PHOTOVOLTAICS
for Small Consumers

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Union des consommateurs is a member of the International Consumer Organization (ICO), a federation of 234 members from 113 countries.

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The generic masculine gender is used herein to facilitate reading and avoid systematic redundancy.

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UNION DES CONSOMMATEURS: *Strength through Networking*

Union des consommateurs[1] is a non-profit organization whose membership is comprised of several ACEFs (*Associations coopératives d'économie familiale*), *l 'Association des consommateurs pour la qualité dans la construction* (ACQC), as well as individual members.

Union des consommateurs' mission is to represent and defend the rights of consumers, with particular emphasis on the interests of low-income households. Union des consommateurs' activities are based on values cherished by its members: solidarity, equity and social justice, as well as the objective of enhancing consumers' living conditions in economic, social, political and environmental terms.

Union des consommateurs' structure enables it to maintain a broad vision of consumer issues even as it develops in-depth expertise in certain programming sectors, particularly via its research efforts on the emerging issues confronting consumers. Its activities, which are nation-wide in scope, are enriched and legitimated by its field work and the deep roots of its member associations in the community.

Union des consommateurs acts mainly at the national level, by representing the interests of consumers before political, regulatory or legal authorities or in public forums. Its priority issues, in terms of research, action and advocacy, include the following: family budgets and indebtedness, energy, telephone services, radio broadcasting, cable television and the Internet, public health, food and biotechnologies, financial products and services, business practices, and social and fiscal policy.

Finally, regarding the issue of economic globalization, Union des consommateurs works in collaboration with several consumer groups in English Canada and abroad. It is a member of Consumers International (CI), a United Nations recognized organization.

INTRODUCTION

Energy demand growth in Canada and concerns about greenhouse gases (HGH) are making governments, energy distributors and consumers more and more interested in decentralized energy production (DEP) from renewable sources.

Among the technologies that might reach a large number of small consumers (residential consumers), solar energy technologies offer very great deployment potential. According to recent data from the Canadian Solar Industries Association (CANSIA), almost half (47%) of Ontario homes could use photovoltaic solar energy to produce electricity, whereas more than 2.5 million homes could use passive solar energy to heat water. This number could climb to 4.7 million by 2025 only in Ontario[1]. Far from being reserved for new housing starts, solar energy technologies can also be integrated to already-built homes.

However, deploying photovoltaic energy for residential consumers raises several questions for consumer rights organizations, notably regarding knowledge dissemination, profitability (in selling the electricity distributor any excess electricity likely to be produced and distributed on the network or grid by photovoltaic installations), energy cost savings, owner liability, as well as equipment certification and safety. The industry is particularly focused on the technological aspects of solar DEP[2], but what barriers confront the small consumer who is interested in solar photovoltaic technology and who could benefit from it?

This document is intended as a status report on photovoltaic energy in Canada, and on issues of concern to residential consumers regarding the deployment of photovoltaic solar energy.

First, we describe this technology's applications for small consumers. Then we draw a portrait of the various aspects that a consumer interested in this technology must consider – products offered, prices in effect, financing or installation terms, standards, maintenance, connection to electrical distribution networks (also called "grids"), etc.

The second part of the document describes the situation and development of photovoltaic markets in Canada, Europe and the United States. In particular, we discuss incentive programs and various policies put forward to stimulate this market and, to the extent possible, we report on the results of those incentives.

This document does not claim to draw an exhaustive portrait of the photovoltaic technology market's situation. Rather, our study describes the deployment of PV technology among small consumers here and elsewhere, in order to issue recommendations as to various paths for establishing a coherent policy of access to photovoltaic technology as a means of producing renewable energy in Canada.

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[1] Rob McMonagle (for the Canadian Solar Industries Association), *Review of the OPA Supply Mix Advice Report: No Forecast of Sunny Days for Ontario*, January 30, 2006. [Online] www.cansia.ca/downloads/report2006/C19.pdf (page consulted on November 12, 2007)

[2] Joseph Ayoub and Lisa Dignard-Bailey (Natural Resources Canada), *Photovoltaic Technology Status and Prospects*, Photovoltaic Power Systems Programme, International Energy Agency. May 26, 2006. [Online] www.iea-pvps.org/ar05/can.htm (page consulted on October 12, 2006)

PHOTOVOLTAIC TECHNOLOGY

Equipment

The raw material

Photovoltaic (PV) solar energy means electricity produced by converting part of solar radiation by using the photovoltaic cell, i.e., an electronic component that, exposed to light (photons), generates electric voltage (this is called the photovoltaic effect)[3]. A set of related cells forms a solar panel or photovoltaic module. A set of many connected modules is called a photovoltaic array.

Photovoltaic systems are danger-free, reliable and low-maintenance. They produce no pollutants or emissions, are inexpensive to operate, and are easily installed on most houses.

The photovoltaic effect was first produced by monocrystalline or polycrystalline silicon. These two technologies, which still make up a large part of worldwide production, have a comparable cost/benefit ratio[4]. But the development of Thin Film Technology, based on amorphous silicon or CIS (copper, indium, selenium), has lowered costs by reducing the quantity of material required to build a cell. Being less efficient, Thin Film Technology requires larger modules to produce a given quantity of electricity. A large part of R&D efforts worldwide to improve the efficiency of PV systems focuses on improving the performance of Thin Film Technology.

Technologies and Performances of Today's Photovoltaic Cells

Technology	Cell Conversion Efficiency	Useful Life
Crystalline silicon	15 to 17% (industrial)	35 years
Thin film of amorphous silicon	7% (industrial)	< 10 years (outdoors)
Thin film of CIS	12% (laboratory)	Not evaluated
Ratio of organic / inorganic	5%	Very low currently

(excerpt from: RÉPUBLIQUE FRANÇAISE: La recherche en matière de solaire photovoltaïque.[5])

Photovoltaic models used for residential applications range in power from 75 to 120 watts and measure about 0.6 m x 1.2 m (approx. 2 x 4 ft.). Given current module efficiency, a 1 m^2 (10.7 $ft.^2$) module produces about 130 watts in full sunshine. A 100-watt photovoltaic model generates on average 400 Wh per day or 100 kWh per year in most inhabited areas of Canada[6].

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[3] Definition taken from Wikipedia. [Online] http://en.wikipedia.org/wiki/Solar_cell (page consulted on October 10, 2007)
[4] NATURAL RESOURCES CANADA. *Op. Cit. 4.*
[5] RÉPUBLIQUE FRANÇAISE - Ministère de l'Écologie, du Développement et de l'Aménagement durables - La Direction Générale de l'Énergie et des Matières Premières; *La recherche en matière de solaire photovoltaïque*. Extrait de la stratégie nationale de recherche énergétique. Approche thématique: les énergies renouvelables. May 2007. [Online] www.industrie.gouv.fr/energie/recherche/solaire-photovoltaique.htm (page consulted on April 14, 2008)
[6] CANADA MORTGAGE AND HOUSING CORPORATION. *Photovoltaics (PVs) – About Your House – General Series*. [Online] www.cmhc-schl.gc.ca/en/co/maho/enefcosa/enefcosa_003.cfm (page consulted on October 10, 2007)

Solar modules of crystalline silicone have a very long useful life. Batteries (also called "accumulators"), on the other hand, have a useful life of only 5 to 10 years[7].

Solar panels are often connected to batteries storing the energy produced, for nighttime uses or in periods of low sunshine.

In addition to PV panels and batteries, PV systems require power-conditioning equipment, including battery inverters and charge controllers.

Power-conditioning equipment[8]

Inverters and charge controllers condition the energy produced by photovoltaic cells to make it reusable for common everyday use.

The current produced and stored by PV cells and batteries is direct current (DC). Most household appliances, however, use alternating current (AC). So an inverter must be added to the system, to convert low-voltage direct current (12 to120 V DC) into higher-voltage alternating current (120 or 240 V AC). This conversion causes a certain loss of energy, since the inverters' efficiency is generally from 80% to 95%. Low-power inverters are suitable for small systems, which supply lighting fixtures, for example. In the case of devices that undergo a strong voltage surge when starting, such as motors, high-power inverters are required.[9]

Charge controllers serve to control the intensity of the current passing through the batteries, which are thus protected against voltage surges and complete discharges. Most often we find "all or nothing" and pulse width modulation regulators, which range from 2 to 300 A and adapt to voltage surges of 12 to 48 V DC.

The majority of electronic components, including inverters and charge controllers, last at least 10 years, if their capacity is not exceeded.

Solar tracker

To obtain maximum power from periods of sunshine, a solar tracker can prove effective. However, this device makes the system more complex and is unsuitable for installations left unattended for long periods. Moreover, in Canada, solar trackers don't make much difference in winter[10]. The main consideration in installing such a device is to determine whether it's more profitable economically and in terms of energy production to use one than to acquire additional fixed PV panels.

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[7] *Ibid.*

[8] NATURAL RESOURCES CANADA. *Op. Cit.* 4

[9] Low-power inverters: 100 to 1,000 W, with input voltage of 12 or 24 V DC and input of 120 V AC; high-power inverters: 1,000 to 4,000 W with input of 12, 24 and 48 V DC and output of 120 or 240 V AC.

[10] NATURAL RESOURCES CANADA. *Op. Cit.* 4

PV Systems and Networks

Off-grid or stand-alone systems
Structures equipped with an off-grid PV system don't depend only on sunlight to meet their electricity needs. These systems generally contain batteries storing produced energy for nighttime or periods of low sunlight. The size of the PV module array and the battery bank must be determined carefully to optimize system performance.

Some PV systems are combined with a wind turbine or a fuel generator, or both simultaneously. These hybrid systems prove useful for applications requiring continuous high power, or when solar radiation diminishes at certain times of year. They also make it possible to reduce the investment in photovoltaic arrays and batteries.

On-grid PV systems
Structures equipped with a PV system linked to the electrical distribution network produce their own energy, but they can also, in low sunlight, be supplied by the network, thus avoiding the need for a substantial battery bank. In this type of installation, the inverter and any connection equipment must meet very strict standards, required by interconnection with public networks.

In periods of high sunlight, systems connected to the network can also forward to the network any excess power they produce, which other customers can thus consume. The contribution of power to the network can be metered, and the independent producer compensated in various ways.

Net metering
The "net metering" option serves to record the conventional quantity of electricity that an autonomous PV producer takes from the public network, and the quantity of PV electricity he injects into it. By subtracting the power injected from the power taken, the "net billing" option results in a corresponding reduction in the quantity of electricity billed to the independent producer by the network.

Feed-in tariffs (FITs)
Feed-in tariffs are a measure adopted by many governments to promote the development of a decentralized renewable energy production network. Through this measure, public utilities are motivated to purchase excess power produced by autonomous renewable energy producers; the utilities pay a guaranteed minimum price that is set by decree and that, as opposed to the net billing option, reflects actual power production costs.

Architectural PV Products

Architectural photovoltaic products are now perfectly integrated to public buildings and homes. Building-integrated PV, or BIPV, are a major innovation in building architecture and design. Although photovoltaic technology is more and more widespread in the world, it is less and less visible. Perfected in the 90s, more than 50 commercial photovoltaic products and special building attachment systems are now on the market and replacing standard construction materials. New construction products, in fact, are used for integrating photovoltaic systems on sloping roofs, flat roofs, façades and shadow-producing structures. Building-integrated photovoltaic products are generally more costly than traditional construction materials, but their cost is falling gradually, making them more and more affordable[11].

The integration of BIPV components to a building offers more than just economic advantages. Building aesthetics may be improved by the integration of photovoltaic modules to the building envelope rather than placing them on rooftop or ground supports. Several glass manufacturers offer products that have distinct patterns, colours or shapes and enable architects to give a building the desired appearance[12]. Some products can replace tiles or siding. These products, offering a choice of surface and colour, also have intrinsic thermal insulation and soundproofing qualities[13].

Germany, Holland, the United States and Japan are world leaders in building-integrated photovoltaic applications. These systems are often connected to a local electricity distribution network. Australia is very active in developing this technology[14].

[11] NATURAL RESOURCES CANADA. *Photovoltaics for Buildings: Opportunities for Canada*. Summary [Online] cetc-varennes.nrcan.gc.ca/fr/er_re/pvb/p_p.html?2001-123 (page consulted on November 7, 2007).
[12] *Ibid.*
[13] INDUSTRY CANADA, Unleashing the Potential of On-Grid Photovoltaics in Canada: An Action Plan to make PV an Integral Component of Canada's Energy Future, Delphi Group. [Online] ic.gc.ca/epic/site/rei-ier.nsf/vwapj/pv_eng.pdf/$file/pv_eng.pdf (page consulted on October 11, 2007).
[14] NATURAL RESOURCES CANADA. *Technologies and Applications – Photovoltaic: Integrating Photovoltaic Arrays in Buildings.* [Online] canren.gc.ca/tech_appl/index.asp?CaId=5&PgId=266
(page consulted on November 7, 2007).
Unleashing the Potential of On-Grid Photovoltaics in Canada: An Action Plan to make PV an Integral Component of Canada's Energy Future, Delphi Group.

ASPECTS AFFECTING CONSUMERS

PV Energy Needs Assessment

Off-grid systems

A needs assessment is particularly important for the installation of an off-grid system, since that assessment will determine the system's size. Accordingly, it's important to determine which appliances will be powered by PV energy, their power consumption, residents' habits, and weather conditions where the system is to be installed. Naturally, the greater the needs, the larger the system must be to meet them. In that vein, reducing demand by purchasing energy-efficient appliances can be a good decision.

The next step is to size the module (panel) array. Once energy needs are determined (in watts), this value is divided by the modules' nominal capacity (generally 20 W to 120 W) to obtain the number of modules required. PV systems being modular, it is possible to proceed in stages, i.e., to begin with a simple installation that meets basic needs and then extend the system as allowed by the budget allows or as justified by the energy demand.

Moreover, the batteries' capacity will depend on the owner's requirements for uninterrupted power and the amount he's prepared to pay. If the system must, for example, supply a cottage used only a few days a week, occasional power failures caused by long periods without sunlight will be less problematic than they would be for a main residence. In any case, it's wise to plan for sufficient storage capacity to ensure power for three to five consecutive days without sunlight.

> "While most homes in Canada use 20 – 30 kWh per day, energy-efficient homes often require only 8 – 12 kWh daily. A highly energy-efficient home may be able to be powered by a two-three kW solar array, while remote cottage systems typically range between 100 watts to 1.0 kW." [15]

On-grid systems

The needs assessment for systems linked to the network is less crucial because, as the case may be, it is possible to rely on the network's power supply. The capacity of these systems is generally established according to the owner's financial means. The capacity of an installation linked to the network does not depend solely on energy needs, but rather on how the owner values the non-financial benefits of solar energy. However, the photovoltaic systems' inherent capacity for self-sufficiency, and thus for independence in the event of power failures, is attractive to many owners[16].

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[15] Canada MORTGAGE AND HOUSING CORPORATION. *Op. Cit. 6.*
[16] *Ibid.*

Weather Conditions

Knowing the solar resources available is key to the design of an efficient PV system. In that regard, Canadian weather conditions pose a special challenge. Indeed, photovoltaic installations must produce electricity even during major seasonal fluctuations of solar radiation, and be capable of withstanding sometimes extreme conditions.

> "Many locations in Canada that have a dry continental climate have the same number of daylight hours as some Mediterranean countries. […] In some urban areas in warm climates, the cost per kilowatt-hour of electricity from grid-connected PV systems is competitive with that of other electricity-generating systems. In areas with less solar radiation, the cost-effectiveness of this type of PV system is still marginal. But there is a potential for peak power savings in areas where air conditioning causes a power peak in the summer. […] In areas with less solar radiation, the cost-effectiveness of this type of PV system is still marginal. […] Contrary to what many people think, PV systems convert sunlight into electricity more efficiently at lower temperatures. However, the winter months in Canada provide half the hours of sunlight as in summer [17]."

Natural Resources Canada has produced maps that indicate the average daily values of peak sunlight hours that strike south-facing, fixed PV arrays in various parts of Canada in September and December[18]. These values assume that the arrays are tilted at right angles to the sun at noon. Alternatively, you can get weather and solar radiation values for various regions from Environment Canada's Meteorological Service of Canada[19] or from RETScreen® International software[20].

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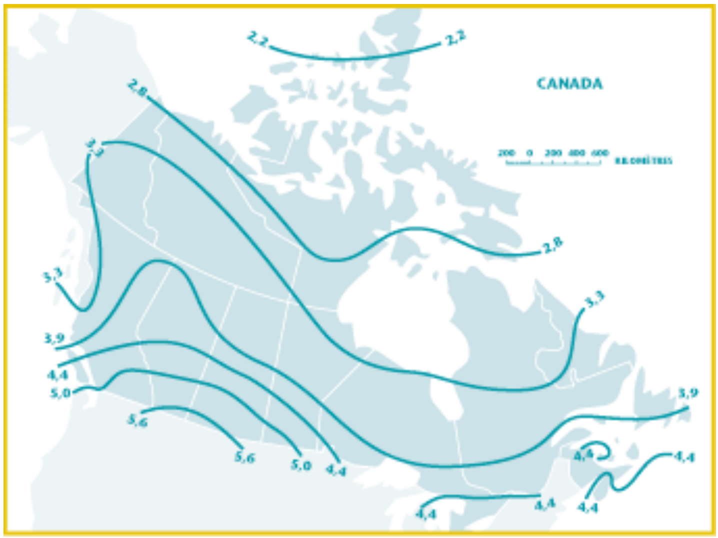
[17] NATURAL RESOURCES CANADA. *Op. Cit. 4.*

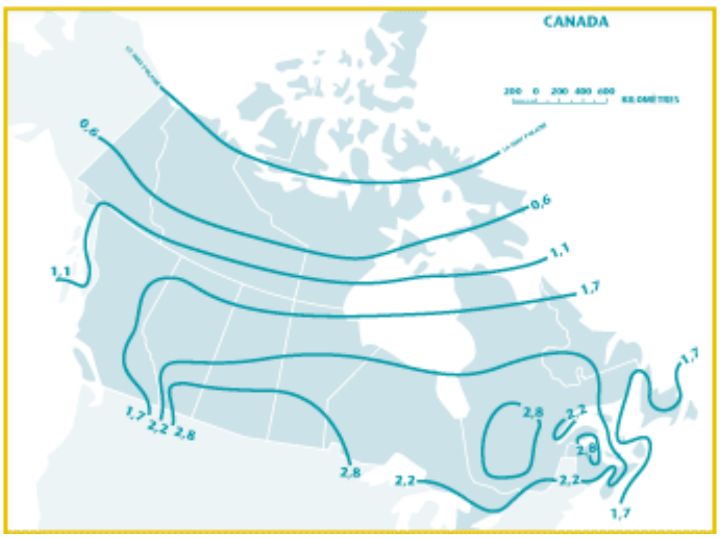
[18] NATURAL RESOURCES CANADA, *Photovoltaic potential and solar resource maps of Canada*. [Online] https://glfc.cfsnet.nfis.org/mapserver/pv/index_f.php?&NEK=e (page consulted on October 22, 2007).

[19] ENVIRONMENT CANADA. *Weather and Meteorology, Government of Canada*. [Online] www.ec.gc.ca/default.asp?lang=En&n=C062DE2A-1 (page consulted on November 15, 2007)

[20] NATURAL RESOURCES CANADA. *Retscreen International – Clean Energy Project Analysis Software.* [Online] www.retscreen.net/ang/home.php (page consulted on October 22, 2007)



Average daily number of peak sunlight hours in September
(use for seasonal summer autonomous systems)
Source: Environment Canada.



Average daily number of peak sunlight hours in December
(use for year-round-operated autonomous systems)
Source: Environment Canada.

Purchases and Prices

In Canada, photovoltaic systems are barely starting to be widely available in hardware and department stores. Most systems in use are customized[21], but more and more are sold as standard kits.

PV systems require a substantial initial investment, but very small operating and maintenance costs. In addition, an attractive feature of these systems is that they are modular and can thus be extended as needs evolve.

The price and cost-effectiveness of a photovoltaic system depend, to a large extent, on where it is installed. To determine the cost-effectiveness of a PV system, it is necessary to weigh the overall cost and compare it to that of other available energy-production options, such as wind power or a fuel generator, while taking into account the initial investment in equipment, the fuel cost, and operating and maintenance costs for the entire useful life of each option[22].

The price per watt of photovoltaic modules has dropped by half in seven years, from $11.09 CAN in 1999 to $5.36 CAN in 2006, for an average annual decrease of 9%. PV panels have a useful life of about 40 years, so they maintain an excellent resale value and generally come with a 20- to 25- year warranty, depending on product type and manufacturer policies[23].

Evolution of the average price per watt of a photovoltaic module in Canada[24]

	1999	2000	2001	2002	2003	2004	2005	2006
Can$	11.09	10.7	9.41	7.14	6.18	5.53	4.31	5.36

In Canada, in 2006, the price of a complete off-grid PV system was estimated at $15.30 US per watt. A basic autonomous PV system of 40 to 100 W that could power a few lamps, the water pump and radio receivers in a cottage, for example, could cost $600 to $1500. On-grid systems were estimated at $8.80 US per watt[25].

The difference in cost between an off-grid system ($15.30 US/w) and an on-grid system ($8.80 US/w) is largely attributable to the batteries, which can represent 25% to 50% of the total cost of an off-grid system. The choice of capacity and battery type is thus a major consideration in designing a system, particularly one without a backup power supply.

As for inverters, the least expensive produce a current that is not of equal quality to that produced by a public utility, so that certain appliances, such as computers, are not sufficiently powered to be used. Modified sine wave inverters usually produce electricity of similar quality to

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[21] NATURAL RESOURCES CANADA. *Op. Cit.* 17.
[22] NATURAL RESOURCES CANADA. *Op. Cit.* 17
[23] *Ibid.*
[24] INTERNATIONAL ENERGY AGENCY. *Trends in Photovoltaic Applications – Survey Report of Selected IEA Countries between 1992 and 2006*. [Online] www.iea-pvps.org/products/download/rep1_16.pdf (page consulted on November 15, 2007)
[25] *Ibid.*

that produced by a distribution network[26]. On-grid system inverters must meet the standards and technical requirements imposed by public distribution networks.

Financing terms

An investigation conducted among a few Canadian banks (Scotiabank, Royal, Toronto-Dominion, National and Montreal) reveals that financial institutions have not established or generalized any special financing plans for acquiring renewable energy-production equipment.

Assessment tools

The Web site of Natural Resources Canada provides a lot of information on renewable energy[27], solar energy, needs assessments, and the installation and maintenance of PV systems. For example, it contains two examples of sizing calculations – for a summer cottage and for a remote residence occupied year-long.

Natural Resources Canada also publishes *The Buyer's Guide*, which offers tools for determining the exact consumption of appliances to be connected to the system, even including invisible loads used by the programming memory of electronic appliances, for example[28].

Finally, Natural Resources Canada has designed the *RETScreen* clean energy project analysis software[29]. It's a decision-making help tool developed in collaboration with industry, government and academic experts. Offered free of charge, this software can be used anywhere in the world to evaluate the energy production and savings, life cycle cost, emission reductions, economic viability, and risks of various energy efficiency and renewable energy technologies. The software includes product, cost and weather condition databases, as well as an online user's guide. The RETScreen International site also presents case studies.

[26] NATURAL RESOURCES CANADA. *Op. Cit.* 17

[27] NATURAL RESOURCES CANADA. *Canadian Renewable Energy Network – Solar Energy* [Online] http://www.canren.gc.ca/solar/index.asp (page consulted on October 10, 2007)

[28] NATURAL RESOURCES CANADA. *Op. Cit. 4.*

[29] NATURAL RESOURCES CANADA. *RETScreen International*. [Online] www.retscreen.net/fr/home.php (page consulted on October 15, 2007)

Installation

Location assessment[30]

For maximum efficiency, a few basic rules are necessary when assessing the PV system's location.

- Photovoltaic panels are placed outside, unprotected, on a weatherproof rigid support;
- Modules are tilted south, at a right angle to the noon sun, and adjusted to take into account the sun's lower angle in winter;
- 10% shade on a PV module can reduce its output power by 100%;
- In most cases, the ideal location for a module array is on the house's roof;
- Batteries must be stored in an insulated and ventilated enclosure where the temperature is maintained between 18°C and 22°C year round. they must be kept well away from open flames or sparks, as they release small quantities of hydrogen while charged;
- They must comply with the standards and requirements of the Régie du bâtiment and the Canadian Electrical Code.

The "solar power centre" of small systems only requires a 0.6 m x 0.9 m wall area. Larger systems may require a 1.21 m x 1.21 m area.

Installation of photovoltaic panels

Owners who acquire a new house or make major renovations and who want to install a photovoltaic system, or at least prepare the house for the eventual installation of a PV system, can more easily take certain measures in view of installing a more efficient PV system. The location and orientation of the house, the roof slope angle, landscaping, tree planting, etc., can have a major impact on the quantity of available solar radiation. Moreover, it is much more economical to install electrical wires during construction or renovation than to have to drill holes later[31].

Maintenance

Aside from clearing the panels of snow in winter and dusting them in summer, the system's maintenance generally involves an occasional inspection of the wiring and of the solar panels. Battery maintenance varies according to the model. An adequate level of electrolyte must be maintained and the density of that solution must be checked regularly with a hydrometer. Distilled water must be added as needed, and terminals must be cleaned and tightened. Leaks and signs of wear and damage should also be checked[32].

[30] CANADA MORTGAGE AND HOUSING CORPORATION. *Op. Cit.* 15
[31] *Ibid.*
[32] NATURAL RESOURCES CANADA. *Op. Cit.* 17

Professional Expertise and Certification Program

The Canadian Solar Industries Association (CanSIA) offers a solar installer training and certification program[33]; graduates must have the necessary knowledge for designing, installing and operating residential photovoltaic systems. In most cases, equipment must be installed by a master electrician. However, since PV installations are not relatively widespread, electricians don't generally have a very good knowledge of solar electricity. Thus, while they are able to install a system that meets current code standards, they may not be able to maximize the solar system's performance when installing it.

To ensure that the electrical installation and the photovoltaic system are up to standards, the installation must be inspected by provincial experts in electrical installation safety. By having an electrical inspection done, the owner transfers the safety liability to the ESA and ensures that his insurer will cover potential home liability claims[34].

Interconnection

The issues involved in implementing distributed energy resources contradict traditional concepts and methods for producing, transmitting and delivering electricity to consumers. The interconnection of PV systems to public networks continues to pose many obstacles to mass marketing, particularly because of the steps consumers must take to obtain approvals; those steps are at times complex and can be attributed to a lack of familiarity and experience with the technology among various stakeholders[35].

To provide a framework for the emergence of this new industry of distributed energy resources, governments and regulatory bodies are responsible for establishing technical guidelines to adopt equipment manufacturing and installation standards, and to establish protocols for reducing costs, red tape and safety problems.

The Canadian Power Connect[36] initiative offers technical and regulatory support for implementing distributed energy resources. A task force formed by industry stakeholders, regulatory authorities and the federal government will contribute to developing an interconnection, net metering and contractual agreement policy[37] in view of the approval of energy net billing in Canada.

The CANMET Energy Technology-Varennes, which coordinates, notably, the scientific component of Natural Resources Canada's photovoltaic energy work, has made major efforts in recent years to define and get adopted, through the MicroPower Connect initiative, Canadian

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[33] THE CANADIAN SOLAR INDUSTRIES ASSOCIATION. *Education* [Online] www.cansia.ca/education.asp (page consulted on April 7, 2008)
[34] CANADA MORTGAGE AND HOUSING CORPORATION. *Op. Cit.* 15
[35] INTERNATIONAL ENERGY AGENCY *National Survey Report of PV Power Applications in Canada – 2006*. [Online] http://cetc-ctec.nrcan-rncan.gc.ca/fichier.php/codectec/En/2007-105/2007-105e.pdf. (page consulted on October 17, 2007)
[36] POWER CONNECT. *Canadian Codes and Standards* [Online] http://www.powerconnect.ca/index-e.htm (page consulted on April 2, 2008)
[37] POWER CONNECT. *Connecting MicroPower to the Grid – A status and review of micropower interconnection issues and related codes, standards and guidelines in Canada - 2nd Edition.* [Online] www.powerconnect.ca/codes/Canada/Connecting%20MicroPower%20to%20the%20Grid.pdf (page consulted on April 2, 2008)

interconnection standards and codes, and is responsible for approving products and their installation. Those efforts resulted in the 2006 publication of the national Canadian standard CAN/CSA-C22.2 No. 257-06. "This standard, one of a series of Standards issued by the Canadian Standards Association under Part II of the Canadian Electrical Code, specifies the electrical requirements for safe interconnection of inverter-based micro-distributed resource (micro-DR) systems connected to 600 V (nominal) or less distribution systems (single or three phase). This standard will facilitate the integration of renewable energy generation to the electricity network in Canada, particularly for end-use customers interested in self-generation[38]".

Net billing
In Canada, electricity is under provincial jurisdiction and connections are generally made according to the requirements of the distribution company. Regulations for net metering and net billing have been enacted in several provinces[39]. They establish rules for power flow between public utilities and decentralized PV systems. Applying those regulations poses a challenge because new equipment (for example, appropriate meters) and billing systems must be installed. Some public utilities (such as BC Hydro[40], Toronto Hydro[41] and Hydro-Québec Distribution[42]) have developed and implemented programs that rationalize the application process and specify net metering requirements.

Feed-in tariffs (FITs)
The concept of feed-in tariffs or FITs generally refers to the minimum guaranteed price that a public utility must pay an autonomous renewable energy producer for each kWh injected in the network. This tariff may be based on the production costs of the renewable energy according to the technology used (wind, solar, biomass, etc.), on the cost charged to the consumer to which is added a bonus taking into account the social and environmental benefits of renewable energy, or on variables such as the hour or the season when the energy is delivered. It can also be set at a certain level, with no direct relation to the cost or price of that energy, simply to encourage the production of renewable energy.

The tariff may be established for a long period, to assure producers of a certain stability, or it may be adjusted periodically depending on reductions in the costs of producing renewable energy, or depending on inflation. Over the past decade, this type of tariff has been a powerful tool for promoting the generation of electricity from renewable sources, notably in Germany, Spain and Japan.

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[38] CETC-VARENNES. *First Canadian Interconnection Standard, Natural Resources Canada.* [Online] http://cetc-ctec.nrcan-rncan.gc.ca/eng/clean_power/pv_buildings/success_stories/5.html (page consulted on November 15, 2007)

[39] POLLUTION PROBE – *A Consumer Guide to Green Power in Canada* [Online] www.pollutionprobe.org/whatwedo/greenpower/consumerguide/c2_4.htm (page consulted on November 15, 2007)

[40] BC HYDRO. *Net Metering* [Online] www.bchydro.com/info/ipp/ipp8842.html (page consulted on November 15, 2007)

[41] TORONTO HYDRO. *Net Metering.* [Online] www.torontohydro.com/electricsystem/customer_care/cond_of_services/generation_connection/net_metering/index.cfm (page consulted on November 15, 2007)

[42] HYDRO-QUÉBEC. *Self-generation*. [Online] www.hydroquebec.com/autoproduction/en/index.html (page consulted on November 15, 2007)

In Canada, only the Ontario government offers, through the Ontario Power Authority (OPA) and the Ontario Energy Board, a standard purchasing program[43]. This program, established in 2006, is intended to encourage the use of renewable energies, including photovoltaic, wind, hydroelectric and biomasss, through small systems connected to the electrical distribution network.

Under the terms of this program, PV energy producers must invest the necessary amounts for acquiring installations, buying distribution network interconnection equipment and metering equipment, and covering certain operating and maintenance costs. For its part, the OPA is committed to pay a rate of $0.42 Can/KWh for small PV projects connected to the network, for the entire term of the contract, i.e., 20 years. The $0.42 rate will be reviewed periodically, but cannot be changed retroactively for contracts in course of execution. Thanks to this standard offer program, the Ontario government hopes to attain the objective of 2,700 MW of renewable energy by 2010[44].

The launch of the Ontario standard offer program regarding renewable energies, on November 22, 2006, was considered by the Canadian PV industry as a major step forward in the development of a strong and competitive Canadian solar energy industry. The standard offer program will make it possible, first, to encourage market leaders, or “early adopters”, to purchase PV systems, and it should attract investments to the Canadian solar energy industry, possibly with Ontario as the economic centre of solar energy in North America.

[43] ONTARIO POWER AUTHORITY. *Standard Offer Program – Renewable Energy For Small Electricity Generators – An Introductory Guide*. [Online] www.powerauthority.on.ca/sop/Storage/44/3985_SOPInformationBrochure.pdf (page consulted on December 15, 2007)

[44] The cumulative results of this program are available on OPA’s site. ONTARIO POWER AUTHORITY. *A Progress Report on Renewable Energy Standard Offer Program – November 2007.* [Online] www.powerauthority.on.ca/sop/Storage/66/6199_RESOP_February_2008_report.pdf (page consulted on April 2, 2008)

CONVERGENT AND DIVERGENT FORCES FOR PV DEVELOPMENT IN CANADA[45]

The Delphi group, in a study of the potential of photovoltaic energy conducted for Industry Canada, reported on several factors that encourage and discourage the development of this form of renewable energy. This study was conducted in 2003, before the development of the first Canadian interconnection standard, published in 2006 (CAN/CSA-C22.2 no 257-06), titled *Interconnecting Inverter-Based Micro-Distributed Resources to Distribution Systems*. The adoption of this standard has made it possible to specify the methods for connecting PV systems to the network, and to simplify the life of eventual small PV producers.

Convergent forces

- Under the Kyoto Protocol, 106 countries adopted concrete measures to reduce national GHG emissions.
- Uncertainty about fossil fuel reserves, combined with energy price instability, is motivating some users to produce their own energy. They are turning toward more-reliable sources with stable prices, such as photovoltaic energy.
- Awareness of air quality issues is leading governments to adopt new regulations, and companies to reduce polluting emissions.
- The production of renewable energies has benefited from major technological advances that make it more economical and, in certain cases, competitive with some forms of conventional energy.
- The deregulation of electricity, which should increase competition and performance, is broadening consumer choices, creating a market where the actual price of electricity determines demand and offers a new chance for network integration, which in turn considerably favours distributed production.

Divergent forces

- The costs of investing in PV equipment are still very high, considering the weakness of conversion performance (14% to 18%).
- The commercial and legislative framework is designed for major providers and centralized production, which again disadvantages distributed energy production and small producers of renewable energies.
- Major actors and decision-makers still have misconceptions and misunderstandings about photovoltaic applications and their advantages, which is making it difficult to develop this sector.
- Architects, designers, electricians, installers, insurers and other actors still lack training and experience.
- End users, utilities, governments and others are not truly succeeding in creating large-scale outlets for PV.
- Market rules and deregulation are currently impairing PV or preventing it from being competitive on the energy market.
- The Canadian photovoltaic industry does not have sufficient influence and presence.
- There is a lack of business incentives — discounts, rebates, subsidies, tax reductions, information campaigns.
- Awareness-raising of PV's positive spin-offs is insufficient.
- Current pilot projects demonstrating PV's feasibility are not numerous enough.

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[45] INDUSTRY CANADA (by the Delphi Group), Unleashing the Potential of On-Grid Photovoltaics in Canada: An Action Plan to make PV an Integral Component of Canada's Energy Future. [Online] www.ic.gc.ca/epic/site/rei-ier.nsf/en/h_nz00017e.html (page consulted on October 11, 2006)

- Standards for roofs covered with photovoltaic modules do not take into account constraints from snow and wind, among other things.

THE STATUS OF PHOTOVOLTAIC ENERGY IN CANADA

Installed PV Power

Total PV power installed in Canada increased by 31% in 2006 to almost 20.5 MW, compared to 16.75 MW at the end of 2005[46]. Sales of PV modules for domestic use totalled 3.74 MW in capacity in 2006, compared to 2.86 MW in 2005, which also represents an increase of 31%.

Distribution of installed PV power in Canada[47]

Off-grid PV (93%)		PV connected to a network (7%)		Total PV	PV per capita	PV in 2006	PV connected to a network in 2006
Residential	Non-residential	Distributed	Centralized				
6,680 kW	12,296 kW	1,443 kW	65 kW	20,484 kW	0.6 w	3,738 kW	384 kW
32.7%	60%	7%	.3%				

In Canada, in 2006, the capacity of off-grid sites increased to almost 19,000 kW, whereas the capacity of on-grid installations was only 1,500 kW. Worldwide, we find the opposite situation: photovoltaic systems connected to a distribution network constitute the vast majority of installations[48].

Cumulative installed PV power in Canada in 1993-2006 (MW)[49]

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1.2	1.5	1.9	2.6	3.4	4.5	5.8	7.2	8.8	10.0	11.8	13.9	16.7	20.5

Since 1993, the Canadian PV market has experienced an average annual growth of 24%.

46 INTERNATIONAL ENERGY AGENCY. *National Survey Report of PV Power Applications for Canada - 2006*. [Online] http://cetc-ctec.nrcan-rncan.gc.ca/fichier.php/codectec/En/2007-105/2007-105e.pdf (page consulted on November 14, 2007)
47 INTERNATIONAL ENERGY AGENCY. *Op. Cit. 24.*
48 *Ibid.*
49 *Ibid.*

Public Budget Earmarked for PV

The total budget earmarked for the photovoltaic sector in Canada increased by $450,000 CAN in 2006, i.e., by 6% more than in 2005. This increase is partly explained by substantial multi-year federal funding of the Canadian Solar Building Research Network.

Trends in public budgets for R&D,
demonstration/field test programmes
and market incentives in Canada in 2005 (CAD x 1000)[50]

	1999	2000	2001	2002	2003	2004	2005	2006
Total fed/prov	890	1,500	1,950	5,955	8,540	9,800	7,700	8,150
Annual trend	-	68%	30%	205%	43%	15%	-21%	6%

Public budgets for R&D, demonstration/field test programmes
and market incentives in Canada in 2006 (CAD x 1000)[51]

	Market Incentives	Demo/ Field Test	R & D	Total
Federal	0	3,050	3,300	6,350
Provincial	100	600	1,200	1,800
Total	100	3,650	4,500	8,150

[50] *Ibid.*
[51] *Ibid.*

Support Programs

Federal

In place since April 2007, the ecoENERGY program, established by Natural Resources Canada, has a budget of $1.48 billion over 10 years to increase Canadian electricity production from wind power, biomass, low-impact hydroelectric stations, geothermal energy, photovoltaic energy and ocean energy. This program will assist in the production of 14.3 terawatt-hours of electricity from renewable energy sources – enough electricity to supply about 1 million households.

ecoENERGY for Renewable Power[52]

The ecoENERGY for Renewable Power program aims to help Canadians use energy more efficiently, to reinforce renewable energy supplies, and to develop less-polluting energy technologies.

Are eligible for this program: companies, municipalities, institutions and organizations.

Under the terms of this program, ecoENERGY for Renewable Power will spend, for a maximum period of 10 years, one cent (1¢) per kilowatt-hour obtained as part of a project carried out between April 1, 2007 and March 31, 2011 to produce clean electricity from renewable energy sources.

Although, as of January 14, 2008, 135 projects[53] totalling 9540.8 MW were approved, none of those projects involves the use of photovoltaic technology.

ecoENERGY for Renewable Heat[54]

The Canadian government, through the ecoENERGY for Renewable Heat program, will invest $36 million over four years to increase the use of renewable thermal energy by industries, companies and institutions. Nothing in this program concerns PV energy production.

In Quebec

No support or incentive program involving PV power is available in Quebec. However, the Quebec government, in its energy strategy for 2006-2011, specifies, about solar energy, that: "*Québec also intends to foster the development of solar energy by asking Hydro-Québec to submit a program to the Régie de l'énergie for the development of active solar technology in Québec, based on the approaches used by other jurisdictions and adjusted to reflect the situation in Québec. The Agence de l'efficacité énergétique, in its new energy technology support program, will also support the development of active solar energy*[55]*.*"

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[52] NATURAL RESOURCES CANADA – ECOACTION *ecoENERGY for Renewable Power* [Online] http://ecoaction.gc.ca/ecoenergy-ecoenergie/power-electricite/projects-projets-eng.cfm (page consulted on November 15, 2007)

[53] NATURAL RESOURCES CANADA – ECOACTION *Projects Registered under ecoENERGY for Renewable Power* [Online] http://ecoaction.gc.ca/ecoenergy-ecoenergie/power-electricite/projects-projets-eng.cfm (page consulted on November 15, 2007)

[54] NATURAL RESOURCES CANADA – ECOACTION *ecoENERGY for Renewable Heat* [Online] http://ecoaction.gc.ca/ecoenergy-ecoenergie/heat-chauffage/index-fra.cfm (page consulted on November 15, 2007)

[55] MINISTÈRE DES RESSOURCES NATURELLES ET DE LA FAUNE. *Québec Energy Strategy 2006-2015*, page 70 of the document [Online] www.mrnf.gouv.qc.ca/english/publications/energy/strategy/energy-strategy-2006-2015.pdf (page consulted on January 7, 2008)

Demonstration and field test Programs

The following are highlights of the main demonstration and field test programs undertaken in Canada in 2006.

Exhibition Place, Toronto[56]
In August 2006, the City of Toronto installed a rooftop PV system of 100 kW – the largest solar energy system in Canada – on the roof of Horse Palace at Exhibition Place. This system includes four subsystems, each using a different combination of solar power, inverters and assembly technologies, and together they should produce 120 MW of electricity annually. The electrical output of each subsystem is separately monitored and compared to determine the best combination of technologies to be used in future projects.

Fred Kaiser Building of British Columbia University[57]
British Columbia University installed an on-grid 7-kW PV system in the skylight of Fred Kaiser Building, which houses UBC's Electrical and Computer engineering Department. The system was designed by a partnership of architects and PV industry representatives. The photovoltaic panels installed on the atrium skylight supply DC power for security lighting and for Power Lab experiments requiring direct current.

Alberta Solar Exhibition Showcase[58]
In 2006, the Climate Change Central partnership, in the province of Alberta, launched the Alberta Solar Municipal Showcase, an on-grid photovoltaic system demonstration project on highly visible public buildings in 20 municipalities. The purpose of the project is to raise the awareness of municipal authorities as well as citizens regarding this form of renewable energy and its positive environmental impact. It is estimated that the completed project will generate 20 megawatts/hour of electricity and reduce CO_2 emissions by about 22 tonnes annually.

[56] CITY OF TORONTO. *Photovoltaic Pilot Project at Exhibition Place* [Online] www.toronto.ca/bbp/photovoltaic-pilot-project.htm (page consulted on January 13, 2008)
[57] LIGHT HOUSE. *Fred Kaiser Building at UBC.* [Online] www.sustainablebuildingcentre.com/learn/fred_kaiser_building_at_ubc (page consulted on January 15, 2008).
[58] ALBERTA SOLAR. *Alberta Solar Municipal Showcase*. [Online] www.lassothesun.ca (page consulted on January 15, 2008)

Demonstration of solar hybrid power systems for remote homes[59]

As part of a demonstration project funded by the TEAM program, the government of Canada is helping Xantrex Technology Inc. to develop components for integrating photovoltaic, wind and fuel cell power systems to classic fossil-fuel electrical production systems, for remote and off-grid applications. In August 2006, the new Hybrid Power System was tested as part of a demonstration project on the territory of the Xeni Gwet'in First Nation, near Chilko Lake, on a remote site. This system, which includes leading-edge electronic components, a battery pack and a generator, provides sufficient electricity to power a medium-size home. Xeni Gwet'in Enterprise plans to install thirty of these systems in as many homes in the region.

Net-Zero Energy Home (NZEH) demonstration pilot projects[60]

In 2006, the federal government announced Equilibrium Housing's initiative, formerly known as the Net-Zero Energy Home demonstration initiative. Twelve teams will build pilot demonstration homes in various Canadian locations. The purpose of EQquilibrium Housing is to reduce to an absolute minimum – by integrating a vast range of technologies, strategies, products and techniques – the environmental effects, power consumption and annual energy costs of housing, while ensuring a healthy indoor environment. Among the aspects considered for those homes: a high-performance thermal envelope, the optimization of passive solar energy, energy recovery and renewable energy sources; the renewable energy systems used are available on the market. This initiative is intended to raise consumers' interest in renewable energy technologies, including PV technology.

[59] XANTREX *Xantrex demonstrates new solar Hybrid Power System for remote homes* [Online] www.xantrex.com/web/did/1544/readnews.asp (page consulted on January 15, 2007)
[60] CANADA MORTGAGE AND HOUSING CORPORATION. *EQuilibrium Housing.* [Online] www.cmhc-schl.gc.ca/en/inpr/su/eqho/index.cfm (page consulted on January 15, 2007)

Research and development highlights

The Canadian photovoltaic program[61]

The main purpose of this program, administered by the CANMET Energy Technology Centre (CETC-Varennes) is to support the development and deployment of photovoltaic technologies in Canada.

In 2006, as part of the PV program, projects focused on:

- integrating thermal and photovoltaic systems to buildings;
- optimizing zero-consumption solar homes;
- developing photovoltaic resource maps for Canada;
- establishing standards and codes for the certification and installation of PV systems and their components;
- establishing national guidelines for connecting small distributed power sources to the public electrical network;
- net billing, in collaboration with Measurement Canada, to settle regulatory issues.

Solar Buildings Research Network[62]

The government of Canada, through the Natural Sciences and Engineering Research Council (NSERC), funds the Solar Buildings Research Network (SBRN). This research consortium has the objective of advancing multidisciplinary collaboration in order to innovate in producing solar power and optimize its use in commercial, institutional and residential buildings in Canada. The SBRN creates opportunities to demonstrate innovative PV projects in Canada and extends knowledge while taking into account the benefits and added value of PV technology in future buildings. The SBRN dominates the research market in this field within Canadian universities.

Manufacturers and suppliers of other components

More than 150 organizations[63] working on solar energy (retail companies, wholesellers, product manufacturers, private consulting firms, system installers and industrial associations) make the wheels of the Canadian PV economy turn.

The Canadian PV manufacturing sector has experienced, in the past five years, considerable growth in servicing domestic and foreign markets. We have observed a slight increase in manufacturing employment in Canada, from 627 in 2005 to 645 in 2006. The leading manufacturers are Xantrex, Carmanah, Automation Tooling Systems and ICP Global.

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[61] NATURAL RESOURCES CANADA – CETC-VARENNES. *Clean Power – Photovoltaic Systems in Buildings*. [Online] http://cetc-ctec.nrcan-rncan.gc.ca/eng/clean_power/pv_buildings.html (page consulted on January 15, 2007)

[62] SOLAR BUILDINGS RESEARCH NETWORK. *Vision* [Online] www.solarbuildings.ca/en/reseau (page consulted on January 15, 2008)

[63] CANADIAN SOLAR INDUSTRY ASSOCIATION. *Canadian Solar Industry Directory* [Online] www.cansia.ca/directory (page consulted on January 20, 2008)

Xantrex Technology[64]
Since 1983, this company has been manufacturing electronic power and emergency power systems that are mobile and adapted to renewable energies.

The company offers a range of power systems, AC and DC, as well as inverters, battery chargers and battery management accessories. It also manufacturers pocket units and high-power appliances. Xantrex's head office is located in Vancouver, and the company is also present in the United States and Spain. It numbers 830 employees. Its revenues totalled $158 M US in 2006.

Automation Tooling Systems (ATS)[65]
Founded in 1978, ATS focuses on the design of automated systems intended for its customers from the medical, computer and electronics sectors. The company produces, among other things, photovoltaic system components. ATS has 24 plants located in Canada, the United States, Europe, Southeast Asia and China. The company's head office is located in Cambridge, Ontario. In 2006, ATS employed about 3500 persons and registered $725 M in revenues, of which $145 M resulted from its activities in the photovoltaic products sector.

Carmanah Technologies Corporation[66]
This company produces solar energy LED lighting systems, off-grid and on-grid photovoltaic systems, and LED road signs. Its head office is located in Victoria, British Columbia, and it also owns a plant in Calgary, as well as sales and service offices in Toronto, Santa Cruz, California and Crawley, England. In 2006, the revenues of Carmanah Technologies Corporation totalled $62 M and it numbered 190 employees.

ICP Solar Technologies[67]
ICP Solar Technologies develops, manufactures and markets solar cells, photovoltaic products and BIPV construction materials. It notably manufactures solar panels to recharge car or recreational vehicle batteries, or to supply additional power to remote boats or cottages. Its products are distributed extensively in the United States and Europe. Located in Montreal, the company has a sales figure of $ 8 M and employs 75 people.

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[64] XANTREX TECHNOLOGY. [Online] www.xantrex.com/index.asp (page consulted on January 20, 2008
[65] AUTOMATION TOOLING SYSTEMS. [Online] www.atsautomation.com (page consulted on January 20, 2008)
[66] CARMANAH TECHNOLOGIES CORPORATION [Online] www.carmanah.com (page consulted on January 20, 2008)
[67] ICP SOLAR TECHNOLOGIES [Online] www.icpsolar.com (page consulted on January 20, 2008)

PV as seen by…

The Corporation of Master Electricians

During a telephone conversation in the week of January 28, 2008, Yannick Vaillancourt, technical consultant at the Corporation of Master Electricians, noted that the Corporation is interested in the development of renewable energy production. The organization already offers its members training in wind energy, but not yet in photovoltaic energy. He observes that public demand for this type of equipment is still very low.

To him, solar technology is ready and has proven itself. The main obstacle remains the very high price and the cost-effectiveness of photovoltaic installations in Quebec, given the very low cost of hydroelectricity.

Mr. Vaillancourt notes, however, that awareness of solar energy is rising nevertheless, as demonstrated by Hydro-Québec's initiative to allow the connection of photovoltaic installations to its network and offer its customers net billing.

Given the off-grid photovoltaic installations already in place, there is among the Corporation's members a certain expertise for this type of system. Anyone who wants to have a PV system installed at home will easily find a professional to do it safely and in accordance with the requirements of the Quebec Construction Code and the Canadian Electrical Code.

Association professionnelle des constructeurs d'habitations du Québec (APCHQ)

According to APCHQ technical services director André Gagné, Quebec and its population are not, in fact, very concerned about ecology, despite the official speeches. In a telephone conversation held in the week of January 28, 2008, he estimated that the efforts of home buyers are rather focused on energy efficiency, mainly to save money, very little by ecological conviction.

The acquisition of renewable energy technology, such as wind or solar power, remains marginal. Several reasons explain this, starting with the cost of those technologies and the difficulty of making the investment cost-effective. In addition, Quebec's climate is a disadvantage, with snow preventing the optimum operation of solar panels in winter. And zoning and urbanism issues are slowing down, in several cities, the installation of energy-production systems. Given the costs of photovoltaic installations and the low public interest, APCHQ members do not promote it to home buyers.

PV TECHNOLOGY ELSEWHERE IN THE WORLD

This section describes the situation and development of PV technology markets in member countries of the International Energy Agency (IEA). Founded in 1974, this independent organization, related to the Organisation for Economic Co-operation and Development (OECD), has set up an energy collaboration program addressed to 21 member nations of the organization. The program for photovoltaic power systems, called IEA PVPS (Photovoltaic Power Systems), is one of the collaborative R&D agreements created by the IEA and, since 1993, its participants have been carrying out various photovoltaic application projects.

The 19 countries participating in the IEA PVPS are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), France (FRA), Germany (DEU), Great Britain (GBR), Israël (ISR), Italy (ITA), Japan (JAP), Mexico (MEX), the Netherlands (NET), Norway (NOR), Portugal (POR), South Korea (KOR), Spain (SPA), Sweden (SWE), Switzerland (SWI) and the United States (USA).

One of the deliverable products of the IEA PVPS is the international fact-finding report *Trends in Photovoltaic Applications,* which contains summary information on trends in photovoltaic power system applications developed by member countries. The report is largely comprised of information excerpted from national fact-finding reports, produced each year by the participants. The AIE PVPS Web site also plays an important role in disseminating information about the program, including national information. The tables presented herein are taken from that fact-finding report[68] .

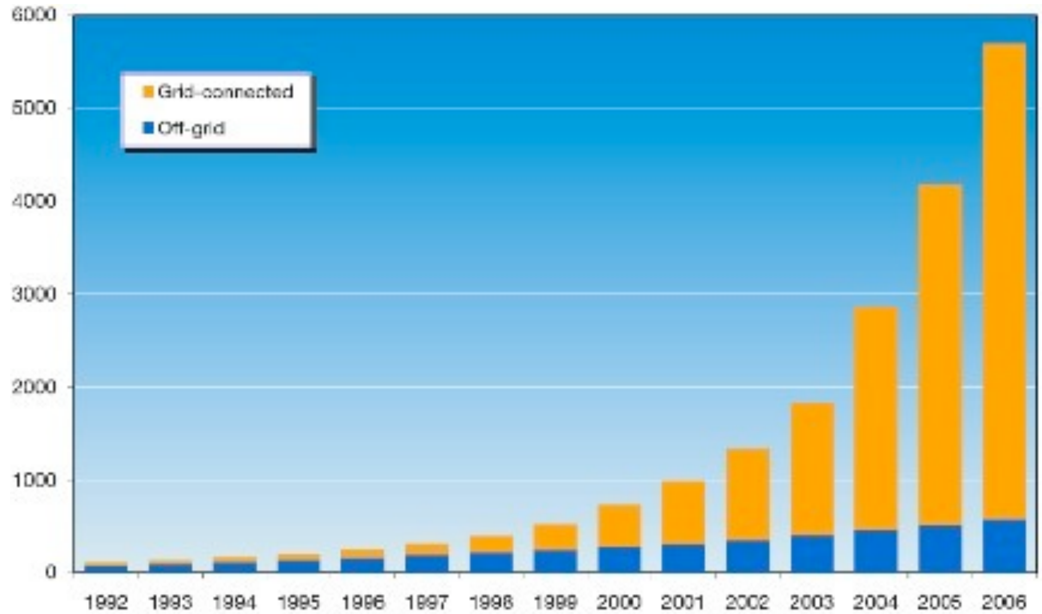
Other than statistical data, the status of PV in 10 countries is presented in detail. These are the IEA PVPS member countries whose PV market growth is, or was, 5 MW or more between 1995 and 2006, as described in Table 3. These countries are Germany, Australia, Austria, Korea, Spain, the United States, France, Italy, Japan and the Netherlands.

[68] INTERNATIONAL ENERGY AGENCY. *Op. Cit. 24.*

Statistics

About 1.5 GW of PV capacity was installed in 2006 – 15% more than in 2005, thus increasing total worldwide PV capacity to 5.7 GW. Most – 82% – of the new installations in recent years have been in Germany and Japan[69].

Graphic 1
Cumulative installed grid-connected
and off-grid PV power in reporting IEA PVPS countries[70]



[69] *Ibid*.
[70] *Ibid.*

Table 1
Installed PV power in reporting IEA PVPS countries at the end of 2006[71]

Country	Cumulative off-grid PV capacity (kW)		Cumulative grid-connected PV capacity (kW)		Total installed PV power (kW)	Total installed per capita (W/Capita)	PV power installed in 2006 (kW)	Grid-connected PV power installed in 2006 (kW)
	domestic	non-domestic	distributed	centralized				
AUS	23 883	36 653	9 005	760	70 301	3,5	9 721	2 145
AUT	3 169		21 263	1 153	25 585	3,1	1 564	1 290
CAN	6 680	12 296	1 443	65	20 484	0,6	3 738	384
CHE	3 050	350	23 740	2 560	29 700	4,0	2 650	2 500
DNK	80	255	2 565	0	2 900	0,5	250	210
DEU	32 000		2 831 000		2 863 000	34,9	953 000	950 000
ESP	17 800		100 400		118 200	2,7	60 500	51 400
FRA	15 015	6 539	22 379	0	43 933	0,7	10 890	9 412
GBR	324	758	12 960	0	14 042	0,2	3 165	3 007
ISR	1 084	210	11	14	1 319	0,2	275	0
ITA	5 300	7 500	30 500	6 700	50 000	0,9	12 500	12 000
JPN	1 212	87 376	1 617 011	2 900	1 708 499	13,4	286 591	285 060
KOR	983	4 960	18 323	10 467	34 733	0,7	21 209	20 929
MEX	15 019	4 573	155	0	19 747	0,2	1 054	116
NLD	5 713		43 673	3 319	52 705	3,2	1 521	1 243
NOR	7 150	390	128	0	7 668	1,7	416	53
SWE	3 630	655	555	0	4 840	0,5	603	301
USA	114 000	156 000	322 000	32 000	624 000	2,1	145 000	108 000
Estimated total	**226 751**	**347 856**	**4 773 271**	**343 778**	**5 691 656**		**1 514 647**	**1 448 050**

71 *Ibid.*

Table 2
Cumulative installed PV power in IEA PVPS countries: historical perspective[72]

Cumulative installed PV power (MW)														
Country	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
AUS	8,9	10,7	12,7	15,7	18,7	22,5	25,3	29,2	33,6	39,1	45,6	52,3	60,6	70,3
AUT	0,8	1,1	1,4	1,7	2,2	2,9	3,7	4,9	6,1	10,3	16,8	21,1	24,0	25,6
CAN	1,2	1,5	1,9	2,6	3,4	4,5	5,8	7,2	8,8	10,0	11,8	13,9	16,7	20,5
CHE	5,8	6,7	7,5	8,4	9,7	11,5	13,4	15,3	17,6	19,5	21,0	23,1	27,1	29,7
DNK	0,1	0,1	0,1	0,2	0,4	0,5	1,1	1,5	1,5	1,6	1,9	2,3	2,7	2,9
DEU	8,9	12,4	17,7	27,8	41,8	53,8	69,4	113,7	194,6	278,0	431,0	1 044	1 910	2 863
ESP	4,6	5,7	6,5	6,9	7,1	8,0	9,1	12,1	15,7	20,5	27,0	37,4	57,7	118,2
FIN	1,0	1,2	1,3	1,5	2,0	2,2	2,3	2,6	2,7	3,1	3,4			
FRA	2,1	2,4	2,9	4,4	6,1	7,6	9,1	11,3	13,9	17,2	21,1	26,0	33,0	43,9
GBR	0,3	0,3	0,4	0,4	0,6	0,7	1,1	1,9	2,7	4,1	5,9	8,2	10,9	14,0
ISR	0,1	0,2	0,2	0,2	0,3	0,3	0,4	0,4	0,5	0,5	0,5	0,9	1,0	1,3
ITA	12,1	14,1	15,8	16,0	16,7	17,7	18,5	19,0	20,0	22,0	26,0	30,7	37,5	50,0
JPN	24,3	31,2	43,4	59,6	91,3	133,4	208,6	330,2	452,8	636,8	859,6	1 132,0	1421,9	1 708,5
KOR	1,6	1,7	1,8	2,1	2,5	3,0	3,5	4,0	4,8	5,4	6,0	8,5	13,5	34,7
MEX	7,1	8,8	9,2	10,0	11,0	12,0	12,9	13,9	15,0	16,2	17,1	18,2	18,7	19,7
NLD	1,6	2,0	2,4	3,3	4,0	6,5	9,2	12,8	20,5	26,3	45,9	49,5	51,2	52,7
NOR	4,1	4,4	4,7	4,9	5,2	5,4	5,7	6,0	6,2	6,4	6,6	6,9	7,3	7,7
PRT	0,2	0,3	0,3	0,4	0,5	0,6	0,9	1,1	1,3	1,7	2,1	2,6	3,0	3,0
SWE	1,0	1,3	1,6	1,8	2,1	2,4	2,6	2,8	3,0	3,3	3,6	3,9	4,2	4,8
USA	50,3	57,8	66,8	76,5	88,2	100,1	117,3	138,8	167,8	212,2	275,2	376	479,0	624,0
Total	**136**	**164**	**199**	**244**	**314**	**396**	**520**	**729**	**989**	**1 334**	**1 828**	**2 858**	**4 180**	**5 695**

72 *Ibid.*

Table 3
Annual market growth in selected IEA PVPS* countries (in MW)[73]

PV power (MW) installed in calendar year												
Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
AUS	2,0	3,0	3,0	3,8	2,8	3,9	4,4	5,5	6,5	6,7	8,3	9,7
AUT	0,3	0,3	0,5	0,7	0,8	1,2	1,2	4,2	6,5	4,2	3,0	1,6
DEU	5,3	10,1	14,0	12,0	15,6	44,3	80,9	83,4	153,0	613,0	866,0	953,0
ESP	0,8	0,4	0,2	0,9	1,1	3,0	3,6	4,8	6,5	10,4	20,3	60,5
FRA	0,5	1,5	1,7	1,5	1,5	2,2	2,6	3,3	3,9	5,2	7,0	10,9
ITA	1,7	0,2	0,7	1,0	0,8	0,5	1,0	2,0	4,0	4,7	6,8	12,5
JPN	12,2	16,2	31,7	42,1	75,2	121,6	122,6	184,0	222,8	272,4	289,9	286,6
KOR	0,1	0,3	0,4	0,5	0,5	0,5	0,8	0,7	0,6	2,5	5,0	21,2
NLD	0,4	0,9	0,7	2,5	2,7	3,6	7,7	5,8	19,6	3,6	1,7	1,5
USA	9,0	9,7	11,7	11,9	17,2	21,5	29,0	44,4	63,0	100,8	103,0	145,0

* Countries whose annual market growth is, or has been, greater than 5 MW.

Table 4
PV support mechanisms reported by IEA-PVPS countries[74] [75]

	AUS	AUT	CAN	CHE	DNK	DEU	ESP	FRA	GBR	ISR	ITA	JPN	KOR	MEX	NLD	NOR	SWE	USA
Enhanced feed-in tariffs		•	•	•		•	•	•		•	•		•					•
Direct capital subsidies	•	•		•	•	•		•	•			•	•		•		•	
Green electricity schemes	•	•	•	•		•			•	•		•			•			•
PV-specific green electricity schemes	•	•		•	•				•									•
Renewable portfolio standards (RPS)	•								•			•					•	•
PV requirement in RPS																		•
Investment funds for PV			•			•	•								•			•
Tax credits			•	•				•	•			•			•		•	•
Net metering	•	•	•	•	•				•		•				•			•
Net billing	•		•	•					•			•						
Commercial bank activities	•					•						•						•
Electricity utility activities	•		•	•	•	•			•			•	•		•			•
Sustainable building requirements	•		•	•			•						•		•			•

[73] *Ibid.*
[74] *Ibid.*
[75] "Renewable portfolio standards (RPS)": Government standards compelling electric companies to produce a fraction of their electricity from renewable sources (wind, solar, geothermal, biomass, etc.).

Incentives[76]

A wide variety of photovoltaic market incentives and support mechanisms are in place nationally, regionally or locally in IEA PVPS countries. Among the most widespread financial instruments for promoting and supporting PV in those countries are feed-in-tariffs (FIT) and subsidy programs.

FITs

The use of FITs to stimulate on-grid PV growth is increasing worldwide. However, if a high tariff has proven effective in stimulating the growth of this market, as in Germany, the conditions for this type of program in certain countries compromise the attainment of satisfactory results or lower the interest of investors. Those conditions often pertain to PV capacity ceilings authorized under those programs, except for certain types of projects (BIPV or large-scale projects), to the lack of tariff differentiation by type of renewable energy, too-short payment guarantee periods, and too-complex administrative procedures.

In addition, tariff determination is particularly important. An excessively high tariff risks overheating the market, whereas one that is too low risks discouraging investors. Germany offered a very generous tariff at first, but under a formula providing for its annual reduction. This program was quickly successful among investors, whose interest it has maintained by progressively lowering prices. The German model has been followed by many countries.

Subsidies

Direct subsidies are an incentive that attenuates the barrier constituted by a photovoltaic system's price – the main obstacle to PV deployment. As opposed to FIT, subsidies can serve as an incentive for acquiring on- or off-grid systems. However, subsidies don't induce owners to ensure the maximum performance of their system, and they don't stimulate consumers to save energy. Moreover, PV purchase subsidies are often seen as an price inflation factor and as assistance to wealthy consumers.

Tax credits

Like subsidies, tax credits can facilitate access to PV technology. But this supposes that the beneficiaries of these measures have fiscal obligations. Although tax credits have proven economically effective, they don't appear to be, as subsidies can be, the measure most indicated for stimulating the market in its first stages of development.

[76] INTERNATIONAL ENERGY AGENCY. *Op. Cit.* 68.

Bank Programs

The photovoltaic market's evolution offers interesting business opportunities to various financial stakeholders. A program of "green" mortgage loans already exists in the United States, which offers preferential conditions to purchasers of eco-efficient homes. And in some countries, we note the emergence of private investment funds based on the environment. It can be expected that more and more economic and financial activities based on the market of renewable and photovoltaic energies will take place.

Renewable Portfolio Standards (RPS)

Given the issues of climate change and energy security, some governments, such as the United States, are showing increasing interest in renewable energy in their energy supply strategies. Thus the concept of Renewable Portfolio Standards (RPS), a regulatory approach that obliges public utilities to produce a certain quantity of renewable energy. However, considering the still-high costs of producing PV energy, other sources of renewable energy are often preferred.

Building standards

Some countries have adopted design standards for new residential and commercial buildings. Many of those standards are simple energy-efficiency measures not targeting PV technology. But some of the standards are stricter, as in Spain, where PV systems are mandatory in new large-scale buildings.

Clean energy programs

Whether to meet their obligations or for business opportunities, certain public utilities are now offering their customers clean energy programs. This market involves a segment of customers for whom respect for the environment is a value in itself, and who are prepared to pay more for green electricity. However, these programs have the same characteristic as do RPSs: they favour renewable energy from less-expensive sources than photovoltaic, such as hydroelectricity, wind and biomass. Still, to meet the expectations of some of their customers, to ensure a certain diversity in the offer, or to respond to market forces, some public utilities offer the opportunity to specifically purchase PV-certified renewable energy.

Country by Country

Germany

Germany is the leading PV market in the world. In its GHG reduction strategy, the federal government has established national targets for producing energy from renewable sources: 12.5% for 2010 and 20% for 2020[77]. These efforts are bearing fruit, since renewable energies, which made up only 6.3% in 2000, attained 11.6% in 2006. The capacity of PV systems in place makes up 2.8% of total renewable energies.

Since 2004, Germany has been the country with the most annual PV installations. Government strategy favours on-grid PV installations (91%)[78], most of them solar roofs, which dominate the market, as well as large high-power PV installations. The off-grid residential sector (9%)[79] is found mainly in the countryside. The German solar industry federation (Bundesverband Solarwirtschaft - BSW) estimates that about 5,000 companies are part of the German solar industry and that they employ about 50,000 people. The industry's sales figure is about €3.8 billion and continues to grow. Among high-development sectors, Thin Film solar panel production could boom in coming years. In 2006, the federal Department of the Environment, Conservation and Nuclear Safety (BMU) granted €38 M to 121 research projects, almost half of which involved the development of Thin Film technology.

The remarkable development of PV in Germany is mainly attributable to its feed-in tariff (FIT) and other incentives. The FIT program, created in 2000 under the Erneuerbare-Energien-Gesetz (EEG) (Renewable Energy Act), was amended to make the tariff more attractive to investors and to establish a downward adjustment mechanism for that tariff (5%/year) depending on the decrease in costs. The FIT was ct€49.2/KW in 2007 and is guaranteed for 20 years. This is the most generous tariff among all European countries that have this program. It thus ensures a quicker return on investment and a guarantee of long-term revenues. The 5% annual decrease of the tariff has two very positive effects: first, it enables rapid market growth in the first stages of development, with no risk of overheating in the longer term. Afterward, the tariff's gradual decrease induces the industry to pass the reduction in component production costs to consumers, so as to maintain the profitability of the investment in a PV system even with a lower tariff. Finally, access to the program has no capacity ceiling. Large PV production plans are therefore possible. According to the PV Policy Group[80], the German FIT constitutes the benchmark for establishing a standard FIT program.

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[77] INTERNATIONAL ENERGY AGENCY. *National Survey Report of PV Power Applications in Germany – 2006.* [Online] www.iea-pvps.org/countries/germany/06deunsr.pdf (page consulted on November 14, 2007)
[78] PV POLICY GROUP. *European Best Practice Report.* [Online] www.pvpolicy.org/documents/PVPolicyEuropeanBestPracticeReport_id205.pdf (page consulted on November 14, 2007)
[79] *Ibid.*
[80] *Ibid.*

Previously, the 100,000 solar roofs program[81] (1999 – 2003), which was addressed to residential buyers, companies and associations, and offered a program of reliable low-rate loans (4.5% under the market rate), led to the installation of about 65,700 PV systems, totalling 345.5 MW. Since 2005, Solarstrom Erzeugen[82] (Solar Power Generation), administered by the Kreditanstalt für Wiederaufbau (KfW), the German development bank, has been offering long-term low-interest loans (max. of €50,000) to fund 100% of the costs of installing PV systems and connecting them to the network. In 2006, this program, which targets individuals and independent professionals, among others, granted more than 30,200 loans totalling €947 M and led to the installation a capacity of 237.5 MW of PV electricity.

Australia

The Australian PV market has experienced constant growth in the past decade, stimulated by government programs and growing public awareness of environmental and climate change issues. The largest part of PV capacity in Australia is concentrated in off-grid industrial and agricultural installations. This market is supported by government loan programs in order to reduce the use of diesel in energy production. Although the price of PV electricity remains high compared to that of conventional electricity, this market should continue growing, given that the federal government has announced the continuation of its incentive programs and that some provincial governments have announced the adoption of renewable energy.

Among the incentives for PV systems in Australia, the Photovoltaic Rebate Program[83], administered by the provincial governments, is addressed to the residential and public sectors, notably schools. This program offered discounts of up to $4,000 AU in 2006 and $8,000 AU in 2005 on purchases of PV systems. Thanks to this program, 1,230 systems were installed in 2006, for a total of $4.9 M AU. Since 2000, this program has granted discounts totalling $40 M AU and led to the installation of more than 8,000 PV systems totalling 10 MW.

Moreover, the Renewable Remote Power Generation Program[84] particularly targets aboriginal and other small communities – since remote homes use diesel to produce electricity – as well as tourist facilities, etc. It grants preferential loans to finance up to 50% of capital costs for a renewable energy production system. In 2006, 1.64 MW of PV capacity were installed thanks to this program. Since 2000, it has enabled the installation of 7 MW of PV capacity.

Finally, the Solar Cities Program[85]**,** administered by a consortium of PV equipment manufacturing companies, banks, provincial governments, public utilities, construction contractors and research groups, favours the penetration of solar technologies and the adoption of various measures to stimulate distributed energy production. In 2007, about 5 MW were installed in four Australian cities thanks to this program, which has also experimented with various financial incentive formulas and a feed-in tariff.

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[81] *Ibid.*
[82] KFW BANKENGRUPPE. Solar Power Generation. [Online] www.kfw-foerderbank.de/EN_Home/Housing_Construction/SolarPower.jsp (page consulted on March 6, 2008)
[83] AUSTRALIAN GOVERNMENT. Photovoltaic Rebate Program. [Online] www.environment.gov.au/settlements/renewable/pv/index.html (page consulted on March 6, 2008)
[84] AUSTRALIAN GOVERNMENT. *Renewable Remote Power Generation Program (RRPGP).* [Online] www.environment.gov.au/settlements/renewable/rrpgp (page consulted on March 6, 2007)
[85] AUSTRALIAN GOVERNMENT. *Welcome to Australia's Solar Cities.* [Online] www.environment.gov.au/settlements/solarcities (page consulted on March 6, 2008)

Austria
In 2006, the Austrian PV market continued to decline due to a lack of incentives. After a high of 6.5 MW installed in 2003, the market continually declined, down to an installed PV capacity of 1.6 MW in 2006, the lowest level since 2001. Although Austria enacted a law establishing a FIT, the Green Electricity Act (Ökostromgesetz), the ceiling of 15 MW related to this program was quickly reached, thus leaving this sector with virtually no incentive measures. Despite the collapse of its domestic market, the Austrian PV industry pursued its activities and exported its production to other European Union countries where the PV market was growing, notably Germany.

In 2006, however, the Green Electricity Act[86] was reviewed, and the administration of a new framework for assistance to renewable energies was entrusted to the OeMAG corporation, created by the Austrian Finance Ministry. Contracts signed under this new framework date from November 2006. It is therefore still difficult to evaluate its impact on the market. The authorities estimate that it should enable the installation of 3MG in PV capacity each year. some observers remain sceptical, due to the program's complexity and the financial limits imposed. In addition, this framework favours biomass, biogases and wind energy. PV makes up less than 10% of the plan, and will have to share with other marginal types of renewable energy (hybrid firing, cofiring plant) a budget of €1,7 M out of a total annual allowance of €17 M.

Korea
Under its new national energy plan, Korea intends to install 100,000 rooftop PV systems and equip 70,000 buildings with BIPV systems, for a total capacity of 1.3 GW by 2012[87]. In 2006, the photovoltaic market grew strongly in Korea. Total PV capacity installed in that country increased by 157% between 2005 and 2006. This spectacular jump is notably due to the establishment of a FIT and of the solar roof program.

In 2006, 52 commercial PV systems totalling 9.2 MW were installed thanks to the FIT, whose tariff corresponds to about $0.69 CAN[88]. Moreover, 2,452 PV systems totalling 6.5 MW were installed on the roofs of single-family and multi-family homes under the solar roof program. Owners benefiting from this program receive assistance equivalent to 30% of the entire system's cost. In addition, 777 on-grid PV systems, totalling 2.2 MW, were installed in schools, public buildings and universities under the General Deployment Program. Under this program, the government assumes 70% of PV system installation costs. Since 2004, the Public Building Obligation Program has been obliging promoters to invest 5% of the total construction budget for new buildings of more than 3,000 m^2 in the installation of a renewable energy production system. From its beginnings to the end of 2006, this program has led to the installation of 349 KW in PV capacity.

Spain
The year 2006 marked a turning point for PV development in Spain, with the introduction of a FIT that has very effectively supported the sector's development. In 2006, 60.5 MW of PV

[86] INTERNATIONAL ENERGY AGENCY, Polices and Measures. [Online] www.iea.org/textbase/pm/?mode=re&action=detail&id=2274 (page consulted on March 6, 2008)
[87] INTERNATIONAL ENERGY AGENCY. *National Survey Report of PV Power Applications in Korea 2006.* [Online] www.iea-pvps.org/countries/download/nsr06/06kornsr.pdf (page consulted on March 11, 2008)
[88] Rates in effect on March 11, 2008

capacity were installed – 8 MW more than in all 10 previous years[89]. This measure has led to the establishment of on-grid networks, which account for 85% of all PV installations in Spain, and to the deployment of a distributed energy production system. Spain is also installing large PV stations capable of producing great quantities of energy. In addition, a new Royal Decree amends the Building Code to make it mandatory to integrate PV systems to new government buildings, office towers, hospitals, schools, etc.

Previously, the ICO-IDEA program, which amalgamated a preferential loan plan of the Instituto de Crédito Oficial with a subsidy plan of the Instituto para la Diversificación y Ahorro de la Energía, had enabled the installation of 1,329 systems (7.5 MW) in 2003 and 3,879 systems (30 MW) in 2004[90]. This program, in place from 1999 to 2004, was addressed to the residential and industrial sectors and favoured the installation of on-grid PV systems. The PV Policy Group[91] designated this program as a benchmark for establishing an assistance plan (subsidies and loans) for PV deployment.

United States

The United States Department of Energy (DOE) has conducted various initiatives to promote the use of renewable energy, including those specific to solar and photovoltaic energy. From 1997 to 2005, the Million Solar Roofs Initiative[92] helped raise consumers' awareness of solar energy and determine the best practices in solar technology market development and deployment. Since 2006, the Solar America Initiative[93] has used R&D to reduce the price of solar energy to a level competitive with conventional energy by 2015 and to stimulate the deployment of this technology among consumers.

The R*esidential Solar and Fuel Cell Tax Credit*[94]*,* a federal tax measure, has granted since 2006 a 30% tax credit to homeowners acquiring on-grid PV systems. These credits can attain $2,000 US per system, so this program has markedly stimulated the PV industry. In 2007, a record 314 MW of PV capacity have been installed in the United States thanks to this program, i.e., an increase of 125% compared to 2006[95]. Given the demand, the program has been extended to the end of 2008.

Electricity production is under state jurisdiction. The states have adopted various incentives, including net billing, FIT, tax credits to promote renewable energies such as PV[96]. In 2006, the total value of incentives established by the states was more than $300 M US[97].

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[89] INTERNATIONAL ENERGY ASSOCIATION*, Op. Cit. 24.*
[90] PV POLICY GROUP. *Op. Cit.* 78.
[91] PV POLICY GROUP. *Op. Cit.* 78.
[92] U.S. DEPARTMENT OF ENERGY. *Million Solar Roofs – Final Report October 2006.* [Online] www.nrel.gov/docs/fy07osti/40483.pdf (page consulted on November 14, 2007)
[93] U.S. DEPARTMENT OF ENERGY. *Solar America Initiative.* [Online] http://www1.eere.energy.gov/solar/solar_america (page consulted on November 14, 2007)
[94] DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY. *Residential Solar and Fuel Cell Tax Credit.* [Online] www.dsireusa.org (page consulted on November 14, 2007)
[95] SOLAR ENERGY INDUSTRIES ASSOCIATION. Statement by Rhone Resch: Solar Energy is Economic Engine for U.S. Economy – Economy - Record Growth at Risk If Federal Tax Credits Expire. [Online] www.seia.org/solarnews.php?id=158 (page consulted on February 7, 2008)
[96] The various measures adopted by the countries are listed and presented here: DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY, *Op. Cit.* 94
[97] INTERNATIONAL ENERGY AGENCY *National Survey Report of PV Power Applications in the United States of America – 2006*. [Online] www.iea-pvps.org/countries/usa/06usansr.pdf (page consulted on November 14, 2007)

California and New Jersey are the two states with the largest PV markets in the United States. The California Solar Initiative, established by the California Energy Commission in 2006, offers a financial incentive of $2.50 US/watt for PV systems installed on existing homes. With a budget of $2.9 billion US, this program spans ten years and intends the installation of 3,000 MW of PV capacity before 2017. With this program, the authorities want to make PV economically profitable. As of December 31, 2007, 2,719 projects totalling 17.9 MW and $46 M US have been approved. Other projects, totalling 170 MW, for a value of $455 M US, were undergoing the approval process[98].

Moreover, the installation of PV systems subsidized by the State of New Jersey increased by 223% between 2005 and 2006, to reach a total capacity of 17.9 MW. Among other measures, the *New Jersey Renewable Portfolio Standard* (RPS)[99] requires each public utility to include in the electricity it sells 22.5% (2.12% solar) renewable energy by 2021. In 2006, the New Jersey Board of Public Utilities undertook to study the means to reach this objective[100]. Other states, including Arizona, Colorado, Delaware, Maryland, Nevada, New Mexico and Pennsylvania, have also adopted the RPS concept and grant additional credits for the purchase of PV energy. The details of these programs can be found on the Web site of the *Database of State Incentives for Renewables & Efficiency*[101].

[98] CALIFORNIA ENERGY COMMISSION, *California Public Utilities Commission - Staff Progress Report, January 2008.* [Online] www.energy.ca.gov/2008publications/CPUC-1000-2008-002/CPUC-1000-2008-002.PDF (page consulted on March 11, 2008)
[99] DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY. *Op. Cit.* 94
[100] NEW JERSEY'S CLEAN ENERGY PROGRAM. [Online] www.njcleanenergy.com (page consulted on March 11, 2008)
[101] DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY. *Op. Cit.* 94

France

More than 10,000 households benefit from photovoltaic electricity in France[102]. More than 7,000 households distant from the network have access to electricity only through this technology, and more than 3,000 individuals connected to the network sell their electrical production to EDF. Historically limited to remote site applications, the French PV market has refocused toward on-grid applications. In 2006, out of 10.9 MW of installed PV capacity, almost 90% was connected to the network. The on-grid photovoltaic market has taken off fast, but still involves volumes 100 times more modest than in Germany[103]. More than half of the power funded to date has been in overseas departments – Martinique, Guadeloupe and la Réunion, where conventional electricity production costs are highest. In 2005, these three regions had more PV power than all 22 regions of continental France[104].

The year 2006 was marked, in France, by the enactment of the Loi sur la planification énergétique, which reinforces the legal and regulatory framework for renewable energy. This law sets ambitious targets for GHG emission reductions, energy savings, R&D and renewable energy production.

New tax provisions adopted in 2006 raised the basic FIT to €0.30/KWh for standard rooftop installations in metropolitan France, with a surcharge of €0.25/KWh for BIPV systems[105], and with a surcharge of €0.40/KWh and €0.15/KWh in overseas departments and territories, respectively. This measure reflects France's determination to foster the market's development and integrate photovoltaic energy to buildings. In addition, owners are eligible for a tax credit reimbursing 50% of equipment costs (excluding installation). This tax measure replaces the subsidies granted to individuals by the Agence de l'environnement et de la maîtrise de l'énergie through its regional offices[106].

Because the French tax credit is among the most effective and attractive of its kind in Europe, it is considered the benchmark by the PV Policy Group[107].

Italy

In early 2006, the very strong demand for financial assistance to install PV systems attained the equivalent of 100 MW, much more than forecast under the FIT program administered by the Ministry of Economic Development (MED). Accordingly, in February 2006, the MDE launched a new program aiming to produce 500 MW of PV energy, with a limit of 85 MW annually. However, despite the interest of designers, architects, investors and the public, and despite the FIT's existence, only a fraction of the projects submitted to the program have been realized. In total, PV energy capacity in Italy is almost 50 MW, including 12.5 MW in 2006 alone. The major

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[102] AGENCE DE L'ENVIRONNEMENT ET DE LA MAÎTRISE DE L'ENERGIE (ADEME). *Solaire photovoltaïque - Situation actuelle et objectifs,* [Online] http://www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=13921 (Consulted on March 14, 2008)

[103] AGENCE DE L'ENVIRONNEMENT ET DE LA MAÎTRISE DE L'ENERGIE (ADEME). Le marché photovoltaïque en France - État des lieux, mise en perspective, rentabilité financière des *systèmes, vision du développement de la filière*. [Online] http://www2.ademe.fr/servlet/getBin?name=7955A6C681FC7A86846DCCC3BFBAAAA71170857228524.pdf (page consulted on March 20, 2008)

[104] *Ibid*

[105] INTERNATIONAL ENERGY ASSOCIATION. *Op. Cit. 24.*

[106] *Ibid*

[107] PV POLICY GROUP. *Op. Cit.* 78.

part of this increase is due to the increase in the market for on-grid installations, which accounts for 60% of all installed PV energy.

Feed-in tariffs (FIT) vary according to the systems' power and range from ct€44.5/kW to ct€49.0/kW. The agreements have a 20-year term and the FITs are re-evaluated from year to year, according to market developments. The basic FIT is increased by 10% for building-integrated installations. On the other hand, it is reduced by 30% if combined with regional tax measures, and it does not apply to PV installations that have benefited from regional programs exceeding 20% of the investment.

The FIT is intended for individuals, registered companies, public organizations and condominiums. In the first quarter of 2006, 3,190 systems of less than 50 KW were registered, corresponding to about 91.2 MW, and 36 projects of 50 KW or more, totalling 28.3 MW[108].

Japan

Between 1994 and 1996, 3,590 residential PV systems totalling 13.3 MW were installed thanks to the *Residential PV System Monitor Program*. From 1997 to 2004, under the *Residential PV System Dissemination Program*, 213,410 residential PV systems totalling 782 MW were installed. In 2004, the program's last year, 36,754 systems totalling 136.3 MW were installed.

In total, these programs have led to the installation of 253,754 residential PV systems, representing 931,575 kW. The *Residential PV System Monitor Program* and the *Residential PV System Dissemination Program* have directly contributed to the creation of the Japanese residential PV market, which accounts for 89% of the entire Japanese PV market. Since 2004, Japan has no longer been offering commercial incentives to develop the PV market, with is self-sustaining and operates according to market forces[109].

Today, 92% of Japanese systems are on-grid, and the vast majority are residential (houses and apartments)[110]. The Japanese off-grid PV market is limited to remote residences, and to certain public and commercial applications. Public utilities have offered net billing on a voluntary basis since 1992. They have also introduced the Green Power Fund, to which their customers can contribute. This fund is used for supporting solar and wind power initiatives. In 2006, 149 PV projects totalling 2,162 kW were developed.

The sale of prefabricated houses equipped with standard PV standards is now current practice among local manufacturers and developers. In addition, the establishment of PV systems in multi-unit residences is a growing trend. Battery manufacturers, construction materials manufacturers and contractors are also present and active in this market.

Netherlands

The Dutch government's strategy for developing the photovoltaic market is long term and focuses on lowering prices through R&D and technology. In 2006, 94% of the €10 M invested in PV went to R&D. Six projects were launched during the year, including two for Thin Film

[108] INTERNATIONAL ENERGY ASSOCIATION*, Op. Cit. 24.*

[109] INTERNATIONAL ENERGY AGENCY*. National Survey Report of PV Power Applications in Japan – 2006.* [Online] www.iea-pvps.org/countries/japan/06jpnnsr.pdf (pages consulted on December 5, 2007)

[110] PV POLICY GROUP. *Op. Cit.* 78

technology, two for crystalline silicone, one for organic solar cells, and one for improving solar cell production methods. The work should result in a 10 MW annual growth in PV capacity starting in 2008[111].

Local authorities also propose initiatives. The municipalities of Zeist and Alkmaar, for example, support the installation of PV systems by respectively granting subsidies of €1 and €3 per watt of installed PV capacity. The Delta electric company also grants a subsidy of €1 per PV watt to residents in the province of Zeeland. Only 1.5 MW of PV capacity were installed in the Netherlands in 2006, i.e., a reduction of 8.5% compared to 2005. This addition brings total PV capacity in that country to 52.7 MW, which is still significant. By the end of 2006, the Netherlands ranked 5th worldwide in the number of watts per resident (3.2).

[111] INTERNATIONAL ENERGY ASSOCIATION. *Op. Cit*. 108.

CONCLUSION

The Canadian residential photovoltaic market is dominated by autonomous systems, mainly installed in remote areas, for homes not connected to electrical distribution networks. This is a Canadian peculiarity compared to the main countries where the photovoltaic market is flourishing: there, the majority of photovoltaic installations are connected to an electrical distribution network, which in many cases they help supply under the principle of distributed electrical production. These countries have opted, in many cases, for measures that encourage the installation of small rooftop systems, linked in a network and often in densely populated environments favouring the establishment of a decentralized energy production model. In that vein, the FIT, which enables residential energy producers to obtain a tariff for reselling their surplus electricity, better reflects the actual production costs of that energy. In Canada, although several public utilities offer their customers net metering and net billing options, only Ontario has established a FIT program. Although it is possible to do so in certain provinces, connecting photovoltaic installations to an electric network is still very marginal in Canada; distributed electrical production is even more so, and the only example of it is in Ontario.

Several factors discourage homeowners from depending on electricity produced by solar panels: the still-high costs of this technology, the relatively low prices of conventional electricity, the lack of government incentives, the slowness of public utilities to consider PV as a viable alternative to producing fuel-generated electricity, are only a few of the reasons for which small consumers' access to PV energy still poses enormous difficulties. If residential PV technology is mainly used in Canada for powering remote residences, it is because only in that niche is it more profitable. Indeed, it is more economical under certain conditions to install a PV system in a remote home than to extend a line from the conventional electrical distribution network.

Moreover, awareness of environmental issues constitutes, in several European countries, a powerful stimulus to the development of the renewable energy industry and PV. In many of those countries, mass production of electricity from fossil fuels or nuclear power has significant effects on the environment or GHG emissions, which governments are trying to reduce. In Quebec and elsewhere in Canada, these environmental problems are less acute, since hydroelectricity is itself considered to be a renewable energy.

Hydroelectric production doesn't raise environmental issues like fossil fuel or nuclear production does, but its development nevertheless has a substantial ecological footprint. In Quebec, hydroelectric energy production has required the construction of immense reservoirs and the harnessing of rivers viewed as ecological jewels. Environmental lobbyists have applied pressure for Quebec to favour the development of new, more environmentally-friendly methods of renewable energy production. Given the still-high costs of photovoltaic technology, as well as the realities of Canada's climate, renewable energy investments and choices have focused rather on wind power and the model of centralized energy production.

However, in a document titled Québec Energy Strategy 2006-2015, the ministère des Ressources naturelles et de la Faune notes, regarding active solar energy (photovoltaic and thermal), that "*Québec also intends to foster the development of solar energy by asking Hydro-*

Québec to submit a program to the Régie de l'énergie for the development of active solar technology in Québec[112]". But the time and guidelines of this program are not specified.

Photovoltaic power is a promising path of development: the solar radiation that reaches the earth in one hour represents a quantity of energy greater than all the energy consumed by humanity in one year. The technology necessary to convert solar radiation into electricity is performing better all the time, and the price of PV components offered to consumers is constantly falling. New products are now integrated to architecture and, in addition to their energy-producing functions, these products are construction materials of higher quality. PV systems require little maintenance, are simple to use, non-polluting (no emission, no noise, no movement) and leave a minimal ecological footprint. It takes a panel from 4 to 10 years to produce the energy consumed to manufacture it. Panels have a useful life of about 30 to 40 years and thus maintain a high resale value. Finally, at the end of its useful life, all the components of a solar panel can be recycled.

The obstacles still preventing small consumers from acquiring photovoltaic systems could be overcome, with true political will. The experience of countries where PV technology is widespread demonstrates that political decision-makers are the ones who led the way by setting high objectives and adopting measures that help develop a PV market, raise consumer awareness, open public utilities to the technology, establish a distributed system of energy production, etc.

The current context still doesn't favour democratizing PV technology in Canada. For one thing, the price of PV electricity is still much higher than that of conventional electricity. This situation could change in the event of an explosion of energy prices and/or a technological breakthrough that would make photovoltaic components more efficient and less costly to produce. In that event, the experience of countries where photovoltaic power is well established gives many indications of the success factors to adopt and the pitfalls to be avoided in deploying this technology.

Canada and the provinces must now show leadership and vision, and lay the foundations for developing this technology of the future. With a view to establishing coherent policies regarding photovoltaic power, we have taken inspiration from foreign experiences and from the recommendations concluding the European Best Practice Report[113].

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[112] MINISTÈRE DES RESSOURCES NATURELLES ET DE LA FAUNE DU QUÉBEC. *Québec Energy Strategy 2006-2015.* [Online] www.mrnf.gouv.qc.ca/english/energy/strategy/ (page consulted on April 4, 2008)
[113] PV POLICY GROUP. *Op. Cit.* 78.

RECOMMENDATIONS FOR THE SUCCESS OF A NATIONAL PV DEPLOYMENT POLICY

- Whereas it is important, in order to develop PV effectively, to raise the interest of industrialists and those likely to invest in this technology;
- Whereas ambitious long-term objectives, the commitment of political authorities at every level, and a range of well-designed incentives are necessary to give industrialists and investors the necessary directions, framework and support to win their commitment;
- Whereas it is important, in order to help create strong demand and sustained market growth, and to ensure a return on investment in reasonable time, to adopt measures likely to ensure long-term investment security;
- Whereas connecting a PV system to an electrical distribution network is an effective way to make this system cost-effective, while providing the network with an additional supply source;
- Whereas foreign experiences have established, among the various incentive programs, the effectiveness of feed-in tariffs (FIT) ;
- Whereas FIT programs enable better quality control and maintenance of PV systems by owners;
- Whereas long decision-making processes, policy doubts during changes in government, and annual program reviews create investor uncertainty;
- Whereas the proportion of on-grid PV installations in Canada is low;
- Whereas on-grid installations should be developed;
- Whereas, to adequately stimulate investors, part of the acquisition costs of a PV system should be assumed by a subsidy or credit;
- Whereas subsidy or credit programs are generally more effective in stimulating the off-grid PV market, while the FIT is better suited for the on-grid PV market;
- Whereas Canadian financial institutions offer no special financing plans for acquiring renewable energy production equipment;

Union des consommateurs recommends that the Canadian and provincial governments develop a harmonized program to develop photovoltaic energy production by consumers.

Such a program should plan for a range of incentives, including:

- a feed-in tariff (FIT) program offering a long-term feed-in-tariff guarantee (15 to 25 years), to secure investments; the Canadian program could be modelled after the German feed-in tariff, which the PV Policy Group considers the benchmark for establishing an effective feed-in tariff program;
- subsidy or credit programs to compensate for part of the acquisition, installation and network-connection costs of PV systems; the Canadian program could be modelled after the French tax credit plan, which the PV Policy Group considers the benchmark for this type of program;
- a preferential loan plan for acquiring PV systems; the Canadian program could be modelled after the Spanish program, which the PV Policy Group considers the benchmark for establishing an assistance plan (subsidies and loans) for PV deployment.

- Whereas an undifferentiated feed-in tariff between the various renewable energy production technologies often puts PV at a disadvantage compared to other means of renewable energy production;
- Whereas PV energy production is more accessible to consumers than are most other types of renewable energy;
- Whereas several types of PV installations are possible and can entail substantially different investments;
- Whereas Canadian regions have a wide variety of climate conditions, which can affect the cost-effectiveness of a PV installation;

Union des consommateurs recommends that the feed-in tariff program to be developed take several variables into consideration for its application:

- The feed-in tariff should favour PV;
- The tariff should take into account the price of the energy provided by the network;
- The tariff should vary according to the type of installation as well as the climate and sunlight conditions of the various regions;

- Whereas the PV industry is still growing and the prices of materials are likely to fall while their effectiveness increases;
- Whereas foreign experiences have demonstrated the effectiveness of FIT reduction mechanisms in enabling small consumers to benefit from the productivity gains and cost reductions of PV systems;

A FIT reduction mechanism should be considered in order to enable small consumers to benefit from the productivity gains and cost reductions of PV systems.

- Whereas it is important to ensure harmonious PV development and monitor public investments in PV systems;
- Whereas national PV system registration programs have proven to be effective monitoring and follow-up tools for on-grid systems;
- Whereas the establishment of an effective and professional PV market performance-measuring tool is necessary for winning the commitment of stakeholders and maintaining long-term political support;

The requirements for obtaining government financial assistance should be linked to the installations' compliance with quality standards, to the employment of installers whose qualifications are officially recognized, and to mechanisms for monitoring and following up on the effectiveness of systems.

- Whereas setting a ceiling for the capacity of PV systems constitutes an artificial barrier to the market's development;

There should be no limits to the number or capacity of PV installations eligible for the feed-in tariff, and no exclusion clause for integrating BIPV components or not, etc.

- Whereas attractive and highly visible demonstration installations on public buildings can constitute good examples for private investors and a good tool for raising public awareness;

Union des consommateurs recommends that all levels of government multiply this type of demonstration installations and promote them to companies likely to participate in this type of demonstration projects.

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ANNEX 1

Recommendations of the Canadian Solar Industries Association[114]

SOLAR ISSUES

The market for solar energy worldwide is growing rapidly with global growth exceeding 25% a year. In Canada, however, we are lagging behind. Canada ranks 14th of 20 reporting IEA countries in deployment of PV and ranks 17th of 22 reporting countries for solar thermal. International growth has been the result of progressive government policies aimed at reducing prices through economies of scale, establishing key infrastructure foundations and supporting the development of sustainable solar markets.

In 2001, Canada's public budget for PV was only $0.10 per capita - placing Canada 16th of the 17 IEA reporting nations. Canada governments invest only 16% of the international average and lag significantly the front-runners of Japan and Germany.

Growing concerns about the sustainability of fossil fuels and nuclear energy now require an effort equal to that provided to these energy sources in the past so that Canadians can take advantage of the economic and environmental benefits of solar energy.

The development of solar technologies is heavily dependent on support from the Canadian investment community if the technological base is to remain in Canadian hands. However the absence of any significant Canadian solar programs has resulted in a lack of awareness of this technology amongst investors, consumers, and decision makers.

Solar power is the only technology that allows grassroots ownership of the power plant today - all the others are in the hands of big companies and utilities. Solar power "on the roof" empowers individuals to make their own contribution to climate change. The importance of this cannot be underestimated in developing broad based support for the growth of new clean technologies.

CanSIA recommends the adoption of the following policies that will help develop a viable, vibrant Canadian solar industry. These policies are needed to create the market momentum to propel the industry into becoming an engine of economic growth in Canada.

CanSIA is working towards the implementation of the following principles:

- A National Energy Strategy
- A long-term plan for renewable energies in Canada, which is part of an overall National Energy Strategy, is necessary.

Integrating Solar with Energy Efficiency and Valuing Demand Side Management

All solar projects and programs must be done in unison with increased energy efficiency measures in the building.

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[114] THE CANADIAN SOLAR INDUSTRIES ASSOCIATION. *Solar Issues* [Online] www.cansia.ca/issues.asp (page consulted on April 4, 2008)

Government Funding of Solar
Increasing government funding and the number of programs in support of research, development, demonstration and commercialization of solar is required.

Focused Funding to Create Model Solar Communities
Canada can maximize the impact of its current funding levels for solar by creating comprehensive programs focused on targeted communities across Canada.

Valuing Externalities
The Canadian government must begin to account for the hidden health, environmental and social costs associated with conventional fossil fuel based energy.

Specific Measures

Financing Mechanisms
It is critical to establish low-interest financing mechanisms for solar purchasers who do not have access to capital that the large power plant developers have. CanSIA recommends the establishment of a "solar bank".

Expanding the Government's Green Energy Procurement Commitment
Set Asides for Each Technology Photovoltaics and other renewable technologies that still have potential for significant cost reductions should have set-asides to allow government commitments to benefit all renewable electrical generating technologies.

- Procurement of Green Heat A commitment to purchase 20% of government's heating needs from renewable technologies will make a significant impact on the solar thermal industries.

High Profile Demonstrations on Government Buildings
The government must encourage consumer demand for solar energy equipment through leading by example. Government must begin using solar technologies on its buildings.

Deployment Program
Government incentive programs for solar should be instituted immediately to encourage public adoption.

- Solar Thermal Deployment A program for the installation of 80,000 solar domestic hot water systems in 10 years.
- Photovoltaics A PV rooftop deployment program in line with other nations.
- Market Incentive Plan Increasing the existing Market Incentive Plan to help consumers use solar technologies.

Expanding the Canadian Renewable and Conservation Expenses Class 43.1

- The size restriction for PV systems should be removed.
- The restrictions on application for thermal solar systems should be removed.