Industry Canada Industrie Canada

Unleashing the Potential of On-Grid Photovoltaics in Canada

An Action Plan to make PV an Integral Component of Canada's Energy Future

2003

Canada

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E-mail: **publications@ic.gc.ca**

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Table of Contents

1.0 Executive Summary 1

2.0 Introduction 5

2.1 Method 6

3.0 Trend Towards More Sustainable Distributed Generation 8

3.1 Significant Co-Benefits of PV 10

4.0 Global PV Markets – A Rapidly Growing Phenomenon 12

5.0 Domestic On-Grid PV – An Untapped Opportunity 15

5.1 Existing Market 15
5.2 Initial Progress 17

6.0 Bumps in the Road - Challenges Slowing PV Growth in Canada 24

6.1 Introduction 24
6.2 Identification and Categorization of Existing Barriers 25
6.3 Prioritization and Consolidation of Identified Barriers 27
6.4 Existing Pricing Challenges 28
6.4.1 Rapid Reductions 28
6.4.2 Multiplicity of the Price Challenge 29
6.5 Electricity Market and Legislative Challenges 34
6.6 Inconsistent Standards, Interconnection Guidelines and Contract Terms 36
6.7 Lack of Awareness and Understanding of PV Applications and Benefits 39

7.0 The Path Forward – Unleashing the Potential of On-Grid PV in Canada 42

7.1 Long-Term Vision for Canadian Photovoltaic Distributed Power Generation 42
7.2 Industry Vision 44
7.3 Strategic Goals 44
7.4 Strategic Measures to Position PV as an Integral Component of Canada's Energy Future 45
7.4.1 Phase I: Establishing the Foundation 47
7.4.2 Phase II: Stimulating Market Demand 48
7.4.3 Phase III: Maintaining the Momentum 51
7.4.4 Ongoing Promotion, Profile and Partnerships 52

APPENDIX A: Bibliography 55

APPENDIX B: Lower Priority Challenges for the PV Industry 59

APPENDIX C: List of Key Informants 60

List of Figures and Tables

Figure 1: Global Energy 8
Figure 2: Converging Forces of Demand 9
Table 1: Ancillary Benefits of PV Systems 11
Figure 3: World Cell/Module Production in MW 12
Figure 4: Total PV installations (W) per capita 2001 13
Figure 5: Global cumulative PV capacity based on EPIA and Greenpeace/EPIA data 13
Figure 6: Proportional Market Share for On-Grid versus Off-Grid PV 14
Figure 7: Cumulative Installed PV power (kWp) in Canada by sub-market 15
Table 2: Annual PV power sales within three sub-markets 16
Table 3: Potential for BIPV in OECD Countries 16
Table 4: Overview of the Climate Change Plan for Canada 18
Table 5: Examples of Existing Federal Initiatives that Support Renewable Energy 19
Table 5: Examples of Existing Federal Initiatives that Support Renewable Energy (continued) 20
Table 6: Examples of Existing Provincial Initiatives that Support Renewable Energy 21
Table 7: Examples of Existing Utility Initiatives that Support Renewable Energy 22
Figure 8: Average selling price of PV modules 1976-1998 28
Table 8: Novel technologies being developed to reach costs at targets below $1/Watt by 2010 through improved solar conversion cell efficiencies and high-volume automated manufacturing 29
Figure 9: Comparative Electricity Costs 30
Table 9: Ontario Disaggregated Electricity Prices 36
Figure 10: Unleashing the Potential of On-Grid Photovoltaics in Canada 43
Figure 11: Unleashing the Potential of On-Grid PV in Canada 46

Acronyms

AC	Alternating Current
BC	British Columbia
BCIT	British Columbia Institute of Technology
BIPV	Building Integrated Photovoltaics
BOS	Balance of System
BP	British Petroleum
CanSIA	Canadian Solar Industry Association
CANWEA	Canadian Wind Energy Association
CCAF	Climate Change Action Fund
CCCDF	Canada Climate Change Development Fund
CCRA	Canada Customs and Revenue Agency
CDM	Clean Development Mechanism
$CDN	Canadian Dollars
CEC	Canadian Electric Code
CERDL	CANMET Energy Diversification Research Laboratory
CEIA	Canadian Environmental Industry Association
CMHC	Canada Mortgage and Housing Corporation
CO_2	Carbon Dioxide
CRCE	Canadian Renewable and Conservation Expenses
CSA	Canadian Standards Association
DC	Direct Current
DG	Distributed Generation
EDA	Electricity Distributors Association
EPIA	European Photovoltaic Industry Association
FCM	Federation of Canadian Municipalities
GHG	Greenhouse Gas
GMEF	Green Municipal Enabling Fund
GMIF	Green Municipal Investment Fund
GPG	Green Power Generation
GST	Goods and Services Tax
O&M	Operation and Maintenance
OECD	Organization for Economic Co-operation and Development
PMO	Prime Minister's Office
IEA	International Energy Agency
IPP	Independent Power Producers
IRAP	Industrial Research Assistance Program
JI	Joint Implementation
LEED	Leaders in Energy and Environmental Design
LPT	Linear Property Tax
MIP	Market Incentive Program
MPC	MicroPower Connect
NABCEP	North American Board of Certified Energy Practitioners
NOx	Nitrogen Oxides
NRCan	Natural Resources Canada
NSERC	Natural Sciences and Engineering Research Council
PV	Photovoltaics
PVPS	Photovoltaic Power Systems
R&D	Research and Development
RAIC	Royal Architectural Institute of Canada
RD&D	Research, Development and Demonstration
RE	Renewable Energy
REDI	Renewable Energy Deployment Initiative
RPS	Renewable Portfolio Standard
SDTC	Sustainable Development Technology Canada
SDTF	Sustainable Development Technology Fund
SESCI	Solar Energy Society of Canada Inc.
SME	Small and Medium-sized Enterprises
SOx	Sulphur Oxides
TEAM	Technology Early Action Measures
TPC	Technology Partnerships Canada
WPPI	Wind Power Production Incentive

1.0 Executive Summary

Photovoltaics (PV) represents a key component of the clean energy distributed generation mix that will be required to meet Canada's burgeoning energy demand, while limiting the growth of greenhouse gases. PV also represents an "innovation connector", one that combines a series of high-tech and traditional technology platforms to produce energy from the sun. The result is a clean energy solution that provides economic, social and environmental benefits including highly-skilled job creation, increasing innovation and technological advances here in Canada, sustainable export industry and zero emission energy.

At the present time, global markets for PV (and more broadly cleaner energy) are being driven by a multitude of converging forces including international action on climate change, energy security, demand for improved air quality, technological advances and energy deregulation around the globe. The result is an accelerating worldwide demand for PV of 23 percent or more per year between 1997 and 2002. In Canada, PV markets also continue to grow exponentially with an average growth rate of 25 percent over the past eight years.

This has created an innovative and prosperous Canadian PV industry with over 150 organizations actively promoting PV power in the country. The vast majority of this group are system resellers, distributors and installers. Approximately 14 companies are involved in manufacturing, many of which are now exporting around the world. In 2002, the Canadian industry employed over 625 highly skilled people and generated revenues of $CDN 95 million.

While off-grid markets in Canada and developing countries continue to grow, the largest potential is in on-grid applications (Building Integrated PV (BIPV) and hybrid systems) in developed countries. In fact, PV has already successfully penetrated and become a key component of the energy mix in countries such as Germany, Japan, the US and Spain. In order to exploit this opportunity here, it is critical that a conducive market be created within Canada – one that encourages distributed generation and recognizes the value of small-scale, adaptable clean energy sources such as PV.

Recognizing the significant opportunity that PV represents, Industry Canada commissioned The Delphi Group to undertake an exhaustive literature and Web search and consult with over 40 key experts and stakeholders in order to:

- Gain an appreciation of existing and emerging markets for distributed generation and more specifically, on-grid PV in Canada and abroad;
- Identify and better understand the challenges that face the PV industry in Canada and how they can be effectively addressed; and,
- Identify specific measures (policies, programs) and partnerships that are critical to stimulating the Canadian market for PV (and clean energy) and enhancing the capacity of Canadian PV suppliers to deploy its solutions into the global marketplace, while providing significant economic, social and environmental benefits to Canada.

The study found that, while a number of existing initiatives are being undertaken to promote renewables including PV, several challenges remain that must be overcome before the on-grid PV market is likely to advance significantly in Canada. These include:

i. **Existing Pricing Challenges:** PV technology is following a similar development and commercialization path to that of many other types of manufactured goods (computers and cell phones, for example) and although tremendous advances have occurred over the past 25 years, PV capital costs remain high.

ii. **Current Market and Legislative Obstacles:** many small-scale generators continue to be impeded from selling their electricity into the provincial grids across Canada, often as a result of regulated or deregulated electricity markets that were designed and are now operated more favourably for large centralized power.

iii. **Inconsistent Standards, Interconnection Guidelines and Contract Terms:** these continue to be a challenge to the design and implementation of various distributed generation systems (including PV) across Canada. Obstacles range from the interpretation of federal electrical codes to inconsistent interconnection and net metering guidelines at the provincial government or utility level to cumbersome municipal building codes and permits.

iv. **Lack of Awareness and Understanding of PV Applications and Benefits:** as with any emerging technology, raising the awareness and understanding of key stakeholders and decision-makers and disseminating useful information is a challenge with regard to timing, focus and scope. This is certainly the case with PV and it is often compounded by the wide variety of individuals, governments, utilities and private companies that play a role in the development of on-grid PV systems.

Although it is unclear what role PV will play in Canada's energy future, it is obvious that there is a significant opportunity to use this resource to help the country meet its longer term energy requirements, while attaining its GHG targets, minimizing air pollution and related environmental and health impacts, and fostering a strong and highly innovative industry that can provide significant economic and social benefits to Canada. Through long-term commitment and strong private-public alliances, Canada's PV industry along with all levels of government can play a vital role in developing policy and programs that will address existing challenges, increase market awareness and catalyse the market over the next 20 years.

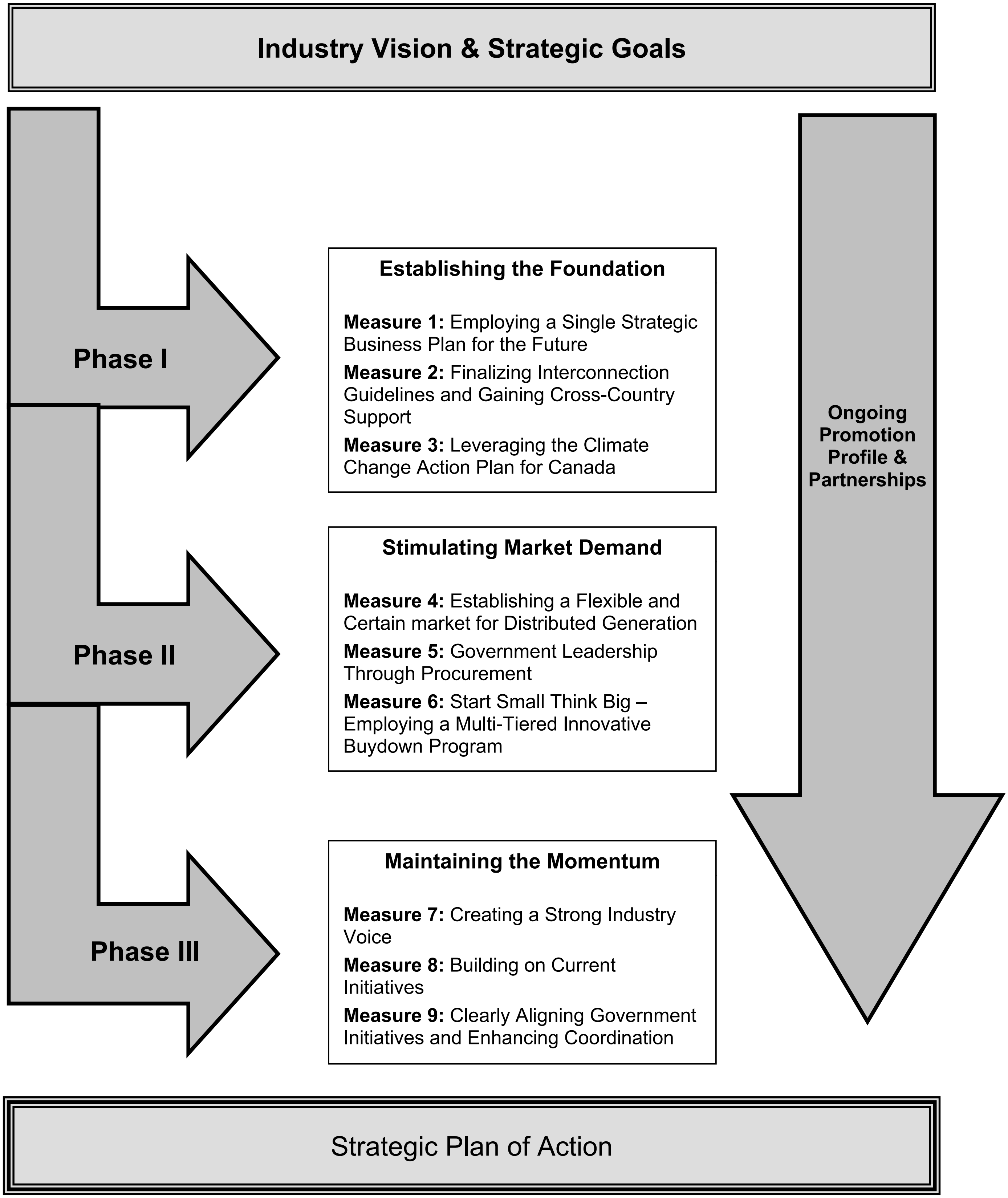
Given that PV/BIPV will not be the only solution, but will be an integrated component of an overall strategy that will see an increase in renewable energy within Canada and a substantial reduction in GHG emissions, a three-phased approach was developed including a set of multi-faceted policy and programming measures. Each of these was designed to accelerate the introduction of PV systems into the Canadian marketplace, while helping to encourage other forms of renewable distributed generation. The proposed action plan is illustrated on the following page, and includes the following ten measures:

Phase I: Establishing the Foundation

Measure 1: Employing a Single Strategic Business Plan for the Future - Federal and provincial government leadership is critical to catalyse action; however, success will be achieved only if industry provides joint leadership and commitment during the implementation of an agreed set of targeted and focused measures in accordance with an agreed business plan.

Measure 2: Finalizing Interconnection Guidelines and Gaining Cross-Country Adoption - MicroPower Connect has released a document outlining procedures for interconnection of distributed generation (DG) systems <600V. Upon approval at the federal level, all industry sectors affected by these guidelines must work together to secure a commitment from all provincial governments and local utilities across Canada to adopt them.

Unleashing the Potential of On-Grid PV in Canada



Measure 3: Leveraging the Climate Change Action Plan for Canada - The PV industry should work in close cooperation with other renewable energy sectors and key stakeholders to obtain a federal commitment to achieving its 10 percent target for new electricity generation by using a variety of renewable sources, including PV.

Phase II: Stimulating Market Demand

Measure 4: Establishing a Flexible and Certain Market for Distributed Generation - Strong federal-provincial cooperation should be fostered through a mechanism such as a Joint Working Group on Distributed Energy with a mandate to optimize key energy regulations and policies in order to remove existing obstacles and maximize the development of more efficient and greener sources of energy.

Measure 5: Government Leadership Through Procurement - A broad range of green power options (including PV) should be sought through the government's aggressive green energy procurement programs – Federal Government Green Electricity Purchase. This could be complemented by innovative financing mechanisms (such as a revolving fund) and expanded green power initiatives at the municipal and utility levels.

Measure 6: Start Small, Think Big – Employing Multi-Tiered Innovative Buydown Programs - Building on the success of other initiatives, an innovative multi-tiered approach should be developed and implemented over a five- to ten-year period starting with a municipal buydown program and gradually growing to a national one.

Phase III: Maintaining the Momentum

Measure 7: Creating a Strong Industry Voice - The PV industry should work with like sectors such as the environment, wind energy, biomass, and small hydro to develop a strong, clear national voice that can lobby, and can coordinate related activities to the benefit of all – including a national clean energy strategy.

Measure 8: Building on Current Initiatives - Continue to highlight the successes of existing initiatives and boost further innovation within the industry by extending those that are most effective, eliminating those that have not shown advantageous results and developing complementary initiatives.

Measure 9: Clearly Aligning Government Initiatives and Enhancing Coordination - Federal government efforts related to PV (and renewables in general) must be more closely aligned and more clearly base on a set of strategic objectives consistent with PV and renewable industry needs and approaches (the agreed business plan is an example – see Measure 1) and on federal climate change policy.

Ongoing Promotion, Profile and Partnerships *(Measure 10)*
It is critical that the government and industry sector maintain, build on and expand current efforts to enhance the awareness and skills of all stakeholders engaged in the financing, design, manufacture, distribution, installation and operation of PV systems, along with those who can influence the uptake of these products through programs and policies. Government and industry have made remarkable progress in this area, but need to continue their efforts on all fronts.

2.0 Introduction

Economic growth continues to drive the global demand for energy to new heights; however, a multitude of issues are transforming the way in which this demand is met. Specifically, there are two apparent and integrally linked trends that are speeding up the process. First, there is a visible shift from large centralized power to smaller more flexible distributed generation (DG). Second, there is a discernible movement towards more sustainable energy sources, particularly for the production of on-grid electricity in developed countries.

DG involves a broad range of sources, including small hydro, biomass, wind and natural gas microturbines. On-grid photovoltaic (PV) systems, and in particular building-integrated photovoltaics (BIPV)[1] will be an integral component of the DG mix, as seen in countries such as Denmark, Japan, Switzerland, the UK and the US (particularly California).

These and other countries such as Germany and Spain are aggressively tackling the obstacles that have traditionally impeded the growth of PV (and other clean energy sources). New policies and programs that are changing the dynamics of the cost structure are being put into place. By providing incentives to buyers and manufacturers, and thus encouraging investment, a more rapid uptake of PV in domestic markets and primary export markets such as those found in many developing countries (such as China) is being facilitated.

With immense and easy-to-access renewable energy resources and some of the world's leading technology companies, why is Canada taking such a conservative approach with respect to on-grid PV (and renewables in general)? What measures could be easily implemented to build on Canada's early progress in this area, accelerate the introduction of on-grid PV systems into the Canadian market and help build a self-sustaining supporting industry? What economic, social and environmental benefits would flow from policies and programs favouring renewables?

Recognizing the significant opportunity that PV represents and the need to answer these and other questions in order to develop an effective strategy, Industry Canada commissioned The Delphi Group to tap the wealth of knowledge and expertise that exists in Canada in order to:

- Gain an appreciation of existing and emerging markets for distributed generation and more specifically, on-grid PV in Canada and abroad;
- Identify and better understand the challenges that face the PV industry in Canada and how they can be effectively addressed; and,
- Develop an action plan including specific measures (policies and programs) and partnerships that will stimulate the market for PV and help to advance the capability of Canadian PV suppliers to deploy its solutions into the Canadian marketplace. Such actions will ultimately help to increase Canada's presence in foreign markets, while providing significant economic, social and environmental benefits to Canada.

1 BIPV refers to any PV system that is integrated into, or installed on or beside, a residential, commercial or industrial building.

2.1 Method

In tackling this complex and important task, Delphi worked in close partnership with Electro-Federation Canada, key government representatives from Industry Canada and NRCan and a broad-range of industry experts. Specific activities included:

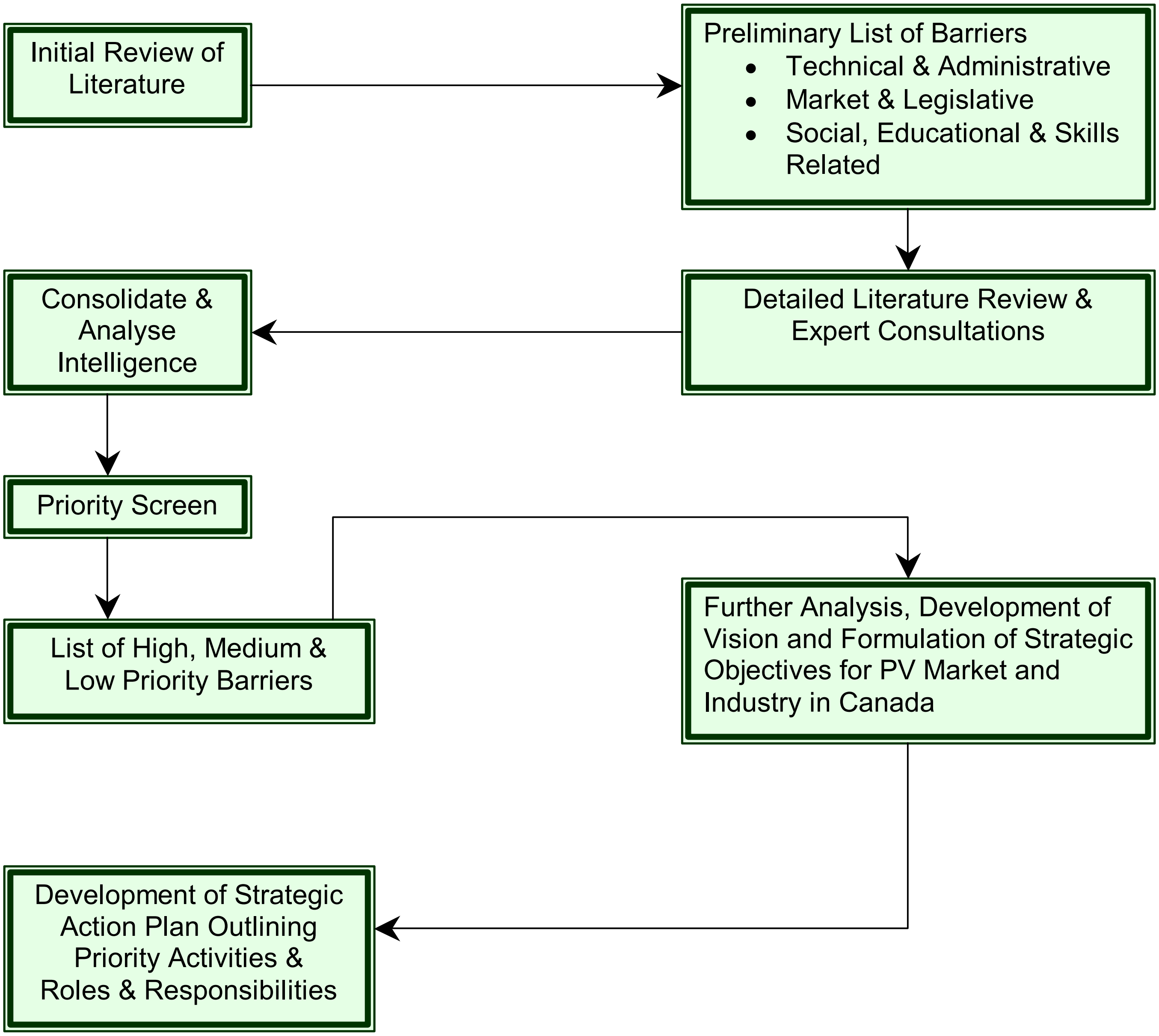
i) An exhaustive literature and Web review of existing industry and market research reports addressing relevant issues pertaining to the PV industry specifically and the renewable energy industry in general. A bibliography is provided in Appendix A.

ii) Consultation with the Industry Steering Committee and government representatives through one-on-one discussions to tap the wide range of knowledge and expertise that exists in these groups.

iii) Approximately 40 key informant interviews were undertaken with experts in the energy sector and a broad range of key stakeholders that influence the PV industry. A list of those consulted during the study is included in Appendix C.

Using the intelligence gathered during these steps, Delphi then consolidated and analysed the results, and summarized the key challenges facing the industry in Section 6. Strategies to mitigate, reduce or remove these barriers were then developed based on input from the key informants, other successful models and the expertise of the team. These are summarized in Section 7, and include priority actions (policies, programs, mechanisms to engage stakeholders, and so on), key players that should be involved, and partnerships that need to be developed.

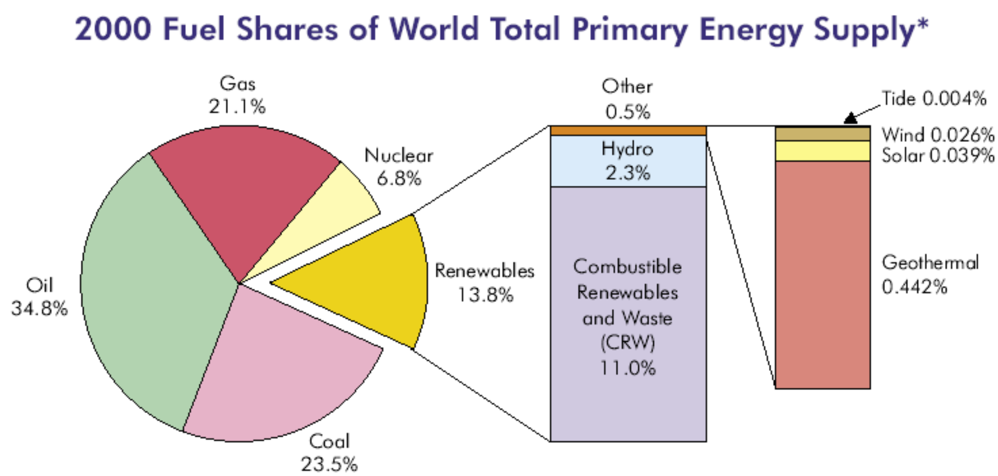
Method


Initial Review of Literature
Preliminary List of Barriers
Technical & Administrative
Market & Legislative
Social, Educational & Skills Related
Detailed Literature Review & Expert Consultations
Consolidate & Analyse Intelligence
Priority Screen
List of High, Medium & Low Priority Barriers
Further Analysis, Development of Vision and Formulation of Strategic Objectives for PV Market and Industry in Canada
Development of Strategic Action Plan Outlining Priority Activities & Roles & Responsibilities

3.0 Trend Towards More Sustainable Distributed Generation

Renewable energy supplied approximately 13.8 percent of the world's total primary energy demand in 2000, with solar PV providing 0.039 percent (Figure 1). Although this appears small, what is significant is the rapid growth that renewables, and more specifically PV, have experienced over the past few decades. In fact, the growth of renewables has been almost identical to the annual growth in total primary energy supply, averaging 2 percent per year over the last 30 years. Impressively, PV, along with other renewable energy sources such as tide, wind, solar thermal and geothermal have recorded a much higher annual growth rate of 9 percent[2].

Figure 1: Global Energy



Source: IEA, Renewables in Global Energy Supply

As noted, the rapid growth in alternative energy is the result of two integrated trends – a global movement towards more sustainable energy sources and a shift to smaller and more flexible distributed power generation. Typically, these trends are being:

1. **Pulled** forward by market demands, particularly in a number of progressive OECD countries (government, industrial and commercial buyers such as Dupont, Interface, etc.) and developing countries (primarily through international financial institutions); and
2. **Pushed** by large multinational suppliers (such as BP Solarex and Shell) and numerous smaller technology companies, all of which have made significant injections of money and resources into the advancement of PV. They see the vast opportunity that exists and the numerous benefits that will result from their investments – for example, lower long-term costs, reduced liability and risks, improved corporate image, an enhanced licence to operate and increased shareholder value.

In fact, a review of the corporate reports of leading organizations around the world, and many of the progressive countries focusing aggressively on expanding renewables and DG, shows that almost all incorporate solar energy as an integral component of their energy strategies. Generally, this is because the organization or government understands the emerging energy market and supply trends that are being driven by a number of converging forces, including:

[2] IEA, *Renewables in Global Energy Supply*

- **International Climate Change Action and the Kyoto Protocol –** There is increasing recognition around the globe that humans are having a significant impact on global weather patterns as a result of rapidly increasing emissions of greenhouse gases (GHGs). As a result, over 180 countries developed and signed the Kyoto Protocol, of which 106 have ratified it, committing developed countries to specific reductions in national GHG emissions by 2008 – 2010.

Figure 2: Converging Forces of Demand

- **Fossil Fuel Price and Energy Security** – The uncertainties of fossil fuel supply and price volatility are creating risks for end-users who, in response, are implementing less energy intensive processes and technologies, looking to generate their own power or switching to more reliable and price-stable sustainable sources.
- **Increasing Understanding of the Link Between Air Pollution and Health** is making governments institute new regulations to curb air pollution and making companies search for new ways to reduce emissions in order to limit potential future liability.
- **Technology Advances and Reductions in the Price of Distributed Power –** Almost all renewable and more sustainable energy sources (micro natural gas turbines, for example) have seen significant technological advances, which have in turn made many distributed energy systems more cost-effective and in some cases competitive with the use of more traditional sources.
- **Electricity Deregulation** that should increase competition and efficiencies, enhance customer choice, create a market where the real price of electricity drives demand and provides a greater opportunity for grid integration (across North America, for example) which substantially increases supply opportunities for distributed generators.

The results of these and other key market forces is that distributed generation and more specifically on-grid PV has "moved squarely into the mainstream of energy planning."[3] In addition, governments, particularly in Europe, the US, Japan and large emerging economies (like India and China) are developing and implementing policies and programs that are further encouraging PV and renewable distributed power in general, while corporations are investing in green power to offset risks, reduce GHG emissions, enhance public image and reduce costs.

3 S. Blankinship, "Distributed Generation: Genie is out of the Bottle", *Power Engineering*, Vol. 103, Issue 3, March 2003.

3.1 Significant Co-Benefits of PV

While on-grid PV technology is less cost-competitive than other forms of traditional or renewable energy, the environmental, social and economic benefits are significant and sometimes forgotten. Specifically, the market deployment of PV offers many valuable advantages outside of the clean, secure and higher quality energy that is produced. For example, the daily electricity demand curve parallels the PV electrical output, thereby reducing peak grid demand. Furthermore, distributed generation reduces the reliance on large single-source electricity sources by establishing more secure (i.e. range of size, type and location), distinct and separated sources of electricity. As a result, transmission and distribution infrastructure costs (e.g. operating, maintenance, capital upgrades, etc.), and transport efficiency losses are reduced. Solar energy is also unique in that unlike any other energy source, sunshine is available everywhere;[4] it can therefore be used as a supplement in any stand-alone hybrid electrical system.

USA: The President's Million Solar Roofs Initiative

In 1997 former American president Clinton announced the "Million Solar Roofs Initiative". Within this program a million roofs in the USA are to be equipped with a PV system and/or a solar thermal system for water heating, pool heating, or space heating. With respect to PV the *Team-Up initiative* with its "friendly PV programs" is of special relevance - eight utilities have joined and market green electricity differently. Moreover, tax credits up to $US 2000 are possible for individual systems.

Environmentally speaking, PV offers zero air emissions (NO_x, SO_x, particulates, and so on) and a less carbon-intensive renewable energy source. Especially with roof-top or integrated PV applications, the small environmental footprint of photovoltaics displaces conventional energy sources and the associated transport of fuel to the generator site.

Architecturally speaking, BIPV can offer a number of attractive options to be creative and enhance building design and construction. Besides colour, surface options, and passive benefits such as shading and acoustic control, BIPV materials typically displace standard building materials such as shingles or siding (Photo 1: Example of BIPV).

Photo 1: Example of BIPV Installation

Photo courtesy of ARISE Technologies Corporation

[4] Canada averages three to four hours of peak sunshine per day over an entire year.

The socio-economic benefits of PV include highly-skilled job creation, increasing innovation and technological advances here in Canada, and the development of a strong, steady and sustainable export industry. Finally, the prestige of PV adoption must be both acknowledged and recognized for its symbolism of vision and sustainable responsibility. Both companies and individuals are poised to benefit from this realization.

Table 1: Ancillary Benefits of PV Systems

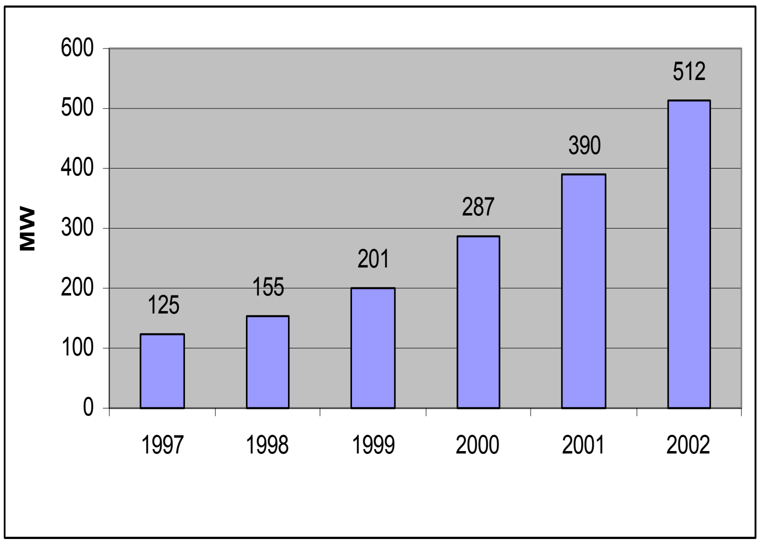
Category	Potential Values
Electrical	➢ KWh generated and kW capacity value ➢ peak generation and load matching value ➢ reduction in demand for utility power ➢ power in times of emergency ➢ grid support for rural lines and reduced transmission and distribution losses ➢ improved grid reliability and resilience, voltage control and smoothing of load fluctuations ➢ filtering harmonics and reactive power compensation
Environmental	➢ Significant net energy generator over its lifetime ➢ reduced air emissions of particulates, heavy metals, CO_2, NO_x and SO_x, resulting in lower greenhouse gas levels, reduced acid rain and lower smog levels ➢ reduced power station land and water use ➢ reduced impact of urban development ➢ reduced tree clearing for fuel ➢ reduced nuclear safety risks
Architectural	➢ Substitute building component ➢ multi function for insulation, water proofing, fire protection, wind protection, acoustic control, daylighting, shading, thermal collection and dissipation ➢ aesthetic appeal through colour, transparency, non-reflective surfaces ➢ reduced embodied energy of the building ➢ reflection of electromagnetic waves ➢ reduced building maintenance and roof replacements
Socio-Economic	➢ New industries, products and markets generating local employment for installation and servicing ➢ local choice, resource use and control, potential for solar breeders, and short construction lead times ➢ modularity improves demand matching and reduces price volatility ➢ resource diversification and reduced fuel imports ➢ deferment of large capital outlays for central generating plant or transmission and distribution line upgrades ➢ urban renewal, rural development ➢ lower externalities (environmental impact, social dislocation, infrastructure requirements) than fossil fuels and nuclear ➢ reduced fuel transport costs and pollution from fossil fuel use in rural areas ➢ reduced risk of nuclear accidents ➢ symbol for sustainable development and associated education ➢ potential for international cooperation, collaboration and long-term aid to developing countries

Reproduced from Table in *IEA-PVPS T1 – 09: 2001, pg. 21, Added Values of Photovoltaic PV Systems*

4.0 Global PV Markets – A Rapidly Growing Phenomenon

In aggregate terms, the current global level of PV installed capacity is both impressive and growing. In 2002, world production of solar cells increased to 512 Megawatts (MW), a 31 percent growth from 390 MW in 2001. The energy from these newly installed systems (i.e. 512 MW) is equivalent to providing the electricity needs for more than 500 000 families. As illustrated in Figure 3, worldwide demand for PV has been accelerating since 1997 growing between 23 percent and 35 percent per year. In fact, the worldwide photovoltaic industry now generates total revenues of over $US 2 billion. While this is relatively small compared to other energy sources, its projected growth is likely to push revenues over $US 10 billion a year by 2010[5].

Figure 3: World Cell/Module Production in MW



Data source: P. Maycock, *PV News* Vol. 22, No. 3, April, 2003

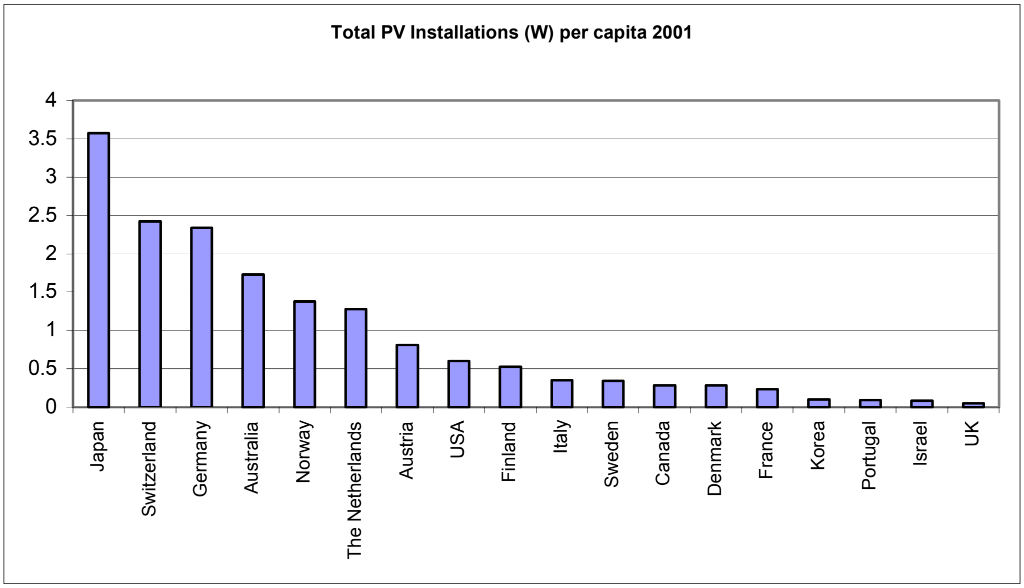
This growth demonstrates that after 20 years of development and cost reduction, PV has finally reached the threshold for take-off. The PV industry is experiencing strong growth in both developing and developed countries. In developing countries, the growth is driven by tremendous need for basic power generation as more than two billion people around the globe live without any form of electricity today, many in sunny areas and where their modest electrical needs do not justify large power plants or miles of electric lines.

At this time, the majority of growth of total installed capacity is due to aggressive programs and policies of select countries, namely Japan and Germany. For example, of the 257 MW of on-grid PV installed in 2001, 79 percent was installed in Japan (122 MW) and Germany (81 MW) combined; with the addition of the US, this figure is raised to 85 percent. This continued high rate of installation in Japan increases this country's lead in installed power per capita (3.6 W per capita)[6] as shown in Figure 4.

But this high growth trend is showing signs of broadening, as price is reduced and more countries and companies see the benefits and advantages of PV. In fact, from a global point of view, Greenpeace and EPIA predict a bright future for PV in which over one billion people will have solar electricity by 2020 (Figure 5). PV is also predicted to actively contribute to job creation worldwide, with an estimated two million jobs in 2020, mainly in small and medium-sized firms.

[5] *Renewable Energy World* Vol.6 No. 1 (P.44)
[6] IEA - *Trends in PV Application 1992 – 2001*

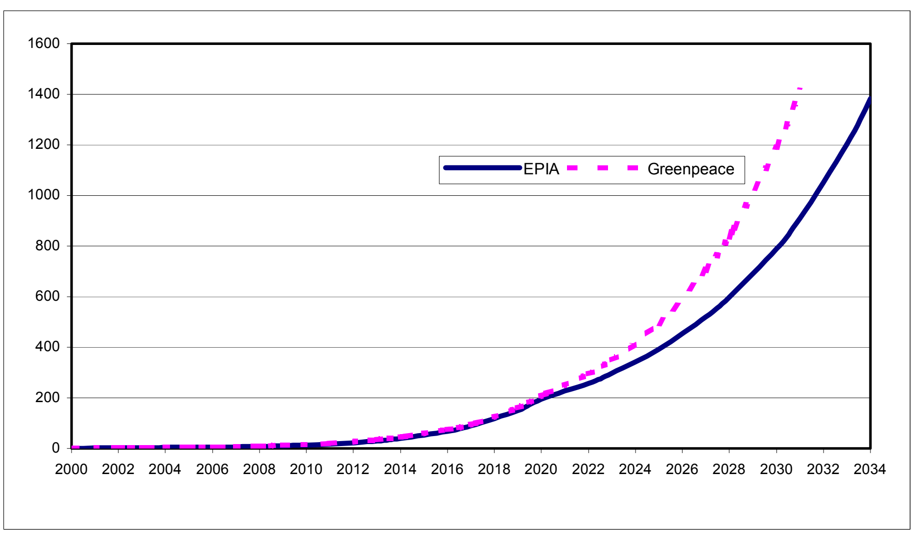
Figure 4



Source: IEA Photovoltaic Power Systems Program available at http://www.iea-pvps.org/

Although it is often believed that rural markets in developing countries offer the greatest potential, on-grid commercial applications in developed countries continue to dominate absolute annual growth. Until 1999, most PV systems installed in developed countries and worldwide were for off-grid applications. However, today the overall trend in developed countries is a rapid increase in the proportion of PV power that is grid-connected. For example, in 1990 only 29 percent of the cumulative installed capacity was connected to the grid, but by the end of 2001 this had reached 68 percent, of which 93 percent was for distributed systems (Figure 6). This trend is particularly strong in Japan, the US and Europe which now account for over 90 percent of the world's PV market, of which over 50 percent is grid-connected commercial and residential[7].

Figure 5: Global cumulative PV capacity based on EPIA and Greenpeace/EPIA data (GW)

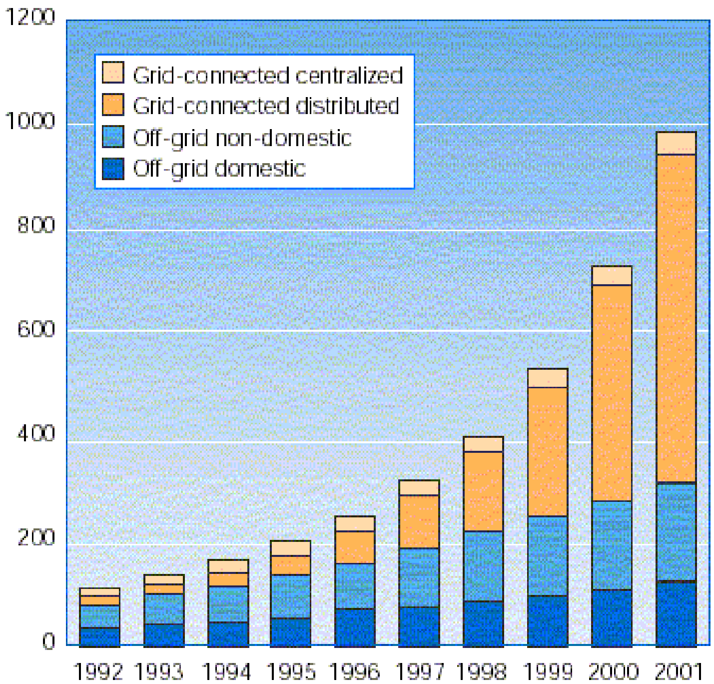


Source: *Learning and Diffusion for Wind and Solar Power Technologies: Monograph in the framework of the VLEEM project* [ECN Report 2001]

[7] IEA-PVPS, "PV Power in 3 IES-PVPS countries", 2002, available at http://www.iea-pvps.org/.

In OECD countries, the focus is mainly on grid-connected PV, as most of their residents are connected to the grid and the cost of these systems is half that of off-grid systems. For instance, in the US, the investment cost of grid-connected systems in a specific area was $5 700/kW in 2000, whereas the corresponding figure for off-grid systems was $13 900/kW (with battery storage)[8].

Figure 6: Proportional Market Share for On-Grid versus Off-Grid PV Cumulative Installed capacity (MW)



Legend (definitions):

- *Grid-connected centralized* are larger PV systems (up to 1 MWp) that are constructed to supply power directly to the grid;
- *Grid-connected distributed* are smaller systems (such as BIPV on residential, commercial and industrial sites) that are installed on the premises of the end-user, typically on the demand side of the utility meter;
- *Off-grid non-domestic (commercial or industrial)* are systems that support activities such as water pumping, signage, communication and monitoring units, safety and protection devices;
- *Off-grid domestic (or residential)* are systems connected to houses and cottages that do not have access to the grid.

Source: IEA Photovoltaic Power Systems Program available at http://www.iea-pvps.org/

Clear patterns are emerging as the global PV industry continues to grow at an impressive rate:

- Most growth in off-grid photovoltaic applications is for rural electrifications in developing countries;
- Almost all the growth in on-grid applications occurs in developed countries, led primarily by aggressive government- and utility-supported initiatives in a number of leading countries, such as Japan, Germany, the US, and the Netherlands;[9]
- The major market for solar consumer products is in developed countries, especially in North America. The vast majority of these products are manufactured in East Asian countries (and in particular China), although there are some strong and growing consumer product manufacturers in developing countries; and,
- Most photovoltaic products, especially solar cells and modules, are still being manufactured in developed countries. However, a trend to local manufacturing and outsourcing of high-labour processes has started to develop, with solar consumer products leading the trend.

[8] *Learning and Diffusion for Wind and Solar Power Technologies: Monograph in the framework of the VLEEM project* [ECN Report 2001]

[9] IEA - Trends in PV Application 1992 – 2001

5.0 Domestic On-Grid PV – An Untapped Opportunity

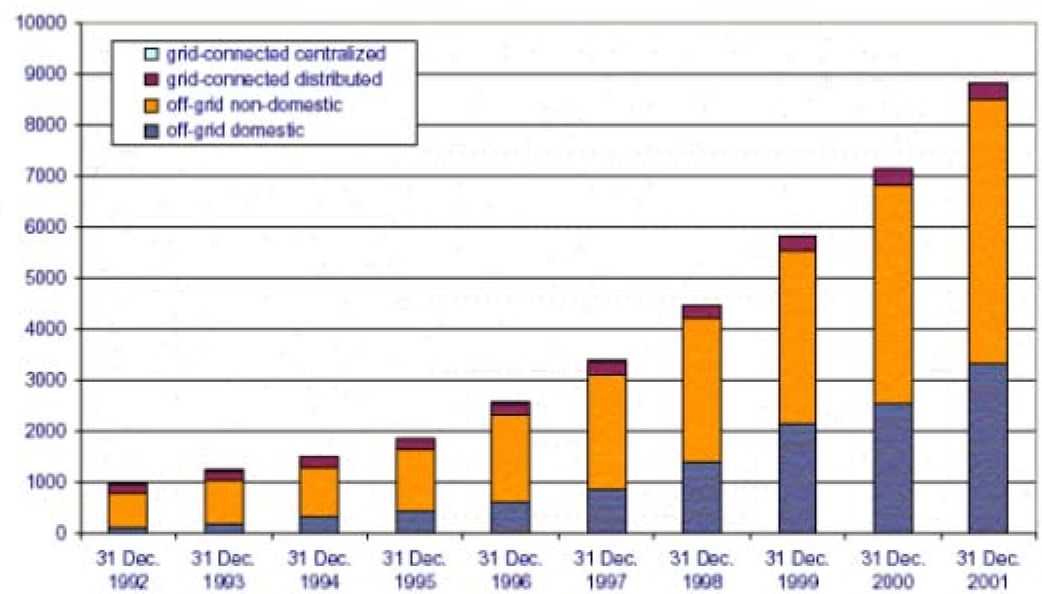
5.1 Existing Market

The Canadian PV industry has grown steadily serving both its domestic on- and off-grid markets, consumer products and the corresponding export market. Canada's PV installed capacity at the beginning of 2003 is almost 10 MW with a sustained domestic market growth average of 25 percent over the past eight years. In 2001, the annual PV module market grew to 1.68MW domestic installations, compared to 1.32MW in 2000, up 27 percent in the year[10].

There are approximately 150 organizations actively promoting PV power. The vast majority of this group are system resellers, distributors and installers. Approximately 14 companies are involved in manufacturing, and the remaining are engaged in various activities including the sale of equipment and providing systems integration functions. It is estimated that the Canadian PV industry generated revenue of $CDN 95 million (this includes manufacturing, sales, installations, consulting and R&D) and employed approximately 625 people in 2002.

The main difference between the Canadian and international PV markets is that although on-grid sales showed the greatest increase in relative growth in 2001, they represent only 2 percent of the entire PV market in Canada. In addition, the relative size of the Canadian market and its absolute growth rate is far behind that of other OECD countries in Europe, Japan and the US. By way of illustration, Canada had over 8.8 MW_p of domestic installed PV in 2001, which equates to 0.28 W/Capita. Other northern OECD countries such as the Netherlands, Germany and Finland have total installed PV capacity in W/capita of 1.28, 2.34 and 0.53, respectively[11].

Figure 7: Cumulative Installed PV power (kWp) in Canada by sub-market



Source : IEA Photovoltaic Power Systems Program,
available at: http://www.oja-services.nl/iea-pvps/countries/canada/index.htm

10 2001 *PV Systems And Modules Survey*, Vasantha Narasimhan for Natural Resources Canada.
11 IEA- PVPS, "Total Photovoltaic Power Installed", available at: www.oja-services.nl/iea-pvps/isr/22.htm.

The largest module sales tend to occur in the off-grid non-residential sub-market (with greater than 50 percent of the market in each of the years 2000 to 2002). Off-grid residential is the second largest sub-market, followed by on-grid distributed. In all cases sub-sector growth rates have varied significantly from one year to the next. While the growth rates for remote and rural off-grid applications are likely to remain high, the market potential is still relatively small.

Table 2: Annual PV power sales within three sub-markets

Applications markets	1995 kW	1996 kW	1997 kW	1998 kW	1999 kW	2000 kW	2001 kW
Off-grid residential	133	166	242	525	776	382	789
Off-grid commercial/ industrial	200	505	565	562	550	928	859
Grid-tied demonstration*	17	29	13	3	30	18	37

**Majority government supported*

Source: Natural Resources Canada (Photovoltaic Technology Status and Prospects Canadian Annual Report 2001)

In comparison, building integrated PV systems represent a huge untapped potential as illustrated in the following table. This opportunity has also been recognized by a broad range of government and private sector experts including federal and provincial governments, industry associations, companies and utilities.

Table 3: Potential for BIPV in OECD Countries

Country	Available Net Solar Surface (Year 2010)		Installed PV Capacity (Year 2010)		Producible PV Energy (Year 2010)	
	Total (Km^2)	M^2/inhabitant	MWp	Wp/inhabitant	MWh/year	KWh/year/inhabitant
Europe	3723	9.5	617 662	1584	494 195 649	1268
US	4563	14.1	757 039	2344	903 579 106	2797
Japan	1050	8.3	174 179	1385	158 503 338	1260
Australia	265	12.2	43 897	2029	61 456 001	2840
Canada	413	13.0	68 556	2150	57 587 360	1806
New Zealand	50	12.9	8374	2147	8 206 059	2104
Turkey	523	6.7	86 711	1117	103 185 630	1330
Rest OECD	1273	9.4	211 231	1564	230 435 051	1707

Reproduced from tables 1.23, 1.24, 5.10, 5.11 of "Photovoltaics: Current Status And A Strategy For European Industrial And Market Development To The Year 2010 - Volume 3", available at http://www.agores.org/Publications/PV2010.htm.

There is a growing number of BIPV products that are for sale for integration into flat and sloped roofs, facades and other building applications. It is estimated that there are over 35 companies around the world producing more than 50 BIPV-related products, including roofing shingles, structural roofs, sunshades, curtain walls, skylights, and semi-transparent windows. A number of these are available in Canada and the US.

However, the rapid increase in worldwide shipments of BIPV, consumer products, and other on and off-grid PV systems, along with the steep growth in manufacturing capacity are a primary result of the positive political, regulatory and market climates in countries such as Japan, Germany, Spain, Denmark, the US and others. In contrast, Canadian BIPV and the broader grid-connected PV market will remain an untapped opportunity, unless key stakeholders adopt a set of practical measures that can help overcome the existing inertia, drive down costs and encourage the development of a robust domestic energy strategy - one that encourages diversified generation sources and maximizes renewable distributed generation, including PV.

Upper Austria's bidding program
The first governmental bidding program for decentralized grid-connected PV so far was launched In Upper Austria in 2000. It set targets and financial incentives for different types of RES-E. A special obligation for PV of 220 kW/year was set. To meet this target an annual budget of €1 million is available. In the first year (2000), this program was successful.

5.2 Initial Progress

Canada has made progress on several fronts, albeit slowly. Federal, provincial and municipal governments, along with various utilities and other stakeholders have instituted a number of encouraging initiatives to foster the development of renewables including PV. These initiatives include policy, demonstration, R&D, deployment, education, tax benefits, financing and Renewable Portfolio Standard (RPS) mechanisms and programs.

Two recent initiatives that warrant notice and are likely to have significant positive impacts on renewables, and more specifically PV, include:

1. **Climate Change Action Plan for Canada**. Canada's recent ratification of the Kyoto Protocol and the government's concern about the economic and environmental impacts of climate change on Canada have made the issue a top priority. As a result, the federal government has allocated close to $3.7 billion since 1998 for initiatives that will reduce domestic and international GHG emissions. Most recently, the Canadian government launched its "Climate Change Plan for Canada" – a strategic document that outlines a three-step approach to facilitate action by Canadian citizens, industry and all levels of government to reduce their emissions and to meet our Kyoto commitments. More specifically, the plan sets a target of 10 percent of new electricity generating capacity coming from emerging renewable sources (Table 4).

2. **MicroPower Connect,** an industry-led initiative managed by Electro-Federation Canada and supported by the Government of Canada. MicroPower Connect partners with industry and government to identify DG issues and develop standardized interconnection regulations and guidelines to address inconsistencies that now exist for distributed generators wanting to connect to the various provincial grids. A report outlining recommendations for interconnection of DG systems <600V is in the final stages of review.

Table 4: Overview of the Climate Change Plan for Canada

	Step 1: Actions Under Way	**Step II**: New Actions	**Step III**: The Remainder
Actions by Canadians and Governments: Transportation and Buildings	13 MT	15-20 MT	Current and potential actions that could achieve approximately 60 MT are outlined on page 14
Large Industrial Emitters	25 MT	55 MT	
Other Industrial Emissions: Technology, Infrastructure and Efficiency Gains		16 MT	
Agriculture, Forestry and Landfills; Sinks and Offsets	38 MT	*	
International Markets	2 MT	Minimum 10 MT	
Total	Approximately 80 MT	Approximately 100 MT	

* Offsets are estimated at 20 to 28 MT; because they may be sold to industry through domestic emissions trading, they are not added to the total. **Reproduced from page 11 of *Climate Change Plan for Canada, 2002,* available at http://www.climatechange.gc.ca.**

Other recent initiatives include the Wind Power Production Incentive and Ontario's new sales tax rebate. Summaries of a sample of these relatively new initiatives and other well-established programs such as the Renewable Energy Information and Awareness Program, Renewable Energy Deployment Initiative (REDI), Green Municipal Enabling Fund, and Market Incentive Program (MIP) are provided in Table 5. In general, these initiatives are broad-based (directed at clean energy in general), although some – such as WPPI and REDI – are targeted more at specific subsectors, and offer a solid foundation upon which to build an advanced energy strategy that catalyses the potential of renewables across Canada, while providing significant economic, social and environmental co-benefits including the reduction of GHG emissions. Many of the federal and provincial initiatives are listed below. It should be noted that PV energy is the only emerging renewable energy technology option that does not have a direct incentive for deployment throughout Canada.

Table 5: Examples of Existing Federal Initiatives that Support Renewable Energy

Initiative	Supporting Agency	Focus	Description
Federal Initiatives			
Climate Change Action Plan for Canada	Climate Change Action Fund (CCAF)	Power Purchase	As part of Canada's strategy to meet its Kyoto targets the federal government has set a target of 10 percent of new electricity generation in Canada that is to come from renewable sources
Market Incentive Program (MIP)	Climate Change Action Fund (CCAF)	Marketing & Adoption	Objective is to encourage electricity utilities and marketers to promote green power, reduce GHGs and establish renewables as mainstream competitors in cross-country electricity markets by 2010. Funding is available from the MIP until March 31, 2006.
Federal Government Green Electricity Purchase	NRCan and Public Works and Government Services Canada	Power Purchase	Action Plan 2000 on Climate Change commitment to purchase 20 percent of electricity from green power sources (mainly wind projects)
Canadian Renewable and Conservation Expenses (CRCE) Allowance	Canada Customs and Revenue Agency (CCRA) & CANMET Energy Technology Centre	Tax Incentives	CRCE allows flow-through share financing for renewable energy project planning/pre-deployment expenses for qualifying investors, and accelerated depreciation of 30 percent annual declining balance for specified renewable energy generation equipment under class 43.1 capital cost allowance.
Sustainable Development Technology Canada (SDTC)	Government of Canada	RD&D	Supporting alliances to bring innovative technologies to market. The initial budget was $100M, but an additional $250M was allocated in the 2003 budget. The focus is on innovative projects which will improve air quality and curb GHG emissions.
GMEF (Green Municipal Enabling Fund), GMIF (Green Municipal Investment Fund)	Federation of Canadian Municipalities (FCM)	Feasibility studies and Green Municipal Infrastructure Projects	A total of $250M ($50M grant, $200M loans) was allocated to FCM to identify solid partnership projects that could be leveraged with additional funding to promote environmental protection, including the adoption of renewable energy and reduction of GHGs in local communities.
CANMET Energy Diversification Research Laboratory (CEDRL)	Natural Resources Canada NRCan through CANMET Energy Technology Centre	RE support	CANMET Energy Technology Centre provides RD&D and commercialization partnerships for RE development.
MicroPower Connect Initiative	Natural Resources Canada (CETC-Varennes) through Electro-Federation Canada	DG interconnection	MicroPower Connect partners with industry and government to identify DG issues and develop standardized interconnection regulations and guidelines to address inconsistencies that now exist for distributed generators wanting to connect to the various provincial grids. A report outlining recommendations for interconnection of DG systems <600V is in the final stages of review.
Renewable Energy Deployment Initiative (REDI)	Office of Energy Efficiency, NRCan	Deployment Incentives	REDI provides incentives for renewable energy installations in municipal, institutional and commercial buildings. Focus has been on solar energy, biomass and ground source heat pumps, although this is being broadened to include other sources of renewable energy

Table 5: Examples of Existing Federal Initiatives that Support Renewable Energy (continued)

Initiative	Supporting Agency	Focus	Description
Federal Initiatives			
Technology Early Action Measures (TEAM)	Climate Change Action Fund	Supports technology innovation – RD&D for GHG reducing technologies	TEAM support technology projects that reduce GHG emissions nationally and internationally. The objective is to accelerate the deployment of new technologies into the marketplace. TEAM began with $CDN60M over three years (1998/99-2000/01) from the CCAF, which was extended to 2003/04, with an additional $CDN35M.
Industrial Research Assistance Program (IRAP)	Industry Canada through the National Research Council	Supports R&D in SMEs	Provide Canadian small and medium-sized enterprises (SMEs) with value-added technological and business advice, financial assistance and a range of other innovation assistance up to $1.5M.
Technology Partnerships Canada (TPC)[12]	Industry Canada	Encourage Innovation	Invests in projects that present technological and net economic benefits for Canada. TPC supports some of Canada's most dynamic companies so that they can continue to advance their technologies and accelerate the pace of innovation. Assistance is generally >$1.5M.
Natural Sciences and Engineering Research Council (NSERC)	Government of Canada	Encourage Innovation	NSERC awards scholarships and research grants through peer-reviewed competition, and builds partnerships among universities, colleges, governments and the private sector. The budget is $538M annually.

Renewable Portfolio Standards (RPS) in the USA

RPSs have been implemented in several US states: Arizona, Connecticut, Iowa, Maine, Massachusetts and Nevada.

[12] ATS Automation Systems (and its subsidiary Spheral Solar and Canadian Solar Inc.) is an example of a Canadian PV success story which has also been very successful at tapping available funding. Recently, $29.5M government funding ($25.5M TPC and $4M CCAF) went to support the development of a new technology (Spheral Solar) and manufacturing facility in Ontario. ATS has also received CCCDF and TEAM funding for projects in China.

Table 6: Examples of Existing Provincial Initiatives that Support Renewable Energy

Name of Initiative	Supporting Agency	Focus	Description
Provincial Initiatives			
Energy for our Future: A Plan for BC (2003)	Government of British Columbia: Ministry of Energy and Mines	Green Energy Adoption	Distributors will voluntarily purchase 50 percent of their new electricity supply from Clean Electricity over the next 10 years, until 2013.
Social Services Tax Act	Government of British Columbia: Ministry of Finance	Tax Incentive	PST exemption for RE equipment.
Alberta's Action Plan on Climate Change	Alberta Environment	Green Energy Adoption	Provincial RE/alternative energy capacity to increase by 3.5 percent by 2008, starting in 2003. Green power to provide 25 percent of provincial government electricity starting in 2003.
Saskatchewan Climate Change Plan: Office of Energy Conservation	Saskatchewan Industry and Resources	Green Energy Adoption	Green power content to be determined.
Select Committee on Alternative Fuel Sources, Final Report.	Minister of Energy: Commissioner of Alternative Energy – Select Committee on Alternative Fuel Sources	Tax Incentives	New green power development eligible for: 10-year corporate income tax holiday 10-year property tax holiday Review of property tax regulations for revenue versus capital PST exemption for RE equipment Net metering policy being developed. Planning to adopt a future RPS. Green power to provide 20 percent of government electricity supply.
Ontario Environmental Protection Act	Ontario Ministry of the Environment	Environmental	Environmental standards to be in place by 2007, will limit smog and related emissions.
Quebec Energy Policy	Government of Quebec	Green Energy Adoption	Committing to wind and biomass energy. Providing incentives (FAIRE & tax credit) for industrial development
New Brunswick throne speech Nov 2002	New Brunswick Government	Green Energy Adoption	Committed to RPS, with details to be released.
PEI Energy Policy	PEI Government: Department of Energy & Minerals	Green Energy Adoption	Green power proportion being determined.
Nova Scotia Green Power Program	Nova Scotia Government	Green Energy Adoption	Will specify RPS depending upon voluntary renewable target of 2.5 percent, as in the Nova Scotia Energy Strategy, 2001.

Table 7: Examples of Existing Utility Initiatives that Support Renewable Energy

Name of Initiative	Supporting Agency	Focus	Description
Utility Initiatives			
2002/03 Green Power Generation (GPG) procurement process	BC Hydro	Green Energy Adoption	800 GWh/year energy cap for the 2002/03 GPG procurement process.
Sustainable Development Policy/Principles	Manitoba Hydro	Interconnection	Considering a net metering policy. Have already issued guidelines for connection <25 kW. Encouraging Power Smart adoption.
EverGreen	Ontario Power Generation	Green Energy Adoption	Have targeted a RE supply of 3TWh by 2005. The EverGreen department has been created to focus on renewable energy. Investment has already been made in a PV array on the CN Tower, and wind turbine deployment in Pickering, and partnerships through the Kortright Centre and other joint projects.
Maritime Electric Green Power Program	PEI - Maritime Electric	Green Energy Development	Have developed a 5 MW wind farm
New Brunswick Energy Policy	New Brunswick Power	Green Energy Development	Wind development under review.
	Newfoundland & Labrador Hydro	Green Energy Development	Wind development under review.
Various initiatives	Hydro Quebec	Green Energy Development	Wind investment.
Saskatchewan Climate Change Plan	Saskatchewan Hydro	Green Energy Development	Wind power developed with industry partnerships.
Yukon Green Power Initiative	Yukon Development Corporation	Green Energy Adoption	Wind development, production incentive for new RE development
Arctic Energy Alliance	Northwest Territories Power Corporation and Nunavut Power Corporation	Green Energy Adoption	Remote wind development as part of a basic guide to energy conservation for residents of Canada's North
Greenmax Program	ENMAX		Certified under Environment Canada Environmental Choice EcoLogo program. Gives customers the choice to pay a premium for green energy.
Beyond Kyoto	TransAlta Corporation	Green Energy Adoption	Purchased wind energy for corporate offices in Calgary, and then purchased VisionQuest outright.
Other Initiatives			
Photovoltaic Installer Certification	North American Board of Certified Energy Practitioners (NABCEP)	Training and Education	Certification for PV designers and installers to ensure installation quality.
LEED Version 2.1 – Energy Efficiency	Leader in Energy and Environmental Design (LEED)		LEED is considered only after building is rated 50 percent or better of ASHRAE specifications (becomes "solar worthy"). PV and renewable energy are among the contemporary design enhancements.

* Note: The RPS and Green Procurement initiatives noted in the above table will tend to favour biomass, wind or potentially small hydro over PV.

The appeal of renewable energy is also creating a buzz in the business community. Leading companies are proactively volunteering to support renewable energy because they understand the positive economic, environmental and social advantages of embracing renewable energy. In Canada, leading corporations such as Suncor Energy, Dupont, Interface, Mountain Equipment Co-Op, The Body Shop, RBC Dominion and others have already made substantial investments in renewable energy projects and commitments to purchase specific percentages of their future energy requirements from renewable sources. While these initiatives are often supported by internal financing, many renewable projects are being financed by private third parties such as the Probyn Group, National Bank of Canada, Leading Edge Alternative Power Fund, or one of the ethical green funds. Other incentives such as GreenTags and the Eco-Logo label are available as instruments to encourage and identify renewable energy development.

Non-profit organizations such as the Pembina Institute, David Suzuki Foundation, and local community cooperatives are emerging as educational instruments to foster awareness and gain the political weight to acquire funding for development of renewable energy projects. The demand for further education and awareness is fostering a growing number of educational activities organized by industry associations (CanSIA, CANWEA and others). Numerous other initiatives include a PV installation course at BCIT, an on-line PV course at Seneca College, a Royal Architecture Institute of Canada (RAIC) course by Enermodal, general interest courses at the Kortright Centre, and numerous manufacturers' workshops. In anticipation of the need for a standard certificate of accreditation, the Association of Community Colleges of Canada is conducting a study to develop a strategy for the introduction of a renewable energy certification course.

These and other exciting initiatives are positive steps that are increasing levels of awareness. As the demand grows, technological innovation through RD&D is highlighting the feasibility and practicality of specific clean energy technology through highly visible demonstration projects, such as PV arrays. The next stage is to build on these initiatives, and use them as educational showcases. This will catalyse market demand for on-grid PV systems in Canada, and drive costs lower and lower.

The German 1000 roofs program

The first comprehensive international dissemination program was the "1000 roofs program" launched in Germany in 1989. This program was completed in 1994. Some 2250 German roofs were equipped with PV systems of an average size of 2.6 kWp and a total capacity of about 6 MWp. Average system costs were US$15000/kWp, average subsidies 70 percent of the investment costs. During this dissemination program and in the aftermath comprehensive investigations of the technical and sociological aspects of this program took place. The major results of this program were that PV systems reached a certain standard of technical reliability, PV system costs dropped, and acceptance of the technology increased considerably. Moreover, experience gained in this program was also applied to similar activities in Austria and Japan.

6.0 Bumps in the Road - Challenges Slowing PV Growth in Canada

6.1 Introduction

Despite the significant benefits of PV (and clean energy DG in general), and the years of steady technological advances and economic progress in the PV field, energy markets in Canada and the existing policy framework still favour large centralized power fuelled by coal, oil and natural gas. This, combined with the fact that cheap high quality electricity is available across much of Canada, has meant that many renewable and independent energy systems have been unable to meet the price points needed to be competitive in the marketplace. This situation is exacerbated under a pricing and economic system that does not take into consideration externalities and the full cost of environmental and social impacts, such as air pollution.

Although high cost structures still dominate many renewables, the challenges facing distributed generation and in particular PV are multi-faceted and arise for a variety of reasons. These obstacles are typical for technologies in the early stages of commercialization and acceptance, and more importantly can be overcome in a cost-effective manner with targeted policies, long-term commitment, and strong alliances among key stakeholders. This has been proven time and time again with all sorts of technologies ranging from wind energy to ground-source heat pumps or from computers to cell phones.

On the path towards full commercialization, mass production and ultimately a well-accepted, cost-effective and mature technology, products must go through a number of phases - development, demonstration, initial deployment, take-off, full acceptance and maturity. As technologies travel along this path, the ‘learning’ or acceptance of the product in the market increases, while price decreases. The pace at which a technology achieves maximum market penetration is dependent upon a number of variables, including:

- Market demand or perceived need within the market for the specific technology. A good example of this is fuel cells, which have been around for over 100 years, but have only now been considered by the market as a necessary technology – one that demands significant resources to make it cost-competitive with more mature competing solutions;
- Government policy and existing regulatory frameworks that can encourage or impede one technology or type of solution over another; and,
- Private and public investment in R&D, demonstration and deployment initiatives.

In a true market, the first point tends to pull demand and drive the other two points. However, in many cases private or public sector investment can push a technology into the market (for example, the introduction of biocatalysts or other innovations that enhance productivity) or specific policies and regulatory frameworks can accelerate market demand – environmental regulations are a good example of such an initiative.

The challenge for policy makers is deciding what and how policies should be structured and whether or not initiatives should be developed that will favour one approach or technology over another – fossil fuels and nuclear over renewables or energy efficiency, for example. In Canada we have an abundant supply of both fossil fuels and renewable energy, but because of circumstances beyond the scope of this study, a policy and regulatory regime was established that favoured fossil fuels and nuclear energy.

Past Government Spending on Energy
$40.4 billion Direct federal spending on fossil fuels between 1970 and 1999.
$16.6 billion Total subsidies to the nuclear energy industry by the Government of Canada since 1953.
$2.8 billion Loans to fossil fuel industry written off by the federal government since 1970, over and above direct spending.
$850 million Federal cost of cleaning up radioactive waste in Port Hope and decommissioning uranium tailings sites. Historical waste practices in the refining and processing of uranium and radium resulted in contaminated sediment on the harbour of this Ontario municipality.
$156 million Federal subsidy to the Canadian nuclear industry in 2000.
$12 million Total average yearly funding for renewable energy by the Canadian government.

Reproduced from Table 2.3, page 8 in *Low-Impact Renewable Energy Policy in Canada: Strengths, Gaps and a Path Forward*, Pembina Institute, February 2003

Renewable energy, and in particular PV, is now playing catch-up. Besides having to compete with a huge fossil fuel industry and well-established infrastructure and policy framework that favours non-renewable and centralized power, PV (and renewables in general) must also overcome a number of challenges that are typical for any technology solution at this point in market acceptance.

6.2 Identification and Categorization of Existing Barriers

The 40 key informants interviewed during this study identified a number of perceived obstacles. As the literature and key informants categorize these challenges in a variety of ways, it was decided to keep the classification of challenges simple and inclusive. The obstacles identified were classified in one of the following four categories:

1. **Technological Challenges,** including issues such as high capital and operating costs, low efficiencies of conversion, lack of availability of low-cost feedstock, quality, reliability or other issues that make PV less attractive and uncompetitive with more traditional sources of energy and other renewable technologies such as wind. Overall, a technological leap is required to reduce costs or increase efficiencies significantly in the near term.

2. **Market and Legislative Challenges,** including market rules, regulations and pricing structures that currently hinder or prevent PV from being competitive in the open energy market;
   - Existing rules and regulations favour large-scale generation and impede small-scale distributed generation
   - Cost of established on-grid sources very low
   - Full cost pricing not considered (incentives, environmental benefits)
   - Electricity pricing structures and associated rules and regulations are inconsistent, and vary by locality
   - Lack of influence, leverage, presence in the Canadian PV industry
   - Limited interest from the investment community
   - High fees for inspection, permitting, insurance

- Permitting barriers to installation and operation of on-grid systems
- Product distribution and deployment channels inefficient
- Isolated R&D efforts (not collective)
- Lack of standards including net metering legislation
- Lack of market incentives including rebates, discounts, RPS, tax breaks, grants, educational campaigns

3. **Technical and Administrative Challenges,** including policies, technical standards and guidelines (or the lack or inconsistency of such mechanisms), along with existing challenges that impede PV and other small DG systems from being connected effectively to the grid or providing reliable high quality electricity; and,
   - Inconsistent standards, codes and interconnection guidelines
   - Complicated contract terms and conditions for purchase and sale of electricity
   - Array support and roof strength, including snow and wind load criteria
   - Product applications not standardized
   - No standard ratings or specifications for products between jurisdictions
   - Small market means low market efficiencies, limited revenue

California's Emerging Renewables Buydown Program (CERBP)

In September 1996, the California legislature passed Assembly Bill No. 1890. This law requires California's three largest investor-owned utilities to collect $540 million from their customers over four years to support electricity generation from renewable technologies. 10 percent or $54 million was approved for a multi-year rebate program for selected emerging technologies, including PV, small wind (10 kW or less), fuel cells using renewable fuels and solar thermal electric generation. Additional funding has since brought the total to $92 million.

4. **Social, Educational and Skill-Related Challenges,** including all issues that impede the effective development, deployment and uptake of PV in the marketplace as a result of misperceptions, inexperience, lack of awareness, or limited knowledge or skills of key stakeholders.
   - Lack of experience in integrating PV into homes and buildings
   - Lack of Canadian PV construction, O&M experience
   - No standard program to qualify skilled PV personnel
   - Lack of awareness and experience among architects, designers, electricians, installers, underwriters and insurers
   - Lack of skilled installer labour coupled with a small installation base
   - Avoidance due to perceived or actual connection issues
   - Lack of understanding of subsidies to competing energy sources
   - Lack of understanding of the full benefits of PV, distributed PV or BIPV, especially as compared with conventional power
   - Lack of links to Canadian construction industry
   - Lack of awareness of benefits of PV
   - Established norms and misperceptions related to PV

- Lack of existing pilot projects which demonstrate the feasibility of PV
- Lack of general understanding by end-users, utilities, governments and others of the business opportunity on a global scale

6.3 Prioritization and Consolidation of Identified Barriers

Upon further analysis, more extensive literature review and further expert consultation, it became clear that many of the identified challenges listed above are multi-faceted, interconnected and often interdependent. More specifically, it was recognized that:

- A number of the preliminary challenges identified were not obstacles in themselves, but were the result of another more critical challenge that needs to be overcome. For example, "inefficient distribution and deployment channels" are the result of a small and fragmented market due to several factors (cost, market environment) that are hindering the uptake of PV.
- A few of the identified obstacles were mechanisms to overcome an obstacle stated in a negative fashion, rather than a challenge in themselves. For example, the "lack of market incentives" is not a barrier to PV deployment; other issues such as high capital costs and low electricity prices create an unfavourable market for PV. However, market incentives can offset some of these obstacles, or eliminate them altogether.
- Several of the obstacles were similar in nature or integrally linked.

As a result, the initial list of obstacles was analysed more closely, based on the input received from key informants, then reconfigured, significantly consolidated and prioritized as either:

1. **Higher priority** – a critical issue that must be addressed to ensure PV deployment is successful. If not mitigated these obstacles will continue to impede the market for PV significantly, whether or not other obstacles are mitigated.
2. **Lower Priority** – important issues that will slow the market uptake of PV if not addressed. However, these are often integrally linked or a result of a high priority obstacle, and are likely to be mitigated or eliminated once the market and the industry grow or one or more of the high priority obstacles are addressed. These can be targeted after the other priorities are attended to.

Key informants had varying opinions about what constituted a lower priority barrier, depending upon their current role (utility, architect, investor and so on) and their perspective. However, the majority agreed that if any one of the following major barriers were not addressed, then successful PV deployment would be all but impossible:

i. Existing pricing challenges

ii. Current market and legislative obstacles

iii. Inconsistent standards, interconnection guidelines and contract terms

iv. Lack of awareness and understanding of PV applications and benefits

The remainder of this section focuses on these four primary challenges, the elimination of which could significantly enhance the price competitiveness of PV in Canada and increase its ultimate uptake in the marketplace. Specific recommendations that address one or more of these higher priority issues are presented in Section 7.

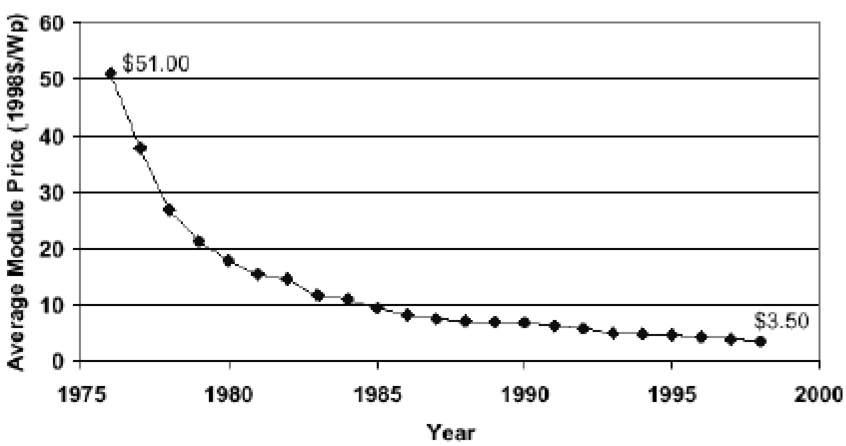
6.4 Existing Pricing Challenges

6.4.1 Rapid Reductions

Significant technology advances over the past 25 years have resulted in ongoing cost reductions throughout the PV industry from the manufacturing of wafers, to the assembly of modules to the integration and implementation of entire PV systems.

PV technology is following a development and commercialization path similar to that of many other types of manufactured goods (such as computers and cell phones). For example, the 'learning rate'[13] for PV modules is close to 20 percent between 1977 and 1997. The PV industry has been able to make continuous improvements in solar conversion efficiency and manufacturing cost reduction. Production costs have come down steadily over the last decade (Figure 8). The cost of PV electricity generation has been reduced over the last 15 years to the $0.50 to $0.30 per kWh range, and even lower for some applications[14]. Based on progress to date, it is likely that the industry will further reduce generation costs to the range of $0.14/kWh to $0.08/kWh between 2010 and 2020.

Figure 8: Average selling price of PV modules 1976-1998



Source: Harmon, C. (2000): *Experience curves of photovoltaic technology*. IIASA, IR-00-014, March 2000.

In fact, using a conservative forecast growth rate of 20 percent a year from 2000, it is estimated that PV modules will become cost competitive with more traditional forms of energy around 2020-2030[15]. This is based on increasing economies of scale from mass-market introduction. It does not take into consideration environmental benefits or possible disruptive technological leaps (Table 8), that may significantly lower costs in advance of market projections. In addition, it should be noted that since 1997, the global market growth rate has accelerated to 30-35 percent annually, indicating that production could double again in the next three to four years and reduce the time PV takes to achieve commercial viability.

[13] The learning rate refers to the cost reduction achieved for every doubling of production. In the case of PV, each doubling of production reduces the price by 20 percent.
[14] US Department of Energy, "Strategic Plan for Distributed Resources"
[15] Class-Otto Wene, *Experience Curves for Energy Technology Policy*, IEA, 2000

Table 8: Novel technologies being developed to reach costs at targets below $1/Watt by 2010 through improved solar conversion cell efficiencies and high-volume automated manufacturing

Technology	Manufacturer	Material	Current Characteristics
Spheral	ATS-Spheral Solar Power Inc., Canada	Monocrystalline silicon	0.4 mm diameter spheres on flexible substrate, efficiency > 10 percent
Ribbon	RWE-ASE; Evergreen USA	Multicrystalline silicon	Thin film crystalline (≈50-100 μm), efficiency ≈ 12.4 percent
HIT	Sanyo Japan	Amorphous silicon on a monocrystalline silicon superstrate	Hybrid technology, efficiency ≈ 14.0 percent
Micromorph	Kaneka, VHF tech. Japan	Amorphous silicon on microcrystalline silicon substrate	Thin film cell (≈2.0 μm), efficiency ≈ 6.9 percent
Multijunction Amorphous	United Solar-EPV USA	Triple junction amorphous silicon (doped with germanium)	Thin film cell (≈0.5 μm), on flexible substrate., Stabilized efficiency ≈ 6.4 percent

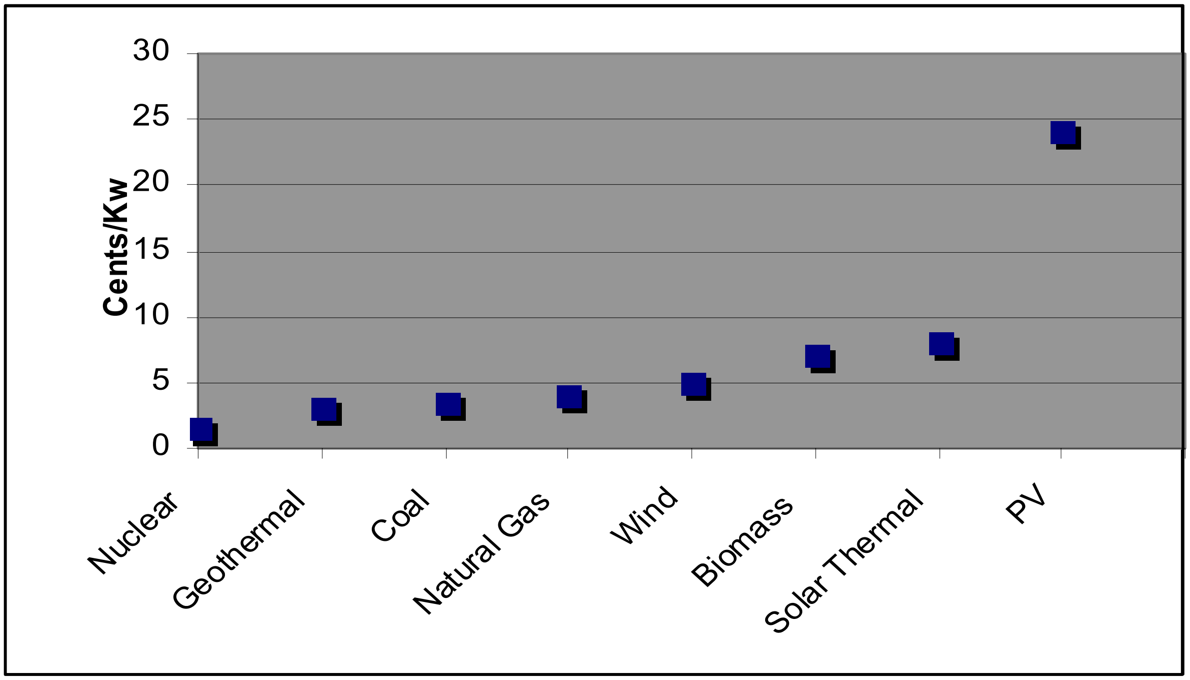
6.4.2 Multiplicity of the Price Challenge

Despite these price reductions and the significant technical advances made over the past thirty years, grid-connected PV continues to remain economically uncompetitive when compared to traditional forms of electricity generation. Even within the field of renewable electricity generation, small hydro, wind and biomass often offer more attractive economics than on-grid PV, by an order of magnitude in some instances.

Costs for PV system installation vary significantly and are dependent upon a variety of factors, but some estimates put the turnkey installation of residential on-grid PV between $1300 per kW (for BIPV) and $9033 per kW (existing on-grid PV system)[16]. This high capital cost creates a significant hurdle, whether a commercial or residential distributed generation system is being considered. Despite low operating costs, financing start-up costs are also normally subject to a premium due to third-party financing. The risk determined by the financing party depends upon a steady income and market reliability. Being a niche market, PV has a limited market presence in Canada, and thus does not receive optimal financing terms. PV is an attractive financial option for many remote off-grid installations where the capital costs are much lower than the cost of connecting to the grid (towers, lines, transformers and so on).

[16] Clean Air Renewable Energy Coalition (CARE) *Fact Sheet #6,* www.cleanairrenewableenergycoalition.com

Figure 9: Comparative Electricity Costs



Source: Reproduced from NREL Energy Analysis Office - available
www.nrel.gov/analysis/docs/cost_curves_2002.ppt

To examine the cost barrier more closely, examples of some of the key areas for potential cost reduction are separated out and presented below. Some of these costs are affected by technology development, others by market mechanisms and policies, while others will remain somewhat independent of technology development, scale of production and policy.

PV Cell and Module Production:

- Silicon wafer production for monocrystalline and polycrystalline PV cells is energy-intensive and time-intensive, especially when producing single crystal silicon. Lower material use through thinner wafers or thinner cells, technologies achieving similar efficiencies using lower grade silicon and fabrication processes that are less energy-consuming represent means to decrease the production costs.
- Highly efficient, large-scale manufacturing processes that can generate economies of scale are still in their infancy in most areas of the world.
- Actual batch processes slow down the production rates. Novel technologies that can be fabricated through roll-to-roll processes on foreign substrates (such as ribbon silicon and thin film technologies) can achieve higher throughput and lower the amortization cost.
- Any R&D efforts (successful or not) are reflected in the existing product price. Although this is typical with any product, it is exacerbated when a technology is lower on the commercialization curve because the added cost is distributed over a smaller number of generated ‘widgets’ than would be produced at the point of full commercialization.

Framing, Mounting and Electrical Connectivity

- The framing and backing for the PV is usually extruded aluminium, a suitable material for limited volume production. At very high volumes of production this may evolve to lower cost stamped sheet or polymer materials for better cost-effectiveness.
- The protective polymer backings and sealants that protect the silicon cells add to the net overall cost of the PV system.

Balance of System (BOS)

- This component is a substantial cost of any distributed generation system. Typical inverters have a capital cost of approximately $1000 per kW of peak capacity. Thus, inverter cost represents about 12 percent to 20 percent of the system capital cost. Cost reductions are possible with higher-volume inverter production, and new manufacturers are appearing. However, no cost disruptive technology development is forecast at present.
- Other BOS components include wiring, switches, circuit protection, battery (for off-grid), dual metering and so on. Many of these components are not specifically engineered for grid connected PV applications, but are sourced from general electrical equipment manufacturers, thus they may not be the most cost effective solution for the requirements. However, since BOS capital costs are not a substantial portion of the overall capital costs, evolutionary cost reductions affecting these components will have more of an incremental impact on total system capital costs. Their design could have significant cost impacts if they were "plug and play", thus reducing installation labour and increasing quality. This is a recognized need of the industry, and R&D in this area continues.
- Variation in net-metering and disconnect regulations may affect hardware requirements, creating high costs, such as for dual metering or equipment to prevent islanding (see below).

Building Integrated Versus Stand-Alone PV Modules

The promise of cost reduction through BIPV is based on the avoided cost of conventional cladding or roofing materials that are replaced and the elimination of the need for key BOS components. In addition, BIPV offers other significant benefits including improved building aesthetics, huge potential to reduce grid loading during peak demand (particularly in the summer, when air conditioning units are on), reduced distribution requirements as electricity is provided on-site, enhanced insulation, good shading devices for windows or walkways, and potential reduction of heat load requirements by pre-heating incoming air.

The result is an installation cost that can be much lower than for an independent PV system for the same building. The challenges are similar of course to those of stand-alone PV systems with regard to electricity, awareness, markets and the like, and at present the lack of off-the-shelf products in Canada and unskilled workers impedes its implementation. Although the BIPV market is still one of demonstration and niche application, in some cases using custom-designed PV modules, cost reductions are expected.

Overall it is believed that within the on-grid sector, BIPV represents the largest and most promising opportunity for PV, given the huge area of space available, the continued growth of building construction and the technology’s added advantages and lower costs.

Distribution Costs

- Distribution channels do exist throughout Canada for PV equipment, particularly for off-grid applications, and larger warehouses are being set up (such as SOLTEK POWERSOURCE). In addition, significant consolidation of these channels is occurring in Canada increasing efficiencies and driving down costs. Thus, distribution capability for off-grid is not seen as a barrier to future cost reductions.
- However, many believe that for on-grid PV systems and BIPV products, distribution channels are small in size and dispersed. This creates a number of inefficiencies, which drive up prices. In addition, premiums are often charged for services such as shipping materials where economies of scale (from shipping large quantities) cannot be attained at this time, driving up costs. Existing systems for off-grid may provide an opportunity for on-grid players as the market develops and demand increases.
- When exporting products to other countries or importing manufactured PV components into Canada, additional costs can be incurred which can compound the costing issue. These may include cost of transport, import duties, load damage, lengthy lead times, different approval and labelling requirements, incorrect equipment, warranty and service issues. Whether or not this is any more problematic than for other small product delivery channels is unclear, but it does represent an area of opportunity for future cost reductions.
- Some anecdotal evidence was alluded to during a couple of the interviews that suggested that margins at present (from manufacturer to distributor, and retailer to customer) are quite high for PV systems, although no substantial information could be found to substantiate this claim. Further study would be required.

Installation Costs

- With a limited number of on-grid systems, architects, engineers, designers, electricians and inspectors are often not familiar with the specific requirements of PV systems. This may lead to a premium charge due to the extra time and effort required to integrate the unfamiliar PV products into the overall design.
- In the case of fixed fee inspections or other approval processes, neither the project proponent nor the authority may know what approval process to follow, leading to waiting periods and excess time (and resultant billings) expenditure.
- Permitting, insurance, mounting, transmission charges and other related costs also drive up the costs (see Market and Legislative Challenges)
- Inconsistent standards and interconnection guidelines, terms and contracts also cause significant added time and resources that add to the overall costs. This could include costs associated with undertaking an interconnection assessment, installing a dual switch for net metering or an anti-islanding feature, hiring legal and engineering experts to decipher utility requirements, or time spent in filling out applications or waiting for them to be processed.

Operational Costs

- Annual and periodic costs can occur due to equipment failure from random or specific events such as lighting strikes. These are not expected to be frequent enough to prevent market development. Past inverter performance did entail significant failures, but present equipment has improved, and continued improvement would be expected as designs evolve. PV cells and modules have generally proven themselves dependable with low maintenance costs for well over twenty years.

- Although day-to-day operating costs are zero, it should be noted that capital costs are driven higher because larger systems must be purchased to offset the lower outputs and efficiencies of PV technology relative to other sources of energy. Although the absolute conversion efficiency is fairly small when comparing PV electricity generation at peak sunlight hours to, say, a coal plant with steam turbine, the fact that the PV system can operate at maximum efficiency for only four to five hours on average per day in Canada substantially reduces its overall daily output. That said, it should be noted that Toronto has a greater annual solar resource than Tokyo, which is the largest PV market in the world. Calgary is comparable to Miami.

Overall, technology advances are required to enhance generation efficiencies and reduce manufacturing costs of the PV modules and BOS to the point where the entire system is cost effective, particularly in Canada, which has a relatively low solar resource as compared to more southerly regions, particularly near the equator.

The Japanese "Residential PV System Dissemination Program"

The largest dissemination program so far was launched in Japan in 1994. In the following years the number of small grid-connected systems skyrocketed. This program was to some extent combined with low-interest consumer loans and comprehensive education and awareness activities for PV. The program made blocks of funds available to PV system retailers in a competitive bid program. This program expired in 2002.

In 1997 the "New Energy Promotion Law" was introduced as part of the New Sunshine project. It ensured subsidies for PV and it announced targets of 400 MWp by 2000 and 4800 MWp by 2010.

A result of these efforts is that Japan is now the world leader in the development of grid-connected systems.

6.5 Electricity Market[17] and Legislative Challenges

Distributed generation could emerge as a viable source of electricity within deregulated energy markets in provinces such as Ontario and Alberta, if existing barriers are removed and the market is allowed to determine the 'true cost' of electricity production. Under true market conditions, it is likely that prices would rise (as they did in Ontario) to a level that would attract investment to construct additional capacity to meet increasing demand. In fact, this potential opportunity, along with the increasing interest in Green Power within both deregulated and regulated markets across Canada, is encouraging independent power producers to develop increasing numbers of non-utility power projects.

While high capital costs are creating hurdles for specific sources of power, such as PV, many small distributed generators are still being impeded from selling their electricity into the provincial grids across Canada for a variety of reasons. These challenges are often directly or indirectly linked to the manner in which existing electricity markets were designed and are now operated more favourably for large centralized power. For example, with the infrastructure in place, and the cost of their development hidden in public debt, Canada has some of the lowest electricity prices in the world. This high quality 'cheap' power amplifies the price gap between renewable and non-renewable electricity and has resulted in an established market that hinders the development of new (and often more economical and environmentally responsible) systems that can compete with established prices, particularly in regulated or price-capped markets.

The monopoly held by many utilities across Canada, the slow transition to deregulated generation in two provinces and a competitive wholesale market in others have created much uncertainty in the marketplace, which translates to added risk for potential developers and investors.

- **Cumbersome legislation and rules** exist within both regulated and evolving deregulated markets. For example:
  - *Capped prices.* In Ontario, retail electricity prices have been capped at $0.043/kWh[18] until 2006, which significantly impedes new investment in cleaner energy sources and reduces the likelihood of being able to sell retail green power in the province (particularly at a premium) unless it is subsidized by the purchasing utility or government. Although spot market prices are volatile during peak times[19], a capped price shelters the consumers, who drive demand. Therefore, they are not motivated to search out, demand or invest in alternatives such as renewable energy, or energy efficiency measures. This has a direct negative impact on distributed generation (from renewable and even traditional energy sources) that was planning to enter the market.
  - *Definitions.* In Alberta, if electricity is generated and then sold off-site, the generator (no matter how small) is classified as an 'industrial electricity provider' that must abide by the rules and regulation of the Energy and Utilities Board and the Electric Utilities Act[20]. The result of this is that a BIPV system established on a home in

[17] The term 'electricity market' in this document refers to the overall rules and regulations governing the sale and distribution of electricity produced by a generator, whether it be a large coal facility owned by a private or public utility or a small private independent renewable power producer.

[18] The cap does not apply to other elements of electricity pricing, therefore growth of costs to the consumer can still occur.

[19] Spot prices in Ontario have soared on the IMO market to over $0.4 kW/h during the summer months.

[20] Howell, Gordon, *Grid-Related Interconnection Issues and Concerns, MicroPower Connect Workshop* (April 08, 2002)

Alberta selling electricity back into the system would be assessed an annual linear property tax (LPT) which could amount to over $500 per year. In addition, if you want to sell electricity to the Alberta Power Pool[21], the generator must become a participant and have a security certificate to download the monthly settlement. In total this would add costs of about $250 per year + GST.

- **Aggregated costs for transmission and distribution** impede DG for residential, commercial or industrial users, because they artificially inflate the price. This occurs because the costs of the established transmission and distribution system are independent of the location of generation. Thus, consumers in Vancouver or Winnipeg will pay the same rate for electricity generated by a large hydro site in Northern BC or Manitoba respectively, as they would for electricity produced by a local distributed generator. These aggregated costs must be reflected in the price of distributed generated electricity even though the costs for actual distribution and transmission may be minimal (in the case of an on-site PV system, for example)[22].
- **Additional charges** such as the debt retirement fee in Ontario are automatically integrated into the cost of electricity, whether or not a generator uses the existing infrastructure to transfer your power throughout the grid. As a result, in Ontario, this situation discourages investment in new generation – both traditional and distributed green energy and will likely make it difficult for many cleaner sources of energy to be brought on line over the short to medium term even if the capped retail prices are eliminated.
- **Net Metering** is allowed in Ontario and the Yukon and being developed in BC and Nova Scotia. Where net metering is not allowed, this all but eliminates the opportunity for PV. Where net metering is allowed, the challenge is that the established rules (or more importantly their implementation) and the needed systems (billing, metering and so on) to effectively ‘net meter’ are not in place, particularly for small generators (refer to next section)[23].

One final challenge that should be noted is that current economics and simple payback evaluation do not account for externalities including reduced GHG emissions or other environmental damage that is avoided through displacement of traditional sources, peak demand shaving and electricity security. This issue is unlikely to be resolved in the near term but does warrant mention and consideration, as these benefits should be factored in for PV and other renewable distributed generation.

[21] Presently net metering is not allowed in Alberta, so these two issues are moot at this time, but will have to be addressed should net metering be allowed in the future

[22] Alberta is considering the use of a mechanism called locational credits to alleviate this challenge and provide an incentive to generators that locate closer to heavy areas of use.

[23] PV will likely be used in multi kW net-metered applications where the avoided cost of electricity may well include other charges, such as delivery and debt. Where legislation will ultimately go on the issue of net metering is not known at present: this is a market uncertainty.

Table 9: Ontario Disaggregated Electricity Prices

Cost Component	Example Charge	Reason for the Cost
Customer Charge	$14/month	The fixed monthly cost of having an account and basic service from the utility.
Distribution Charge	1.4¢/kwh	Construction and maintenance of the system in your community.
Transmission Charge	1.1¢/kwh	Getting the electricity from the generating station to your city or town's border.
Debt Retirement Charge	0.7¢/kwh	A fee to cover the retirement of the debt of the former Ontario Hydro.
System Operation and Regulation	0.1¢/kwh	Market regulation and the Ontario Independent Market Operator (IMO) overseeing the system.
Energy Charge (commodity)	5.7¢/kwh	The cost of actually generating the electricity. This is the deregulated portion. Any marketer offer should be compared to this.
Total	9.0¢/kwh	This should be comparable to the rate on your electricity bill.

Source: modified from www.energyshop.com/prices/on

6.6 Inconsistent Standards, Interconnection Guidelines and Contract Terms

Inconsistent or non-existent standards, codes and interconnection guidelines, and contract terms and conditions that are less than easy to understand, constitute a challenge to the design and implementation of PV systems, and distributed renewable power in general. Obstacles range from the interpretation of federal electrical codes to inconsistent interconnection and net metering guidelines at the provincial government or utility level, and cumbersome municipal building codes and permits.

It is impossible to identify and discuss all the different issues that are an added cost or impediment to PV systems across Canada, given the numerous stakeholders and jurisdictions involved. A few examples are therefore provided below.

Interconnection Standards and Guidelines

As noted, most utilities across Canada are large-scale energy producers. As a result, interconnection standards that accommodate the needs and characteristics of large electricity producers remain in place. Small-scale generators are currently managed on a case-by-case basis in both deregulated and regulated jurisdictions across Canada. This is cumbersome for all parties involved because efficient standardized administrative processes have not been established. In addition, engineering and legal expertise is often required on both sides to assess each individual project, and ensure it meets existing safety and quality requirements and satisfies existing interconnection requirements and policies, which can be difficult to interpret.

There is a nationally used standard for the physical installation requirements of a PV system that is grid-connected as part of a customer-owned service (see text box). All provinces and parties have agreed to abide by CEC Codes[24]. However, Section 84 Rule 84-002 states that: *"Interconnection arrangement shall be in accordance with requirements of the supply authority"*. Therefore, the ultimate tie-in authority rests with the utility. As a result, there are often subtle differences between the main reference CEC and the governing document which each domain produces, especially related to shock and fire protection, which includes voltage cut-off, time to shutoff, and over/under voltage protection.

Canadian Electric Code (CEC)

The CEC governs the electrical safety requirements for all of Canada. Provincial electrical safety codes are derived from this national code and cannot contravene its requirements. The codes of interest to this study have been addressed as early as the 1998 CEC. CEC-2002 updated the requirements established for current practice. Examples of sections of the CEC that directly impact the installation of PV systems and their interconnection with supply authority systems include:

Sections 10 and 14, which deal with Grounding and Bonding and Protection and Control respectively. Section 14 in particular describes the requirements for protection devices and is referenced in Section 84 described below. The key issue with this section is that electronic protection is not permitted. This matter relates to the anti-islanding feature of the inverters. The Code does not permit the anti-islanding (considered electronic control) as a safe means of disconnecting power export to the utility distribution system.

Section 50 – Solar Photovoltaic Systems. This section describes the requirements for the photovoltaic power source and associated DC distribution.

Section 84 – Interconnection of Electric Power Production Sources. This section applies to consumer owned electric power generators connected and operating in parallel with another supply authority. The key issue relates to the requirement for a disconnecting means for the consumer-owned generators (PVs) to be readily accessible for use by the utility supply authority. It is important to note that this section is driven by the utilities and primarily serves their interest.

Since each party involved (utility, inspector, designer, installer) has unique criteria to satisfy before approving a system, when referring to separate standards that may be vague or out of date, interpretation by all parties becomes challenging, especially when working on an unfamiliar PV system (see next section). This prompts installers, inspectors and utilities to be cautious with acceptance based on their specific code requirements, which increases the resources and time required to gain approval of the project. When coupled with differing standards between jurisdictions, the process for interconnection becomes even more inefficient.

Interconnection standards are not a new concept for utilities, but many believe demand must increase to justify the adoption of national interconnection protocols. The majority of local utilities interviewed indicated that despite the occasional enquiry, actual on-grid PV installations were either nil or few in number. Several 'project developers' interviewed also indicated that they were 'bounced around' to various contacts when trying to clarify a DG grid-connection issue. On the other hand, several people interviewed expressed complete satisfaction, asserting that progress was a matter of developing a friendly rapport with the utility.

In some cases, regulations are in place for connecting generators to the supply authority systems. Provincial utilities, such as Hydro One and ATCO have well-established connection requirements. Toronto Hydro Electric System (a municipal distribution company) has similar regulations under the provisions for Embedded Generation. Manitoba Hydro and BC Hydro have also taken the initiative to produce guidelines for small utility interconnection systems,

[24] Note: the CEC is divided into Part I (installation code) and Part II (product safety standards). CEC Part I requires that the products used for an installation must conform to the Part II safety requirements.

although all of these are distinct approaches and highlight the need to standardize protocols across the country[25].

During the informant interviews, several other key issues were raised, including:

> **Islanding** is a condition with distribution systems whereby a portion of a system has generation and loads which remain energized during an outage in the greater distribution system. This is the condition where a facility installed PV system is producing power during a utility outage. Islanding creates a safety concern when required maintenance or emergency repair is necessary, as electricity transferred to the line could result in electrocution or other equipment damage. Static inverters have a built in anti-islanding feature to prevent the generating system from transferring AC power to the grid when utility power is removed.

- **Need for a manual disconnect** switch between the power source and the power line to prevent islanding. Under the Canadian Electrical Code (CEC), this switch is still required in addition to the inverter anti-islanding feature as a second means of preventing an islanding situation. During the interviews, opinions ranged from confidence to scepticism regarding inverters and their anti-islanding feature performance. Although reliability issues have plagued inverters in the past[26], inverter anti-islanding appeared to be generally accepted by the utilities, particularly for systems < 10 kW. However, it has not been accepted as a replacement for the manual isolating disconnect switch and thus the added cost must be incurred.

> **Meters for Net Metering**
> Single phase services (200A and less) can use two detented mechanical kWh meters, one installed with the line connections on the utility side and the other with the line connections on the load (and PV inverter) side. The detented meters will not run backwards. Therefore one meter will record the importing kWh and the other, the exporting kWh. This configuration adds cost to the installation.
>
> Bidirectional meters will accurately measure in both directions and hence come at a premium over the standard meters. For residences, the premium is in the order of $200. Commercial bidirectional metering carries a premium of approximately $6000.

- **Consistent net metering is not institutionalized among Canadian utilities (discussed previously)**
- **Added cost for meters.** When the consumer-owned electric power generator (embedded generation) exports to the grid, revenue metering by the utility is required to measure the kWh flowing back from the facility. Conventional metering is calibrated and certified by Measurement Canada for revenue purposes in the forward (importing) direction. Although it is known that some standard mechanical meters will run backwards with energy flowing in the exporting direction, their calibrated accuracy varies with a margin of error of 5-25 percent (see Electricity Distributors Association (EDA) Position on Net Billing Issues). Hence, many consider them inappropriate for bi-directional revenue metering. This forces the end-user to purchase either two single-phase meters or a bidirectional meter. Inconsistent rules also exist in this area. For example, Ontario Hydro has a single device net meter option available for distributed generation connection for systems < 10 kWp, provided the homeowner waives the responsibility for meter inaccuracy. Elsewhere in Canada, New Brunswick Power is considering metering for all installations up to 100kW, while Saskatchewan Power provides a new meter for DG interconnections.

[25] See BC Hydro's Web site for the four-page standard guide and one-page application for units <5kW. Manitoba has a document for systems <25 kVA.

[26] For example, Manitoba Hydro's recently released *Interconnection Guidelines for Connecting Distributed Resources to the Manitoba Distribution System* – DRG2003 (Jan 2003), lists synchronism and islanding as inverter concerns. Manitoba Hydro accordingly mandates anti-islanding protection and requires a disconnect switch, installed, owned, maintained and operated by Manitoba Hydro on the high side (grid side) of the interconnection transformer.

Codes and Standards

Several interviewees noted that existing codes cover switches, fuses, breakers and so on, but do not consider the smaller power levels from PV systems and thus tend to cause these parts to be over-rated and more costly than PV applications require.

Dealers, consumers and installers have a variety of rated products to select from, instead of the simple and clear options that make installation easier. Hence, installations are not uniform, and result in two difficulties: effort required to design, and validation of non-standard systems. At the moment, designers are confused.

> **Power quality** is important so that excessive electrical 'noise' does not disrupt the integrity of the system by causing any interruptions and associated problems. Power quality involves the real and reactive components of the power, as well as the frequency. The instrument that achieves this conversion of generated DC power to AC power is the **inverter**. Canada is home to the world's leading power converter (inverter) manufacturer: Xantrex based in Vancouver, BC.

Interconnection Terms and Conditions

There is a lack of willingness on the part of the utilities to embrace the PV installations exporting to the grid. They do not believe the safety issues are settled and in almost every case, guidelines and regulations remain in draft form. However, in the absence of institutionalized regulations, a number of utilities are willing to work with customers on a 'demonstration project' basis.

An interconnection contract is the agreement between an electrical generator and the local regulator for the purchase and sale of electricity to the grid. To manage this exchange the flow of electricity must be measured and the selling/purchasing rate must be specified. For a variety of reasons centred on these two requirements, setting the terms and conditions is often laborious. In addition, inspectors, installers, utilities, etc. interpret the terms and conditions differently (along with local utility, provincial or municipal regulations, standards and codes interpretation).

6.7 Lack of Awareness and Understanding of PV Applications and Benefits

With any emerging technology, raising the awareness and understanding of key stakeholders and decision-makers and disseminating useful information becomes a challenge with regard to timing, focus and scope. Often, information and appropriate training are unavailable, misinformation is present and misperceptions are numerous. This is certainly the case with PV. In addition, these challenges are compounded by the wide variety of individuals, governments, utilities and private companies that play a role in the development and implementation of an on-grid PV system. The following description provides a brief summary and a few examples of specific areas where additional education and awareness are needed.

End-users and Investors

The general public, industrial and commercial consumers, utilities and the financial community do not have a solid understanding of the opportunity that PV presents, nor do most of them understand:

- How PV works, how it can be easily connected to the grid, the potential for electricity that can be generated by a home solar system or BIPV installation in Canada, and so on.

- The true cost of installation and operation relative to more traditional forms of energy or its financial performance under different conditions or applications
- The added benefits PV provides apart from cost, such as modularity, short lead time, fuel diversity and reduced price volatility, load growth insurance and load matching, avoided plant and grid construction and grid transmission losses, GHG emission reduction and the added value this might represent.
- Energy market rules and regulations, the approval process at the provincial and municipal levels, available funding, or incentives to install PV.
- Product options and applications, visual appearance, BIPV opportunities, potential suppliers, installer and maintenance personnel and the like.

Supporting industry stakeholders

The supporting industry encompasses a wide range of individuals including architects, designers, builders, electricians, insurers and many others. As each of these stakeholders has a different role and perspective, their understanding of different issues varies significantly. However, their ability to bring PV into the market place and maintain it is significantly affected if a critical mass (numbers and levels of knowledge) does not exist. Following are examples of low awareness levels in Canada:

- Architects and designers are unfamiliar with the opportunities of BIPV. They tend not to know about suppliers, cost of products, range and availability of different materials or application, process of integrating them effectively into building design, and so on.
- Installers and electricians lack experience with installation because of small demand, and often are not familiar with related technical issues such as DC power, CEC standards or provincial guidelines for interconnection. Various education initiatives are in progress, but the regulatory bodies have not formally approved any of these.
- The building industry is not likely to consider PV because architects and designers are not familiar with it and contractors are even less knowledgeable about its potential.
- Underwriters and insurers have little if any experience with PV systems. A few bad experiences from the past will also tend to overshadow the industry for a long time. As a result, they will be cautious with insurance and can set boundaries, as PV is still considered a niche market requiring premium coverage.

The 200 roofs program of HEW in Hamburg

In 1997 within the "Hamburger Solarkonzept" in total 200 PV systems with an overall capacity of 350 kWp were installed on private roofs. In this program the municipal utility of Hamburg HEW rented 200 roofs to install these systems. Over ten years the roof owner gets 10 percent additional ownership of the PV system every year. This is the rent the utility pays for the roof. The total project costs were 2.25 Mill EUR.

Key government decision-makers

On the whole, municipal, provincial and federal government decision-makers have little understanding of PV or its potential to be part of Canada's climate change solution, while encouraging innovation in Canadian companies, providing job opportunities, reducing air pollution, moving forward with sustainable development objectives, offsetting future capital expenses related to new power plants, shaving peak loads and so on. Policy makers are also unsure of:

- How PV works, how it can be easily connected to the grid, the potential for electricity that can be generated within Canada;
- The existing industry in Canada, which includes several leading manufactures of PV products and supporting equipment (such as inverters and batteries);
- The true cost of installation and operation, or the cost per tonne of CO_2 reduction that would result from the installation of BIPV systems on, for example, existing government buildings relative to more traditional forms of energy
- How municipal, provincial or federal policy could provide incentives to the PV industry and develop policies that would enhance its uptake and that of all renewable distributed generation.

Awareness and education are required on two fronts – i) stimulating demand by demonstrating the added value and multiple benefits of PV to various stakeholders, thereby enticing potential end-users, consumers and investors to purchase and support the development of PV/BIPV systems; and ii) establishing a strong technical base of experts that can more effectively design, implement and maintain PV/BIPV systems, thereby creating a strong and sustainable industry base.

Building experience through technology – Demonstrations in the City of Waterloo

Homebuyers in the Kitchener–Waterloo region will soon be generating electricity with the sun that strikes their rooftops. With just over $1 million in support from the federal government, an innovative private-public partnership has been formed between the City of Waterloo and ARISE Technologies Corporation, Cook Homes, Waterloo North Hydro, Canadian Imperial Bank of Commerce and Professor Ian Rowlands of the University of Waterloo.

This two and a half year community-scale demonstration project will be the first of its kind in Canada. The project will showcase leading Canadian technology, increase awareness of the benefits of PV, help to accelerate acceptance of PV technologies in the market and study the impact of solar-powered neighbourhoods from the perspective of the electrical utility, financial institutions, and municipal planning and bylaws.

PV panels capable of generating 45 kilowatts of power will be installed on eight to ten new homes. The panels will also send surplus energy back to the grid, while reducing air pollution and GHG emissions.

7.0 The Path Forward – Unleashing the Potential of On-Grid PV in Canada

7.1 Long-Term Vision for Canadian Photovoltaic Distributed Power Generation

As illustrated in Section 2, it is apparent that a number of converging factors will continue to significantly increase the demand for distributed renewable generation around the globe, with PV playing an integral part in the world's transition to more sustainable energy sources. In addition, government policies in countries such as Germany, Japan and the US are being shaped by the obvious economic, social and environmental benefits of PV, along with the realization that the large and rapidly emerging market represents an opportunity for their industry to become world leaders in the manufacture and supply of innovative solutions powered by the sun.

Although the role PV will play in Canada's energy future is unclear, it is obvious that there is a significant opportunity to tap this resource to help us meet our longer term GHG targets and minimize air pollution and related environmental and health impacts, and foster a strong and highly innovative industry that can provide significant economic and social benefits to Canada. Through long-term commitment and strong private-public alliances, Canada's PV industry along with all levels of government, can play a vital role in developing policy and programs that will address existing challenges, increase market awareness and catalyse the market over the next 20 years.

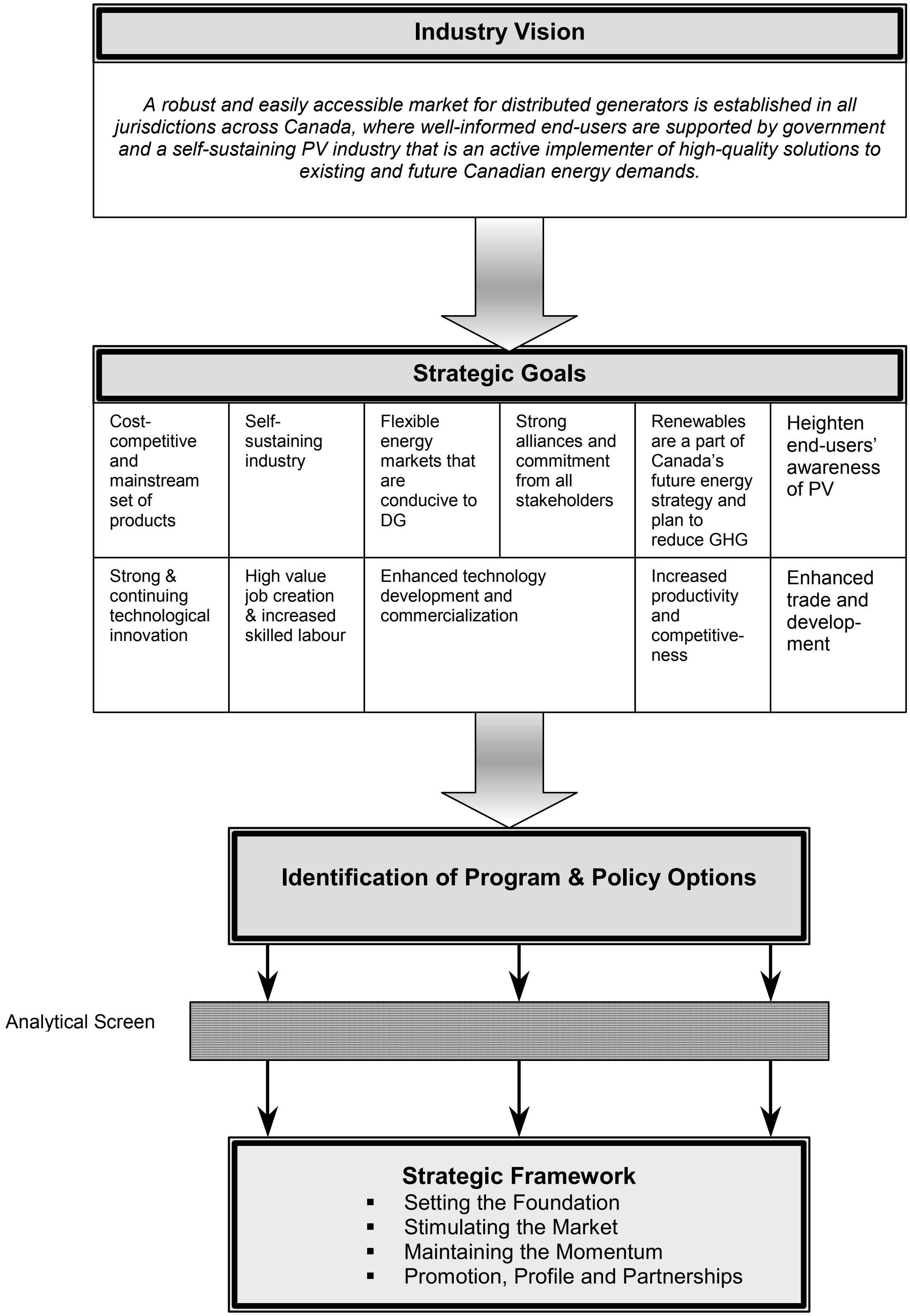
To accomplish this effectively, a strategic framework must be established that encompasses Canada's goals of continuous innovation, strong economic growth, continual productivity improvements, a high standard of living including environmental integrity, and the eagerness to enhance Canada's global presence in the provision of clean energy solutions. This framework must also be effective under various scenarios that might arise as we move closer to, and beyond, the first budget period of the Kyoto Protocol (2008-2012).

Taking this into consideration, a set of multi-faceted policy and programming measures were developed under the current scope of work that would help to accelerate the introduction of PV systems into the Canadian marketplace, while encouraging other forms of renewable distributed power generation.

Given that PV/BIPV will not be the only solution, but will be an integrated component of an overall strategy that will see an increase in renewable energy within Canada and a substantial reduction in GHG emissions, a five-stage approach was adopted.

First, an overall vision for the PV industry was developed. Second, a set of strategic objectives consistent with this vision and with current Canadian priorities, including climate change, compatible with existing government policies and programs and our economic framework, and supportive of the PV industry, were then established. A set of initial options was then developed and subsequently screened using an analytical process designed to optimize the introduction of PV into the marketplace in a cost effective manner that will maximize Canada's ability to achieve the proposed strategic objectives, reach our climate change targets and meet future energy needs. Finally, a consolidated set of measures was drafted and is offered for consideration. This process is illustrated in Figure 10.

Figure 10: Unleashing the Potential of On-Grid Photovoltaics in Canada



7.2 Industry Vision

Given the broad range of stakeholders that play an important role in the PV industry, a number of different scenarios or visions of the future were foreseen. Specifically, a range of comments were provided by the 40+ stakeholders interviewed during this study. These comments (and others) were integrated into a simplified vision statement that was used as a starting point for discussion:

> *A robust and easily accessible market for distributed generators is established in all jurisdictions across Canada, where well-informed end-users are supported by government and a self-sustaining PV industry that is an active implementer of high-quality solutions to existing and future Canadian energy demands.*

7.3 Strategic Goals

Policies and programs that assist in facilitating the introduction of one or a set of technology solutions or specific approaches – in this case on-grid PV – must strive to attain specific strategic objectives that are consistent with the proposed vision. At the same time, implemented measures should not put other comparable solutions at a disadvantage, adversely affect the economy, business competitiveness or the environment, and should be consistent with other key national mandates (such as innovation and climate change).

As a result, it is recommended that developed and implemented policies and programs strive towards two sets of strategic objectives, including:

PV Industry Objectives

1. **Drive down price and enhance competitiveness** in order to develop a set of mainstream products within the marketplace.
2. **Establish a self-sustaining industry** including knowledgeable manufacturers, distributors, installers and inspectors.
3. **Establish flexible provincial energy markets** across Canada to encourage all forms of distributed generation.
4. **Develop strong alliances, support and long-term commitment** from all stakeholders – governments at all levels, education and R&D institutions, electricians, architects and so on.
5. **Ensure that renewables are an integral part of Canada's future energy strategy** and its plan to reduce GHGs, with PV being one of many key technologies within the mix.
6. **Heighten broad-based understanding** and awareness of PV among end-users, investors, industry supporters (including designers, builders and electricians) and the general public.

Broader Objectives

1. **Strong and Continuing Technological Innovation** – Innovation is the greatest asset of a knowledge-based firm – an openness to change and a willingness to adapt are

required to maintain market share and meet the evolving needs and demands of today's customers. Proposed measures should support Canada's innovation agenda.

2. **Enhance Technology Development and Commercialization** – Canada has several PV technology firms that could be world leaders. Thus, it is critically important to encourage innovation, attract investment and help these Canadian firms build their internal capacities to compete internationally and protect their intellectual property.
3. **High Value Job Creation and Increased Skilled Labour** – will not only strengthen the PV industry, but it will also have a major multiplier effect throughout the country.
4. **Increase Productivity and Competitiveness** – Global markets will continue to expand at a rapid pace, providing Canadian companies with unlimited opportunity, but also exposing them to increased competition from abroad. Thus, policies must not impede corporate competitiveness, but instead catalyse enhanced productivity, and support the transition to sustainable energy in a manner that maintains high economic growth within the country.
5. **Enhance Trade and Development** – Emerging clean energy markets in Canada are modest in size. A large portion of future growth and opportunity will therefore be based on exports, which are fundamental to a healthy economy. Supporting strategies should help to penetrate these markets, particularly where demand is high and Canadian firms can provide a cost- or quality-competitive advantage.

7.4 Strategic Measures to Position PV as an Integral Component of Canada's Energy Future

Upon conducting the literature review and key informant interviews, it was determined early on that a broad range of actions, policies and programs could be presented that if implemented would drive down costs, stimulate the market for PV and help to advance the capability of Canadian PV suppliers to deploy its solutions into the Canadian marketplace. Upon further discussion and review, it was decided that it would be more advantageous to focus the recommendations on a few targeted measures that, if developed and implemented in a coordinated and phased approach, would maximize their effectiveness (Figure 11).

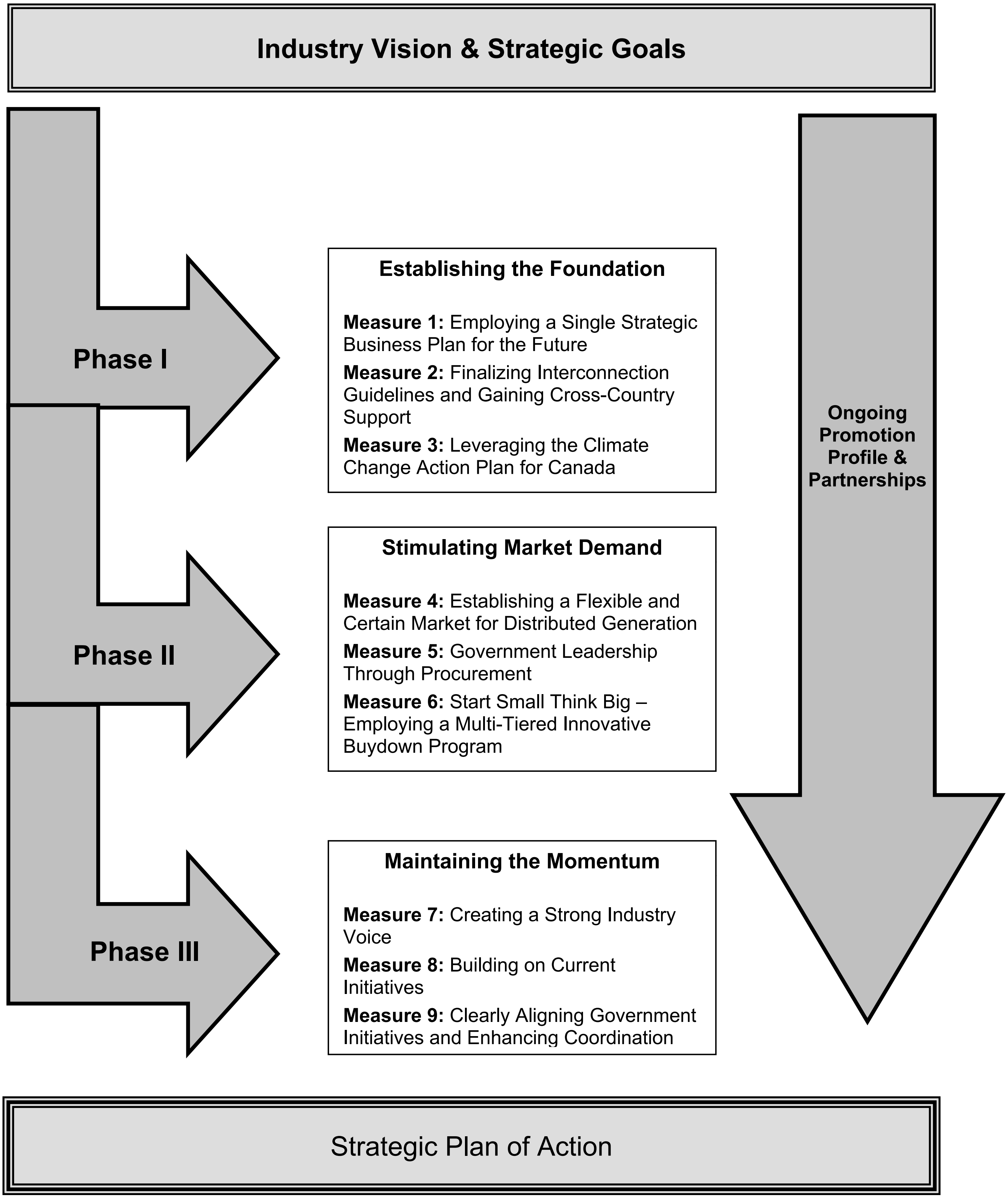
The proposed measures consolidate many of the standard, proven and well-known activities, build on existing policies and programs and incorporate some creative ideas that may not have been contemplated in the past, but are put forth for consideration. As a result, a set of measures is presented that if acted upon will help to address the key challenges noted in Section 5, assist both industry and government in attaining the strategic objectives listed above, and ultimately move the industry closer to its vision of the future.

These measures are the building blocks of an effective renewables strategy. Successful implementation will require a shared vision, specific objectives and milestones, focus, long-term commitment and leadership by all key stakeholders. Each of the identified measures is described below.

Spain: PAEE

The P.A.E.E. ("Plan de Ahorro y Eficiencia Energética") was run by different regions in Spain. It subsidized PV installations to a maximum of 4.1 EURO/Wp (600 PTA/Wp) for on-grid and 8.2 EURO/Wp (1200 PTA/Wp) for off-grid systems. The PAEE started in 1991 and ended in 2000. The public contribution to promote PV was 2950 million pesetas, 50 percent of the associated investments. Currently it is estimated that due to the P.A.E.E. about 7000 MWp of PV (including stand-alone systems, grid-connected systems and demonstration projects) were installed by the end of 2000.

Figure 11: Unleashing the Potential of On-Grid PV in Canada



7.4.1 Phase I: Establishing the Foundation

Measure 1: Employing a Single Strategic Business Plan for the Future

There have been numerous studies undertaken in Canada and around the world to identify mechanisms, policies and programs that will drive down costs and stimulate the uptake of PV/BIPV and renewables in general[27]. Although this report consolidates many of these findings and appropriate recommendations into a concise plan of action, it is recommended that the federal government (Industry Canada and NRCan) take a leadership role and:

i. Distribute this report to gain additional input and feedback from key stakeholders within the industry regarding its content and more importantly the proposed measures.

ii. Host a national forum upon finalizing this document and the proposed action plan, with the objective of gaining industry and stakeholder buy-in for this plan (or a modified version) as its single context and focus for the next few years. Specific roles and responsibilities for key stakeholders should also be agreed upon.

iii. Determine whether or not the PV industry and key stakeholders want the agreed measures to form the basis of an industry business plan for on-grid PV/BIPV only, or if they should be integrated into an overall business strategy for Canada's renewable energy industry. Specifically, the PV industry must decide whether and how it collaborates with other renewable energy sectors in order to advance its agenda and maximize the development of distributed energy. If it agrees that a coordinated effort would be more beneficial, then targeted stakeholder engagement should be pursued to develop and gain buy-in for an integrated business strategy.

iv. Assist the industry associations - CanSIA and SESCI (or possibly a consolidated group of other renewable energy associations) to implement the proposed action plan by providing appropriate guidance, resources and input under existing or future programs and policies.

Although the federal government can provide the leadership initially to catalyse action, success will be achieved only if industry stakeholders take on this role during the implementation of an agreed set of targeted and focused measures driven by a long-term vision.

Measure 2: Finalizing Interconnection Guidelines and Gaining Cross-Country Adoption

MicroPower Connect has released a document outlining procedures for interconnection of DG systems <600V. After further review, this will be presented to the CSA as a basis for the electrical code. Upon approval at the federal level, it is recommended that all industry sectors affected by these guidelines work together to gain the buy-in and commitment of all provincial governments and local utilities across Canada to adopt these standards.

Subsequently, MicroPower Connect could be tasked with the coordination and development of other interconnection standards or related codes that are currently inconsistent, not developed or impeding the development of distributed power in Canada. For example, consider if it would be appropriate for MicroPower Connect to tackle the issue of:

- Islanding and the anti-islanding feature on inverters. If a quality standard were accepted by the electrical supply or distribution utilities as an alternative to disconnect switches,

[27] For example, Pembina Institute recently wrote a report entitled, "Low-Impact Renewable Energy Policy in Canada: Strengths, Gaps and a Path Forward" (Feb 2003), CanSIA held a strategic planning session for the industry in March 2003, and NRCan prepared an extensive report on BIPV entitled "Photovoltaics for Buildings – Opportunities for Canada" (2001)

the CEC could be amended to permit it. This would reduce the capital cost of the installation and improve system economics;

- Net metering guidelines for adoption across Canada by all utilities. Once a net metering policy is in place with clear goals, it will be necessary to develop a series of procedures and protocols to ease implementation. This will provide an incentive for a commitment by other market players, especially utilities, to begin preparing for the DG market; and
- Standard interconnection contracts that employ specific terms and conditions and simplify the agreement between a distributed generator and a utility so that the need for legal expertise and input is minimized;

Given the numerous stakeholders, breadth of expertise and existing infrastructure, it is likely that this group of experts will be highly successful.

Measure 3: Leveraging the Climate Change Action Plan for Canada
The federal government explicitly states within its plan that a target of 10 percent of new electricity generating capacity will come from emerging renewable sources. However, it does not indicate how this will be accomplished. It is imperative that any strategy include measures that promote a variety of renewable energy sources. It is recommended that the PV industry work in close cooperation with other renewable energy sectors and key stakeholders to:

i. Obtain a commitment from the federal government to achieve this target with a mix of energy sources including on-grid PV and BIPV; this commitment could be extended to a minimum percentage (perhaps 1-2 percent) that must be on-grid PV/BIPV.

ii. Illustrate the benefits of a more aggressive effort to attain either Kyoto or post-Kyoto targets and attempt to gain buy-in from the federal government (for example, 10 percent of all existing generated power, excluding large hydro).

iii. Identify the specific mechanisms that will ensure the conservative target of 10 percent of new generation is easily and cost-effectively met, help Canada meet its short- (that is Kyoto) and longer-term climate change targets and will maximize the potential of Canada's breadth of renewable resources, including solar. See Measure 4 listed under Phase II below.

iv. Ensure the government purchases GHG emission reduction credits that are generated from CDM (Clean Development Mechanism), JI (Joint Implementation) and domestic offset projects that are on-grid PV/BIPV initiatives as part of the estimated 10 MT of reductions that it has stated it will buy each year to meet Canada's commitments.

7.4.2 Phase II: Stimulating Market Demand

There are a number of tax incentives, financial mechanisms and policies that can be employed to stimulate the market demand for on-grid PV/BIPV and distributed energy in general. These are well documented in the literature. Based on the feedback received during this study and successful programs launched to date, it is recommended that the following three measures be implemented.

Measure 4: Establishing a Flexible and Certain Market for Distributed Generation
Most energy-related issues fall within provincial jurisdiction. However, it would be advantageous to gain strong federal-provincial cooperation. Joint leadership is in fact required to move the clean energy and distributed power issue to the forefront and effectively move Canada closer to a sustainable energy strategy – one that ultimately helps Canada meet its Kyoto targets. Although this is a challenging task, the federal government should work directly with the provincial and territorial governments to establish a Joint Working Group (or Task Force) on

Distributed Energy with a mandate to optimize key energy regulations and policies in order to remove existing obstacles, maximize the development of more efficient and greener sources of energy, and ultimately assist in addressing key issues such as innovation, climate change, air pollution and economic prosperity.

The specific mechanisms employed to accomplish these objectives will be developed by the Joint Working Group over the coming years, but should include a range of innovative policies including:

- Mandatory net billing and time-of-use metering (the specifics and technicalities of implementation could be jointly developed by a group of experts, such as MicroPower Connect, as noted above)
- A minimum national Renewable Portfolio Standard (RPS) that each province would adhere to, or surpass
- Adoption of consistent, fair and uniform interconnection protocols devised by MicroPower Connect
- A requirement that utilities offer standardized and simple energy-purchase agreements for distributed generators
- Agreement on a price premium, favourable pricing mechanisms (like Alberta's locational credits, GST or PST exemptions, or making interest on investments in renewable energy tax-deductible) and the elimination of specific fees such as debt reduction or transmission charges for green power. These types of initiative would not only help PV/BIPV, but would also help to establish cleaner sources of energy (like wind and landfill gas) throughout Canada and make the evolving market more competitive.

This group should also be tasked with the ongoing review of federal and provincial tax and financial policies (see Measure 8 below) to identify other specific mechanisms that will enhance distributed generation, support innovation and investment in less carbon-intensive solutions and spur economic growth and competitiveness. Finally, this group or another subcommittee of experts could then be tasked with assisting provinces in the implementation of these actions in a coordinated fashion and in ongoing communication (sharing of ideas, successes, failures and so on).

Measure 5: Government Leadership Through Procurement

The Canadian government has already established one of the most aggressive green energy procurement programs in the world – Federal Government Green Electricity Purchase. This is a laudable program that will generate significant benefits. To build on this success and leverage the results, it is recommended that:

- Industry Canada and NRCan ensure that a broad range of green power options are procured, including on-grid PV/BIPV, through the existing initiative. Although the most cost-effective options are often supported with good reason, the purchase of other forms of green power will help to build awareness, profile their application, encourage others to consider these options and help build a well-rounded renewable energy industry in Canada
- Consider the establishment of innovative financing mechanisms such as a securitization or low interest revolving fund to encourage green power purchases by facilities owned and operated by federal, provincial and municipal governments. This could include social and government-assisted housing stock, schools, government buildings, parks, streetlights and the like. This type of fund could be capitalized by contributions from government and private investors on the understanding that all funds would have to be

paid back to the funding agencies with interest. Additional monies would be leveraged through private sources thereby minimizing the risk to taxpayers. As the program matures it could be expanded in conjunction with other policies to stimulate further activities in this area.

- Key stakeholders commit provincial and municipal governments (through FCM's Climate Protection Program, for example), along with corporations and local utilities to implement or expand on existing green power initiatives.

The Dutch "NOZ-PV" program

In 1994 in The Netherlands various organizations under the leadership of the ministry for energy and environment (represented by NOVEM) launched cooperation for a broader market dissemination of decentralized PV systems, the NOZ-PV program. Under the Dutch "PV introduction plan" it was planned to install 7.7 MWp of PV capacity by the year 2000 and 500 MW by 2010. The first target of 7.7 MWp was surpassed with 9.2 MWp installed by the end of 1999 and 12.5 MW installed by the end of 2000. The new PV covenant is anticipated to aim at a target of 300 MW by 2010 and 1400 MW by 2020. Moreover it is intended to reduce the investment costs to 2.75 NLG/kW in 2010

Measure 6: Start Small, Think Big – Employing Multi-Tiered Innovative Buydown Programs

Examples of very successful buydown programs can be found in the US, Japan, Germany and other jurisdictions around the world. These initiatives provide significant benefits, including enhancing the profile of PV, establishing new job opportunities and skilled and experienced stakeholders, helping to spur innovation, drive demand and reduce the price, and foster collaboration, and many others. The challenge is that these programs require long-term commitment and are often perceived as expensive subsidies that favour specific technologies. It is therefore recommended that an innovative multi-tiered approach be developed and implemented over a five- to ten-year period. Specific actions include:

i. *Building on success at the local level*. Rather than initiate a national buydown program, start by identifying two or three proactive municipalities that are enthusiastic about implementing local programs (such as that being implemented by Kitchener-Waterloo). These would be one- or two-year demonstration projects that would leverage funding from various existing sources (like SDTF, GMIF, REDI and FCM) or future government programs (if TEAM is renewed), be integrated into the Climate Change Action Plan for Canada (see Measures 3 and 4), incorporate Canadian technologies where appropriate, and employ creative public-private partnerships between local municipalities, investors, utilities, suppliers, builders and so on.

ii. *Broaden the horizon to the provincial level*. While the initial demonstrations are being developed and implemented, specific provincial and utility leadership would be sought to expand the program to the next level over a three-year period, establishing a 100 000 solar-roof program in a leading province, for example.

iii. *Go National.* Once the success of the program has been established, and other critical issues have been fully addressed (measures 1-3) and specific actions are implemented (measures 4 and 5), the program can be expanded across Canada, as a 250 000 to 500 000 installation program, potentially as an integral component of Canada's climate change implementation strategy.

To be successful, this three-point plan must ensure that, once it reaches the national level:

- Institutional barriers are removed.
- Long-term commitment is in place for funding and innovative mechanisms such as a revolving fund are instituted to reduce taxpayer risk.
- Clear and transparent rules and processes are in place, including specific levels of funding and timelines for ramping down funding.
- Flexibility is kept to adapt to the marketplace without creating uncertainty and to allow various technologies to access the program and not necessarily just one.
- Creativity and innovation must be encouraged. For example, where possible a range of applications could be developed and profiled (such as BIPV for Parliament Hill's Centre Block or the athletes' complex for the 2010 Winter Olympics in Whistler), different technologies could be employed (BIPV and stand-alone PV systems), and multi-faceted approaches could be supported.
- Coordination, communication and partnership development are fostered and maintained throughout.

7.4.3 Phase III: Maintaining the Momentum

It is critical to ensure market stimulation does not fade by taking measures to support technological progress, skill development and market growth over the short, medium and long terms. This can be accomplished by augmenting many of the measures noted above, enhancing partnerships and awareness building activities discussed in the following section and creating an influential representative body. It is recommended that the following measures be undertaken.

Measure 7: Create a Strong Industry Voice

Industry representatives and other stakeholders must lobby the government for further action in order to ensure the government policies and programs noted in this action plan (such as RPS or additional funds for RD&D programs) are considered and ultimately implemented. At present, CanSIA is the voice of Canada's solar industry.

It is therefore recommended that the PV industry work with like sectors such as the environment, wind energy, biomass, and small hydro industries to develop a strong national umbrella association that can lobby and coordinate related activities beneficial for all involved – including the implementation of a national targeted business strategy. As each sector has its own issues and agendas, a coordinated and innovative approach with strong leadership would be required. There are potential business models that are attempting this in other fragmented sectors such as biotechnology – BioProducts Canada – which are proving to be successful.

Measure 8: Building on Current Initiatives
As noted in Section 4.2, there are a broad range of initiatives already being implemented to support the PV industry and renewables in general. It is important to continue to highlight the successes of these initiatives and boost further innovation within the industry by extending those that are most effective, eliminating those that have not shown advantageous results and developing complementary initiatives. Examples of activities that might be considered include:

- Coordinating government efforts within various departments (Measure 8).
- Reviewing existing funding mechanisms such as TPC, TEAM and SDTF to assess how they can be more effectively applied to promote this sector or be adapted to enhance their effectiveness in encouraging the development, demonstration and deployment of PV/BIPV and renewable DG in general.
- Assessing whether or not federal incentives such as the WPPI can be extended to other renewable energy technologies
- Analysing provincial energy policies to identify effective means of removing existing barriers and establishing innovative policies such as those listed under Measure 4 in order to catalyse cleaner sources of energy.
- Reviewing R&D initiatives such as IRAP and NSERC, which are critical to driving down the price of Canadian technologies and making them cost-competitive, optimizing their application and expanding their resources in order to accelerate Canadian PV technology innovation and development. This will ultimately lead to lower prices, which will increase demand.

Measure 9: Clearly Align Government Initiatives and Enhance Coordination
It is recommended that federal government efforts related to PV (and renewables in general) be more closely aligned with one another and more clearly based on a set of strategic objectives consistent with PV and renewable industry needs and approach (including an agreed business plan – see Measure 1) and federal policy around climate change

PV is a critical component to achieving emission reductions and gaining a foothold in the future economic opportunities of renewable energy. Federal government leadership and support have been essential to the advancement of PV in Canada thus far. However, due to the breadth of Canada's governance, many of the initiatives relating to solar energy are not clearly aligned. For example, Industry Canada manages PV under the Marine Branch umbrella while Solar Thermal Air, and Solar Thermal Water are listed under two different branches. Similarly, the Energy Sector at NRCan manages deployment through the Renewable and Electricity Division and R&D through CANMET's Energy Technology Branch. While coordination is excellent at times, the multiple mandates of these offices can result in duplication of effort, disconnected policy and strategic planning, and ineffective resource allocation as compared to industry needs.

Coordination of these groups is challenged further by a multitude of other influencing federal government agencies such as the Office of Energy Efficiency (separate division within NRCan), the Climate Change Action Fund (which funds the neutral Climate Change Secretariat through the PMO), and Canada Mortgage and Housing Corporation (a Crown corporation). Provincial and municipal jurisdictions also complicate issues.

7.4.4 Ongoing Promotion, Profile and Partnerships

Throughout the development and implementation of the above noted measures it is critical that the government and industry sector maintain, build on and expand its current efforts to enhance the awareness and skills of all stakeholders engaged in the financing, design, manufacture, distribution, installation and operation of PV systems, along with those who can influence the uptake of these products through programs and policies. Government and industry have made remarkable progress in this area, but need to continue their efforts on all fronts in order that stakeholders can stay in tune with new technological innovations, product availability and price, more effectively employ policy and market mechanisms to leverage opportunities, and better understand the benefits of PV and distributed generation in general.

Communication, profiling and promotion are well-understood techniques and include, for example:

- Updating existing Web sites.
- Providing market and industry overviews.
- Undertaking regional education and awareness programs for various stakeholders.
- Participating in conferences - not only environmental and clean energy sessions, but also electricity, building and construction, consumer and specific industrial sector-oriented forums.
- Supporting demonstration activities that pilot Canadian technologies in targeted domestic and export markets, promoting Canadian industry innovation in successful PV applications.

Strong partnerships and alliances are critical to lift the industry to a new level, develop a stronger and more influential voice and most importantly to advance the industry's agenda, successfully implement the proposed measures and ultimately attain the strategic objectives and vision of the industry. This means working hard to strengthen existing partnerships, while fostering new and possibly more creative alliances. For example, consider:

- Building a stronger industry voice by identifying the need for key executives within the PV industry and other stakeholders to play a stronger role within the association.
- Establishing a new working relationship with other members of the distributed generation community in order to more effectively integrate PV and renewables into Canada's future energy strategy and its climate change implementation plan. Measures 1 and 7 are examples of the suggested approach.
- Forming an alliance with a large retail chain, such as Home Depot, as an awareness-building exercise for the public. Various PV products (consumer, BIPV) could be displayed with information or be available for purchase through a financing program. Specific experts from the industry could work with the retail chain to help interested consumers select and install PV systems, apply for various permits, and tap available funding or tax incentives. This alliance could also be part of the buydown program suggested under Measure 6.
- Working more closely with municipal governments to gain buy-in and advance the agenda (using a bottom-up approach), while cultivating relationships with utilities and provincial governments. Being selective in this process and target leaders and proactive communities, provincial agencies and organizations.
- Continuing alliances between government and business (such as Micro Power Connect), and establishing new public-private alliances that engage others, such as academics, to advance R&D, innovation and skill development. It might be beneficial to examine the mandates and programs of current initiatives such as the National Centres of Excellence, Foundation of Innovation and the Research Chairs Program to determine if

they can facilitate progress in PV technology – for example, would a National Centre of Excellence on Renewables be useful?

- Foster multidisciplinary collaboration – engaging stakeholders with a wide range of skills and expertise that are required to develop and implement complex and creative initiatives, commercialize emerging technologies, and increase the uptake of the products. For example, a multidisciplinary team of individuals from various levels of government, types of investor, utilities, architects, building engineers, developers, inspectors, electricians and others will be required to successfully develop the proposed buydown program (Measure 6).

Thailand: 20 MWp target to 2002

In 1997, the National Energy Policy Office (NEPO) of Thailand introduced policy to support widespread use of PV applications and set a goal to install 20 MWp between 1998 and 2002 (within the `8th National Social and Economic Development Plan). NEPO is encouraging measures to encourage the use of photovoltaic energy by providing subsidies up to 50 percent for grid-connected systems and stand alone systems. The grid connected photovoltaic systems proposed can be roof-top (6 MWp) or utility- supplied applications (4 MWp); the Electricity Generating Authority of Thailand (EGAT) will be the responsible implementing agency.

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APPENDIX B: Lower Priority Challenges for the PV Industry

Low Priority

- Lack of a governing standard for PV products - currently, many products in Canada are designed to US standards, not Canadian standards. Hence, approval in Canada requires after testing at a CSA-approved lab (such as BodyCote in Mississauga). This will also facilitate installation and inspection.
- The small, fragmented PV industry results in a lack of influence, leverage and presence.
- Product variety, distribution and deployment channels are inefficient. Although the channels are in place, PV is still a cottage industry – advertising, economies of scale and so on are difficult to develop; however, these will likely come naturally as the industry grows;
- Limited financial support or interest from the investment community for PV as a result of small demand, lack of awareness and poor financial returns based on current economics.
- High fees and professional consultation required for services related to PV. Items such as inspection, permitting and insurance bear a premium because of the small number of experts and small market. These costs will be driven down by supply and demand factors as a healthy market develops.
- No standard program to qualify skilled PV personnel as there is a limited domestic market for graduates. Educational programs will emerge as the demand for PV increases, driving up the demand for skilled workers.

APPENDIX C: List of Key Informants

Name	Title	Company	Telephone	Email
Allen, Leonard	President	Phantom Electron Corporation	(905) 430-6512	leonard@phantomelectron.com
Ben, Michael	CFO	ARISE Technologies Corporation	(519) 725-2244 ext223	michael.ben@arisetech.com
Brandon, Rob	Project Manager	NRCan - CETC Ottawa	(613) 992-2958	rbrandon@nrcan.gc.ca
Brightwell, Ken	Technical Advisor	Electrical Safety Authority	(613) 849-3071	ken.brightwell@electricalsafety.on.ca
Brown, Paul	Director of Engineering	Hamilton Hydro Inc.	(905) 317-4718	pbrown@hamiltonhydro.ca
Busby, Peter	Principal	Busby & Associates	(604) 684-5446	info@busby.ca
Chang, Liuchen	Engineering Professor	University of New Brunswick	(506) 447-3145	lchang@unb.ca
Coady, Teresa	Architect	Bunting Coady Architects	(604) 685-9913	tcoady@buntingcoady.com
Corkins, Dean	President	Radiant Resources Canada Ltd.	(905) 572-6359	oncanman@sympatico.ca
Dalacu, Nick	President	CANROM	(905) 526-7634	
DeKlerk, Henry	Electrical Inspector	City of Calgary Electric System	(403) 268-5767	hdeklerk@gov.calgary.ab.ca
Dignard-Bailey, Lisa	Section Head, PV Program	Natural Resources Canada, CETC-Varennes	(450) 652-5161	lisa.dignard@nrcan.gc.ca
Drewes, Per	Principal Engineer	Sol Source Engineering	(905) 898-0098	perdrewes@rogers.com
Dreyer, Bert	Distributed Generation Engineer	Enmax Power Corporation	(403) 514-3284	bdreyer@enmax.com
Drolet, Benoit	Charge de Projet	Ministère des Ressources Naturelles du Québec	(418) 627-6380 ext8118	b.drolet@mrn.gouv.qc.ca
Eckel, Tim	Engineering Supervisor, Regina Region, Transmission & Distribution	Sask Power	(306) 566-2927	teckel@saskpower.com
Edey, Charles	Senior Business Development Officer	Ontario Power Generation	(416) 592-2767	charles.edey@opg.com
Egles, David	President	Soltek Powersource Ltd.	(250) 727-7720	degles@spsenergy.com
Ellis, Bill	Manager, Sales Delivery	Nova Scotia Power Inc.	(902) 428-6401	william.ellis@nspower.ca
Fulton, Richard	Distribution & Planning	B.C. Hydro	(604) 528-3227	richard.fulton@bchydro.com

Name	**Title**	**Company**	**Telephone**	**Email**
Gardener, Michael	Chief Electrical Safety Codes Officer, Building Regulations & Approvals	City of Calgary Electric System	(403) 268-1059	mgardene@gov.calgary.ab.ca
Gardner, Mike	Technical Advisor, Utility Coordinator	Alberta Municipal Affairs	(780) 415-0480	mike.gardner@gov.ab.ca
Green, Thomas	Senior Researcher, Policy and Research Division	CMHC	(613) 748-2340	tgreen@cmhc-schi.gc.ca
Henderson, Shawna	Owner	Abri Sustainable Design	(902) 821-2118	shawna@abridesign.com
Heron, Wendy	Manager, Education and Special Events	Kortright Centre for Conservation	(905) 832-2289	kcc@look.ca
Hilhorst, Gerry	Assistant General Manager	Waterloo North Hydro Inc.	(519) 886-5090	ghilhorst@wnhydro.on.ca
Howell, Gordon	President	Howell-Mayhew Engineering	(780) 484-0476	ghowell@compusmart.ab.ca
Ince, Martin	Manager	Positive Power Co-operative Inc.	(905) 689-3900	info@positivepowerco-op.com
Johnson, John	Business Development	Your Energy Company Inc.	(403) 710-5710	john@boiledfrog.org
Kalmbach, Eric	President	Generation PV Inc.	(905) 831-6111	ekalmbach@generationpv.com
Krause, Don	Senior Account Executive, Customer Solutions	Hydro One Networks Inc.	(416) 345-5990	don.krause@hydroone.com
Lapp, Steve	President	SGA Energy Ltd.	(613) 376-6363	lapp@sgaenergy.com
Le Courtois, Eric	Resource Engineering	Hydro-Québec	(819) 539-1400 ext 1408	lecourtois.eric@ltee.ireq.ca
Lee, Cathy	Engineer	Halsall Associates Limited	(416) 487-5256	sholyk@halsall.com
Lenssen, Nicholas	Senior Director, Distributed Energy	Primen	(303) 545-0100	nlenssen@primen.com
Gobell, Charles	President	Renewable Energy of Plum Hollow	(613) 544-7050	kingston@renewableenergy.on.ca
Maher, Gord	Special Projects Engineer, Resource Planning & Market Analysis	Manitoba Hydro	(204) 474-3930	gamaher@hydro.mb.ca
Mak, Alan	Engineer - Distribution	EPCOR	(780) 412-4491	amak@epcor.ca
Martel, Sylvain	Project Officer, Renewable Energy & Hybrid Systems	Natural Resources Canada, CETC-Varennes	(450) 652-6747	smartel@NRCan.gc.ca
Mascarenhas, David	Program Manager, Electrical	CSA International	(416) 747-4158	david.mascarenhas@csa.ca
Mauch, Konrad	Director of Advanced Development	Xantrex Technology Inc.	(604) 422-8595	konrad.mauch@xantrex.com

Name	Title	Company	Telephone	Email
McMonagle, Rob	Project Manager	Canadian Solar Industries Association	(613) 736-9077	rmcmonagle@cansia.ca
Montminy, Gilbert	Direction de la Normalisation, Secteur electricite	Régie du batiment du Québec	(418) 643-1913	Gilbert.Montminy@rbq.gouv.qc.ca
Newel, Ken	Manager	Powersource Energy Systems	(403) 291-9039	ken@powersourceenergy.com
Olechna, Ted	Provincial Code Engineer	Electrical Safety Authority	(905) 712-5366	ted.olechna@electricalsafety.on.ca
Pape-Salmon, Andrew	Director of the Sustainable Energy Program	Pembina Institute	(604) 904-8568	andrewp@pembina.org
Paterson, Murray	Manager of Business Development	Ontario Power Generation	(416) 592-4940	murray.paterson@opg.com
Pelton, Michael	Mechanical Engineer	Enermodal Engineering Ltd.	(519) 743-8777	mpelton@enermodal.com
Peress, Sass	President	ICP Global Technologies	(514) 270-5770	speress@icpglobal.com
Plamondon, Marc	Équipe Orientation du Reseau	Hydro-Québec	(514) 289-2211 ext 7153	plamondon.marc@hydro.qc.ca
Prentice, Laura	Technical Consultant, Energy Solutions Centre	Yukon Development Corporation	(867) 393-7145	laura.prentice@gov.yk.ca
Robertson, Rick	Vice President of Business Development	Spheral Solar Power	(518) 756-1779	info@spheralsolar.com
Robitaille, Lise	Education and Development Manager	Association of Canadian Community Colleges	(613) 746-2222 ext3131	lrobitaille@accc.ca
Smiley, Eric	PV Project Leader	BCIT Technology Centre	(604) 432-8657	esmiley@bcit.ca
Thomas, Ray	President	New Sun Technologies Ltd.	(613) 723-5750	rthomas@newsun.ca
Tsisserev, Ark	Chief Electrical Inspector	Vancouver City Hall	(604) 873-7561	arkady_tsisserev@city.vancouver.bc.ca
Wilkinson, Brian	President	Matrix Energy Inc.	(514) 630-5630	bwilkinson@matrixenergy.ca