IEA INTERNATIONAL ENERGY AGENCY

Urban Photovoltaic Electricity Policies

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

Report IEA-PVPS T10-07:2009

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PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Urban Photovoltaic Electricity Policies

IEA PVPS Task 10, Activity 2.2

IEA – PVPS T10-07: 2009

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Contents

Foreword

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

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

The mission of the Photovoltaic Power Systems Programme is "to enhance the international collaboration efforts which accelerate the development and deployment of photovoltaic solar energy as a significant and sustainable renewable energy option." The underlying assumption is that the market for photovoltaic systems is gradually expanding from the present niche markets of remote applications and consumer products, to the rapidly growing markets for building-integrated and other diffused and centralised photovoltaic generation systems.

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. By the end of 2007, 12 Tasks were established within the PVPS programme.

The objective of Task 10 is to enhance the opportunities for wide-scale, solution-oriented application of photovoltaics in the urban environment as part of an integrated approach that maximizes building energy efficiency and solar thermal and photovoltaics usage. The Task's long term goal is for urban-scale photovoltaic to be a desirable and commonplace feature of the urban environment in IEA PVPS member countries.

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More information of the activities and results of Task 10 can be found on:
www.iea-pvps.org

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Executive summary

Solar electricity from photovoltaics(PV) has the potential to provide solutions to local jurisdictions responsible for infrastructure planning and thus a major energy source for urban areas of the future. Nevertheless, photovoltaic deployment in urban areas requires a set of policies and procedures already implemented in cities with various efficiencies, but seldom fully integrated with the full suite of infrastructure planning elements. An analysis of the present policies and of the present obstacles helps to foster a photovoltaic deployment in the complex urban environment,

The goal of the present study is to evaluate on a standardized basis the urban policies regarding photovoltaic integration in a set of cities of the International Energy Agency, PV Power Systems, Task 10: Urban Scale PV, participating countries.

The investigation was focused on three topics:

A. the present state of the policies,
B. the prospect for future policies fostering photovoltaic deployment, and
C. the prospect for future policies to master large-scale photovoltaic integration.

The information was collected via a multiple-choice questionnaire that participants completed with attached comments if they considered it necessary. The intention was to get as much comparable data as possible. In each participant city, the questionnaire was completed as the expression of a local consensus between multiple stakeholders, such as the authority representatives, utilities, architects, and investors. Sixteen cities in eight participating countries were investigated.

The first section considers the state of the policies. At the time of the interviews, PV deployment plans at the national levels were generally absent. As a matter of fact, national plans have been set after the interviews. On the contrary, most of the participating cities have an energy plan including PV either in the late 90's or in recent years. In our sample, the supports are also more local, with widespread policies regarding public buildings. However, the best PV penetration is made when support plans are made at the national levels (Japan, Germany, Spain). The plans are generally discussed with a large panel of stakeholders, but the financing sources (private or public) are various. Subventions or feed-in tariffs are the main support policies. Though urban jurisdictions initiated policies early on, it is the national support plans that create the impetus to integrate and thus reduce the final barriers for strong deployment.

Procedure and associated procedure costs are very curious. Extremes can be found in neighbouring countries. Guidelines for integration are not associated with a low installed grid capacity. On the opposite, high procedure costs can reduce the penetration rate. The economical effects are higher than the regulatory ones. Guidelines for building integration and aesthetic filters improve the acceptance of the integration without reducing the penetration rate.

This analysis is confirmed in section 2, which deals with present obstacles to PV deployment and solutions to overcome them. Obstacles were found the highest where PV is the least developed, and the lowest where high penetration is reached. Insufficient public support is the first identified obstacle. Financial obstacles are clearly dominant to legal restrictions or complex procedures. The lack of knowledge by investors, architects also represents a significant barrier. The necessary steps for faster deployment confirms this analysis, Thus, the priority is to introduce or reinforce public support, and secondly to reinforce stakeholders' cooperation.

The third section investigates future prospects of PV deployment with the question of mastering large-scale integration. Considering a market where PV has reached competitiveness (with or without financial incentives), leading to the probable limiting case of PV contribution to electricity consumption,, where 100% of the demand of a sunny summer day is covered by PV, different questions have been addressed from the point of view of urban integration. Firstly, the model relying on low regulation and incentives, as well as the one based on market regulation based are favoured. At the same time, policy revision regarding almost all themes from urban regulation and guidelines to

financial instruments is deemed necessary. Building owners are seen as the unique investors of PV deployment. In most countries, intervention of the central state was desired to foster the deployment, under the form of regulation and guidelines.

Conclusions are that cities could formulate urban solutions by developing integrated, specific provisions for PV deployment in their urban infrastructure planning. Sacrificing good urban integration to facilitate procedures has no obvious favourable impact on photovoltaic growth. In the perspective of a large photovoltaic deployment, it is therefore important to have policies which include a good integration policy since the beginning. These local jurisdictions have the authority to assure the PV is deployed with the maximum benefit to the community while reducing actual installation barriers associated with codes and permits. Public buildings are also ideal to increase awareness of the technology benefits.

PV can be the solution to load growth in the dense urban environment. PV addresses grid overload without construction disruptions and the high level of commercial loads on the urban grid match closely with PV generation. PV does not require additional land in built-out urban areas, it can be building-integrated or use rooftop areas. Unlike other distributed generation, PV does not require fuel storage or add emissions to urban areas struggling to attain acceptable levels of air quality. Though most of the cities participating in the study had energy plans, none had plans which were fully integrated with the urban area's long term comprehensive plan. **When integration of energy with all elements of comprehensive planning - transportation, air quality, economic development, land use, water, waste water, etc. – occurs, PV technology emerges as the best choice option.**

Introduction

Solar photovoltaic electricity has the potential to be a major energy solution, sustainably orientated for urban areas of the future. Today, half of the world population lives in densely populated urban environments – "the cities of the world". Solar energy from photovoltaics provides solutions for commonplace urban issues, as well as innovative opportunities for urban plans to meet the global energy and environmental demands of high quality urban lifestyles.

Urban environments are highly populated and built out. Modifications, upgrades and even maintenance to the grid can result in construction disruptions. Fossil fuel based distributed generation requires fuel storage, can be noisy, and increases emissions in urban areas already affected by poor air quality. Other renewable energies require either land or fuel resources that are scarce in the overbuilt environment: hydropower requires high level differences or interception of large water flows; biomass needs vast areas of fertile soils; wind energy, even using building mounted generators, has limited applicability in high density developments; deep heat mining can cause small earthquakes that are not appreciated in cities [1]. However, photovoltaics can be built at any scale and only need well oriented supports and a low voltage electric grid. It is therefore ideal for exploitation in the urban environment. The possible contribution of photovoltaic electricity to the demand of IEA cities was evaluated from 15% to 60%, depending on the city structure and considering all the well-oriented roof surfaces [2] with the available technology.

The deployment of the solar electricity production in the urban environment is highly suitable, as it can be attached or integrated to buildings in a built-out land use scenario. It also produces energy close to the consumers. Cost-saving synergies are possible between energy production and building coating as photovoltaic modules can serve as enveloping elements (solar tiles, façade coatings, canopies). Additionally, due to the heat effect in urban areas, many buildings are air conditioned even in colder climates. The resulting building or network load closely matches the photovoltaics generating profile.

Fostering photovoltaic deployment in cities through integration with existing urban planning mechanisms is therefore necessary. In order to elaborate recommendations for that encouragement, understanding and benchmarking of the existing instruments and their efficiency is necessary. As well, determination of the present and possible future obstacles is required, in order to devise ways to overcome them.

With instruments like enhanced feed-in tariffs, photovoltaic plants are prone to become standard building equipment. That evolution is challenging for urban planners who will require long term, reliable and safe construction, operation and maintenance. An aesthetically pleasing design and long term solar access will also be appreciated. Analysis of the existing regulations and instruments is therefore advisable to determine whether they ensure good architectural and urban integration of photovoltaic installations. Such a precaution is a necessary step for the future of photovoltaic deployment: examples of bad integration can rapidly discredit a presently well-accepted technology.

Evaluations exposed in the present study were conducted in each city with the collaboration of various stakeholders concerned with photovoltaic integration: authorities' representatives, engineers, architects, investors, owners. They should represent in each case a local consensus which was gathered in the frame of a workshop or by interviews.

1 Methodology

The questionnaire (Annex 1) was elaborated as an Excel spreadsheet with multiple choice answers. A format of predefined lists of possible answers was chosen with the purpose of allowing easy comparison between cities. Participants who felt the list of answers was too restrictive or not adapted to specific conditions had the possibility to complete the questionnaire with comments.

The questionnaire was divided in 3 sections:

A. State of the policies,
B. Prospect for future policies - fostering photovoltaic (PV) deployment,
C. Prospect for future policies fostering - mastering large-scale urban integration.

It was distributed to all IEA PVPS Task 10 participants, with the request to complete it for two of three cities in the country. The questionnaire comprises a first part (Figure 1) where some data of the investigated cities are given, in particular the list of stakeholders taking part in the elaboration of the consensual answers. That consensus was gathered either during a dedicated workshop of by interviews.

The answers to the questions were asked at both the national and the local level, the latter incorporating the regional level. In federal states (Austria, Canada, Switzerland, USA), the federated states have large legal competences. The data provided for the local level therefore possibly incorporates a high share of policy of that intermediate level.

City 1		Number of interviewed stakeholders		
Name	<city 1>	Authorities	Planners	Architects
Energy policy evaluation	average	1	1	1
Yearly PV yield in kWh/kWp	1050	Engineers	Owners	Investors
Number of inhabitants	<number>	1	1	1
City 2		**Number of interviewed stakeholders**		
Name	<city 2>	Authorities	Planners	Architects
Energy policy evaluation	strong	1	1	1
Yearly PV yield in kWh/kWp	1150	Engineers	Owners	Investors
Number of inhabitants	<number>	1	1	1
City 3		**Number of interviewed stakeholders**		
Name	<city 3>	Authorities	Planners	Architects
Energy policy evaluation	weak	1	1	1
Yearly PV yield in kWh/kWp	950	Engineers	Owners	Investors
Number of inhabitants	<number>	1	1	1

Figure 1 – Data of the participating cities of a country and involved stakeholders.

QUESTION	LEVEL			
	National	<city 1>	<city 2>	<city 3>
A. State of the policies				
Please mention the policy instrument at the city level only if it is additionnal to the instruments at the national level				
(additionnal obligation, subvention…). The "city" level includes the regional level and its instruments. NP: legally not possible				
Existing instruments				
Energy plan	☐ Yes	☐ Yes ☐ NP	☐ Yes ☐ NP	☐ Yes ☐ NP
if yes, since (year)				
with special provisions for PV ?	☐ Yes	☐ Yes	☐ Yes	☐ Yes
Specific plan for PV development ?	☐ Yes	☐ Yes	☐ Yes	☐ Yes
if yes, established with stakeholders participation ?	☐ Yes	☐ Yes	☐ Yes	☐ Yes
if yes, with investors ?	☐ Yes	☐ Yes	☐ Yes	☐ Yes

Figure 2 – View of the organization of the questionnaire, with the two (national and local) levels.

2 Results

2.1 Participants

Table 1 – Overview of the cities participating in the present study

Country	City	Inhabitants	Energy policy	kWh/ kWp	Interview date	Participants to evaluation					
					Quarter Year	authorities	planners	architects	engineers	owners	investors
Canada	Toronto	5 100 000	average	1 150	1-2008	1					
	Peel[i]	1 200 000	average	1 150	1-2008				1		
	Kelowna[ii]	162 300	average	1 050	1-2008		1				
Denmark	Horsens	70 000	weak	850	4-2007		2	2	3		
France	Lyon	1 500 000	average	1 100	4-2007				1		
Holland	Heerhugowaard	49 000	strong	870	1-2008	2			1		
	Langedijk	26 000	strong	870	1-2008	2			1		
	Alkmaar	94 000	strong	870	1-2008	2			1		
Japan	Hachinohe	245 000	strong	900	1-2007	1					
	Ota	213 000	strong	850	3-2007	1					
	Tokyo	8 500 000	strong	800	3-2007	1					
Sweden	Malmö	250 000	average	800	4-2007		1	1	1	1	
Switzerland	Neuchâtel	32 500	strong	950	3-2007		1	1	2	1	1
	Zurich	365 000	strong	850	1-2008	4	1	1	1		
USA	Boston	576 000	strong	1 150	10-2008	1	1				
	Orlando	228 000	average	1 200	10-2008	1					

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With 16 cities from 8 IEA countries, the survey can be considered to be based on an appreciable sample. The interviews were made during the years 2007 and 2008.

The level of commitment in the energy policy of most of the investigated cities was considered as strong, i.e. superior to the average level in the country. However, none of them have a high penetration rate. Therefore, they are not facing yet the beginning of the "paradigm shift" when PV production approaches the critical value of 12% of the total electricity generated. [iii]

[i] The Regional Municipality of Peel (Ontario, Canada) encompasses three municipalities directly to the west of Toronto. The regional municipality is made up of the cities of Brampton and Mississauga, and the town of Caledon.

[ii] British Columbia.

2.2 Section 1: State of the policies

This first section of the survey deals with the present policies in the investigated cities. The existence of specific plans and supporting instruments in favour of photovoltaic energy was determined, as well as the procedure that must be followed according to the law and regulation for the installation of a PV plant. The purpose of this evaluation was to measure the diversity of the policies applied to photovoltaic energy and to evaluate their impact. In conjunction with sections 2 and 3, it should help elaborate recommendations for urban PV deployment.

2.2.1 Energy plans

The existence of an energy plan, at the national and/or local level is an important part of the framework conditions revealing the level of commitment in the field of energy, with consequences on the support for PV deployment. The definition of an energy plan is not restrictive and encompasses any kind of program or master plan with precise steps and clear objectives and in the domain.

Table 2 – Existence of an energy plan and special provisions for photovoltaic energy at the national and local levels. Green = existing plan; red = no plan; grey – NP = not legally possible.

Country	City	Energy plan					
		National	Since	provisions for PV	Local	since	provisions for PV
Canada	Toronto					1998	
	Peel					2007	
	Kelowna					?	
Denmark	Horsens		<1996		NP		
France	Lyon		2005			2005	
Holland	Heerhugowaard					1997	
	Langedijk					1997	
	Alkmaar					1997	
Japan	Hachinohe					2004	
	Ota		2006			2006	
	Tokyo					2006	
Sweden	Malmö		?			?	
Switzerland	Neuchâtel		1990			1998	
	Zurich					<1996	
USA[iii]	Boston					2005	
	Orlando					2007	

With slightly over half of the participating countries having specific energy plans an observation may be made as to the potential to respond to global issues affecting quality of life. Almost all the investigated cities have a plan, most of the time with special dispositions regarding PV. The years of introduction of those plans reveal two periods of decisions: the late 90' and the recent years. They follow for the former the emergence of the concern about global warming (IPCC first assessment report 1990) and sustainable development ("Earth summit" Rio 1992) and for the latter the fast growth

[iii] The US has passed 3 Energy Policies, 1992, 2007 and 2008, but are not listed here because they were policies rather than plans.

of oil price since 2003. An additional point to be drawn from a more local planning focus is that urban areas have a unique set of conditions, environmental, economic and population density for which PV technology can provide a solution. It's close to the load, thus saving energy losses and avoiding construction disruptions. Photovoltaic energy appears in most cases to be considered as a valuable resource at the city level.

2.2.2 Plans for PV deployment

The existence of plans for the deployment of photovoltaic energy illustrates the conviction that the free market (possibly with orientation through economic instruments) does not suffice to ensure PV deployment, but that public engagement is necessary, even if via the action of a public utility.

Table 3 – Existence of a plan for photovoltaic deployment at the national and local levels. Green = existing plan; red = no plan. Participation of stakeholders to the establishment of the plan: I = investors; O = building owners; A = architects and planners; U = utility.

Country	City	Specific plan for PV deployment											
		National	stakeholders	focus on large systems	objective 2010 Wp/capita	objective 2015 Wp/capita	% public investment	Local	stakeholders	focus on large systems	objective 2010 Wp/capita	objective 2015 Wp/capita	% public investment
Canada	Toronto								U		0.5	3	
	Peel								O				
	Kelowna												
Denmark	Horsens												
France	Lyon												
Holland	Heerhugowaard								IOAU	X			
	Langedijk								IOAU	X			
	Alkmaar								IOAU	X			
Japan	Hachinohe										50		
	Ota				38								
	Tokyo												
Sweden	Malmö												
Switzerland	Neuchâtel								IAU	X	8	15	100%
	Zurich								U		19	28	25%
USA	Boston								IOAU	X		45	
	Orlando								OAU		4	6	

Table 3 shows the general absence of specific plans for PV deployment at the national level. Japan is an exception, revealing a willingness to plan the deployment of solar electricity that can also be found in Korea and China.[iv] Cities are more active, with specific plans in most of them, setting objectives that are either higher than the national goal (Hachinohe) or fixed in absence of national goal (Toronto, Neuchâtel, Zurich, Orlando, Boston). Focusing of the efforts is variable, with preference for dissemination (Japan, Canada, Zurich) or for concentration on large equipment (Holland, Neuchâtel, Boston). Financing also relies on a large set of options: from 100% public (by the city utility in Neuchâtel) to mainly private.

[iv] In Korea, the 'Solar Land 2010' program aims at installing 30,000 roof-top 3kW systems by 2010. By 2012 the aim includes 1.3GW with 100,000 (3kW) roof-top systems, 40,000 (10kW) systems for public buildings and 30,000 (20kW) systems for the commercial sector. In China, the PV plans aim to install 40GW by 2020.

2.2.3 Support for PV deployment

Support for PV deployment can take various forms: obligations, subventions, green electricity scheme, net metering, enhanced feed-in tariffs, loans with reduced rates or tax credits. Applied alone or in combination, they can have strong effects on the development of photovoltaic penetration.

Table 4 – *Policy support steps for photovoltaic deployment at the national and local levels. Green = existing support; red = no support; grey – NP = not legally possible. In green boxes: year of introduction. EL = energy levy; C = community; U = utility.*

Country	City	Policy support for PV deployment														
		National level							Local level							
		Obligation on new building	Obligation on retrofitted	Obligation on public buildings	PV policy for public buildings	Subventions	Amount	Financed by	Obligation on new building	Obligation on retrofitted	Obligation on public buildings	PV policy for public buildings	Subventions	Amount EUR/kWp	Financed by
Canada	Toronto								NP	NP	NP	07	NP		
	Peel								NP	NP	NP	07	NP		
	Kelowna								NP	NP	NP		NP		
Denmark	Horsens								NP	NP	NP	NP	NP		
France	Lyon											06			
Holland	Heerhugowaard									NP	NP		02		EL
	Langedijk									NP	NP		02		EL
	Alkmaar									NP	NP		02		U
Japan	Hachinohe								NP	NP	NP	NP			
	Ota								NP	NP	NP	NP	01	400	C
	Tokyo								NP	NP	NP	NP	<96		C
Sweden	Malmö					05									
Switzerland	Neuchâtel														
	Zurich											01	<96	1400	EL
USA[v]	Boston								NP	NP	NP	07	NP		
	Orlando														

As shown by Table 4, at the national level few of the participating countries (except Sweden and Japan) are engaged in policy support to PV by obligations or subventions. However, the strongest markets for PV: Germany, Japan, and Spain, currently all have national support. Cities in the sample may represent emerging markets. Specific policies regarding public buildings are more widespread and may represent an initial action by the city to "set an example". Subventions appear to have been the first type of promotional step introduced and remains appreciated, probably for its simplicity. In a majority of cases, the subvention is financed by energy sales, either via an energy levy, or directly by the utility. The strongest measure, i.e. obligation to equip new or existing buildings with PV installations, remains rare but is emerging through enforcement of building energy performance codes. When energy codes are set at a high level, on-site generation is often required to achieve this.

Table 5 illustrates the large variety of financial support policies. Green electricity schemes, where utility buy the solar electricity and sell it in distinct brands are widespread, either at national or at local (utility) level. Green schemes have resulted in high prices relative to the ultimate energy production, partly because of administrative costs, and they have not resulted in any substantial deployment in this sample. Enhanced feed-in tariffs are more commonly introduced by national legislation. However, local regulations have also introduced it, either at the state level (Ontario in the case of Toronto and Peel) or at the city level in the case of Zurich (which has its own utility). Delimitation between green electricity schemes and enhanced feed-in tariffs can be blurred from the point of view of the electricity

[v] Through the Federal Energy management Program, FEMP, the US has made various commitments to renewable power on a set number of buildings

producer as in both cases his electricity is bought by the distributor at a usually cost-covering price. Additionally, feed-in-tariffs result in more PV deployment then green pricing schemes. Caution must be taken when analysing tax credit support in terms of commitment as fiscal schemes on buildings. The different tax incentives include:

- Investment tax credits which directly reduce either national or local income taxes based on capital investment
- Production tax credits which directly reduce either national or local income taxes based on energy production
- Tax deduction which reduces the amount of income that taxes are based on, usually by an amount related to the capital investment. In this case the amount of the incentive is dependent on the tax rate of the investor
- Property tax exemption which prevents property tax assessors from raising the property value due to the added value of the PV system
- Sales tax exemption.

Some of these tax schemes can be enacted by local governments. It has been recognised that without property tax exemption, the incentives meant to promote the PV market are diminished by the added property taxes for the life of the system.

Table 5 – *Financial support steps for photovoltaic deployment at the national and local levels. Green = existing support; red = no support; grey – NP = not legally possible. In green boxes: year of introduction or amount.*

Country	City	Financial support for PV deployment													
		National level							Local level						
		Green electricity scheme	Net metering	Feed-in tariffs	EUR/kWh	BIPV bonus EUR/kWh	Loans with reduced rate	Tax credits	Green electricity scheme	Net metering	Feed-in tariffs	EUR/kWh	BIPV bonus EUR/kWh	Loans with reduced rate	Tax credits
Canada	Toronto			07	0,01	0					06	0,26	0		NP
	Peel										06	0,26	0		NP
	Kelowna												0		NP
Denmark	Horsens								NP	NP	NP			NP	NP
France	Lyon			03	0,30	0,20		00							
Holland	Heerhugowaard														
	Langedijk														
	Alkmaar														
Japan	Hachinohe								NP	NP	NP			NP	NP
	Ota								NP	NP	NP			NP	NP
	Tokyo								NP	NP	NP			NP	NP
Sweden	Malmö														
Switzerland	Neuchâtel			08	0,47	0,09		<96							<96
	Zurich										97	0,46	0		<96
USA	Boston							06	NP		NP				NP
	Orlando							06			06	0,03	0	07	NP

The set of instruments used to support photovoltaic electricity, additional to those exposed in Tables 4 and 5 appear limited (Table 6). Either cities have a restricted margin for extra steps, or they didn't manifest creativity in that field. Zurich presents an interesting example of an innovative step with the free disposal of public roof space for PV production. Legally binding targets for PV electricity in the utility mix is not widely used. Public tenders for the acquisition of PV electricity, which were often presented as an alternative to enhanced feed-in tariffs, are still applied but are likely to reduce as the latter extend.

Table 6 – *Other support steps for photovoltaic deployment and general acceptance of building-integrated PV at the national and local levels. Green = existing support; red = no support; grey – NP = not legally possible. L = low; M = medium; H = high.*

Country	City	Support for PV deployment									
		National level					Local level				
		other in kind advantages	other building rules in favor of PV	Obligation for utilities of a share of PV electricity in future mix	Public tenders for acquisition of PV electricity	General acceptance of BIPV	other in kind advantages	other building rules in favor of PV	Obligation for utilities of a share of PV electricity in future mix	Public tenders for acquisition of PV electricity	General acceptance of BIPV
Canada	Toronto					L		NP	NP		M
	Peel							NP	NP	NP	M
	Kelowna								NP	NP	
Denmark	Horsens					L			NP	NP	H
France	Lyon					L					M
Holland	Heerhugowaard					M					H
	Langedijk										H
	Alkmaar										H
Japan	Hachinohe	Green certificates				H					H
	Ota										H
	Tokyo										H
Sweden	Malmö					L					M
Switzerland	Neuchâtel					M					H
	Zurich						Free use of roof of public buildings				M
USA	Boston					M				NP	L
	Orlando										M

2.2.4 Procedure for PV installation

The procedure for the installation of a BIPV plant, in its complication, length and cost can represent an obstacle to the deployment of solar electricity. Two kinds of procedures can be an obstacle, the integration in the local utility, and the approval of the architectural side. In this study, the focus was on the architectural side and the approval of authorities. To this extend, procedures were analysed in the different cities. Three cases were defined: a small (1 m^2), a medium (10 m^2) and a large (100 m^2) plant project. The authorities having to give an agreement were listed together with the number of days required for the whole procedure and its cost. The possibility for neighbours to oppose the installation was also investigated. The nature of the authority able to evaluate the aesthetics was recorded, as well as an appreciation regarding the quality of integration of the photovoltaic plants in the building. Results are compiled in Table 7. In almost all cases authorizations are required. A noticeable exception is Denmark where no authorization is necessary. In the other countries, procedure takes between 30 and 120 days with variable costs, from zero to 1800 EUR. For small (1 m^2), this cost can represent a substantial part of the investment and therefore a significant barrier. As the fees are not proportional to the surface, they become negligible for larger plants. For medium and large installation, authorization from the utility and/or a technical authority is always required. In Denmark, the authorisation is replaced by an announcement: when the system is installed, the installer fills in a form on the Internet with the PV information. The Internet platform is the same the

electricians use for registration of changes in a building's electrical installation (meters, switchboard, fuses etc.). The Internet form is automatically sent to the utility that will change the meters if necessary.
The "aesthetic filters" seem to play a role on the quality of building integration. Where no evaluation is made and where neighbours can't oppose the authorization (Denmark, France, US), the integration is judged "satisfactory". At the other end, where a specialized commission evaluates the aesthetics for the authority (Holland, Neuchâtel), and where neighbours have the right of opposition, the integration is felt as "good" or "excellent".

Overall, it is striking to observe that extremes can be found in two neighbouring countries, with the absence of procedure in Denmark and the most demanding one in Sweden.

Table 7 – *Procedure for the installation of a PV plant in 3 different sizes. Green = existing guidelines; red = no guidelines; B = building code authority, U = utility, T = technical authority, N = neighbours; S = satisfactory; G = good; E = excellent.*

Country	City	Installation of BIPV plant: procedure													
		Nat.	Local level												
		Available guidelines for building integration of PV	Available guidelines for building integration of PV	1 m^2: authorization required	1 m^2: duration days	1 m^2: cost EUR	10 m^2: authorization required	10 m^2: duration days	10 m^2: cost EUR	100 m^2: authorization required	100 m^2: duration days	100 m^2: cost EUR	Right of neighbours to oppose the authorization	Evaluator of aesthetics of project for authorization	Quality of the integration of existing BIPV
Canada	Toronto			BU	60	0	BU	60	0	BU		0	N	A	
	Peel			UT	90	0	UT	120	0	UT	120	0	Y	A	
	Kelowna														
Denmark	Horsens			No authorization required except on listed buildings											S
France	Lyon			BT	120	0	BT	120	0	BT	120	0	N	N	S
Holland	Heerhugowaard			BU			BU			BU				C	G
	Langedijk			BU			BU			BU				C	G
	Alkmaar			BU			BU			BU				C	G
Japan	Hachinohe			BU	30	0	BU	30	0	BU	30	0	N	A	G
	Ota			U			U			U					S
	Tokyo			U			U			U					S
Sweden	Malmö			BN	90	600	BUTN	90	600	BUTN	90	1200	Y	A	
Switzerland	Neuchâtel			BN	30	200	BU	60	200	BU	90	400	Y	C	E
	Zurich			U			U			BUT	100	1800	Y	A	G
USA	Boston			BU			BU			BU			N		S
	Orlando			BU	40	250	BU	40	250	BU	60	500	N		S

2.2.5 PV penetration and growth

As depicted in Table 8, the level of PV equipment of the different investigated cities is very diverse. High values can be found in small cities where an important effort was concentrated. Large cities have less installed capacity per capita than average national values; illustrating the fact that photovoltaics is not yet perceived or exploited as an urban resource. The intensity of local commitment exhibits no correlation with intensity of sunshine, as shown by the high values reached by the Dutch cities. PV deployment appears clearly to depend chiefly on willingness rather than on local climate.

Procedural costs may have a role on PV penetration, as Sweden has a low installed capacity and Orlando with its costly procedure has a much lower penetration rate than Boston, where the procedure is free.

Table 8 – *Level of PV penetration, expressed in installed watt peak per capita and growth rate in 2005. Values for the three Holland cities are expected capacities for 2008 at the completion of the 5 MW project "City of the Sun".*

Country	**City**	**PV penetration and growth**				
		National		**Local level**		
		Installed grid-connected capacity in Wp/capita	Growth rate of PV capacity in 2005 in %	Installed grid-connected capacity in Wp/capita	Share of BIPV in that capacity	Growth rate of PV capacity in 2005 in %
Canada	Toronto	0,52	20%	0,10		10%
	Peel					
	Kelowna					
Denmark	Horsens	0,49	16%	2,85	<50%	20%
France	Lyon	0,54	27%	1,00	<50%	100%
Holland	Heerhugowaard	3,10	3%	73,47	100%	
	Langedijk			15,38	100%	
	Alkmaar			10,64	100%	
Japan	Hachinohe	11,10	26%	10,00		58%
	Ota			20,00		12%
	Tokyo			2,00		22%
Sweden	Malmö	0,47	10%	1,00	<50%	100%
Switzerland	Neuchâtel	3,70	14%	4,50	100%	0%
	Zurich			16,00	100%	16%
USA	Boston	2,8	27%	20,00		30%
	Orlando			0,5		0

2.3 Section 2: Prospect - fostering PV deployment

The goal of this second part of the survey was to evaluate ways of fostering photovoltaic energy deployment in urban environments. Present obstacles were first identified and steps to overcome them for faster PV dissemination were proposed.

2.3.1 Present obstacle to PV deployment

Participants were asked to qualify the different types of obstacles as *strong*, *medium*, *weak* or *inexistent*. For calculation of average values, these qualifications were given the respective values of 3, 2, 1, and 0.

Table 9 relates to a first category of obstacles of the type *lack/insufficiencies*. The insufficiency of public support by feed-in tariffs or subventions appears clearly to be the main barrier while additional complexity in legal procedures is the weakest one. In details, the ranking was as follows:

1. Insufficient public support (tariffs, subventions,…) ; national: 2,86 / local: 2,57.
2. Lack of knowledge or interest by the owners and investors; national: 2,57.
3. Lack of knowledge or interest by the architects; national: 2,00 / local 1,64.
4. Lack of knowledge or interest by the local authorities; local: 1,64.

5. Limited choice of products; national: 0,86.
6. Additional complexity in legal procedures for BIPV; national: 0,71 / local 0,86.

Table 9 – *Appreciation of the various types of obstacles to PV deployment in the investigated cities. Red = strong, orange = medium, yellow = weak, green = no obstacle.*

Country	City	Present obstacles to PV deployment								
		National level					Local level			
		Insufficient public support (tariffs, subventions,...)	Lack of knowledge or interest by the architects	Lack of knowledge or interest by the owners and investors	Limited choice of products	Additional complexity in legal procedures for BIPV	Insufficient public support (tariffs, subventions,...)	Lack of knowledge or interest by the architects	Lack of knowledge or interest by the local authorities	Additional complexity in legal procedures for BIPV
Canada	Toronto									
	Peel									
	Kelowna									
Denmark	Horsens									
France	Lyon									
Holland	Heerhugowaard									
	Langedijk									
	Alkmaar									
Japan	Hachinohe									
	Ota									
	Tokyo									
Sweden	Malmö									
Switzerland	Neuchâtel									
	Zurich									
USA	Boston									
	Orlando									

By countries, obstacles were found to be the highest where PV is the least developed (around 0,5 Wp per capita in Canada and France) and the lowest where high penetration is reached in the considered cities (more than 3 Wp per capita in Holland, around 11,1 Wp per capita in Japan).

Table 10 presents a second category of obstacles than can be gathered under the designation *limitations imposed by third parties*. They include legal, social and financial limitations. Obviously, their importance is lower than that of the former category (Table 9). Financial barriers appear the highest, in accordance with the identification of insufficient public support as the first obstacle above. In details, the ranking was as follows:

1. Obstacle for BIPV due to financing scheme; national: 1,71 / local: 1,57.
2. Restrictive aesthetic criteria or practices; national: 0,43 / local: 1,21.
3. Difficulty to integrate PV in building profitability plans; national: 1,00.
4. Legal restrictions; national: 0,43 / local: 0,79.
5. Reluctance or hostility of utility / network regulation; national: 0,57 / local: 0,71.
6. Public perception; local: 0,50.
7. Neighbours hostility; local: 0,43.

This category of obstacles was again considered to be higher in Canada and France than in other countries, with minimal weighting in Japan. In Japan, only legal restrictions and restrictive aesthetic criteria or practices may be an obstacle, for only one city of the sample. Evaluations didn't show large local differences for each topic, except the financial ones, with questions that can have been understood in different ways accounting in part for the spread. It appears however that in places where integration of photovoltaic as standard building elements is usual (Japan) or where a long experience of green electricity scheme exists, financial or profitability problems appear to be nonexistent. Restrictive aesthetic criteria can be a significant barrier at the local level, with the exception of big cities (Tokyo, Toronto), emphasizing the importance of good building integration to ease PV expansion. Solar electricity, having a good public image, does not suffer social barriers like, for instance, biofuels.

Table 10 – *Appreciation of the various types of obstacles to PV deployment in the investigated cities. Red = strong, orange = medium, yellow = weak, green = no obstacle.*

Country	**City**	**Present obstacles to PV deployment**										
		National level					**Local level**					
		Legal restrictions	Restrictive aesthetic criteria or practices	Reluctance or hostility of utility / network regulation	Difficulty to integrate PV in building profitability plans	Obstacle for BIPV due to financing scheme	Legal restrictions	Restrictive aesthetic criteria or practices	Reluctance or hostility of utility / network regulation	Neighbours hostility	Public perception	Obstacle for BIPV due to financing scheme
Canada	Toronto											
	Peel											
	Kelowna											
Denmark	Horsens											
France	Lyon											
Holland	Heerhugowaard											
	Langedijk											
	Alkmaar											
Japan	Hachinohe											
	Ota											
	Tokyo											
Sweden	Malmö											
Switzerland	Neuchâtel											
	Zurich											
USA	Boston											
	Orlando											

In conclusion, obstacles to PV deployment in urban environments are clearly economic. The insufficiency of financial public support makes the investment unprofitable. Lack of knowledge by investors, architects and local authorities also represent a significant barrier. The third obstacle lies in aesthetic restrictions and appears as the only typically urban barrier.

2.3.2 Necessary steps for faster deployment

As a corollary to the identification of obstacles to PV deployment, it is necessary to determine the advisable measures to foster it.

All participants considered it necessary to introduce or reinforce public support, in coherence with the main barrier identified in part 2.3.1. As a new instrument to be introduced at national level, feed-in tariffs have the preference. It is also in majority considered as the most suitable for supporting photovoltaic deployment. At the local level, subventions appear to be more adapted. Information to stakeholders is also considered necessary. No consensus was gathered on the target of that information. Depending on local circumstances, authorities, architects, investors and owners were identified to need information as the first priority. Cooperation between stakeholders was another necessary step identified by participants. Simplification of procedures obtained more diversified positions. The elaboration of a calculation tool only got polite interest. Among the five possible priorities, reinforcing public support on the one hand, and reinforcing cooperation between stakeholders on the other hand were the only two chosen steps.

Table 11 – *Necessary steps to foster PV deployment in urban areas. Dark blue = necessary, light blue = useful, pink = secondary, red = useless. Instruments: T = enhanced feed-in tariffs, S= subventions, O = obligation, X = nothing. Stakeholders: A = authorities, I = investors, R = architects, W = owners. Priorities: PS = introduce or reinforce public support, RC = reinforce cooperation of stakeholders, IS = inform stakeholders, SP = simplify procedures, CT = provide calculation tool*

Country	City	Necessary steps for faster deployment							
		National level					Local level		
		Introduce or reinforce public support	Inform stakeholders	Reinforce cooperation of stakeholders	Simplify procedures	Provide economic calculation tools for stakeholder	Introduce or reinforce public support	Simplify procedures	Priority: most important step
Canada	Toronto	S	W				S		PS
	Peel						S		PS
	Kelowna						T		PS
Denmark	Horsens	T	R				T		PS
France	Lyon	X	A				X		PS
Holland	Heerhugowaard	T	I				S		RC
	Langedijk						S		RC
	Alkmaar						S		RC
Japan	Hachinohe	X	W						PS
	Ota						S		PS
	Tokyo						S		PS
Sweden	Malmö	T	I				T		PS
Switzerland	Neuchâtel	T	W/R				O		PS
	Zurich						X		RC
USA	Boston	T/O	A/I				T		PS
	Orlando								PS

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2.4 Section 3: Prospect - mastering large-scale urban integration

This section evaluates what could happen in the future as photovoltaic energy, owing to its decreasing cost and to increasing public support with simultaneous increase of fossil energy prices, will become an interesting investment at every level, and finally a standard building component. Such an evolution could be challenging for urban planning, that will have to deal with a multiple of more or less well integrated PV plants in the built landscape. Potentially, the difficulties could be much larger than those encountered with parabolic antennas or cellular phone antennas. As seen under 2.3.1, aesthetic restrictions are already a significant obstacle for PV deployment. Determination of the amplitude of the future problems and evaluation of the instruments needed to master PV penetration in the urban environment are therefore necessary.

Table 12 – *Prospect for future PV deployment in the urban environment: evaluation of needs for policy and choice of models. Column 3 and 4: green = yes, light green = probably yes, light red = probably no, red = no. Other columns: green = favoured, yellow = possible, red = refused.*

Country	City	Prospect - mastering large-scale urban integration								
		Can the free market and the present urban regulation lead to good PV integration ?	Will strong PV deployment demand policy revision ?	Type of model favoured for orderly deployment of PV installations and to favour urban integration				Likely market shares		
				Free market, low regulation, incentives	Oriented market, regulation for good integration	Oriented market, regulation to promote concentration of PV in large installations	PV deployment only by utility	Investment by the owners on own building(s)	Investment by third parties on rented building surfaces	of which (100%), by utility
Canada	Toronto							100%	0%	-
	Peel							100%	0%	-
	Kelowna							100%	0%	-
Denmark	Horsens							100%	0%	-
France	Lyon							100%	0%	-
Holland	Heerhugowaard							100%	0%	-
	Langedijk							100%	0%	-
	Alkmaar							100%	0%	-
Japan	Hachinohe							100%	0%	-
	Ota							100%	0%	-
	Tokyo							100%	0%	-
Sweden	Malmö							100%	0%	-
Switzerland	Neuchâtel							30%	70%	50%
	Zurich							30%	70%	70%
USA	Boston							100%	0%	30%
	Orlando							100%	0%	50%

Regarding the need for policy change in case of strong growth of PV penetration, most participants think that present regulation and a free market should be able to ensure good integration. At the same time, and somewhat paradoxically, they estimate that policy revision will probably be necessary. Consideration of the answers to the next questions, allows concluding that a majority estimate that, within the present regulatory frame, a policy based on incentives will suffice to foster PV dissemination.

The type of model preferred to master the urban deployment of photovoltaic energy is rather open and decentralized. The model relying on low regulation and incentives as well as the market oriented one based on regulations are favoured. Options implying centralization of the deployment in the hands of large operators or utilities are less appreciated but not completely rejected. Apart from the urban constraints linked to good building integration, it is likely that the level of centralization of the PV deployment in large installations will depend on how the incentives orient the market. Generous feed-in tariffs and equal chances for all sizes of installation will favour decentralization. More restrictive support and priority to large plants will favour concentration. It is striking to observe that participants to the survey don't see a significant role for third party investors like utilities in future PV deployment, except in Switzerland. Building owners are seen as the sole actors of PV expansion, even though present market developments show that rental of building envelopes by solar investors is a growing tendency.

Table 13 – *Prospect for future PV deployment in the urban environment: evaluation of needs for policy. Green = necessary, light green = useful, yellow = secondary, orange = useless, red = ill-fated.*

Country	**City**	**Prospect - mastering large-scale urban integration**									
		Incentives or regulations to be developed for good PV integration individual investments in larger projects									
		National level				**Local level**					
		New or modified urban regulation	New or reinforced guidelines	Enhanced financial incentives for good integration	Financial instruments to promote gathering of individual investments in larger projects	New or modified urban regulation	Planned PV concentration in defined areas	New or reinforced guidelines	New practice or standards for aesthetics evaluation	Enhanced financial incentives for good integration	Financial instruments to promote gathering of individual investments in larger projects
Canada	Toronto										
	Peel										
	Kelowna										
Denmark	Horsens										
France	Lyon										
Holland	Heerhugowaard										
	Langedijk										
	Alkmaar										
Japan	Hachinohe										
	Ota										
	Tokyo										
Sweden	Malmö										
Switzerland	Neuchâtel										
	Zurich										
USA	Boston										
	Orlando										

Further, participants were asked to evaluate the need for different types of instruments, as *necessary*, *useful*, *secondary, useless* or *ill-fated*. For calculation of average values, these qualifications were given the respective values of 2, 1, 0, -1 and -2.

In most countries, intervention of the central state was desired to help in fostering large-scale urban PV deployment, in the form of regulation, guidelines or incentives. It was not the case in Switzerland

where decentralized competencies doesn't play in favour of reinforced national intervention. At a local level, all the proposed instruments obtain favourable majorities, with the following ranking:

1. New or modified urban regulation: 1,79
2. New or reinforced guidelines: 1,50
3. Financial instruments to promote gathering of individual investments in larger projects: 1,50
4. Planned PV concentration in defined areas: 1,21
5. New practice or standards for aesthetics evaluation: 1,14
6. Enhanced financial incentives for good integration:1,14

The classical instrument of urban regulation appears thus to be the best way for the promotion of good PV integration, together with adapted guidelines that can help the owners and architects in their effort to comply with the required quality. Quite astonishingly, financial incentives to promote concentration of solar plants in large realizations received large support, indicating that scattering of small installations is perceived as problematic. This may in part be due to the traditional central power supply model being better understood.

3 Conclusion and recommendations

Urban governments are in the business of assuring a high quality of life to their citizens and energy plays a large part. Photovoltaics can provide many solutions for the business of urban governments.

1. With half the world's population in high density urban areas, this represents a major PV market.
2. Cities have the jurisdiction to facilitate, remove obstacles, and achieve rapid PV deployment.
3. Urban PV deployment has the potential to modify the aspect of the built environment, by integrating functional energy solutions and aesthetics.

These three postulates were corroborated by the present study and their implications and modalities were identified.

Almost all the investigated cities have a high commitment towards energy policy compared to the national average. Most have established energy plans. However, provisions regarding photovoltaics are often missing. **Dependable urban energy policy implies planning of future renewable energy development with special emphasis on solar electricity integration with energy efficiency, and other building energy management – i.e. whole building design**. With respect to the answers given in other sections of the survey, it appears that PV deployment in cities cannot rely only on private initiatives but requires a certain level of planning. In urban areas, new policies are needed regarding PV deployment, such as a better regulation concerning solar access. The solar access issue is not always well understood by planners and architects, thus requiring a comprehensive approach. Solar access is separated into two distinct areas: solar easements (ability to continue to receive sunlight across property lines) and solar rights (ordinances and building codes). [iv]

Cities can reflect the commitment of the community by introducing subventions, as well as obligations for both energy profiles and equipment. Since customer sited PV, whether or not it is building integrated, is a novel energy solution, often the first step is for public buildings, resulting in greater public awareness and community support. Broadening the obligations to new buildings and re-developments can often be achieved through building energy codes and by introducing benefits such as expediting permits and inspections. Cities also have jurisdiction over property appraisals, preventing increased assessment which can lead to higher taxes and the diminishing of PV system values to the property owner. Local governments also have the ability to **integrate PV deployment schemes with other infrastructure planning such as land use, transportation, air and water quality and building aesthetics, resulting in higher community values.** Financial incentives through feed-in tariffs appear to belong more and more to the national policies but the local level often have sufficient competencies to be able to act as pioneers or to maintain specific mechanisms linked to green electricity schemes. **The role of the cities in financial support hence must be seen as innovators showing the way to national policies**. Photovoltaics have a major potential among the other renewable energies for developing the social aspects, offering an energy solution to improve the environmental quality of cities.

The present obstacle to urban PV deployment is chiefly economic. The insufficiency of public support and the lack of interest or knowledge by investors and owners are clearly identified as the main limiting factors. The latter barrier can be considered as a consequence of the former. Other obstacles such as the lack of knowledge by architects, or authorities, as well as the legal procedures are not considered as determining. This conclusion is in good agreement with the observations of the PV boom in countries where the economic obstacle was removed by the introduction of appealing feed-in tariffs. The consideration of economic development values as justification for policies was not considered in this report, but is emerging as a metric for both local and national policies.

Consistently, the existence of "**aesthetic filters**" in the form of authorization procedures, maybe with the intervention of a commission dealing with aesthetic appreciation, even though it can be felt as a medium level barrier, appears to have **no effect** on PV penetration and growth and positive impact on the quality of urban integration.

PV can be the solution to load growth in the dense urban environment. PV addresses grid overload without construction disruptions and the high level of commercial loads on the urban grid match closely with PV generation. PV does not require additional land in built-out urban areas, it can be building-integrated or use rooftop areas. Unlike other distributed generation, PV does not require fuel

storage or add emissions to urban areas struggling to attain acceptable levels of air quality. Though most of the cities participating in the study had energy plans, none had plans which were fully integrated with the urban area's long term comprehensive plan. **When integration of energy with all elements of comprehensive planning - transportation, air quality, economic development, land use, water, waste water, etc. – occurs, PV technology emerges as the best choice option.**

[1] As for instance in Basel in December 2006: http://www.swissinfo.ch/eng/front/detail/Man_made_tremor_shakes_Basel.html?siteSect=105&sid=7334248&cKey=1165839658000

[2] Report IIEA PVPS T7-4 : 2002 Potential for building Integrated Photovoltaics

[iii] EPIA, EU DG TREN "European Energy and Transport: trends to 2030, update 2007", Eurostat Data Portal,EU JRC Photovoltaic Geographical Information System, A.T. Kearney analysis

[iv] Report Solar America Board for Codes and Standards : A comprehensive review of solar access law in the United States