar energy technologies will definitely become a primary need for the country.

Australia

Australian utilities are becoming aware of the opportunities offered by PV technology for remote stand-alone electrification purposes but, what is more, also applications for grid-connected distributed generation are more and more being taken into consideration, specifically as regards

- **Area grid support** through larger grid-connected PV capacities installed near to substations allows utilities to achieve advantages in all those cases, where peak power demand presents a similar behavior in time as the availability of Solar PV power, e.g. typically where a consistent share of power is consumed for air conditioning purposes.
- **Radial line support** is provided by siting larger PV capacities along single feeder distribution circuits, allowing thereby to alleviate various utility problems such as, for example, load growth beyond feeder capacity, voltage drops along the feeder, or simply bad power quality.

Projects of this kind are likely to be started in Australia in the next future

5.3.2 **Grid-connected small-scale applications**

5.3.2.1 Capacity installed 1980-1994

Except for some few experimental installations, for the time being, in countries outside the OECD there is no evidence of grid-connected small-scale PV applications.

Although not really a small-scale application, the McMillan Rehabilitation Centre, since a rooftop application, may be considered to fall under the distributed generation utility concept.

The system, which has been installed on the roof of the Hugh McMillan Rehabilitation Centre, a children's hospital in Toronto, is a 75 kWp grid-connected PV plant which feeds directly into the electric load of the hospital to reduce summer peaking loads on the utility due to air conditioning demand.

The system also serves as a research and development tool.

5.3.2.2 Grid-connected small-scale applications (rooftops): the potential demand today

The market category of grid-connected small-scale PV systems embraces such typical applications as PV rooftops, PV building facades and building integrated PV facilities in general.

These systems are expected to become the backbone of the **distributed generation utility concept**, where the utility network is expected to provide no more exclusively for the distribution to consumers of power produced by few concentrated generation facilities, but to collect, at the same time, power from a large number of self-producers distributed over the territory.

Lack of adequate statistical data concerning the other ROW countries has allowed to estimate the potential demand for grid-connected small-scale PV applications only for OECD countries.

On the other hand, at least for the time being, this kind of application may be expected to present significant developments primarily (if not exclusively) in OECD countries, so that the error in the resulting market evaluation should not be significant.

The following table 5.6 presents the estimated net surface in km^2 available for solar rooftop installations in OECD countries belonging to the ROW category (Rest of OECD, excluding EU, USA and Japan).

Table 5.6 - Estimated net solar rooftop surfaces available in OECD countries belonging to ROW (1992)

Countries	Irradiation kWh/ m2 year	Net Available Solar Surface			
		houses km2	offices & services buildings km2	industrial buildings km2	TOTAL 1992 km2
Australia	2.000	153	36,0	25	214
Canada	1.200	224	76,0	55	355
New Zealand	1.400	34	6,0	4	44
Turkey	1.700	324	37,0	33	394
Rest of OECD		**735**	**155**	**117**	**1.007**

The following table 5.7 gives instead the figures per inhabitant for available solar rooftop surfaces for year 1992 and interpolation results for year 1990 (required for extrapolation calculations).

It must be emphasized, that **calculations do not take into consideration** that a consistent part of the available solar rooftop surfaces will be used for **concurrent thermal solar applications**, which obviously will have to be subtracted from the quantified rooftop surface potential.

Table 5.7 - Estimated available net solar surface procapita in 1992 and 1990

Countries	Available net Solar surface pro capita					
	houses m2/ inhabitant	offices & services buildings m2/ inhabitant	industrial buildings m2/ inhabitant	TOTAL 1992 km2	TOTAL 1992 m2/ inhabitant	TOTAL 1990 km2
Australia	8,7	2,1	1,4	214	12,2	209
Canada	8,2	2,8	2,0	355	13,0	344
New Zealand	10,0	1,8	1,2	44	12,9	43
Turkey	5,5	0,6	0,6	394	6,7	378
Rest of OECD	**6,9**	**1,5**	**1,1**	**1.007**	**9,4**	**972**

By making the same assumptions as presented in corresponding paragraph for the total world potential of PV rooftops, the present (1990) potential for grid-connected (distributed) small-scale PV (rooftop) capacities has been calculated **for the rest of OECD countries** (excluding EU, USA and Japan) to be roughly **122.000 MWp (~ 1.140 Wp/inhabitant)** of installed PV capacity, whereas the producible PV energy has resulted to be roughly **134TWh/year (~ 1300 kWh/year per inhabitant)**. The results obtained for each country are presented in table 5.8.

Table 5.8 - Installable PV Rooftops Capacity in 1990 for the selected OECD Countries

Countries	*Installable PV Capacity 1990*		*Producible PV Energy 1990*	
	MWp	*Wp/ inhabitant*	*MWh/year*	*kWh/year inhabitant*
Australia	26.123	1.493	36.572.600	2.140
Canada	43.047	1.571	36.159.471	1.360
New Zealand	5.419	1.594	5.310.735	1.585
Turkey	47.204	807	56.173.035	1.002
Rest of OECD	**121.794**	**1.140**	**134.215.841**	**1.302**

On the basis of the above results, the producible PV rooftop electric energy has then been compared with the overall final electricity consumption of same OECD countries, to quantify the share of overall consumptions, which can be covered by PV rooftop power.

In the remaining OECD countries (excluding EU, USA, Japan), the 1990 potential contribution of PV rooftop power would be roughly 1300 kWh/year per inhabitant equalling more than 19 % of final electricity consumptions.

The following table 5.9 and related figure 5.4 show in addition a comparison with the present **hydropower contribution** to electricity consumption in the investigated OECD countries. The purpose of this comparison was to provide a rough quantification means for the maximum Solar PV power contribution, which the utility network would be able to absorb without need for significant changes in present network management techniques (for more details see corresponding chapter for whole world potential calculation).

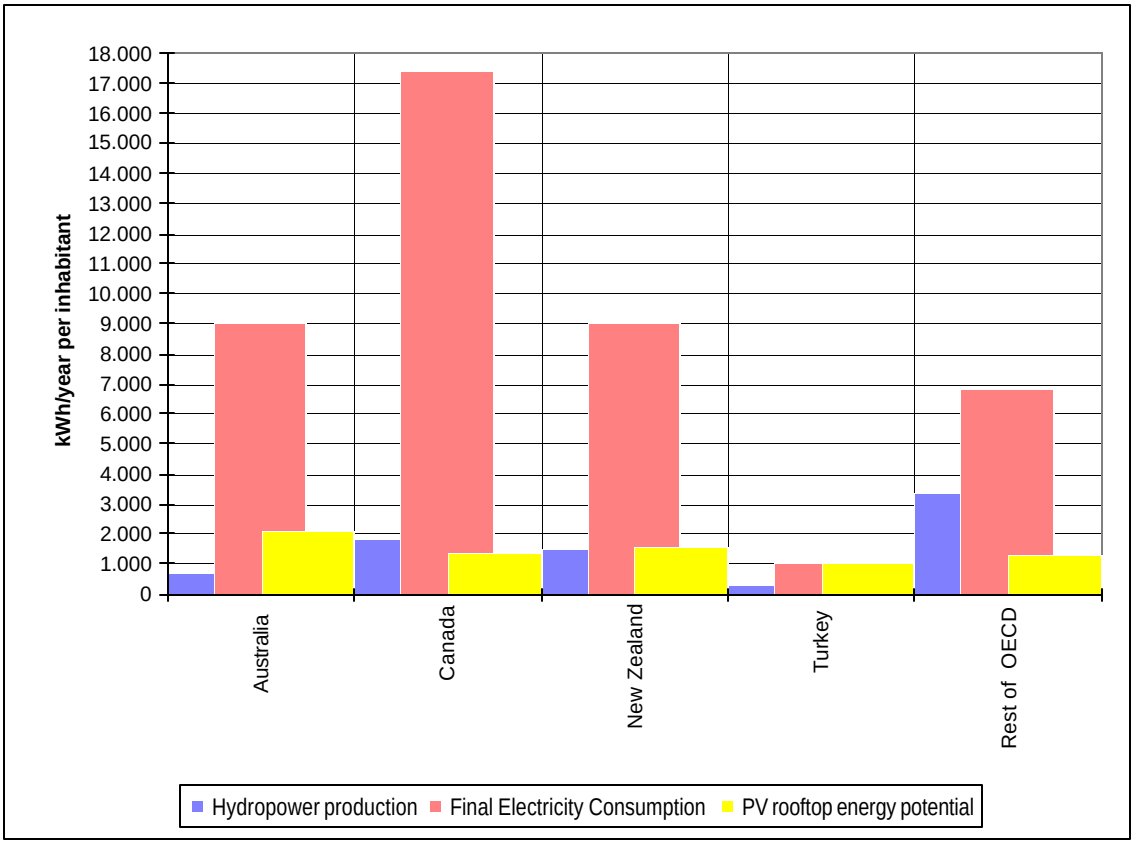
On the other hand, in case that distributed PV generation capacities are installed primarily in areas presenting a significant share of air conditioning consumptions, this will, to a large extent, allow to compensate this kind of problem, since the resulting daily load profile meets the daily solar energy availability curve.

Table 5.9 - Todays potential PV Rooftop share as compared to Final Electricity Consumption

Countries	*Final Consumption of Electricity* *1990*		*PV Rooftop Potential Energy Share [*]* *1990*	*Actual Hydro Energy Share [*]* *1990*
	MWh/year	*kWh/year inhabitant*	*%*	*%*
Australia	155.077.000	9.074	23,6%	9,9%
Canada	463.334.000	17.432	7,8%	65,0%
New Zealand	30.158.000	9.002	17,6%	19,2%
Turkey	55.906.000	997	100,5%	41,5%
Rest of OECD	**704.475.000**	**6.834**	**19,1%**	**49,0%**

[*] as compared to total final electricity consumption

Figure 5.4 - Comparison between PV rooftop potential, final electricity consumption and hydropower share in the rest of OECD Countries (1990)



5.3.2.3 Grid-connected diffused application potential demand forecast

The potential market forecast for year 2010 specifically for grid-connected small-scale PV systems (rooftops and similar) has been extrapolated for the investigated rest of OECD countries, following same assumptions and procedures as presented in the corresponding chapter for the whole world potential calculation.

Tables 5.10, 5.11 and 5.12, as well as figure 5.5 produce a synthetic overview of relevant results.

Table 5.10 - Forecast for year 2010 of available net solar rooftops in rest of OECD countries

Countries	*Available net Solar surface year 2010*	
	TOTAL *km2*	*per capita* *m2/ inhabitant*
Australia	265	12,2
Canada	413	13,0
New Zealand	50	12,9
Turkey	523	6,7
Rest of OECD	**1.273**	**9,4**

Table 5.11 - Forecast for year 2010 of installable PV rooftop Capacities in remaining OECD Countries

Countries	*Installable PV Capacity year 2010*		*Producible PV Energy year 2010*	
	MWp	*Wp/ inhabitant*	*MWh/year*	*kWh/year inhabitant*
Australia	43.897	2.029	61.456.001	2.840
Canada	68.556	2.150	57.587.360	1.806
New Zealand	8.374	2.147	8.206.059	2.104
Turkey	86.711	1.117	103.185.630	1.330
Rest of OECD	**211.231**	**1.564**	**230.435.051**	**1.707**

Table 5.12 - Forecast for year 2010 of potential PV Rooftop share in remaining OECD Countries as compared to Final Electricity Consumptions

Countries	*Final Consumption of Electricity* *year 2010*		*PV Rooftop Energy Share [*]* *year 2010*	*Hydro Energy Share [*][**]* *year 2010*
	MWh/year	*kWh/year inhabitant*	*%*	*%*
Australia	261.176.217	12.071	23,5%	5,9%
Canada	736.296.500	23.086	7,8%	40,9%
New Zealand	47.979.100	12.302	17,1%	12,0%
Turkey	100.860.067	1.300	102,3%	23,0%
Rest of OECD	**1.146.311.883**	**8.489**	**20,1%**	**30,1%**

[*] as compared to total final electricity consumption
[**] hydro energy production (in MWh/year) assumed equal to year 1990

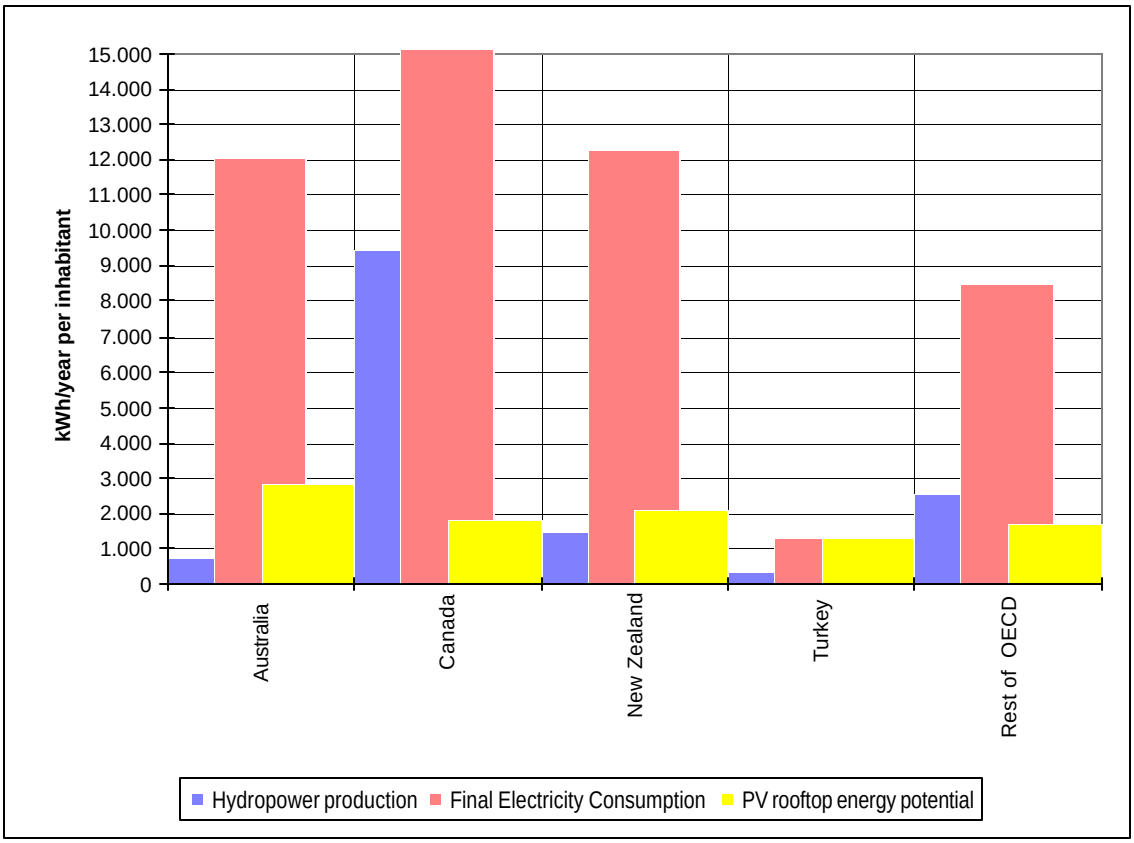



Figure 5.5 - Comparison between PV rooftop potential, final electricity consumption and hydropower share in remaining OECD countries (year 2010)