IEA INTERNATIONAL ENERGY AGENCY

Potential for Building Integrated Photovoltaics

Achievable levels of electricity from photovoltaic roofs and façades: methodology, case studies, rules of thumb and determination of the potential of building integrated photovoltaics for selected countries

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Report IEA - PVPS T7-4 : 2002 (Summary)

Photos on the cover

Façade integrated photovoltaic power station (47 kWp). Within the frame of refurbishment work on so-called „Plattenbauten“ in Berlin-Marzahn in former German Democratic Republic / East Germany. Source: Marcel Gutschner

Roof integrated photovoltaic power station (50 kWp) on the roof of the main station in Zurich, Switzerland. Source: energieburo® Zurich

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 amongst 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 concerned with the application of photovoltaic conversion of solar energy into electricity. The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (Tasks) is the responsibility of Operating Agents. Currently activities are underway in seven Tasks.

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

Within PVPS, Task 7 is the international collaborative effort focusing on building integrated PV, linking developments in IEA countries world wide. The overall objective of Task 7 is to enhance the architectural quality, technical quality and economic viability of photovoltaic power systems in the built environment and to assess and remove non-technical barriers for their introduction as an energy-significant option. Task 7 started its work in January 1997, building on previous collaborative actions within IEA (Task 16 of the Solar Heating and Cooling Programme).

The primary focus of this Task is on the integration of PV into the architectural design of roofs and façades for all types of building and other structures in the built environment (such as noise barriers). Task 7 motivates the collaboration between urban planners, architects, building engineers, PV system specialists, utility specialists, the PV and building industry and other professionals involved in photovoltaics.

More information on the activities and results of the Tasks can be found on www.iea-pvps.org.

This report has been prepared under the supervision of PVPS Task 7 by:

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in co-operation with the following countries: Australia, Austria, Germany, Japan, the Netherlands, Spain, Sweden, United Kingdom and the United States of America,

and approved by the PVPS programme Executive Committee.

The report expresses, as nearly as possible, an international consensus of the opinions on the subject dealt with. The full technical report* is available for IEA member country participants on request from

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Introduction

The interest in photovoltaics is growing rapidly world wide. In OECD countries, one of the main focus areas in the introduction of photovoltaics as renewable energy power source is the use of building surfaces for photovoltaic installations. To support the development of sound market introduction policies for photovoltaics, it is valuable to have knowledge of achievable contributions of photovoltaics to renewable energy portfolios, given the availability of building surfaces.

In order to assess the potential of building integrated photovoltaics (BIPV), an analysis of the building stock with respect to suitability of the building skin for photovoltaic deployment is required. Some building surfaces will have technical limitations, others will have limited capabilities to generate photovoltaic power due to inadequate orientation, inclination or shading effects. In this report, the available area corrected for photovoltaic suitability is referred to as the BIPV potential. The assessed BIPV potential thus comprises the area in the building stock that is suitable for photovoltaic use under architectural and solar aspects.

To analyse and compare different building and solar data sets as well as potential studies already carried out around the world can help to model an approach to calculate the BIPV potential with its essential elements and to develop comprehensive easy-to-use rules of thumb. Finally, BIPV potential figures calculated using different methodologies are confirmed thanks to the knowledge acquired and the approach validated on an international level.

The objectives of this study are with respect to (the determination of) the BIPV potential:

- to assess and compare different approaches, potential estimates and case studies
- to formulate an accepted and validated methodology
- to develop a comprehensive set of rules of thumb

In the end, the BIPV potential calculations and estimates lead to a number of general findings useful to incorporate in future photovoltaic roadmaps. The report is structured according to the objectives set.

Methodology

The existing different approaches and data sets imply, of course, studies of lower, intermediate and higher accuracy. A number of potential studies have either rough assumptions or a poor data base and therefore low accuracy. This can be justified by hinting at the "huge" area potential and at the fact that photovoltaics still experiences economic restrictions much more than technical ones. Nevertheless, it would be appropriate to use the most specific data sets and methods taking into account the main aspects described in the approach used in the report. Accurate BIPV potential studies are part of the fundamental base to evaluate the market potential and their target and focus groups, to assist the photovoltaic industry and the building sector (with respect of BIPV products), utilities, energy policy makers and to provide information to planners and lawmakers.

An assessment of the BIPV Potential starts with a determination of the total roof and façade area, which is subsequently corrected for architectural suitability for solar utilisation. For most countries and regions, hardly any direct statistical information concerning roof and façade areas is available. However, in the methodology presented in this report, BIPV potential calculations are based on ground floor area figures, which are transformed into roof and façade surface figures. The BIPV potential can subsequently be calculated by applying factors for solar yield and architectural suitability to the gross roof and façade surfaces.

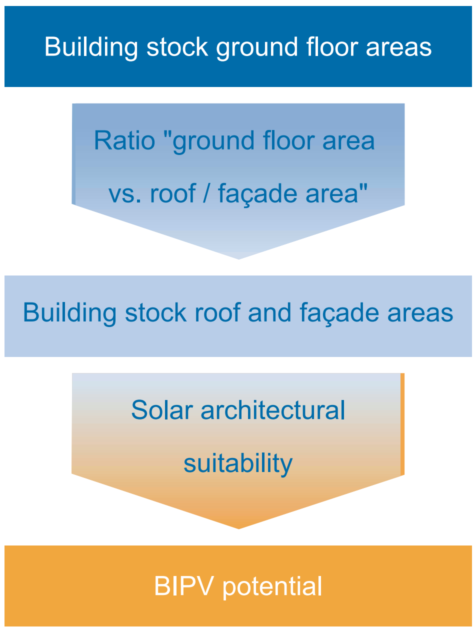


***Figure 1**: Most significant terms and factors for the BIPV potential*

Architectural and solar suitability are described as follows:

- Architectural suitability includes corrections for limitation due to construction (HVAC installations, elevators, terraces, etc.), historical considerations, shading effects and use of the available surfaces for other purposes.
- Solar suitability takes into account the relative amount of irradiation for the surfaces depending on their orientation, inclination and location as well as the potential performance of the photovoltaic system integrated in the building.

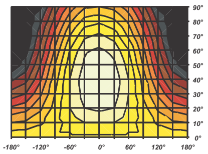
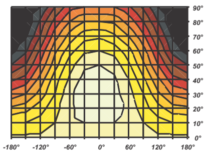
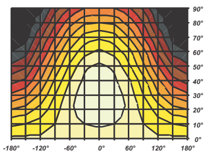
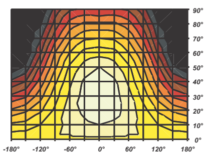
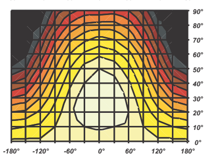
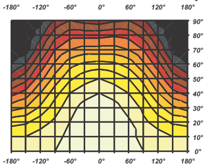
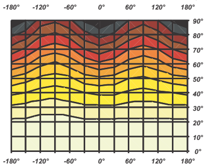
Solar-architectural suitability is expressed in relative terms and results in utilisation factors.

These utilisation factors reflect the BIPV potential in most significant relative terms. In order to extract absolute figures in square meters and kilowatt hours, the relative figures have to be combined with the building areas and the solar irradiation available.

Factors for moving from ground floor area to roof and façade surface area, as well as for solar and architectural suitability, can be derived by analysing representative samples with a limited number of buildings and sections of a particular building stock, and then up-scaling the results to the overall building stock. This sampling demands some resources and is part of an accurate methodology, which has been applied in Switzerland to a number of cities and states [Gutschner/Nowak, 1997 - 1999].

As presented in this summary, it appears that now sufficient data and methodological knowledge is available to derive some general factors for calculation of the BIPV potential, given a specific building stock.

Table 1*: Annual solar yield (irradiation on the surface) for the various elements of the building envelope and for different locations on the globe. Azimuth: 0° for equator direction, +values for west orientation, -values for east orientation, 180° for pole direction. Colours: light yellow is for solar yield over 90%, dark yellow for 80 - 90%, orange for 70 - 80% and red for 60-70%. Source: Meteonorm for absolute maximum values, PVSYST3.1 for relative values, NET for graphical design.*

	Place	*Flat roof*	*Sloped roof*	*Façade*
	**Stockholm** Latitude: 59.1° N Longitude: 17.6° E Altitude: 5 m Best solar yield: 1 145 kWh/m²	Solar yield: 84%	Best tilt: 40° Good yield area on south axis: 0° to 85° Good yield area for 30° tilt: -90° to +90°	Best azimuth: 0° Best yield: 75% Good yield area: -80° to +80°
	**Zurich** Latitude: 47.4° N Longitude: 8.6° W Altitude: 556 m Best solar yield: 1 167 kWh/m²	Solar yield: 91%	Best tilt: 30° Good yield area on south axis: 0° to 75° Good yield area for 30° tilt: -110° to +110°	Best azimuth: 0° Best yield: 65% Good yield area: -100° to +100°
	**Tokyo** Latitude: 35.3° N Longitude: 139.5° E Altitude: 5 m Best solar yield: 1 350 kWh/m²	Solar yield: 91%	Best tilt: 26° Good yield area on south axis: 0° to 75° Good yield area for 30° tilt: -105° to +105°	Best azimuth: 0° Best yield: 65% Good yield area: -90° to +90°
	**Los Angeles** Latitude: 33.5° N Longitude: 118.1° W Altitude: 10 m Best solar yield: 2 103 kWh/m²	Solar yield: 89%	Best tilt: 28° Good yield area on south axis: 0° to 70° Good yield area for 30° tilt: -100° to +100°	Best azimuth: ±30° Best yield: 61% Good yield area: -95° to +95°
	**Sydney** Latitude: 33.5° S Longitude: 151.2° E Altitude: 5 m Best solar yield: 1 744 kWh/m²	Solar yield: 91%	Best tilt: 30° Good yield area on north axis: 0° to 70° Good yield area for 30° tilt: -105° to +105°	Best azimuth: ±30° Best yield: 63% Good yield area: -95° to +95°
	**Mexico City** Latitude: 19.2° N Longitude: 99.1° W Altitude: 2277 m Best solar yield: 1 903 kWh/m²	Solar yield: 95%	Best tilt: 18° Good yield area on south axis: 0° to 60° Good yield area for 30° tilt: -120° to +120°	Best azimuth: ±60° Best yield: 55% Good yield area: -115° to +115°
	**Singapore** Latitude: 1.1° N Longitude:104.1° E Altitude: 5 m Best solar yield: 1 626 kWh/m²	Solar yield: 100%	Best tilt: 0° Good yield area on south axis: 0° to 45° Good yield area for 30° tilt: -180° to +180° (all around)	Best azimuth: ±90° Best yield: 54% Good yield area: -20° to -160° and +20° to +160°

Analysis and comparison of existing BIPV potential estimates and case studies

The methodology is useful to analyse and compare a set of available estimates and case studies. The different case studies show the wide range and variety of methods how to assess the BIPV potential. The partly very diverging results communicated so far can be explained by differences in the building stock but a great deal is due to methodological differences, especially the way of evaluating architectural and solar suitability. Keeping the key criteria in mind, general figures can be derived from the case studies and data gathered from the countries involved in this report.

Architectural suitability

A cross country weighted value for the suitable part of the building area taking into account constructions, shading and historical elements is on average 60% for roof areas and 20% for façade areas.

Solar suitability

A "good" solar yield is – allowing some simple but corroborated generalisation of hourly, daily, seasonal and annual solar yield values - understood as 80% of the maximum local annual solar input, separately defined for slope roofs and façades and individually for each location. Allowing only roof or façade areas with solar yields above this threshold reduces the available area potential depending on the solar conditions in the specific location. By combining database figures on the building stock with relevant data on the solar conditions (see table 1 on previous page), overall figures for the solar architectural suitability can be calculated in relative terms expressed as the solar utilisation factor. This factor is close to 50% for facades, and approximately 55% for roofs.

Solar architecturally suitable area

As stated earlier, the architecturally suitable part of building surfaces is 60% for roofs and 20% for façades. Of this architecturally suitable building area, about half of the does obtain a good solar yield, this is the case for 55% for roof areas and 50% for façade areas. Finally, based on these two figures, the ratio "solar architecturally suitable area / ground floor area" (called the "utilisation factor") can be calculated. A ground floor area of 100 m^2 results correspondingly in 40 m^2 of solar-architecturally suitable roof area (utilisation factor of 0.4) and in 15 m^2 of solar-architecturally suitable façade area (utilisation factor of 0.15).

***Table 2**: Solar-architectural rules of thumb for BIPV potential calculation*

Solar architectural rules of thumb for BIPV potential on...			
	...roofs		*...façades*
Ground floor area	1 m^2	Base of BIPV potential in relative terms	1 m^2
Gross area	1.2 m^2	Ratio " gross area / ground floor area"	1.5 m^2
	60%	Suitable building envelope parts taking into account construction, historical and shading elements, including vandalism factor	20%
Architecturally suitable area	0.72 m^2	Ratio " architecturally suitable area / ground floor area"	0.3 m^2
	55%	Suitable building envelope parts taking into account sufficient solar yield	50%
Solar architecturally suitable area	0.4 m^2	Ratio " solar architecturally suitable area / ground floor area" (utilisation factor)	0.15 m^2

It can be stated that the relative values reflected in the utilisation factors have limited variation and are relatively coherent on an international level between countries and world regions. The absolute figures for the BIPV potential in square meters vary much more, even when the ground floor area per capita is taken into account.

Rules of thumb

Based on the case studies and further data sent by the partners of the participating IEA countries, some rules of thumb can be derived, as shown in table 2. The methodology can be used in order to seize essential global figures and generate corroborated BIPV area potential data.

Rules of thumb for solar architecturally suitable building envelope area in absolute terms for Central Western Europe

The ground floor area can be aggregated, e.g. for Central Western Europe. A typical statistical building for a person living in Central Western Europe has about 45 m^2 of ground floor area. Half of it is used for residential purposes, 7 m^2 for the primary sector, 6 m^2 each for the secondary sector and for the tertiary sector and the rest for other purposes.

Applying the corresponding overall utilisation factor of 0.4 for roofs and 0.15 for façades (for the building stock), the solar-architecturally suitable building roof and façade areas per capita are calculated for Central Western Europe.

There are 18 m² of roof area per capita potentially usable for photovoltaics with a good solar yield. Additionally, there are 6.5 m² of façade area per capita fulfilling solar architectural requirements hence potentially usable for photovoltaics. About 3/4 of the BIPV area potential is attributed to roof areas, about 1/4 to façade areas.

The statistical building is - compared to the ground floor area of 45 m² per capita for Central Western Europe - much bigger in the US and Australia, where the ground floor area is about double. This is mainly due to much higher values for available residential building areas. Consequently, the share of ground floor area for residential purposes is bigger and makes up around 2/3. Japan, on the other hand, has just 20 m² of ground floor area.

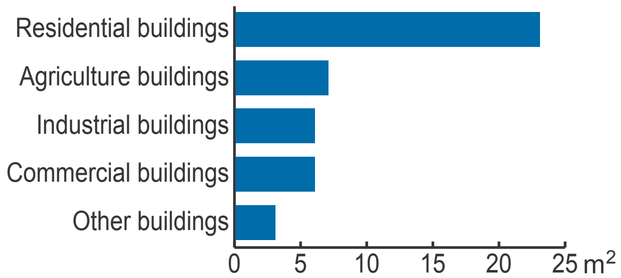


***Figure 2**: Use of the ground floor area of a statistically typical building in Central Western Europe (45 m²)*

***Table 3**: BIPV potential for Central Western Europe for roof and façade areas in m² per capita*

BIPV potential for Central Western Europe per capita on...		
...roofs		*...faç ades*
9 m²	Residential buildings	3.5 m²
3 m²	Agriculture buildings	0.5 m²
2.5 m²	Industrial buildings	1 m²
2.5 m²	Commercial buildings	1 m²
1.5 m²	Other buildings	0.5 m²
18 m²	**All buildings**	**6.5 m²**

Determination of the BIPV potential for selected IEA countries

Linking the average figures of solar-architecturally suitable area per capita to country-specific features (mainly population size and annual solar irradiation) the solar electricity potential can be calculated.

More precisely, the formula ingredients are:

- Building type: residential, agriculture (primary sector), industry (secondary sector), commercial (tertiary sector), other and total (all building stock)
- Available area per capita: average figures / standards. The values are given in m².
- Utilisation factor (suitability in relative terms) of 0.4 for roofs and 0.15 for façades*
- Population size: number of people living in the country in millions
- Solar yield: weighted average relative yield of good areas per geographical unit (here: countries)
- Solar irradiation: country-specific weighted value for the maximum annual solar input in kWh/y/m²
- Global conversion efficiency: ratio of „electricity output / solar irradiation" (simplified ratio: generally 10%)
- Production of solar electricity: Product of the factors described above in TWh/y

* Further differentiation can be proceeded for the various building types (see first point mentioned)

Applying this calculation scheme leads to the following figures for the solar electric BIPV potential (see table 4 and 5 and figure 12).

Figures 4 - 11 illustrate some BIPV applications on different building types and parts of the building skin.

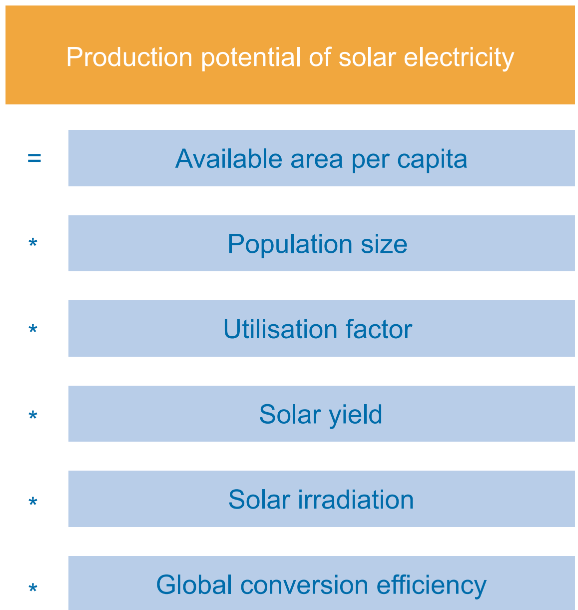


***Figure 3**: Calculation scheme for the production of BIPV solar electricity*

Table 4*: Solar electricity BIPV potential fulfilling the good solar yield (80% of the maximum local annual solar input, separately defined for slope roofs and façades and individually for each location / geographical unit). Source: IEA for electricity consumption in 1998*

Solar electricity BIPV production potential	Potential production of solar electricity (TWh/y) on roofs	Potential production of solar electricity (TWh/y) on façades	Potential productio of solar electricity (TWh/y) on buildin envelope	Actual electricity consumption (in TWh)	Ratio "solar electri production potenti electricity consumption"
Australia	68.176	15.881	84.057	182.24	46.1%
Austria	15.197	3.528	18.725	53.93	34.7%
Canada	118.708	33.054	151.762	495.31	30.6%
Denmark	8.710	2.155	10.865	34.43	31.6%
Finland	11.763	3.063	14.827	76.51	19.4%
Germany	128.296	31.745	160.040	531.64	30.1%
Italy	103.077	23.827	126.904	282.01	45.0%
Japan	117.416	29.456	146.872	1 012.94	14.5%
Netherlands	25.677	6.210	31.887	99.06	32.2%
Spain	70.689	15.784	86.473	180.17	48.0%
Sweden	21.177	5.515	26.692	137.12	19.5%
Switzerland	15.044	3.367	18.410	53.17	34.6%
United Kingdom	83.235	22.160	105.395	343.58	30.7%
United States	1 662.349	418.312	2 080.661	3 602.63	57.8%

Table 5*: BIPV area potential for roofs and areas of some selected IEA countries, differentiated according to residential, agriculture, industrial, commercial and other buildings (in km²) and fulfilling the good solar yield (80% of the maximum local annual solar input, separately defined for slope roofs and façades and individually for each location)*

BIPV area potential (in km²)		*Residential buildings*	*Agriculture buildings*	*Industrial buildings*	*Commercial buildings*	*Other buildings*	*All buildings*
Australia	Roof	373.50	22.50	6.00	16.5	3.75	422.25
	Façade	140.06	2.81	2.25	8.25	1.41	158.34
Austria	Roof	85.65	17.13	15.19	17.45	4.20	139.62
	Façade	32.12	2.14	5.70	8.73	1.58	52.36
Canada	Roof	727.20	36.36	60.60	133.32	6.06	963.54
	Façade	272.70	4.55	22.73	66.66	2.72	361.33
Denmark	Roof	50.88	14.84	10.60	10.60	1.06	87.98
	Façade	19.08	1.86	3.98	5.30	0.40	32.99
Finland	Roof	78.28	21.01	19.16	8.45	0.41	127.31
	Façade	19.08	1.86	3.98	5.30	0.40	32.99
Germany	Roof	721.78	164.04	229.66	164.04	16.40	1 295.92
	Façade	270.67	20.51	86.12	82.02	6.15	485.97
Italy	Roof	410.26	113.96	136.75	91.17	11.40	763.53
	Façade	153.85	14.25	51.28	45.58	4.27	286.32
Japan	Roof	753.88	40.48	75.89	91.07	5.06	966.38
	Façade	282.71	5.06	28.46	45.54	1.90	362.39
Netherlands	Roof	127.48	42.70	52.75	35.80	0.63	259.36
	Façade	47.81	5.34	19.78	17.90	0.24	97.26
Spain	Roof	251.97	78.74	55.12	55.12	7.87	448.82
	Façade	94.49	9.84	10.67	27.56	2.95	168.31
Sweden	Roof	134.52	36.11	32.92	14.51	0.71	218.77
	Façade	50.45	4.51	12.35	7.26	0.27	82.04
Switzerland	Roof	67.12	21.90	21.05	12.80	15.36	138.22
	Façade	25.17	2.74	7.89	6.40	5.76	51.83
United Kingdom	Roof	601.88	71.09	61.61	168.24	11.85	914.67
	Façade	225.70	8.89	23.10	84.12	4.44	343.00
United States	Roof	6 791.83	322.91	602.76	2 260.36	118.40	10 096.26
	Façade	2 546.94	40.36	226.04	1 130.18	44.40	3 786.10

***Figure 4**: Marchwart project with roof integrated PV installation 53 kWp on multi-family buildings in a residential area of Zurich, Switzerland. Source: Enecolo*

***Figure 5**: Langedijk solar and sustainable housing (some of the 2600 houses with 3775 kWp) in the Netherlands. Source: BEAR Architecten, photo: M. van Kerckhoven*

***Figure 6**: Children day care centre in Frankfurt, Germany with 10 kWp PV system positioned parallel to the glass house construction. Source: IEA PVPS T7 database*

***Figure 7**: National equestrian centre in Bern, Switzerland, with four roof slopes fully covered with sunslates (80.5 kWp). Source: Atlantis Solar Systems*

***Figure 8**: Children's Museum of Rome, Italy, with a semi-transparent canopy of 8.2 kWp solar power. Source: Abbate e Vigevano Architetti*

***Figure 9**: Industrial building with façade integrated PV system (8.4 kWp) at APS Photovoltaic Factory in Fairfield, California, USA. Source: DOE*

***Figure 10**: Commercial building with 214 kWp PV power incorporated in the skin of Kyocera headquarters in Kyoto, Japan. Source: Kyocera Corporation*

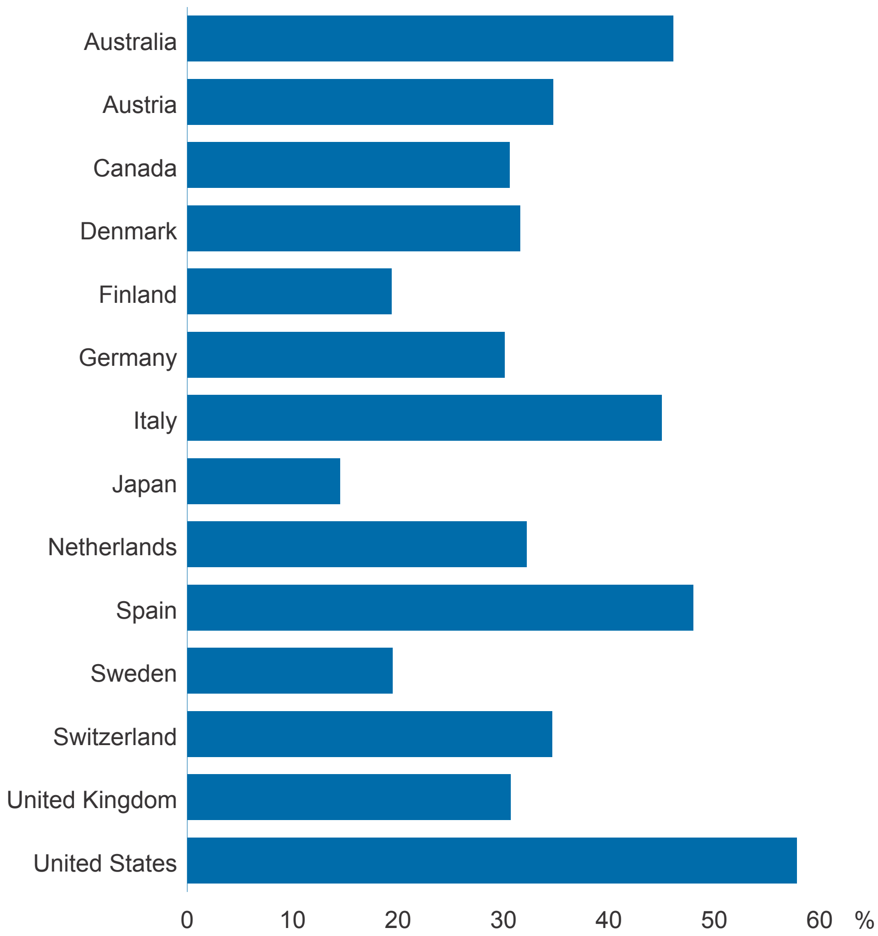
***Figure 11**: Superdome installation with 70.5 kWp of photovoltaic power at the Olympic stadium in Sydney. Source: University of New South Wales*

Conclusions and overall findings

Some general statements can be derived concerning the solar electricity production potential:

- Assuming good solar yield of about 80%, achievable levels (ratio "BIPV solar electricity production potential / current electricity consumption") of solar power production by photovoltaic roofs and façades vary from 15% to almost 60%. Applying some strict solar yield criterion of 90%, these achievable levels are almost reduced by a factor 2 (from 8% to 30%). If all the architecturally suitable building area is used, the achievable levels are nearly double (from 30% to almost 120%).
- The BIPV solar electricity production potential is even larger when a more progressive global conversion efficiency rate (more than 10% solar electricity output out of total solar energy irradiated) is assumed.
- The achievable levels depend (besides technical aspects) mainly on the building areas available and, obviously, on solar irradiation and the electricity consumption.
- The achievable levels are significantly higher for the US of America and Australia on one hand, and much lower for Japan on the other hand. This is mainly due to available building areas. Generally, it can be stated that densely populated areas tend to have less areas available per capita (e.g. Japan in the global IEA context, the Netherlands in the Central Western European context). The achievable levels are lower for Sweden because of the specific electricity use (high share of electricity in the energy consumption) although Sweden possesses an outstandingly (for European standards) high building area.
- There is an average of 18 m² roof area per capita potentially usable for photovoltaics in Central Western Europe. For the US/Australia, this figure is approximately 36 m², whereas in Japan only 8 m² are available per capita.
- For façades, there is about 6.5 m² of BIPV area per capita in Central Western Europe.
- Overall, about 3/4 of the BIPV area potential is attributed to roof areas, about 1/4 to façade areas.
- About 15% – 20% of the BIPV electricity production potential can be attributed to façade areas.
- Interestingly, the relative share of solar-architecturally suitable area is fairly coherent within and between the countries considered, i.e. the utilisation factor (ratio between suitable area and ground floor area) is 0.4 for roofs and 0.15 for façades. This enables one to assess the BIPV potential with easy-to-use rules of thumb.

***Figure 12**: Achievable levels of solar power production from photovoltaic roofs and façades in IEA countries. Levels are expressed in the ratio "solar electricity production potential / electricity consumption", given the solar yield criterion of 80% and an overall photovoltaic system efficiency of 10%.*



Glossary

Achievable levels of solar power production: are expressed in the ratio "solar electricity production potential / electricity consumption". They depend on the minimum solar yield criterion applied.

Available area: refers to gross building areas (ground floor area, roof area, façade area)

BIPV / Building integrated photovoltaics: photovoltaic systems integrated in the building skin, i.e. roofs and façades

Building stock: comprise all buildings / houses of an area given

Geographical unit: countries form the basic geographical unit to be considered within this study. Characteristics like building stock, climatic conditions in general, solar irradiation in particular, etc. depend on the location, spatial distribution. These characteristics are aggregated for the countries. An example: solar yield (criterion) is weighted for the whole building stock and is therefore an approximated figure for the geographical unit under consideration.

Global conversion efficiency: ratio of „electricity output / solar irradiation" (generally 10%)

Good solar yield (criterion): relative value of solar energy irradiated on a given surface is at least 80% of the maximum annual solar input of the best oriented surface

High solar yield (criterion): relative value of solar energy irradiated on a given surface is at least 90% of the maximum annual solar input of the best oriented surface

Photovoltaic / PV system efficiency: conversion ratio between solar yield (irradiation on the active surface) and the electrical output of the photovoltaic system.

Photovoltaics: technology directly transforming light into electricity

Solar yield (criterion): relative value of solar energy irradiated on a given surface in % of the maximum annual solar input of the best oriented surface (see also geographical unit)

Suitable area: refers to net building areas (roof and façade areas solarly and / or architecturally suitable for photovoltaics)

Utilisation factor: ratio "solar architecturally suitable area / ground floor area" (utilisation factor)

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