

Compared assessment of selected environmental indicators of photovoltaic electricity in OECD cities



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Electricity production based on solar photovoltaic (PV) technology is pollution-free at the local as well as the global level, it does not emit greenhouse gases, it does not dip into finite fossil fuel resources and it can be easily integrated into the urban environment, close to major consumption needs.

These particularities make PV one of the major and most suitable options in the mid-to long term future for producing electricity worldwide in OECD and non-OECD countries.

However, prior to producing electricity, manufacturing and installing PV systems and later on dismantling and recycling them at the end of their commercial life, require spending a certain amount of energy, which must be “reimbursed” before electricity from PV can be considered as renewable and clean.

Although this is no longer an issue among the scientific community and PV-related Industry, unfounded rumours still persist here and there that question the status of PV as a renewable energy, including an “infinite energy pay-back-time” and an overall negative impact on the global environment.

The purpose of the new report “Compared assessment of selected environmental indicators of photovoltaic electricity in OECD cities” published in April 2006 jointly by the International Energy Agency-Photovoltaic Power Systems Programme (IEA-PVPS), the European Photovoltaic Technology Platform and the European Photovoltaic Industry Association (EPIA) is to provide clear and well-documented answers to politicians, decision-makers and the general public about what PV can and cannot achieve in terms of renewable, clean energy production and environmental protection.



Based on a worldwide survey of existing studies concerning the energy input of PV systems, used to calculate the so-called “energy pay-back time” (defined as the time in years needed for a PV-system to “reimburse” its initial energy content) and the derived “energy return factor” (the number of times a PV system will reimburse its energy content during its commercial life cycle), and on commonly recognised and readily available data concerning pollution indicators such as CO₂ emissions in the electricity mixes of 26 OECD countries, this report provides clear and incontestable figures :

- The **energy pay-back time (EPBT)** of a complete PV system (not only panels, but also wires and electronic connexion devices) is, depending on the solar irradiation of its location, in the range of 19 months (just over one year and a half) to 40 months (three years and 4 months) for a roof-mounted system, and from 32 months (2 years and 8 months) to 56 months (4 years and 8 months) for a PV-façade.
- Based on a commonly admitted 30 year-long commercial life cycle, the **energy return factor (ERF)** is between 8 and 18 for roof-mounted systems, and between 5.4 and 10 for façades.
- Varying widely from one country to another, using the energy production mix from each country, 1 single kW of PV panels (roughly 10 square meters) can **avoid up to 40 tons of Carbon dioxide (CO₂)** during its whole commercial life cycle - 23.5 for a façade.

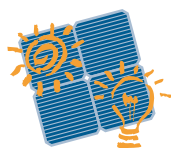
The complete report describes the methodology used for the calculation of the 3 indicators in relation with the location where the PV systems are installed: EPBT and ERF depend on the amount of sun at the location and the CO₂ indicator depends on the local electricity mix.

With a view to both better reflect the varying reality and to facilitate the use of the results at national and local levels by making customised figures available, the performance of PV systems is assessed in the full version on a country-by-country basis and even a city-by-city approach in larger countries where the potential for urban-scale integrated PV is highest, covering in total 41 main cities in 26 OECD countries.

These figures clearly demonstrate how beneficial urban-scale PV systems are for reducing the use of highly polluting conventional energy sources and for contributing to improving the general efficiency of large cities wherever they may be located worldwide.

With the publication of this report long-awaited for by the Industry and policy-makers, and expected to be largely authoritative and consensual, the authors and the publishers hope to definitively close some unjustified controversies that still prevent the large-scale development of PV in several countries, and to provide PV supporters who are more and more numerous worldwide with proven and indisputable arguments.

The full report prepared by Hespul with the support of the French Agency for Environment and Energy Management (ADEME) can be downloaded on the IEA-PVPS website www.iea-pvps.org.



IEA-PVPS Task 10

The Photovoltaic Power Systems Programme is a collaborative R&D Agreement, established within the International Energy Agency, and conducting projects on the application of solar photovoltaic electricity. The objective of Task 10 is to enhance the opportunities for wide-scale, solution-oriented application of photovoltaics (PV) in the urban environment as part of an integrated approach that maximizes building energy efficiency and solar thermal and Photovoltaics usage.

www.iea-pvps.org



European Photovoltaic Technology Platform

The Photovoltaic Technology Platform is an initiative which aims at mobilising all the actors **sharing a long-term European vision** for photovoltaic; realising the **European Strategic Research Agenda** for PV for the next decade(s) and give recommendations for implementation; ensuring that Europe maintains **industrial leadership**.

www.eupvplatform.org



European Photovoltaic Industry Association

With over 80 members drawn from across the entire solar electricity sector, the European Photovoltaic Industry Association **represents over 95% of the European photovoltaic industry**. EPIA represents the whole value-chain of the photovoltaic industry from silicon producers, cells and module manufacturers to system providers. The Association's mission is to deliver to its Members a distinct and valuable service driven from the strength of a single European photovoltaic (PV) voice.

www.epia.org



Country reports

The following 26 country reports are summarizing on a country-by-country basis the results for all OECD countries. For each country, the following elements are presented :

- A map shows the location of cities that were selected for the calculation of those indicators.
- For each city, a table summarises the value of each indicator calculated within the study and also gives specific data such as the global horizontal irradiation of the city and the estimated annual energy output of PV systems in kWh/kWp in this city.
- For each PV systems and each city, a figure gives the EPBT ranked from the shortest to the longest. It also shows the contribution of the laminate, the frame and the balance of system.
- For each city, a graph shows the net energy production over the system lifetime The negative value at year 0 corresponds to the energy required for manufacturing the PV system expressed in electrical energy (2 525 kWh/kWp). The year at which the curve crosses the x-axis is the EPBT and the value at year 30 is the net energy production over the system lifetime.

The 26 countries included in the report are the following :

- Australia
- Austria
- Belgium
- Canada
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Greece
- Hungary
- Ireland
- Italy
- Japan
- Republic of Korea
- Luxembourg
- The Netherlands
- New Zealand
- Norway
- Portugal
- Spain
- Sweden
- Switzerland
- Turkey
- United Kingdom
- United States

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Bear architects

Inside photos
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Design
Bliss communication - www.blisscommunication.be

Paper
Bio Top 3 (ecologically friendly paper)

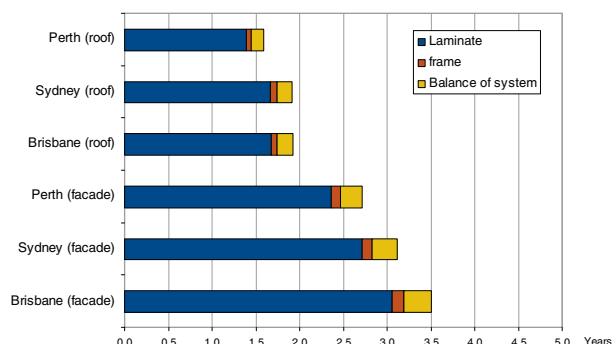


Location of studied cities

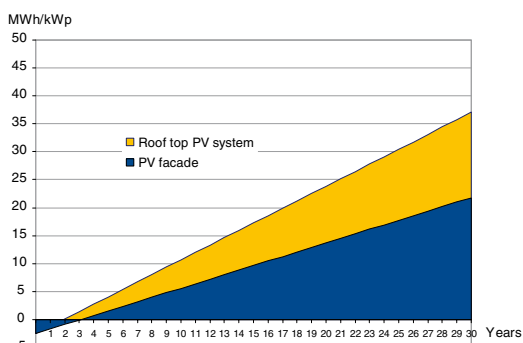
Sydney	Global horizontal irradiation 1614 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 319	811
Energy Pay-Back Time [years]	1,91	3,11
Energy Return Factor [number of times]	14,7	8,6
Potential for CO ₂ mitigation [tCO ₂ /kWp]	33,285	20,459

Perth	Global horizontal irradiation 1941 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 587	932
Energy Pay-Back Time [years]	1,59	2,71
Energy Return Factor [number of times]	17,9	10,1
Potential for CO ₂ mitigation [tCO ₂ /kWp]	40,028	23,503

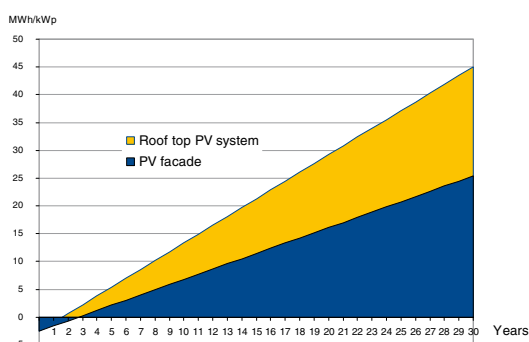
Brisbane	Global horizontal irradiation 1686 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 315	721
Energy Pay-Back Time [years]	1,92	3,50
Energy Return Factor [number of times]	14,6	7,6
Potential for CO ₂ mitigation [tCO ₂ /kWp]	33,174	18,182



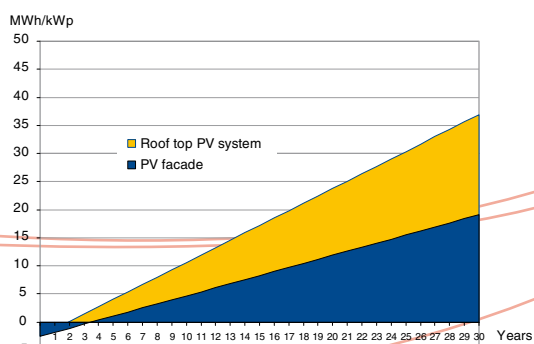
Energy Payback time



Cumulative net energy production over system lifetime for Sydney



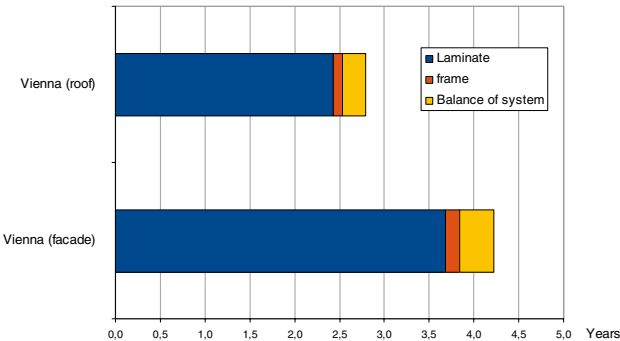
Cumulative net energy production over system lifetime for Perth



Cumulative net energy production over system lifetime for Brisbane

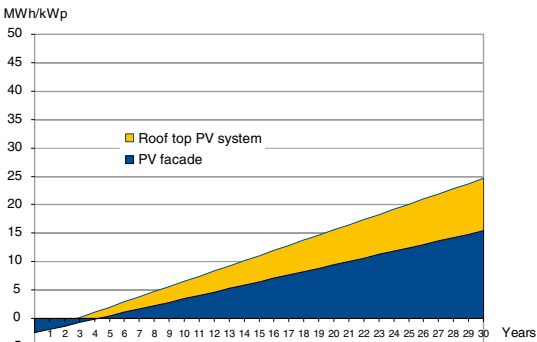


Location of studied city



Energy Payback time

Vienna	Global horizontal irradiation 1108 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	906	598
Energy Pay-Back Time [years]	2,79	4,22
Energy Return Factor [number of times]	9,8	6,1
Potential for CO ₂ mitigation [tCO ₂ /kWp]	5,742	3,793

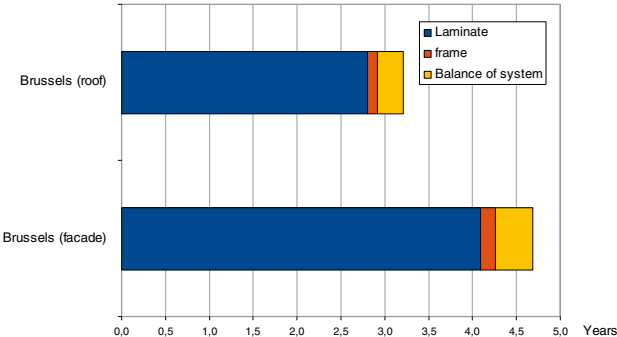


Cumulative net energy production over system lifetime for Vienna

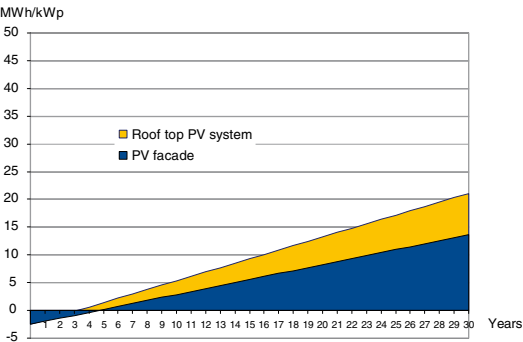


Location of studied city

Brussels	Global horizontal irradiation 946 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	788	539
Energy Pay-Back Time [years]	3,21	4,68
Energy Return Factor [number of times]	8,4	5,4
Potential for CO ₂ mitigation [tCO ₂ /kWp]	5,861	4,013



Energy Payback time

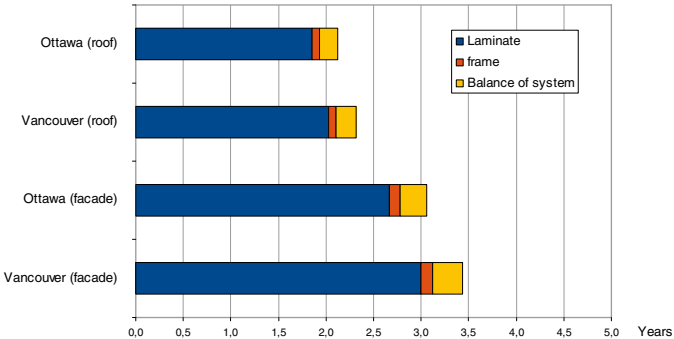


Cumulative net energy production over system lifetime for Brussels

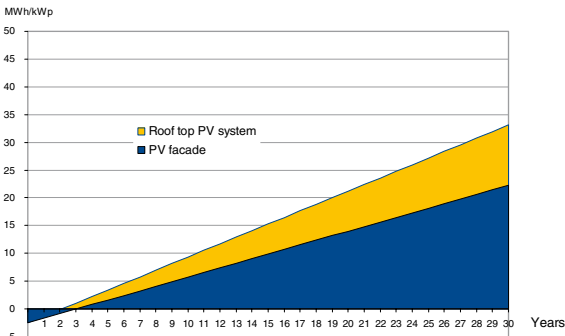


Location of studied cities

Ottawa	Global horizontal irradiation 1377 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 188	826
Energy Pay-Back Time [years]	2,13	3,06
Energy Return Factor [number of times]	13,1	8,8
Potential for CO ₂ mitigation [tCO ₂ /kWp]	8,659	6,024

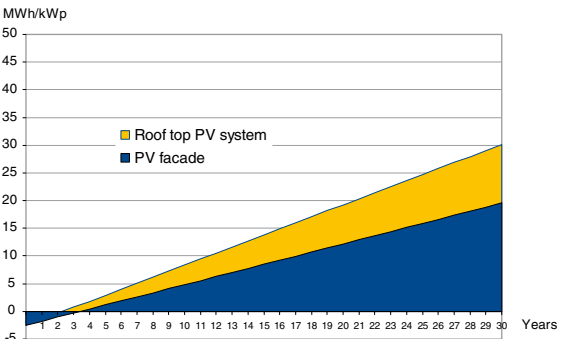


Energy Payback time



Cumulative net energy production over system lifetime for Ottawa

Vancouver	Global horizontal irradiation 1273 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 088	735
Energy Pay-Back Time [years]	2,32	3,44
Energy Return Factor [number of times]	11,9	7,7
Potential for CO ₂ mitigation [tCO ₂ /kWp]	7,935	5,360

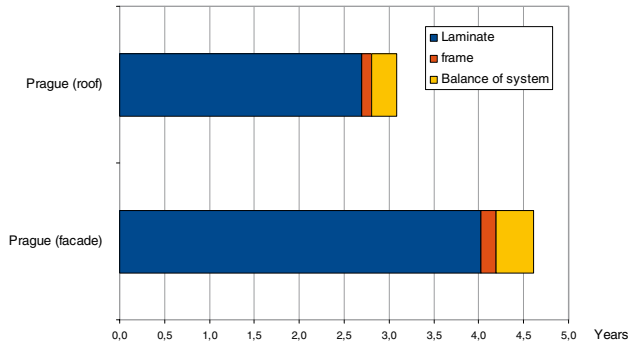


Cumulative net energy production over system lifetime for Vancouver

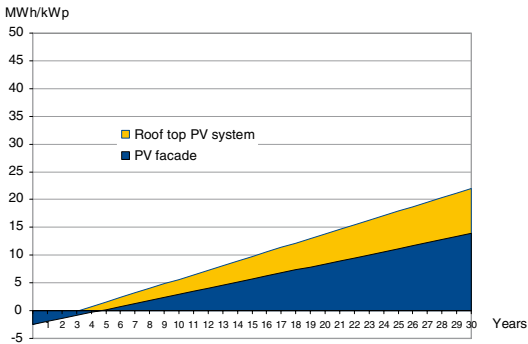


Location of studied city

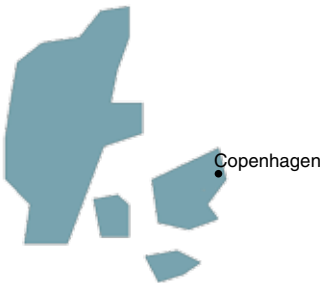
Prague	Global horizontal irradiation 1000 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	818	548
Energy Pay-Back Time [years]	3,09	4,61
Energy Return Factor [number of times]	8,7	5,5
Potential for CO ₂ mitigation [tCO ₂ /kWp]	12,685	8,495



Energy Payback time

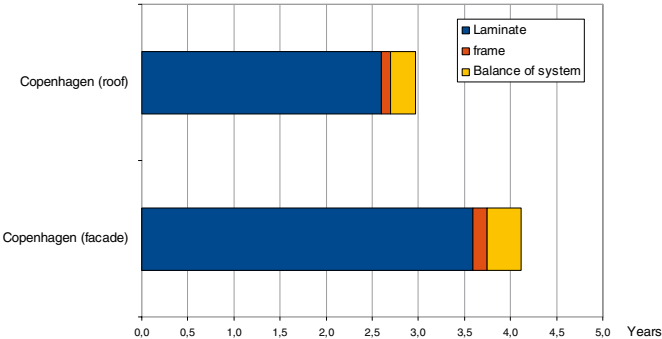


Cumulative net energy production over system lifetime for Prague

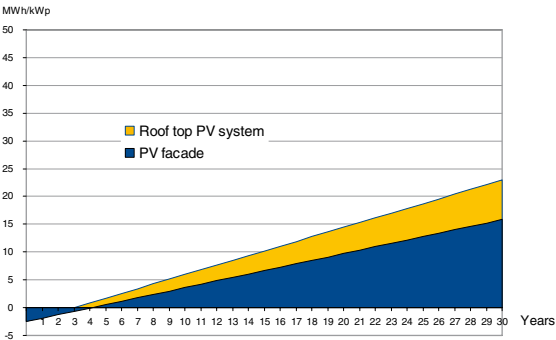


Location of studied city

Copenhagen	Global horizontal irradiation 985 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	850	613
Energy Pay-Back Time [years]	2,97	4,12
Energy Return Factor [number of times]	9,1	6,3
Potential for CO ₂ mitigation [tCO ₂ /kWp]	13,672	9,868



Energy Payback time

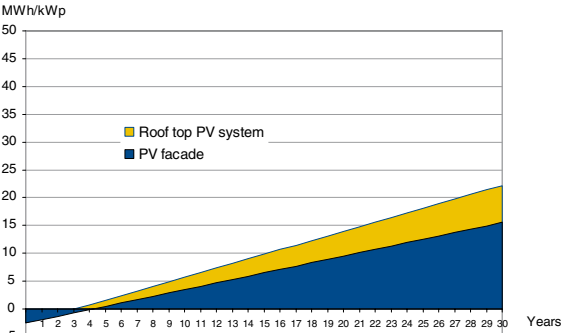
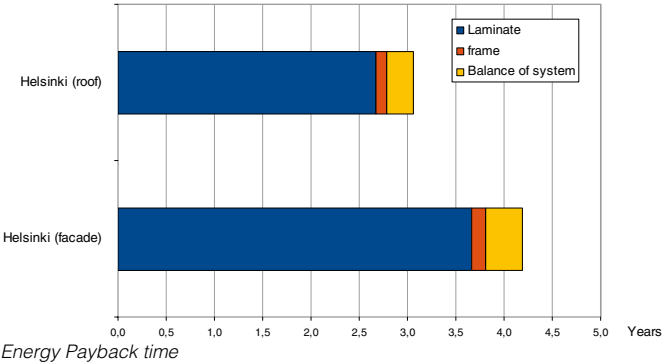


Cumulative net energy production over system lifetime for Copenhagen



Location of studied city

Helsinki	Global horizontal irradiation 956 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	825	602
Energy Pay-Back Time [years]	3,06	4,19
Energy Return Factor [number of times]	8,8	6,2
Potential for CO ₂ mitigation [tCO ₂ /kWp]	7,780	5,683

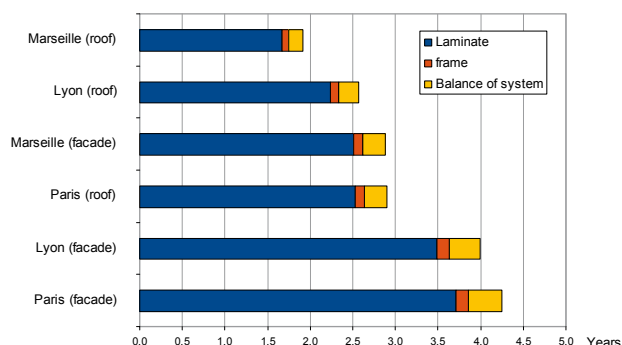


Cumulative net energy production over system lifetime for Helsinki

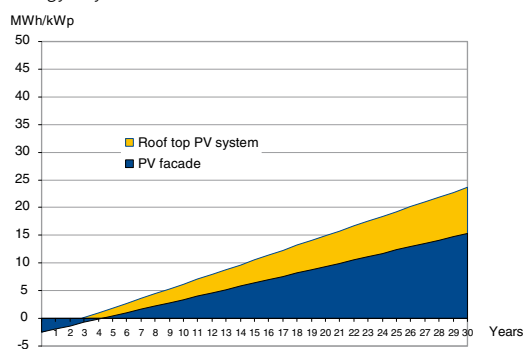


Location of studied cities

Paris	Global horizontal irradiation 1057 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	872	595
Energy Pay-Back Time [years]	2,90	4,25
Energy Return Factor [number of times]	9,4	6,1
Potential for CO ₂ mitigation [tCO ₂ /kWp]	2,095	1,428

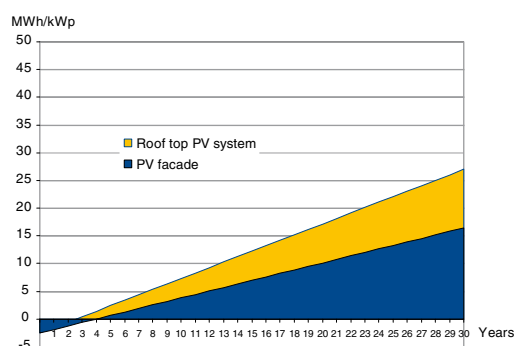


Energy Payback time



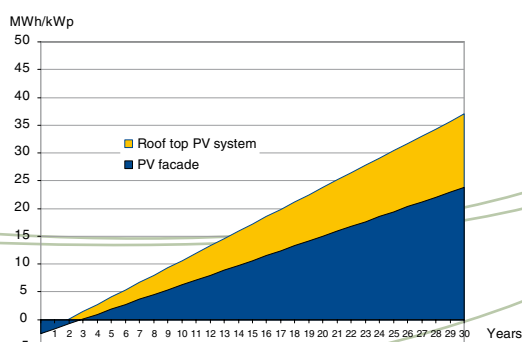
Cumulative net energy production over system lifetime for Paris

Lyon	Global horizontal irradiation 1204 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	984	632
Energy Pay-Back Time [years]	2,57	4,00
Energy Return Factor [number of times]	10,7	6,5
Potential for CO ₂ mitigation [tCO ₂ /kWp]	2,364	1,518



Cumulative net energy production over system lifetime for Lyon

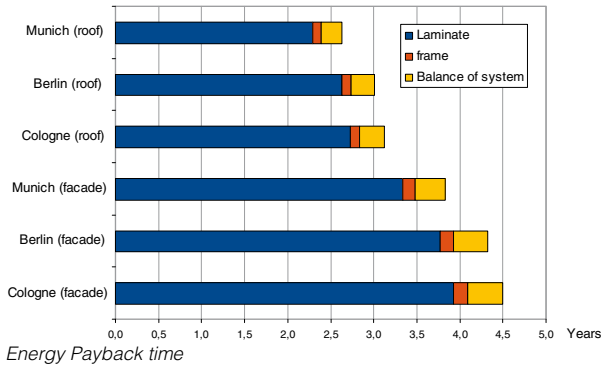
Marseille	Global horizontal irradiation 1540 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 317	878
Energy Pay-Back Time [years]	1,92	2,88
Energy Return Factor [number of times]	14,6	9,4
Potential for CO ₂ mitigation [tCO ₂ /kWp]	3,163	2,108



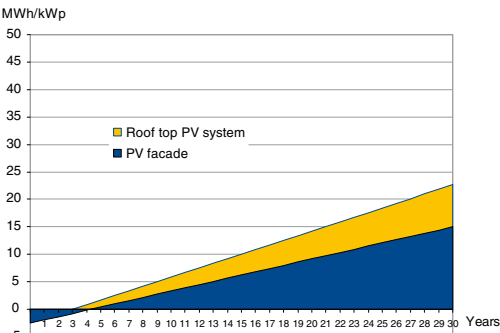
Cumulative net energy production over system lifetime for Marseille



Location of studied cities

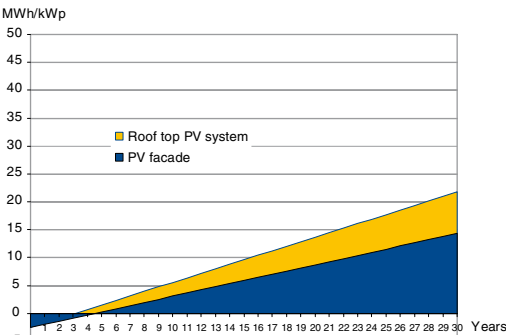


Berlin	Global horizontal irradiation 999 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	839	584
Energy Pay-Back Time [years]	3,01	4,32
Energy Return Factor [number of times]	9,0	5,9
Potential for CO ₂ mitigation [tCO ₂ /kWp]	14,445	10,060



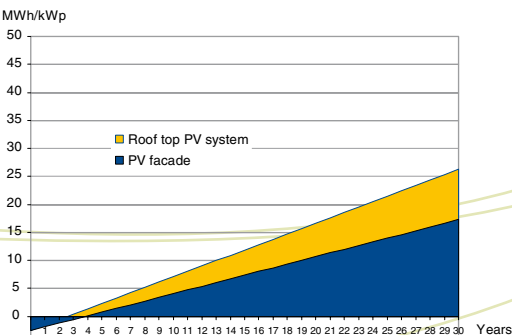
Cumulative net energy production over system lifetime for Berlin

Cologne	Global horizontal irradiation 972 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	809	561
Energy Pay-Back Time [years]	3,12	4,50
Energy Return Factor [number of times]	8,6	5,7
Potential for CO ₂ mitigation [tCO ₂ /kWp]	13,929	9,663



Cumulative net energy production over system lifetime for Cologne

Munich	Global horizontal irradiation 1143 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	960	660
Energy Pay-Back Time [years]	2,63	3,83
Energy Return Factor [number of times]	10,4	6,8
Potential for CO ₂ mitigation [tCO ₂ /kWp]	16,528	11,363

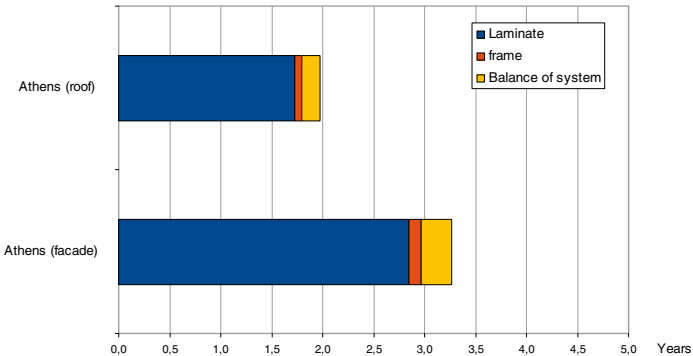


Cumulative net energy production over system lifetime for Munich

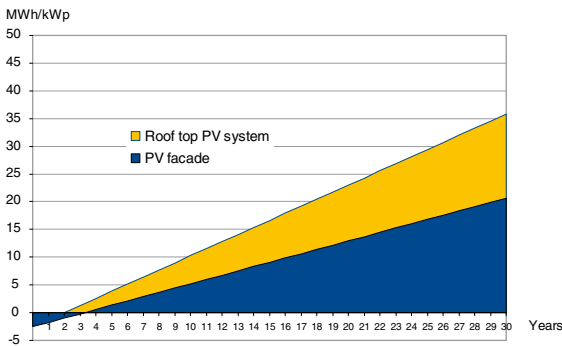


Location of studied city

Athens	Global horizontal irradiation 1563 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 278	774
Energy Pay-Back Time [years]	1,98	3,26
Energy Return Factor [number of times]	14,2	8,2
Potential for CO ₂ mitigation [tCO ₂ /kWp]	30,687	18,581



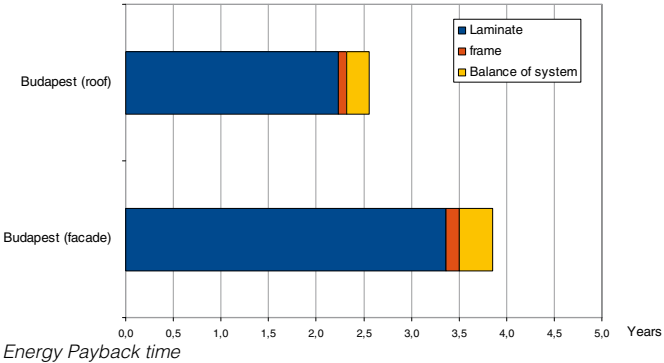
Energy Payback time



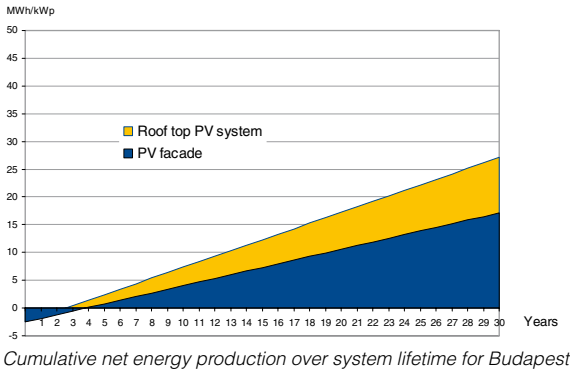
Cumulative net energy production over system lifetime for Athens

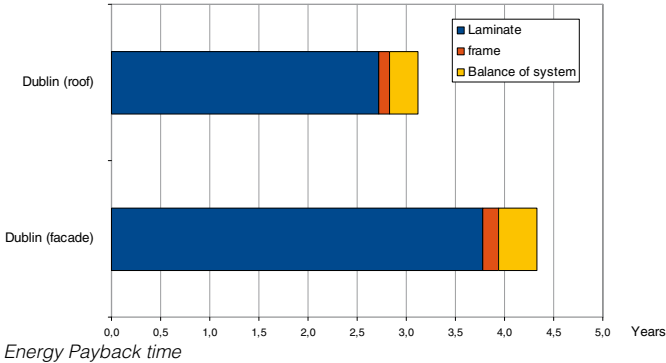


Location of studied city

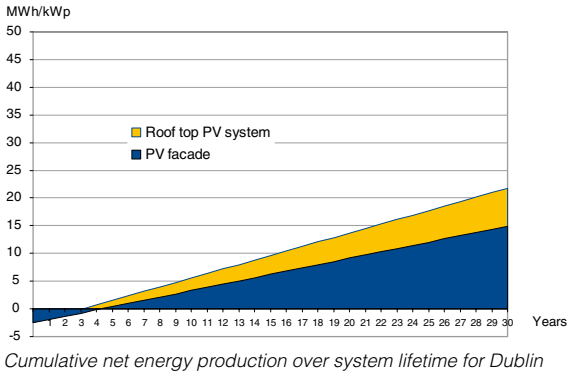


Budapest	Global horizontal irradiation 1198 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	988	656
Energy Pay-Back Time [years]	2,56	3,85
Energy Return Factor [number of times]	10,7	6,8
Potential for CO ₂ mitigation [tCO ₂ /kWp]	12,124	8,046





Dublin	Global horizontal irradiation 948 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	811	583
Energy Pay-Back Time [years]	3,12	4,33
Energy Return Factor [number of times]	8,6	5,9
Potential for CO ₂ mitigation [tCO ₂ /kWp]	15,602	11,223

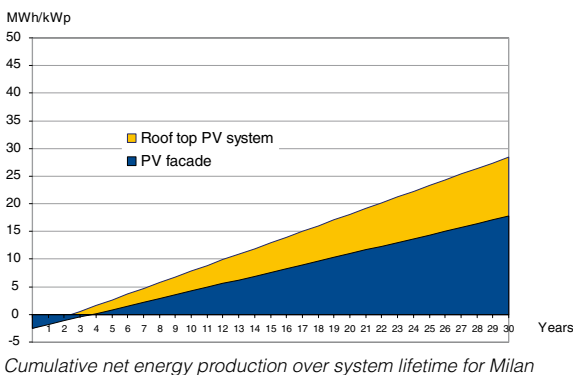
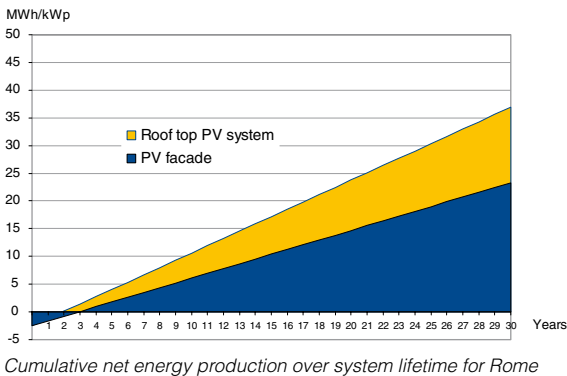
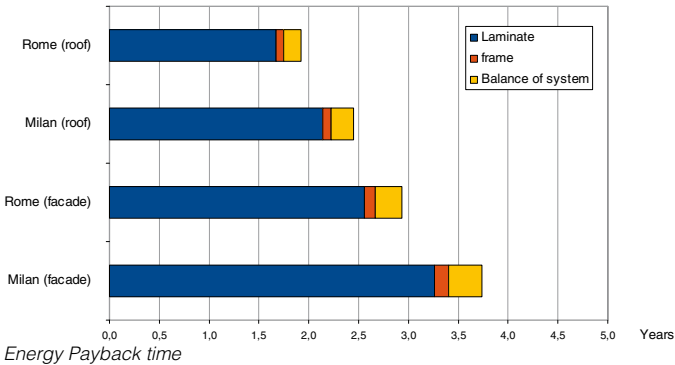




Location of studied cities

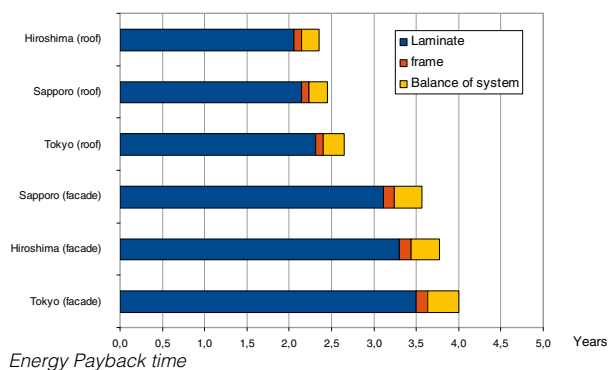
Rome	Global horizontal irradiation 1552 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 315	861
Energy Pay-Back Time [years]	1,92	2,93
Energy Return Factor [number of times]	14,6	9,2
Potential for CO ₂ mitigation [tCO ₂ /kWp]	22,441	14,696

Milan	Global horizontal irradiation 1251 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 032	676
Energy Pay-Back Time [years]	2,45	3,74
Energy Return Factor [number of times]	11,3	7,0
Potential for CO ₂ mitigation [tCO ₂ /kWp]	17,608	11,526

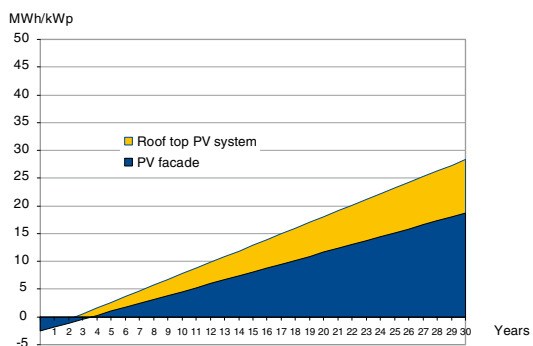




Location of studied cities

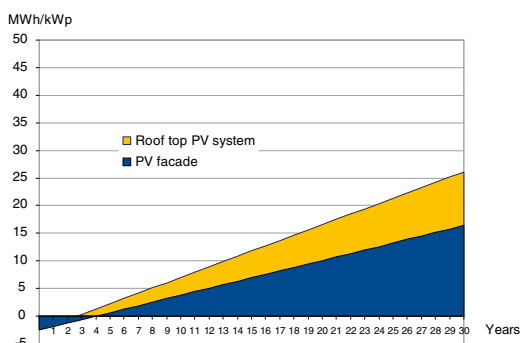


Sapporo	Global horizontal irradiation 1225 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 029	707
Energy Pay-Back Time [years]	2,45	3,57
Energy Return Factor [number of times]	11,2	7,4
Potential for CO ₂ mitigation [tCO ₂ /kWp]	15,673	10,775



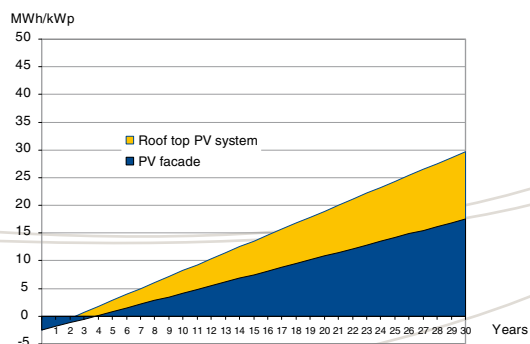
Cumulative net energy production over system lifetime for Sapporo

Tokyo	Global horizontal irradiation 1168 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	955	631
Energy Pay-Back Time [years]	2,64	4,00
Energy Return Factor [number of times]	10,3	6,5
Potential for CO ₂ mitigation [tCO ₂ /kWp]	14,544	9,607



Cumulative net energy production over system lifetime for Tokyo

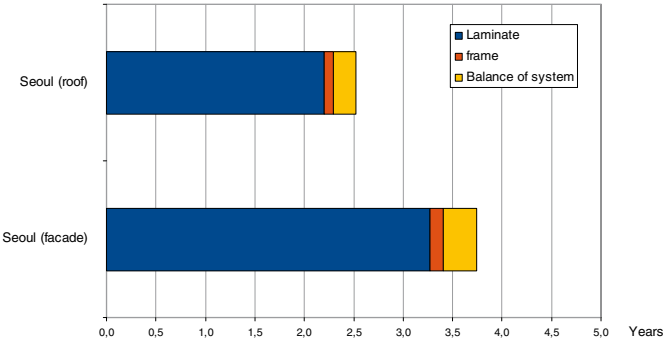
Hiroshima	Global horizontal irradiation 1350 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 073	668
Energy Pay-Back Time [years]	2,35	3,78
Energy Return Factor [number of times]	11,7	6,9
Potential for CO ₂ mitigation [tCO ₂ /kWp]	16,347	10,178



Cumulative net energy production over system lifetime for Hiroshima

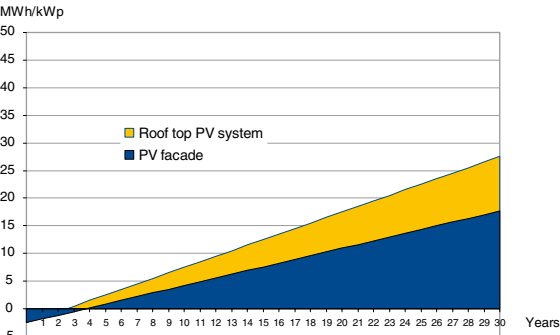


Location of studied city

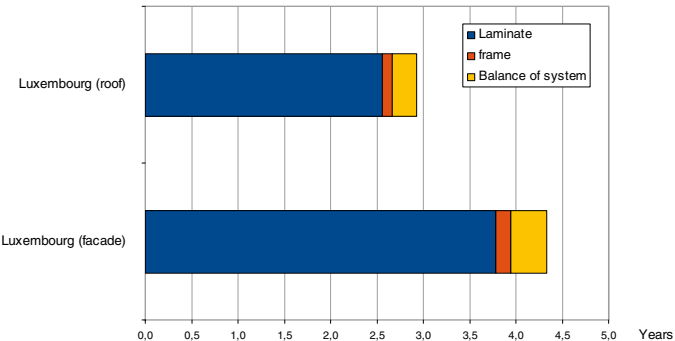


Energy Payback time

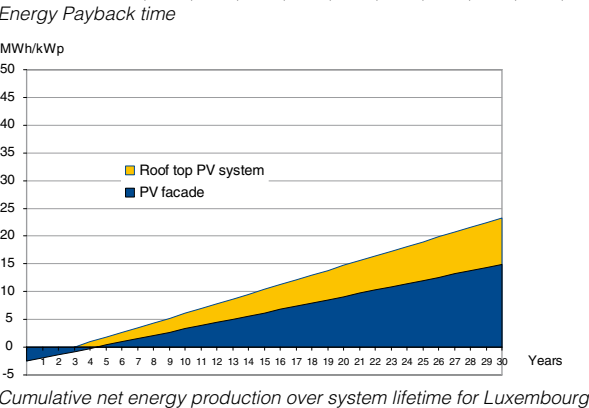
Seoul	Global horizontal irradiation 1215 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 002	674
Energy Pay-Back Time [years]	2,52	3,75
Energy Return Factor [number of times]	10,9	7,0
Potential for CO ₂ mitigation [tCO ₂ /kWp]	14,963	10,066



Cumulative net energy production over system lifetime for Seoul



Luxembourg	Global horizontal irradiation 1035 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	862	582
Energy Pay-Back Time [years]	2,93	4,34
Energy Return Factor [number of times]	9,2	5,9
Potential for CO ₂ mitigation [tCO ₂ /kWp]	7,628	5,154



THE NETHERLANDS

Compared assessment of selected environmental indicators
of photovoltaic electricity in OECD cities

International Energy Agency-Photovoltaic Power Systems Programme

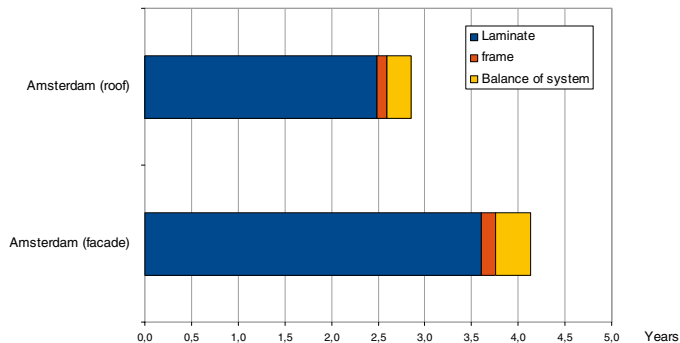
European Photovoltaic Technology Platform

European Photovoltaic Industry Association

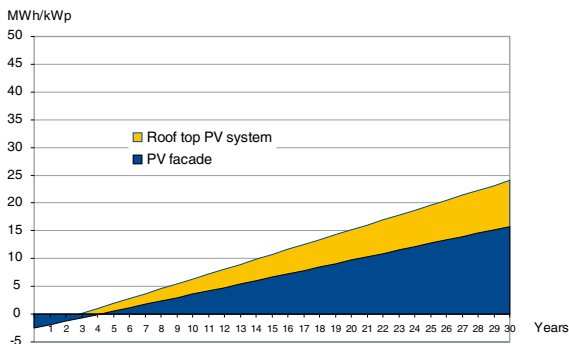


Location of studied city

Amsterdam	Global horizontal irradiation 1045 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	886	611
Energy Pay-Back Time [years]	2,85	4,13
Energy Return Factor [number of times]	9,5	6,3
Potential for CO ₂ mitigation [tCO ₂ /kWp]	13,599	9,387



Energy Payback time

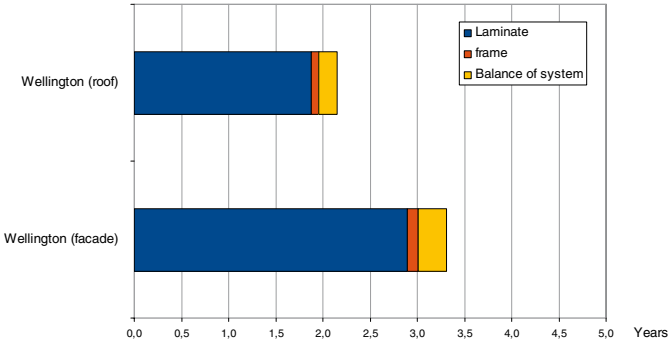


Cumulative net energy production over system lifetime for Amsterdam

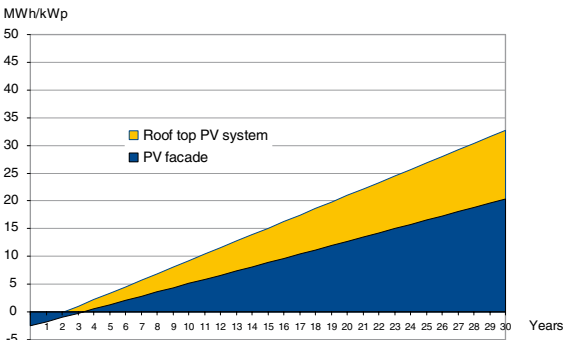


Location of studied city

Wellington	Global horizontal irradiation 1412 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 175	762
Energy Pay-Back Time [years]	2,15	3,31
Energy Return Factor [number of times]	13,0	8,1
Potential for CO ₂ mitigation [tCO ₂ /kWp]	6,611	4,289



Energy Payback time

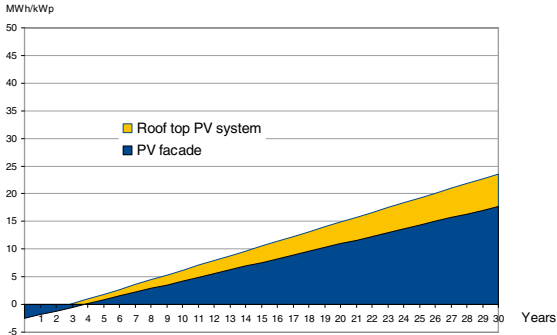
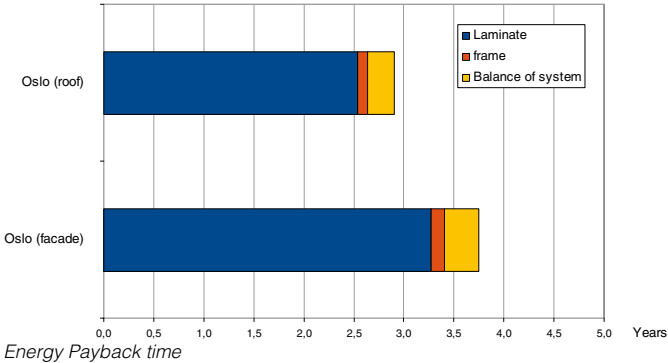


Cumulative net energy production over system lifetime for Wellington



Location of studied city

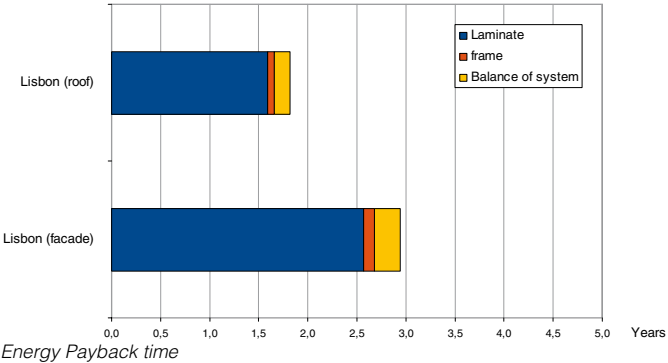
Oslo	Global horizontal irradiation 967 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	870	674
Energy Pay-Back Time [years]	2,90	3,74
Energy Return Factor [number of times]	9,3	7,0
Potential for CO ₂ mitigation [tCO ₂ /kWp]	0,056	0,044



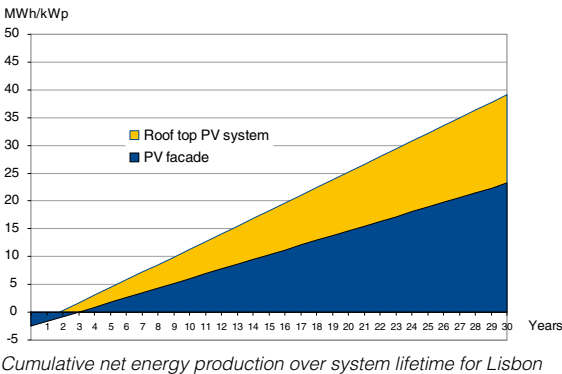
Cumulative net energy production over system lifetime for Oslo



Location of studied city

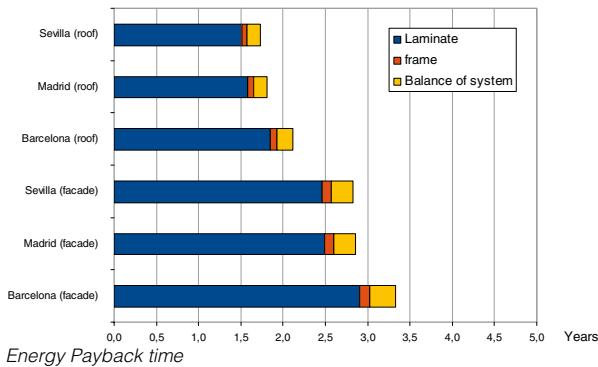


Lisbon	Global horizontal irradiation 1682 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 388	858
Energy Pay-Back Time [years]	1,82	2,94
Energy Return Factor [number of times]	15,5	9,2
Potential for CO ₂ mitigation [tCO ₂ /kWp]	20,461	12,648

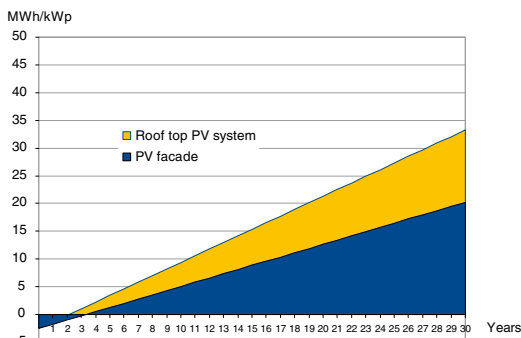




Location of studied cities

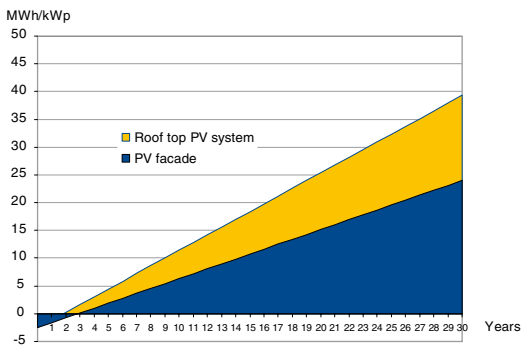


Barcelona	Global horizontal irradiation 1446 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 193	759
Energy Pay-Back Time [years]	2,12	3,33
Energy Return Factor [number of times]	13,2	8,0
Potential for CO ₂ mitigation [tCO ₂ /kWp]	15,895	10,115



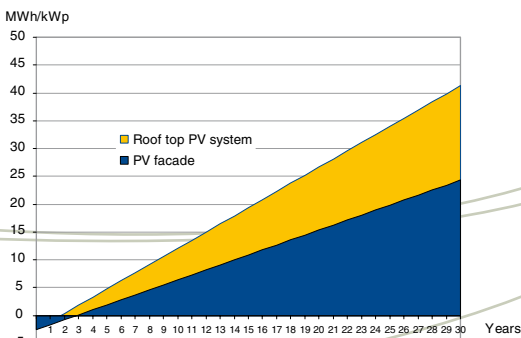
Cumulative net energy production over system lifetime for Barcelona

Madrid	Global horizontal irradiation 1660 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 394	884
Energy Pay-Back Time [years]	1,81	2,86
Energy Return Factor [number of times]	15,6	9,5
Potential for CO ₂ mitigation [tCO ₂ /kWp]	18,579	11,778

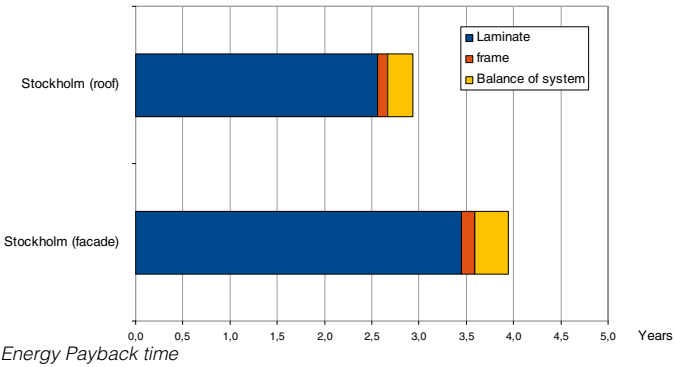


Cumulative net energy production over system lifetime for Madrid

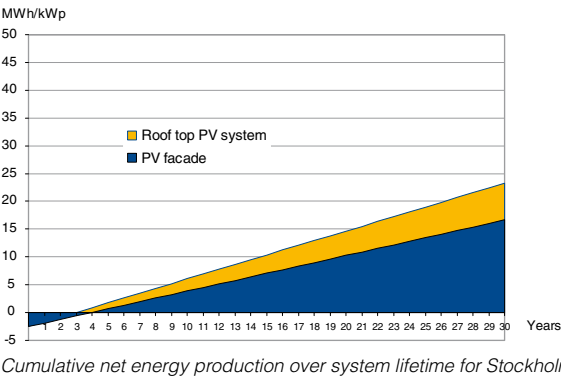
Sevilla	Global horizontal irradiation 1754 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 460	895
Energy Pay-Back Time [years]	1,73	2,82
Energy Return Factor [number of times]	16,3	9,6
Potential for CO ₂ mitigation [tCO ₂ /kWp]	19,456	11,919

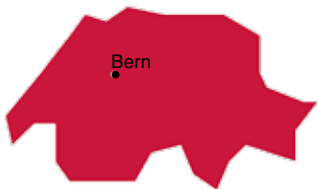


Cumulative net energy production over system lifetime for Sevilla

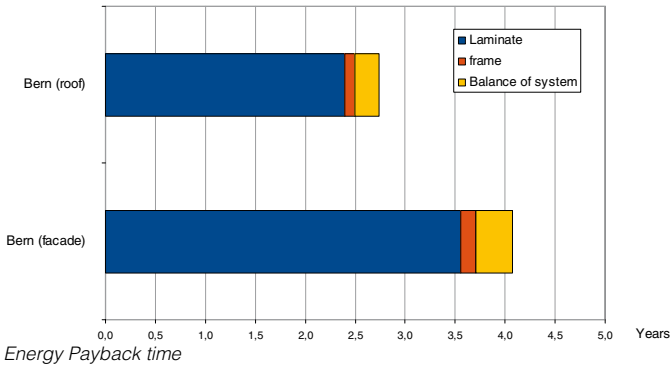


Stockholm	Global horizontal irradiation 980 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	860	639
Energy Pay-Back Time [years]	2,94	3,95
Energy Return Factor [number of times]	9,2	6,6
Potential for CO ₂ mitigation [tCO ₂ /kWp]	1,078	0,801

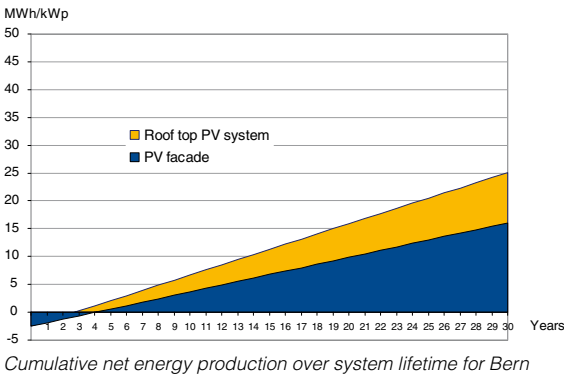




Location of studied city

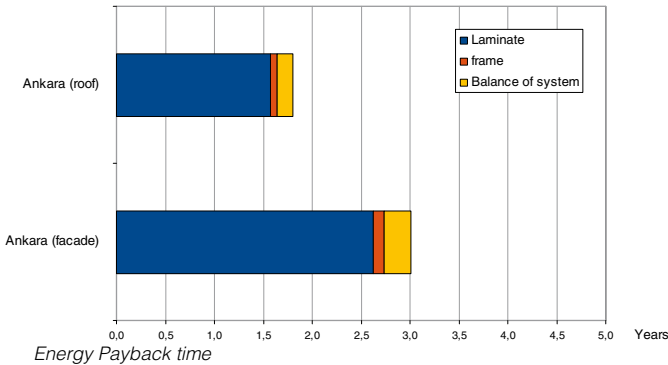


Bern	Global horizontal irradiation 1117 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	922	620
Energy Pay-Back Time [years]	2,74	4,07
Energy Return Factor [number of times]	9,9	6,4
Potential for CO ₂ mitigation [tCO ₂ /kWp]	0,180	0,121

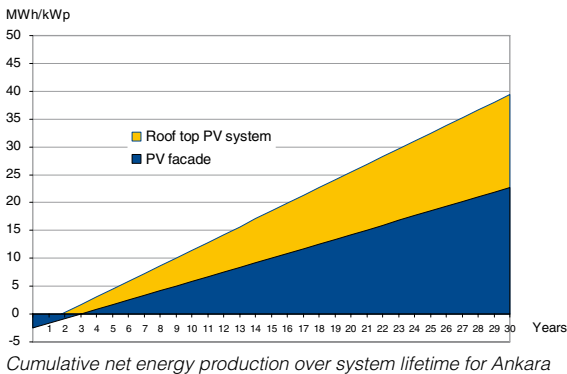




Location of studied city

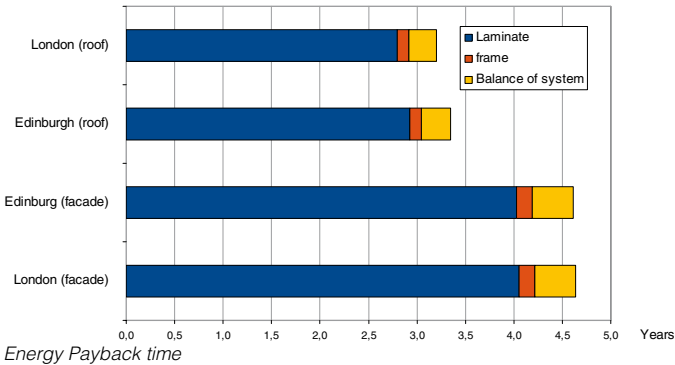


Ankara	Global horizontal irradiation 1697 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 400	840
Energy Pay-Back Time [years]	1,80	3,01
Energy Return Factor [number of times]	15,6	9,0
Potential for CO ₂ mitigation [tCO ₂ /kWp]	20,555	12,333

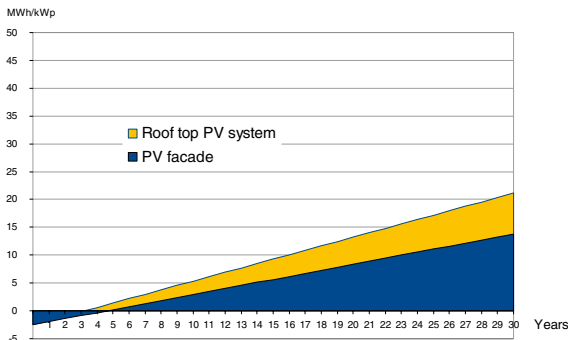




Location of studied cities

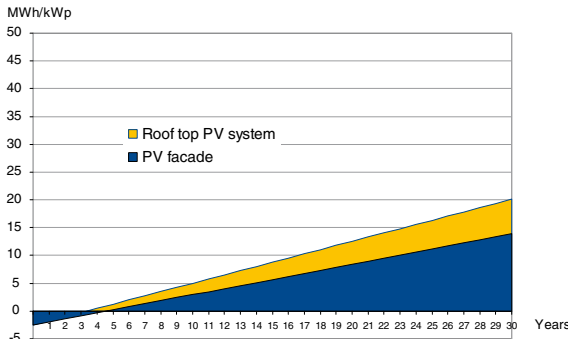


London	Global horizontal irradiation 955 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	788	544
Energy Pay-Back Time [years]	3,21	4,64
Energy Return Factor [number of times]	8,4	5,5
Potential for CO ₂ mitigation [tCO ₂ /kWp]	12,571	8,685



Cumulative net energy production over system lifetime for London

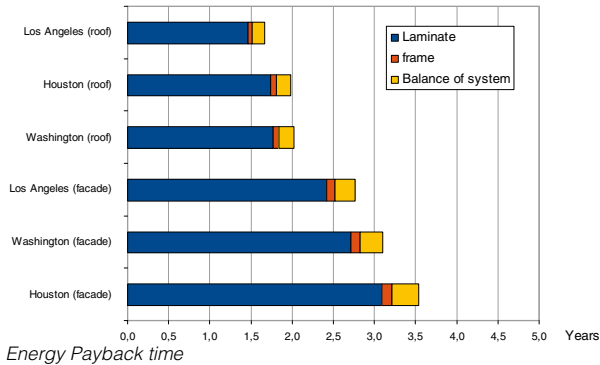
Edinburgh	Global horizontal irradiation 890 kWh/m²	
	Roof-top	Façade
Annual output [kWh/kWp]	754	547
Energy Pay-Back Time [years]	3,35	4,61
Energy Return Factor [number of times]	8,0	5,5
Potential for CO ₂ mitigation [tCO ₂ /kWp]	12,034	8,733



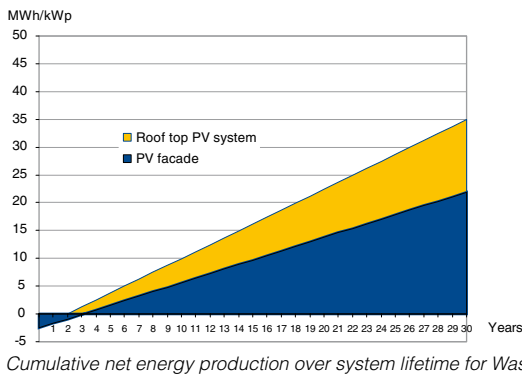
Cumulative net energy production over system lifetime for Edinburgh



Location of studied cities

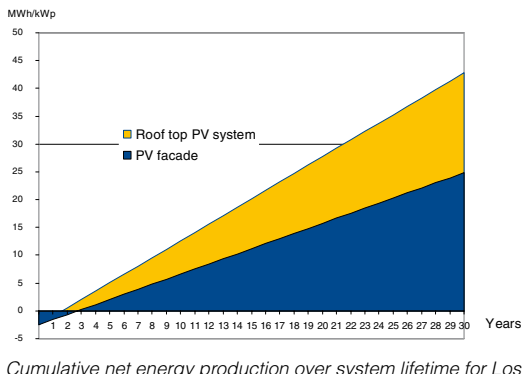


Washington	Global horizontal irradiation 1487 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 249	814
Energy Pay-Back Time [years]	2,02	3,10
Energy Return Factor [number of times]	13,8	8,7
Potential for CO ₂ mitigation [tCO ₂ /kWp]	22,809	14,867



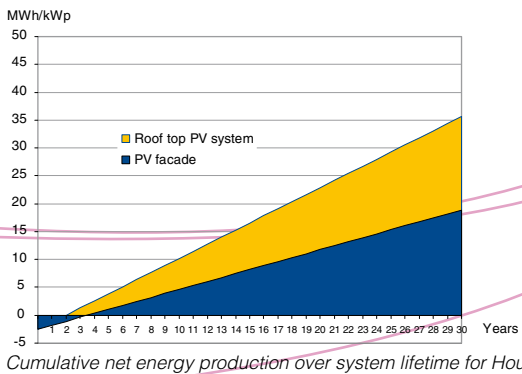
Cumulative net energy production over system lifetime for Washington

Los Angeles	Global horizontal irradiation 1816 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 512	913
Energy Pay-Back Time [years]	1,67	2,77
Energy Return Factor [number of times]	17,0	9,8
Potential for CO ₂ mitigation [tCO ₂ /kWp]	27,607	16,664



Cumulative net energy production over system lifetime for Los Angeles

Houston	Global horizontal irradiation 1615 kWh/m ²	
	Roof-top	Façade
Annual output [kWh/kWp]	1 272	715
Energy Pay-Back Time [years]	1,99	3,53
Energy Return Factor [number of times]	14,1	7,5
Potential for CO ₂ mitigation [tCO ₂ /kWp]	23,225	13,050



Cumulative net energy production over system lifetime for Houston

