The Pembina Institute Green Power Guidelines for Canada

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Pembina Institute
for Appropriate Development

About the Pembina Institute

The Pembina Institute is an independent, citizen-based organization involved in environmental education, research, public policy development and corporate environmental management services. Its mandate is to research, develop, and promote policies and programs that lead to environmental protection, resource conservation, and environmentally sound and sustainable resource management. Incorporated in 1985, the Institute's main office is in Drayton Valley, Alberta with other offices in Ottawa and Calgary, and research associates in Edmonton, the Vancouver area and other locations across Canada.

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1.0 Introduction

Public interest in the environmental impacts of consumer products and services has grown steadily in Canada over the last decade. More recently, several provinces have begun to deregulate their electricity markets, creating expanded consumer choice for this important commodity. Many electricity consumers have indicated their willingness to purchase power from a more environmentally sustainable source, even at a premium price. With this marketplace demand and increasing competition, it is more important than ever to have a clear understanding of what is meant by an “environmentally sound source of electricity” – commonly called “Green Power.”

As electricity markets in Ontario and Alberta are opened to retail competition, more marketers are expected to offer Green Power products. Two firms are already marketing Green Power in Alberta,[1] several have been established in Ontario, and numerous U.S. jurisdictions also offer Green Power options.[2]

Over the past two years, electric utilities in Calgary, Edmonton, and the West Kootenay region of British Columbia have offered their customers the option to purchase electricity derived from Green Power sources, at price premiums ranging from 1.5¢ to 6¢ per kilowatt-hour above their regular market tariffs.[3] Recently, several utilities in Ontario began offering Green Power to their customers, including utilities in Cambridge and Toronto and Ontario Hydro Services Company. These initiatives are typically referred to as “green utility rates” or “green tariffs.”

A more environmentally-effective alternative to green utility rates or green power marketing is a government or utility initiative that commits electricity suppliers to obtain a minimum portion of their electricity from Green Power and to share the cost of those purchases among all their customers and/or shareholders. These programs, commonly referred to as green or renewable energy “portfolio standards” or “set-asides,” are highly effective because a) they enable Green Power operators to achieve economies of scale and improve economic efficiency by developing large facilities; and b) the cost premium over conventional power supplies is shared among all consumers. For example, BC Hydro has committed to meeting ten percent of all new electricity capacity from Green Power sources[4] and Hydro Québec has already developed Canada’s largest wind farm with a capacity of 100 Megawatts (MW). A study conducted in 1998 by the BC Task Force on Electricity Market Reform[5] estimated the cost premium of a ten percent standard for “environmentally-desirable” electricity supplies in the province to be about one-tenth of a cent per kilowatt-hour.[6] This is less than one-tenth the rate impact of the existing green utility rates, although it does apply to the entire customer base and not just to individual consumers who are willing to pay a price premium.

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[1] Vision Quest Windelectric (http://www.greenenergy.com) and Canadian Hydro Developers (http://www.canhydro.com).

[2] See a listing of U.S. initiatives at http://www.eren.doe.gov/greenpower/

[3] For information, see their respective Internet web pages – http://www.enmax.com/greenmax.htm; http://www.epcor-group.com/pages/Energy/EnergyHome/GeenPower/GreenPower.html; and http://www.wkpower.com/customerservice/green_rates.html

[4] See their Integrated Electricity Plan, year 2000 update; http://www.bchydro.com

[5] See http://www.ei.gov.bc.ca/~electricitytaskforce/

[6] However, it should be noted that the cost premium reflects low-cost renewable energy resources that may not be consistent with all emerging definitions of Green Power, including the ones proposed in this paper.

Another approach is to facilitate electricity consumer investments in Green Power technologies through programs such as "net metering"[7] and programs that include tax credits for Green Power technologies and/or consumer financing mechanisms.[8]

Most of these Green Power programs are backed by a labeling standard that assures stakeholders[9] as to the environmental benefits of their investments in Green Power. These standards, referred to as "eco-labeling," can be used to differentiate environmentally sound sources of electricity from other sources. Eco-labels already exist for many consumer products and services such as recycled paper, organic vegetables, and ethanol-blended gasoline. They are typically backed by an independent and credible system that requires consumer products and services to meet criteria designed to maintain environmental quality and other objectives.

An eco-labeling standard can certify individual technology sources of Green Power (such as wind generators) as well as Green Power consumer products sold by electricity retailers. Electricity generators, electricity distributors, and/or electricity retailers who promote Green Power could therefore, use such a standard.

The leading eco-labeling standard in Canada is the federal government-sanctioned Environmental Choice Program (ECP), which has, since 1996, offered a labeling standard and "Eco-Logo" for "Alternative Source Electricity Generation."[10] Terra-Choice Environmental Services Inc. is the delivery agent for ECP in Canada. Through a process that started in October 1998 and which is expected to conclude by mid-2000, Terra-Choice has worked to revise those standards through a Guideline Review Committee made up of several key stakeholders. The new standard will apply specific environmental performance criteria to certify sources of Green Power. The new labeling standard is expected to be released following a public review in the summer of 2000.

The main objective of this paper is to provide information about issues surrounding the definition of Green Power. The paper:

- reviews current definitions of Green Power under various "eco-labeling" schemes and identifies similarities and differences among them;
- identifies characteristics of Green Power;
- defines the Pembina Institute Green Power criteria; and
- provides examples of power sources that have the potential to meet Green Power criteria and examples of generation that are not likely to meet the criteria.

From the perspective of the Pembina Institute, the overarching purpose of developing criteria and an eco-label for Green Power is to identify, promote, and provide a market advantage for **electricity that demonstrates today's best overall environmental performance**. Technologies that demonstrate the highest standard of environmental performance will change over time due to improvements in science and management practices; thus, definitions for Green Power will require ongoing upgrades as information on the highest standards becomes available.

This paper focuses on eco-labeling of Green Power technologies that only *supply* electricity, as opposed to specifying criteria for *packaging and selling* Green Power products to electricity consumers. Labeling specifies the types of claims that marketers can make about their products and

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[7] For more information, see the report *Clean Power at Home* – http://www.davidsuzuki.org/Acrobat/Clean.pdf
[8] For more information on these and other mechanisms to support Green Power, see the report "Low-Impact Renewable Energy" at http://www.canwea.ca
[9] Including participating electricity consumers, government, and/or investing industry players.
[10] Guidelines No. PRC-018 and PRC-029.

informs consumers who invest in Green Power. This is important because many products include a portfolio of different electricity supplies and services, often blended with conventional electricity supplies, and utilizing both new and existing technologies. These distinctions are significant; for example, a consumer product that does not include *new* Green Power supplies does not result in an incremental environmental benefit. Likewise, some consumer products may mask large portions of electricity obtained from nuclear power or coal and other fossil fuels, with only a small proportion actually being Green Power.

An example of a consumer product labeling system is the Green-E, which is managed by the Center for Resource Solutions and which currently certifies products in California and Pennsylvania.[11] In Canada, the draft ECP Guidelines specify conditions under which retailers can use the Eco-Logo in their marketing efforts.

The Pembina Institute recognizes that energy efficiency measures to reduce electricity consumption can have major positive impacts on environmental quality by reducing the need to produce and transmit electricity. However, because Green Power, *per se*, deals only with the production of electricity, these technologies are not included in the definition of Green Power presented here. Energy efficiency technologies that reduce demand for power, often referred to as “negaWatts” or “negaWatt-hours,” should be considered in other eco-labeling initiatives.

[11] http://www.green-e.org

2.0 Existing Definitions of Green Power

Various sources define Green Power in print and on the internet, including:

- California Energy Commission; http://www.energy.ca.gov/greenpower/
- Center for Energy Efficiency and Renewable Technologies (CEERT); http://www.ceert.org/
- Environmental Choice Program (ECP): Verification and Licensing Criteria for Alternative Source Electricity Generation (PRC-018), and Alternative Source Electricity Generation from Sawmill Waste-Wood (PRC-029).
- Green-E Program, managed by the Center for Resource Solutions (NGO); http://www.green-e.org/
- Sustainable Energy Development Authority in Australia; http://www.seda.nsw.gov.au/

Many of the definitions focus on technology and frequently exclude entire classes of electricity sources. Very few working definitions of Green Power specify performance criteria that can be directly related to the protection of the environment. However, some of the emerging definitions, such as the revised Canadian Environmental Choice guidelines, do provide specific environmental performance criteria.

Definitions of Green Power usually have two primary characteristics:

- The electricity is generated from renewable resources that do not compromise the opportunity of future generations to gain access to reliable, efficient, and affordable electricity supplies.
- The definitions promote the protection of human health and environmental quality.

Green Power is electricity, generated from renewable sources, that mitigates climate change by producing few or no greenhouse gas emissions. It is generally further defined as having minimal effect on:

- local and regional air quality (hazardous air pollutants, particulate matter, and precursors to the production of ground level ozone/smog, and acid rain);
- water quality;
- watersheds, river systems, and fisheries;
- flora and fauna;
- geophysical features;
- noise;
- visual esthetics; and
- any additional build-up of hazardous or toxic waste.

Most definitions of Green Power identify generation technologies that minimize these impacts relative to conventional electricity supply systems. Examples of specific technologies and resources include:

- Solar: photovoltaics, thermal electric generators (e.g., including solar water and air heating, specific building designs).
- Wind: individual turbines and wind farms.
- Environmentally-desirable and/or small hydroelectricity (various definitions):
  - run-of-the-river hydroelectric facilities of less than 20MW that do not require a dam for storage and the electricity output relies on the seasonal flows of water in the river;[12] and
  - small hydoelectric facilities of less than 30 MW or meeting the definition of *Low-Impact Hydropower.*[13]

[12] ECP Guideline PRC-018.

- Biomass-fired generators (various definitions[14]):
  - include wood waste from forestry operations, grain- and wood-derived alcohols, and biogas derived from livestock or human waste;
  - adherence to Canadian Standards Association standard – *A Sustainable Forest Management System: Guidance Document;*[15]
  - be generated from fluidized bed combustion;
  - not use by-products of manufacturing processes, including (i) chipwood; (ii) plywood; (iii) painted woods; (iv) varnished woods; (v) pressure treated lumber; and (vi) other wastes excluded from the definition of biomass; and
  - include landfill gas, digester gas, municipal solid waste, waste tires.[16]
- Geothermal heat and power.
- Wave and freestream tidal power stations and water velocity turbines.
- Other technologies that use media such as hydrogen, compressed air or fuel cells to control, store and/or convert renewable energy sources.[17]

The definitions also specify that generating plants must comply with provincial, federal, or state environmental laws and regulations, including:[18]

- limits on air emissions such as carbon monoxide, nitrous oxides, and sulphur dioxide;
- effluent limits affecting biochemical oxygen demand, total suspended solids, dissolved oxygen, temperature, pH, residual chlorine; and
- environmental assessment processes; among others.

Some definitions of Green Power exclude the use of hydrocarbon fuels (fossil fuels) entirely, while others allow certain hydrocarbon technologies to be included. These are usually in the form of “super-efficient technologies, such as fuel cells, [which] can also be considered clean power sources because they are able to operate on a variety of fuel sources and emit very low levels of pollution.”[19]

Although there is general consensus that Green Power should protect the environment, no energy system has zero environmental impact. Furthermore, certain conventional energy systems have substantial environmental benefits over other conventional systems (e.g., natural gas cogeneration replacing coal-fired power) yet are not considered to be Green Power.

There is also clear consensus that legitimate Green Power sources cannot address one environmental issue by creating other problems through poor environmental performance in different areas (referred to as “environmental burden shifting”). For example, greenhouse gas emissions may be reduced by the use of large-scale hydro or nuclear plants, yet neither is considered Green Power because they create significant environmental problems elsewhere in the ecosystem (e.g., flooding of land, destruction of watersheds, radioactive waste production).

Finally, the documents reviewed for this paper reflect consensus that Green Power should be fuelled by a renewable (and thus sustainable) resource. However, all current energy systems, including solar and wind, require some inputs of non-renewable resources in their manufacture, construction or maintenance. Also, certain scales and configurations of renewable energy are environmentally destructive and should not be considered Green Power, among them hydroelectric systems with dams that significantly alter watersheds.

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[13] Green-E Program. 1999. See Appendix A for the definition of Low-Impact Hydropower.
[14] First four bullets for biomass-fired generators from ECP Guideline PRC-029.
[15] CAN/CSA-Z808-36.
[16] California Energy Commission Customer Credit requirements.
[17] ECP Guideline PRC-018.
[18] ECP Guideline PRC-029.
[19] Centre for Energy Efficiency and Renewable Technologies.

3.0 Developing a Benchmark to Define Green Power Criteria

The Pembina Institute defines Green Power in terms of its ability to:

- be renewable over many centuries, thus providing a long-term supply of energy, and
- protect the environment significantly better than the current mix of available technology. In other words, Green Power is derived from technologies that demonstrate today's best overall environmental performance.

The rest of this paper presents the views of the Pembina Institute on definitions of Green Power, describing several specific criteria for what constitutes Green Power and what does not. Although these views are not intended to represent a new eco-labeling system for use in Canada, the Pembina Institute will apply this perspective in the work it does with government, industry, communities, and the public, in energy system analysis and advocacy.

Power generation sources vary in their level of environmental performance, with certain technologies and energy resources performing much better than others. The result is a continuum of "greenness" for the power. To use a color analogy, the continuum would range from "brown" for technologies that demonstrate poor environmental performance to "olive" for those that perform moderately well to "gold" for high environmental performance.

The goal of this paper is not to prevent the development of "olive" power technologies, as they can make a significant contribution to meeting our electricity needs with less impact on the environment than "brown" technologies. Instead, the intent is to clearly define the characteristics of "gold" technologies and management practices so as to differentiate them from other power sources. Electricity consumers are expected to be willing to pay a price premium for "gold" sources, while they should not have to do so for the "olive" ones. It is the view of the Pembina Institute that society should direct power supply investment funds away from "brown" sources, as they are not conducive to long-term sustainability.

To properly define the criteria for Green Power, all stages of power generation must be considered, including upstream raw material acquisition, fuel production, manufacturing, operation, maintenance, and final decommissioning. The Pembina Institute advocates this life-cycle analysis approach as being the only legitimate way to assess the environmental impacts or "greenness" of electricity supply technologies. All technologies assessed in this manner can therefore be compared on an equal basis. For more information on Life-Cycle Value Assessment (LCVA), see Appendix B.

Based on both quantitative and qualitative assessments, the Pembina Institute has made a judgment on technologies and resources that represent Green Power "gold" standards and against which other electricity sources are benchmarked. From the Institute's perspective, solar technologies, environmentally benign run-of-river hydro,[20] and wind power currently demonstrate the highest environmental performance on the market. Based on 15 years of analysing energy systems, the Pembina Institute considers these sources to be clearly superior when assessed against a variety of environmental performance indicators. This judgment is also based on public perception of green power sources. In a 1998 poll by the B.C. Government,[21] the public, on average, clearly indicated that solar, wind, and hydro were the preferred sources in terms of their environmental performance.

[20] "Environmentally-benign run-of-river hydro" has no impoundment of water or flooding of lands, and limited environmental impact.

[21] BC Government. "Public Attitudes on Environmental Issues." September 1998. Solar energy was viewed by 44% of respondents as one of their most preferred sources of power, wind power by 35%, tidal energy by 31%,

Some indicators of the life-cycle environmental performance of the "gold" standard technologies – wind power, micro-hydro, and solar photovoltaic (PV) – are presented in Table 1. These categories of indicators were built from the list of environmental considerations compiled in Section 2. In general, these three technologies have minimal environmental impact compared with the operation of conventional power generation technologies that are fuelled by coal or natural gas. In any case, potential environmental impacts must be considered, as a matter of due diligence, when installing any power generation technology. This information will be refined in the future by the Pembina Institute as further LCVA work sheds light on these technology characteristics.

Table 1. Life-Cycle Performance of Wind Power, Solar Power and Run-of-River Hydro[22]

Environmental / Social Stressor	Wind Power[23]	Solar Power[24]	Run-of-River Hydro[25]
Greenhouse Gas Emissions – CO_2 Equiv. (grams/kWh)	12	10 – 200[26]	Greenhouse gas emissions from flooding terrain are limited due to the minimal size of the facility head pond.
Acid Deposition Precursors – SO_2, NOx (grams/kWh)	0.03 for each	N/A	Small – from construction fuels only.
Hazardous Air Pollutants – Hydrocarbons, CO, NOx (grams/kWh)	0.09 for CO, 0.01 for Non-methane hydrocarbons	N/A	Small – from construction fuels only.
Particulate Matter (grams/kWh)	0.025	N/A	Small – from construction fuels only.
Ground Level Ozone Precursors – NOx, VOCs (grams/kWh)	0.03 for each	N/A	Small – from construction fuels only.
Potential Impacts on Water Quality	Minimal impacts, if any.	Minimal impacts, if any.	No chemical or physical alteration of water.
Direct Impacts on Watersheds	Minimal impacts, if any.	Minimal impacts, if any.	No diversion or significant impoundment of water. The residence time of water in the head pond of the facility does not exceed six hours.[27]

small-scale hydro by 21%, large scale hydro by 9%, and biomass by 9%. Nineteen percent of respondents in northern regions prefer biomass, likely recognizing the local environmental and economic benefits of using biomass.

[22] Where information gaps exist, no information is provided. The Pembina Institute will strive to fill these information gaps in the future through LCVA work.

[23] Wind Power Assumptions: lifetime of wind system is 20 years, based on evaluation of a Vestas 600 kW wind turbine such as those in southwest Alberta connected with the ENMAX Green Power program; emissions are the result of acquiring and processing raw materials, transportation, and maintenance. Production of different turbines may result in different amounts of emissions. Data sources: McCulloch et.al., 1999; OECD, 1993.

[24] Solar Power Assumptions: Life time of solar photovoltaic system is 20 years; Solar Grade Silicon system with 15% conversion efficiency and 13% utilization factor; Emissions are the result of acquiring and processing raw materials, manufacture, and maintenance. Data source: OECD, 1993.

[25] Developed by the Pembina Institute based on site visits of hydroelectricity facilities developed and/or operated by Appropriate Energy Systems (tel: 250-679-8589) and Canadian Hydro Developers (http://www.canhydro.com). Specific facilities that were toured include: (AES) Sechart Whaling Station, Brakendale, Gambier Island, Purcell Lodge, (CHD) Taylor, Waterton, Belly River, Akokylex.

[26] Dependent on production scale and technology applied.

[27] This is consistent with mid-size head ponds in existing run-of-river plants in western Canada.

Environmental / Social Stressor	Wind Power[23]	Solar Power[24]	Run-of-River Hydro[25]
Direct Impacts on Landscape	With minimal road construction and appropriate tower siting, wind farms have very low impacts on the productive characteristics of the land.	If integrated into existing building architecture, there will be no impacts on the landscapes.	The head pond does not extend beyond natural high-water conditions (i.e., approximately 10-year average levels).
Potential Impact on Flora and Fauna	No impact, except potentially on birds. Locating turbines away from feeding grounds can mitigate this.	Minimal impacts, if any.	Provided there is no watershed diversion or impoundment, and no alteration of water quality, the impact on aquatic organisms will be minimal.
Noise and Visual Impacts	Potential visual and noise impacts, particularly if located in urban areas. Several have been successfully established in urban areas.[28]	Minimal visual impact, if any, depending on the integration of panels with building features.	Minimal impacts, if any, provided that the powerhouse is located away from homes.
Hazardous and other Solid Waste	Minimal if any.	Depends on the technology, but materials are recoverable/ recyclable. Particular concern with cadmium compounds in thin films.	Minimal impacts, if any.
Sustainability of Feedstock	Renewable energy resource. Construction may require non-renewable fuels.	Renewable energy resource. Construction may require non-renewable fuels.	Renewable energy resource. Construction may require non-renewable fuels.

N/A – Information not available

In contrast, Table 2 presents the potential life-cycle impacts of power generated from coal, large-scale hydro, and nuclear.

[28] Examples include the European cities of Hamburg and Bremen, Germany and Copenhagen, Denmark. The level of public acceptance may be linked to the economic benefits of the wind power industry in those countries. The German criteria for siting turbines include: 35 dB(A) noise level in residential areas, 40 dB(A) in commercial areas, and a rule that ensures that no blade shadows appear on windows of adjacent buildings. (American Wind Energy Association email list discussion).

Table 2. Life-Cycle Performance of Coal, Large-Scale Hydro and Nuclear Power

Environmental / Social Stressor	Coal Power[29]	Large-Scale Hydro[30]	Nuclear Power[31]
Greenhouse Gas Emissions – CO_2 Equiv. (grams/kWh)	900 – 1200	25 – 167	35 – 70
Acid Deposition Precursors – SO_2, NOx (grams/kWh)	4.0 – 6.0	From construction only.	From mining and construction only.
Hazardous Air Pollutants – Hydrocarbons, CO, NOx (grams/kWh)	3.0 – 5.0	From construction only.	From mining and construction only.
Particulate Matter (grams/kWh)	0.25	From construction only.	From mining and construction only.
Ground Level Ozone Precursors – NOx, VOCs (grams/kWh)	2.0 – 3.0	From construction only.	From mining and construction only.
Potential Impacts on Water Quality	Dependent on location but typically adverse due to acid mine drainage and cooling ponds. Also, water temperature increase from Rankine Cycle.	Potentially large impact due to altered flow of watershed (e.g., dissolved nitrogen, sedimentation, mercury contamination in some regions).	Potentially significant – will raise water temperature for power generating cycle. In the event of an accident, potential radioactive releases. Surface and ground water contamination from mining.
Direct Impacts on Watersheds	Dependent on location and type of mine. Major impact if open pit mining.	Large impact due to altered flow of watershed (e.g., impoundment and diversion).	From mining and construction only.
Direct Impacts on Landscape	Potentially large due to mining.	Large impact due to flooding through water diversion and impoundment.	From mining and construction only.
Potential Impact on Flora and Fauna	Potentially large due to mining.	Large impact, especially on fish. Potential recreational benefit for people.	Potentially catastrophic in accident case.
Noise and Visual Impacts	Visual impact large (e.g., air emissions from generators and loss of land from mining).	Location dependent.	Potentially catastrophic in accident case.
Hazardous and other Solid Waste	Ash disposal (approx. 37 g/kWh).	Minimal.	Radioactive waste and tailings from mining and transport. Potentially catastrophic in accident case.
Sustainability of Feedstock	Long-term depletion of coal – non-renewable (9.0 – 18.0 MJ/kWh).	None. Water is renewable.	Long-term depletion of uranium – non-renewable.

[29] Data sources: Deluchi, 1991; OECD, 1993; TransAlta Utilities. Does not include technology production and facility construction.
[30] Data sources: OECD, 1993; Yundt. Does not include the lost opportunity for carbon sequestration when forested areas are flooded.
[31] Data sources: OECD, 1993; Deluchi, 1991. Does not include construction.

4.0 Green Power Criteria

4.1 Primary Source Considerations

Green Power criteria can be defined using the information presented in Tables 1 and 2. If the life-cycle performance of a technology is approximately in line with that of wind, run-of-river hydro, or solar power, and is orders of magnitude better than coal, large-scale hydro, and nuclear power, a particular technology might be considered as a source of Green Power. Criteria for Green Power were developed based on these comparative methods and are presented in Table 3. It is not the intention of the Pembina Institute to exclude electricity supply technologies that demonstrate a "gold" standard of environmental performance with these criteria. As we learn more about the continuum of environmental performance of all electricity supply technologies (i.e., from "brown" to "olive" to "gold"), we will update these criteria appropriately.

Table 3. Pembina Institute's Primary Green Power Criteria

Environmental / Social Stressor	Minimum Life-Cycle Performance to Qualify as Green Power
Greenhouse Gas Emissions (grams/kWh)	The life-cycle emissions to be less than 100g CO_2-equivalent/kWh over the useful life of the system.[32]
Acid Deposition Precursors – SO_2, NOx (grams/kWh)	The operational emissions of SO_2 should be less than 0.03 g/kWh[33] and the operational emissions of NOx should be less than 0.09 g/kWh, each averaged over a 12-month period.[34]
Hazardous Air Pollutants – Hydrocarbons, CO, NOx (grams/kWh)	The operational emissions of non-methane hydrocarbons should be less than 0.03 g/kWh averaged over a 12-month period. CO emissions should be less than 0.27 g/kWh.
Particulate Matter (grams/kWh)	Operational emissions of Particulate Matter (PM_{10}) should be less than 0.075 g/kWh averaged over a 12-month period.
Ground Level Ozone Precursors – NOx, VOCs (grams/kWh)	Operational emissions of NOx and VOCs should be less than 0.09 g/kWh each, averaged over a 12-month period.
Potential Impacts on Water Quality	No alteration to the chemical or physical properties of the water.
Direct Impacts on Watersheds	No diversion or significant impoundment of water. The residence time of water in the head pond of the facility does not exceed six hours.
Direct Impacts on Landscape	The head pond does not extend beyond seasonal high-water conditions as assessed on a 10-year average basis.
Potential Impact on Flora and Fauna	Mitigation of any significant impacts on aquatic or terrestrial organisms must be provided. There must be no impact on endangered species selected by provincial or federal legislation.
Noise and Visual Impacts	Noise levels should be below levels that would have a significant impact on area residents and other potential receptors. These should be aligned with existing guidelines established for urban areas. A public review involving all stakeholders can also serve to develop a consensus on this issue.
Hazardous and other Solid Waste	Materials used in manufacturing and at the end of the project life should be minimized, reused and recycled with a guarantee of no adverse health impacts. Wastes that are not recyclable must not be proven toxins or carcinogens.
Sustainability of Feedstock	The energy source should be based on a renewable feedstock and the manufacturing of technologies and construction should consume no more than 4 MJ of natural gas energy equivalents per kWh of electricity production.[35]

[32] The mid-point on the range for solar PV technologies.
[33] This is set at the level calculated for the wind turbine in Table 1.
[34] All of the air quality criteria, except for SO_2 in Acid Deposition Precursors, are set at three times the figure of the wind energy turbine and construction to provide flexibility for differing project circumstances.

4.2 Additional Criteria for Biomass Feedstocks to Combustion Technologies

A number of definitions of Green Power include the conversion of waste and biomass to electricity through combustion, sometimes preceded by gasification. The environmental impacts and benefits of biomass combustion are readily disputed among different stakeholders. The dispute arises from whether or not the source of fuel is sustainable and whether the combustion process results in significant emissions of local air pollutants such as particulate matter, nitrogen oxides (NOx), and volatile organic compounds (VOCs). In some cases, the combustion of biomass for electricity generation may improve local air quality relative to previous modes of waste management. Additional criteria for biomass technologies are listed in Table 4.

Table 4. Additional Green Power Criteria for Biomass Resources

Environmental/Social Stressor	Description
Acid Deposition Precursors; Hazardous Air Pollutants; Particulate Matter; and Ground Level Ozone.	The combustion process meets the emission criteria of Table 3.[36]
Greenhouse Gas Emissions	The combustion of biomass creates greenhouse gas emissions at the power plant. However, the growth of biomass sequesters carbon dioxide. To demonstrate zero net greenhouse gas emissions, the growth of biomass needs to be equivalent to or greater than the utilization of biomass. (See "Sustainability of Feedstock" below.) In addition, soil carbon must be protected and maintained. The principal means of doing this are replanting and natural regeneration, and avoiding burning of slash. For forestry-derived biomass, logging slash must remain in the forest, be used for energy production off site, or be composted, rather than combusted on site. When methane gas is captured from biomass waste such as landfills, sewage, or agricultural facilities and burned to generate power, methane is converted to carbon dioxide, a less potent greenhouse gas. While this process cannot be used to demonstrate Green Power, it could contribute to the production of greenhouse gas emission reduction offsets (see Section 6.0).
Potential Impacts on Water Quality; Direct Impacts on Watersheds; Direct Impacts on Landscape; Potential Impact on Flora and Fauna; and Noise and Visual Impacts	The use of biomass products must be consistent with the criteria set out in Table 3. It is important to consider the life-cycle impacts of the biomass for the power plant. For example, the evaluation of a wood waste power plant must consider the logging practices that lead to the eventual provision of wood waste: logging, log transportation, sawmill processing, and power plant use of wood waste.
Sustainability of Feedstock	A Green Power project should utilize a renewable energy resource; that is, the growth-harvest cycle of biomass feedstocks must be managed in a sustainable manner so the rate of growth equals or exceeds the rate of removal. In the case of trees, this means the cut rate must not exceed the rate of natural and planted regrowth. For both wood and grain biomass sources, soil quality and nutrients must be protected. Another element of sustainability is an assessment of alternative uses of the biomass feedstock if it is a waste product. Biomass waste products derived from an industrial or agricultural operation should not be diverted from existing uses of the wood waste that show better environmental or social performance (e.g., particle-board manufacturing or crop fertilization).

[35] The Pembina Institute (McCulloch et al, 1999) and Pape (1997) found that the life-cycle fossil fuel inputs for developing and constructing a wind energy turbine require between 2 and 4 MJ per kWh of electricity output. A high efficiency natural gas, combined-cycle turbine consumes approximately 8 MJ per kWh, excluding component manufacturing and installation. In contrast, a simple-cycle turbine consumes about 11 MJ/kWh.

[36] It is likely that this will limit the applicability of wood waste for green power to the latest gasification technologies with electrostatic precipitators.

A concern in classifying waste-to-power as Green Power is that it potentially promotes the over-production of waste for the sake of using it to produce power. This has implications for the sustainability of the feedstock. Some considerations for different types of biomass waste products are noted below.

Wood Waste

To demonstrate sustainability and net reductions in greenhouse gas emissions, the biomass feedstock must meet the following criteria:

- It must comply with the environmental performance considerations listed in Tables 3 and 4.
- It must be grown and harvested in a sustainable manner to ensure the feedstock is truly renewable. (Criteria for sustainable harvesting practices such as those of the Forest Stewardship Council should be considered.)
- There must be no additional logging to generate more wood waste, due to the other negative environmental impacts from logging.
- The biomass waste product must have no technically viable alternative wood product use with a reasonable financial profile (e.g., particleboard).

Landfill Gas

Anaerobic decomposition[37] of organic wastes (such as food and paper products) in landfills produces methane, which can be captured and burned to produce electricity. When methane (CH_4) is combusted, one of the by-products is carbon dioxide (CO_2). Methane and CO_2 are both greenhouse gases, but the global warming potential of methane is 21 times greater than that of CO_2. Therefore, methane capture and combustion is an environmentally desirable practice because it reduces the amount of methane that would otherwise be released to the atmosphere. In theory, the sources of organic landfill wastes are renewable. However, when organic material in the landfill is fully decomposed, the source of fuel ceases. Since the mid-1980s municipal recycling and composting programs have substantially reduced the amount of waste going to landfill, although these programs are unlikely to successfully divert all organic material.

Landfill gas (LFG) could be considered Green Power if it meets the following conditions:

- the use of LFG complies with the environmental performance considerations listed in Tables 3 and 4;
- the LFG is derived from landfills that were established and capped before 1990. Subsequent landfilling activity should have been accompanied by the introduction of composting and recycling programs, thus “Green Power” credit should not be attached to LFG capture from newer landfill cells; and
- liquids stripped from LFG are disposed of properly and not re-injected into the cell, a practice that represents an improvement over simply leaving them in place.

Biogas from Feedlot Waste

Livestock feedlots are creating a significant waste management issue in many rural areas. Environmental concerns associated with these wastes include air emissions, fecal coliforms getting into ground- and surface waters, and nutrients that cause algal growth in surface waters. Livestock wastes can be collected and decomposed, or “digested,” under anaerobic conditions to produce biogas – a mixture of methane, carbon dioxide, and other gases. Biogas typically contains 50 to 80 percent

[37] Anaerobic decomposition occurs in the absence of oxygen.

methane, which can be burned to produce electricity. Biogas used in this way may be considered Green Power if:

- the use of the feedlot waste complies with the environmental performance considerations listed in Tables 3 and 4;
- the solids from the digester process are used as a co-product, such as fertilizer, to minimize waste; and
- the upstream impacts of intensive livestock operations comply with the land and water related criteria in Table 3.

4.3 Additional Criteria for Hydroelectricity

The environmental impacts and benefits of hydroelectricity vary greatly from site to site. Projects that impound or divert the flow of a river, cause extensive flooding, or flood sensitive areas are not sources of Green Power. These systems often destroy stream-side habitat and aquatic populations and can have significant land impacts. At the other end of the scale are micro-hydro electric and run-of-river systems, both of which have minimal impacts on the environment.

Because the environmental impact of a hydropower system using a dam is not necessarily determined by its size, there has been a movement away from Green Power labeling procedures that specify a maximum electrical generating capacity as the main Green Power criterion. For example, the current Environmental Choice Program Guideline PRC-029 states that all plants under 20MW that are "run-of-river" qualify as Green Power. In contrast, the Revised ECP Guidelines to be released for public comment in the summer of 2000 will specify environmental performance criteria for hydroelectricity that are not tied to a maximum electrical generating capacity.

In the U.S., where Green Power markets have been in place for several years, the non-profit organization American Rivers,[38] together with Green Mountain Energy Resources, a Green Power marketer, has developed criteria for "Low Impact Hydropower" facilities. The American Rivers criteria are designed to ensure that:

1. fish are protected;
2. river flows are satisfactory;
3. water quality is preserved;
4. flooded habitat is mitigated;
5. cultural resources are protected; and
6. recreational opportunity is available.

These objectives have been adapted for the Green-E labeling system, as noted in Appendix A.

Because many of the American Rivers criteria are based on U.S. laws and regulations, they cannot be applied directly in Canada. Also, there is an over-emphasis in the American Rivers criteria on compliance with existing laws and regulations. Defining environmental performance criteria as mere compliance with environmental legislation or regulations, while important, is not sufficient. This sends a message to producers and consumers that simply complying with the law or regulations is enough to create a premium product. A green power premium must rely on clearer, objectively determined qualitative and quantitative standards of environmental performance.

The criteria proposed in Table 5 should be met by "green" hydroelectricity facilities. Many of them match the criteria listed in Table 3 but are more specific to hydroelectricity projects. Each facility

[38] http://www.amrivers.org

should be assessed by a professional with expertise in the particular area of concern. In many cases, these criteria involve a professional judgment as to the conformity of the facility with historical watershed conditions and characteristics, a judgment that should be made by impartial professionals registered by governing agencies. Examples include professional engineers, biologists, foresters, hydrologists, or hydrogeologists who must adhere to a code of practice or ethics that holds them publicly accountable and makes their judgments legally binding. The professional must be hired by the proponent at their cost but all reports must be made available to the public.

Table 5. Primary Green Power Criteria for Hydroelectricity

Environmental / Social Stressor	Life-Cycle Performance to Qualify as Green Power
Greenhouse Gas Emissions (grams/kWh)	The life-cycle emissions to be less than 100 g CO_2 -equivalent/kWh over the useful life of the system. Hydrocarbon emissions (e.g., methane) resulting from the flooding of lands associated with a storage reservoir must be estimated for those cases where the lands contain biomass.
Potential Impacts on Water Quality	The project proponent must demonstrate through a generally accepted monitoring methodology that the following water quality characteristics are met, focusing on the protection of aquatic organisms both upstream and downstream of the facility: • The dissolved nitrogen and dissolved oxygen content of water must not increase above normal levels. • The water temperature must not increase above normal levels. • The concentration of toxic or carcinogenic substances in the water (such as methylmercury, cadmium, and others) must not increase above normal levels. • pH must not change beyond normal levels. • Turbidity must not increase above normal levels. “Normal levels” need to be assessed separately for each element of water quality, by a professional. The range of values chosen must recognize seasonal variability and be derived from baseline monitoring results determined on a case-by-case basis for each hydroelectric project.
Direct Impacts on Watersheds	To protect the watershed, a project must not cause any significant diversion or impoundment of water upstream of the water intake. Thus, the project must be “run-of-river.” The project head pond must not exceed a volume of storage that exceeds six hours of normal flow conditions for any month in a 10-year average water flow regime.
Direct Impacts on Landscape	The project must not cause the flooding of lands beyond what is seasonally attributed to the river as demonstrated by a professional based on the 10-year-average seasonal hydrology regime.
Potential Impact on Flora and Fauna	There should be no significant impacts on organisms within the watershed, including aquatic and terrestrial organisms. Where impacts do occur, mitigation of any significant impacts must be provided. In particular, the facility must provide effective fish passage for riverine, anadromous and catadromous fish,[39] and protect them from entrainment. There must be no impact on endangered species selected by provincial or federal legislation.
Noise and Visual Impacts	Noise levels from generators should be below levels that would have a significant impact on area residents and other potential receptors. A public review involving all stakeholders can also serve to develop a consensus on this issue.

[39] Riverine fish spend all their life in the river; anadromous fish swim upriver from the sea to spawn (e.g., salmon); catadromous fish swim downriver to the sea to spawn (e.g., eel).

5.0 Assessment of Selected Energy Technologies and Resources

This section provides a brief and preliminary assessment of selected energy technologies and resources against the Green Power criteria developed by the Pembina Institute. The criteria should be applied on a case-by-case basis rather than assuming that all applications of a particular technology or resource are "green" or otherwise.

Table 6 lists energy systems that have a strong possibility of being recognized as Green Power under the Pembina Institute's guidelines and the relative conditions of compliance that must be met for them to qualify as Green Power. The Pembina Institute does not imply by this that all technologies of a certain type are able to receive a Green Power label. Individual facilities must be assessed through a life-cycle value assessment (see Appendix B) or other similar process to determine the conformity of the renewable energy technology or resource with the Green Power criteria presented in Tables 3, 4, and 5. For smaller-scale technologies such as photovoltaics, assessments of representative applications are adequate, making a life-cycle value assessment of every single facility unnecessary.

Table 6. Examples of Systems with Strong Potential for being Considered Green Power

Energy System	Considerations to Ensure Criteria are Met
Wind Power	• Construction process must minimize water and land impacts. • Location does not adversely affect fauna (i.e., birds). • Location considers land use, aesthetics, and noise.
Photovoltaic (PV) Solar	• Manufacturing process does not result in greenhouse gases or other air emissions that cause the equipment to exceed the air pollutant criteria in Table 3 over the production (service) life of the PV module. • Hazardous wastes (e.g., cadmium) must be minimized or at least mitigated when solar cells are decommissioned.
Solar Thermal	• Location does not adversely affect fauna and considers aesthetics. • If a non-renewable fuel such as natural gas is used to supplement heat, only the solar portion is marketed as Green Power.
Tidal and Wave Power	• The tidal facility does not include a dam on a tidal area (i.e., only freestream tidal facilities are eligible). • Facility does not adversely affect watershed. • Location does not adversely affect flora or fauna. • The facility should not significantly affect recreational opportunities.
Geothermal	• Air emissions comply with Table 3 levels. • Construction impacts must not compromise Table 3 criteria. • Location does not adversely affect flora or fauna in the long term.
Hydrogen Fuel Cells	• The life-cycle environmental characteristics of obtaining and processing the hydrogen meet Table 3 environmental criteria, and originate from renewable resources (i.e., no fossil fuels are converted to hydrogen). • Fresh water usage must be sustainable.
Run-of-River Hydro	• Includes pressure hydro (e.g., use potential energy to generate power) and water velocity hydro turbines (e.g., use kinetic energy). • All the characteristics in Table 5 must be met.

Table 7 lists energy systems that could be deemed Green Power, along with considerations for their recognition.

Table 7. Examples of Systems with Potential for being Considered Green Power

Power Source	Criteria to Consider Carefully
Wood Waste	• Air emissions criteria in Table 3 must be met. • Must be linked to a sustainable forest practice to meet Table 4 criteria. • If a non-renewable fuel such as natural gas is used to supplement wood waste, only the wood portion is marketed as Green Power.
Biogas from Livestock Waste	• Air emission criteria in Table 3 must be met. • Land and water impacts must be minimized as noted in Table 4. • If a non-renewable fuel such as natural gas is used to supplement biogas, only the biogas portion is marketed as Green Power.
Landfill Gas	• Air emission criteria in Table 3 must be met. • Land and water impacts must be minimized as noted in Table 4. • Only closed landfills qualify, given the availability of composting and recycling programs since the late 1980s in most Canadian regions. • If a non-renewable fuel such as natural gas is used to supplement landfill gas, only the landfill gas portion is marketed as Green Power.

Table 8 lists energy systems that are clearly incapable of being considered Green Power, along with reasons for their exclusion.

Table 8. Examples of Systems with Little Potential for being Considered Green Power

Power Source	Criteria Failed to Meet
Nuclear	• Potential impacts on landscape from mining. • Hazardous waste production – radioactive solid waste. • Depletable fuel – non-renewable.
Coal combustion	• Significant greenhouse gases and other air emissions due to combustion. • Potential impacts on landscape from mining. • Depletable fuel – non-renewable.
Light fuel oil, heavy fuel oil and diesel	• Greenhouse gases and other air emissions due to combustion. • Potential impacts on landscape or watersheds due to upstream operations. • Depletable fuel – non-renewable.
Natural Gas Turbine	• Greenhouse gases and other air emissions due to combustion. • Potential impacts on landscape due to upstream operations. • Depletable fuel – non-renewable.
Natural Gas Cogeneration	• Greenhouse gases and other air emissions due to combustion. • Direct impacts on landscape due to upstream operations. • Depletable fuel – non-renewable.
Storage Hydroelectricity	• Direct impacts on watersheds due to change in water flows. • Direct impacts on landscape due to flooding. • Potential impact on flora and fauna due to change in water flows.
Solution Flare-Gas	• Greenhouse gases and potentially other air emissions due to combustion. • Depletable fuel – non-renewable.
Municipal Solid Waste (MSW) Incineration and Industrial Solid Waste	• Greenhouse gases and potentially other air emissions due to combustion. • Depletable fuel – non-renewable. • Poor alternative uses since MSW can be composted and recycled.

6.0 Generation of Greenhouse Gas Offsets from Green Power

A key driver for Green Power investments in the economy today is the potential for investors to realize greenhouse gas emissions reductions for their operations. Electricity consumers who choose Green Power should be guaranteed that their purchase results in some amount of greenhouse gas emissions reduction or that, at least, no increase in greenhouse gas emissions results from their purchase of power from a "green" source instead of conventional electricity sources.

However, it can be a challenge for Green Power operators to demonstrate ownership of greenhouse gas emissions reductions and to quantify the magnitude of reductions due to the production of a unit of Green Power. For example, generating electricity from wind power produces no greenhouse gas emissions but there is some question as to what power source it is displacing in an integrated electricity market. The wind power could be displacing power generated from a coal plant or a hydroelectric facility in an electrical grid, or it could be delaying the construction of a new natural gas turbine. The first and third displacements reduce greenhouse gas emissions, but the second does not. The quantity of greenhouse gas emission reductions depends on the specific conditions under which the Green Power is generated, what emitting plants are being offset, and the timing of electricity production. Thus, each application needs to be considered separately.

The issue of ownership has both a legal and an environmental component. In some jurisdictions, fossil fuel producers argue that any greenhouse gas emission reductions associated with Green Power accrue to their plants because it is the fossil fuel plant that ultimately reduces greenhouse gas emissions, not the Green Power source. This can be addressed through contractual agreements between Green Power producers and affected emitting plants. In the emerging Environmental Choice Program Eco-Logo for renewable low-impact energy in Canada, ownership of emissions reductions is automatically granted to the producer of Green Power unless transferred to another entity.

Another element of ownership is that the same greenhouse gas emissions reductions may be reported to the public or regulatory authorities twice or more. Canada's Voluntary Challenge and Registry receives Climate Change Action Plans and Progress Reports from companies. A Green Power company may report emissions reductions from its plants while at the same time, one or more fossil fuel power producers may report reductions in their emissions that were caused by the same plant. For example, the emissions reductions from renewable energy plants built in the 1980s in Alberta under the Small Power Research and Development Act have been accounted for multiple times by several companies, including TransAlta, ATCO Electric, EPCOR and formerly Niagara Mohawk Utility who used to own the wind farm near Pincher Creek (now owned by Canadian Hydro Developers).

The Pembina Institute takes the position that a Green Power labeling system cannot guarantee the ownership of any particular emissions reductions associated with a Green Power source. It is suggested that Green Power producers contract with associated emitters to resolve ownership issues. It is also suggested that the government clearly indicate how double counting will be addressed.

Green Power labeling is also not intended to identify specific greenhouse gas emission reduction "offset" quantities. The process of demonstrating these values is cumbersome and should be handled as a completely separate mechanism from the Green Power labeling protocol. Separate programs have been established to certify greenhouse gas emission reduction "offsets," including the Greenhouse Gas Emission Reduction Trading Pilot,[40] the Kyoto Protocol's Clean Development Mechanism, and others. To determine the greenhouse gas emission reductions associated with the production of their power, Green Power suppliers must use a quantitative assessment tool.[41]

[40] http://www.gert.org/
[41] For example, the Pembina Institute's Life-Cycle Value Assessment process explained in Appendix B.

The emission reductions created by a Green Power project are equivalent to the difference between project "baseline" emissions and the actual emissions that occur after a project has been implemented. Determining emission reduction levels has three components; it requires:

(a) a clear definition of the project boundaries;
(b) the development of an emissions baseline for the project; and
(c) the measurement and verification of actual emission levels once the project has been implemented. In order to accurately state emissions reductions, they should only be recognized after they have actually occurred.

Defining project boundaries involves delineating the physical and temporal boundaries that contain the facility or community that currently generates greenhouse gas emissions. For a grid-intertied Green Power project, the project boundaries should be the electrical system where it is operating; for example, it could be the entire province of Alberta and all transactions made through the Alberta Power Pool.

An emissions baseline is an estimate of what the emission levels would have been in the absence of the project (i.e., under regular business practices within the boundaries set by the project), or it can be done through a generalized methodology that applies to a specific class of projects. A project baseline forecast has two essential elements – the emissions factor and the activity level.

1. The "emissions factor" is the level of emissions per unit of production of electricity expressed in tonnes of greenhouse gas emissions per unit of electricity (i.e., GWh). The emissions factor can apply to individual power plants or to entire electrical systems. The former would be applied if the Green Power source were displacing a single fossil fuel plant, while the latter would be applied if the Green Power source displaces several plants. Both approaches need to be justified.
2. The "activity level" is equivalent to the expected displacement of electricity production caused by the Green Power source. This displacement should be to the point of power consumption and should incorporate all associated transmission losses. The activity levels should be in units of electricity production (that is, kWh).

The baseline emissions of a project equal the emissions factor times the activity level. The activity level should include a measurement of actual production of electricity from the Green Power source, monitoring of typical transmission line losses, production levels from the displaced fossil fuel plant, and other relevant factors.

How do these factors all come together? Consider an emission reduction project such as a 150 MW wind energy farm that displaces electricity production from a 1000 MW baseload coal plant and a 100 MW peaking oil plant.

The project boundaries could be defined to include the three electricity generation facilities – the coal plant, oil plant, and wind farm. The project baseline could be defined as the output from the coal and oil plants if they were operating as before: the baseload plant at its full capacity, minus any short-term maintenance or market shutdowns (i.e., low electricity demand), and the peaking plant serving those additional loads during peak periods. A sample calculation of the emissions baseline is provided below.

Table 9. Baseline Emissions for Windfarm Project Example

	Capacity (MW)	Capacity Factor	Annual Generation (GWh)[42]	Emissions Factor (t/GWh)[43]	Emissions (kilotonnes)
Coal Plant	1,000	90%	7,884	1,000	7,884
Oil Plant	100	10%	88	800	70
TOTAL	1,110		7,972		7,954

Actual emissions levels for the delivery of an equivalent amount of electricity will be reduced after the wind energy farm is installed. The wind energy farm has low emissions (from Table 1) and supplies 150 MW with a 33 percent capacity factor. The capacity factors for the coal and oil plants would likely be reduced relative to the amount of new electricity entering the system. A hypothetical outcome is illustrated below.

Table 10. Project Emissions for Windfarm Project Example

	Capacity (MW)	Capacity Factor	Annual Generation (GWh)	Emissions Factor (t/GWh)	Emissions (kilotonnes)
Coal Plant	1,000 MW	85%	7,458	1,000	7,459
Oil Plant	100 MW	9%	80	800	64
Wind Farm	150 MW	33%	434	12	5
TOTAL			7,972		7,528

The emission reduction credits created equal the baseline emissions minus post-project emissions, in this example, 426 kilotonnes per year. Actual emissions credits would only be awarded on an annual basis after data from the coal, oil, and wind plants are examined to verify the assumptions for quantifying emissions reductions.

[42] A Gigawatt-hour = 1 billion watt-hours or 1 million kilowatt-hours.
[43] Tonnes of greenhouse gas emissions per unit of electricity production in GWh.

7.0 Conclusions

Green Power has the potential to improve environmental quality relative to conventional power sources such as coal, storage hydroelectricity and natural gas. Performance criteria for defining Green Power have been developed based on the general consensus that solar photovoltaic, wind, and micro-hydro power are today's most environmentally benign sources of electricity.

Legitimate Green Power sources produce few greenhouse gases and local air emissions, have minimal impacts on watersheds, do not negatively affect flora and fauna, and do not contribute toward hazardous waste build-up. To receive a "Green Power" designation, facilities must not negatively affect communities through noise or visual impacts, and the energy source must be indefinitely sustainable. More specific criteria are provided for biomass and hydroelectricity sources.

Individual power facilities must be assessed through a life-cycle value assessment (see Appendix B) or similar process to assess the conformity of the renewable energy technology or resource against the Green Power criteria presented in Tables 3, 4, and 5. For smaller-scale technologies such as photovoltaics, assessments of representative applications are adequate, making life-cycle value assessment of every facility unnecessary.

The following energy systems have a strong possibility of being recognized as Green Power under the Pembina Institute's guidelines:

- Wind Power
- Photovoltaic (PV) Solar
- Solar Thermal
- Tidal and Wave Power
- Geothermal
- Hydrogen Fuel Cells (operating on "green" hydrogen)
- Run-of-River Hydro

The following energy systems could potentially be recognized as Green Power under the Pembina Institute guidelines:

- Wood Waste
- Biogas from Livestock Waste
- Landfill gas

The Pembina Institute takes the position that a Green Power labeling system cannot guarantee the ownership of any particular emissions reductions associated with a Green Power source. It is suggested that Green Power producers contract with associated emitters to resolve ownership issues. It is also suggested that the government clearly indicate how double counting will be addressed.

The specific quantity of greenhouse gas emission reductions depends on the conditions under which the Green Power is generated, what emitting plants are being offset, and the timing of electricity production. It is recommended that Green Power producers incorporate the quantification of greenhouse gas offsets into a life-cycle value assessment of their facilities. Emission reduction offsets generated by Green Power facilities should be considered as discrete commodities from the Green Power "eco-label," to be handled by a separate "offset" determination mechanism.

References

California Energy Commission. Customer Credit Information. http://www.energy.ca.gov/greenpower/suppliers.html.

Canadian Hydro Developers. Personal Communications with John Keating and Bill Johnson.

Center for Energy Efficiency and Renewable Technologies (CEERT). http://www.ceert.org/power.html

Deluchi, M.A. 1991. “Emissions of Greenhouse Gases from the Use of Transportation Fuels and Electricity.” Argonne National Laboratory.

Environmental Choice Program (ECP). 1996. “Verification and Licensing Criteria for Alternative Source Electricity Generation” (PRC-018) and “Alternative Source Electricity Generation from Sawmill Waste-Wood” (PRC-029).

Federal Government Press Release. Ottawa, April 14, 1997: Anne McLellan, Minister of Natural Resources and Sergio Marchi, Minister of the Environment.

Green-E Program. Managed by the Center for Resource Solutions (an NGO). http://www.green-e.org/power/index.html

Helios Centre for Sustainable Energy Strategies. “Environmental Ranking of Hydropower Facilities in Canada.” Presented to the Low-Impact Stakeholders Alliance (LISA). March 28, 2000.

Personal communication with B. Kelly, formerly of Ontario Hydro.

McCulloch, M., M. Raynolds, and M. Laurie. 1999. “Life-Cycle Value Assessment of a Wind Turbine, Alberta, Canada.” Pembina Institute. Available at http://www.pembina.org/

OECD. 1993. Proceedings of “Expert Workshop on Life-Cycle Analysis of Energy Systems.”

Pape, Andrew. “Implementing Sustainable Energy under Competitive Electricity Markets.” Fall, 1997. Graduate Thesis, Simon Fraser University. Summary available at http://www.island.net/~sustener/

Sustainable Energy Development Authority (SEDA). New South Wales, Australia. http://www.seda.nsw.gov.au/renewable/greenpower.htm

TerraChoice Environmental Services Inc. “Background Materials – Technical Briefing Note Low-Impact Electricity Generation (Green Power) and ECP Draft Guideline.” February 1999.

Yundt, P.E. “Estimation of Greenhouse Gas Emissions from Canadian Hydroelectric Dams and Reservoirs.” Environment Canada.

Appendix A – Green-E Definition for Low Impact Hydropower[44]

1. Flows: The flows criterion is designed to ensure that the river has healthy flows for fish, wildlife and water quality, including seasonal flow fluctuations where appropriate. For instream flows, a certified facility must comply with recent resource agency recommendations for flows, or meet one of two alternative standards to demonstrate that flows are appropriately protective of water quality, fish and wildlife.

2. Water Quality: The water quality criterion is designed to ensure that water quality in the river is protected. The water quality criterion has two parts. First, a facility must demonstrate that it is in compliance with state water quality standards, either through producing a recent Clean Water Act Section 401 labeling or providing other demonstration of compliance. Second, a facility must demonstrate that it has not contributed to a state finding that the river has impaired water quality under Clean Water Act Section 303(d). In 2001 and after, a facility will also have to demonstrate that it has a program for monitoring water quality.

3. Fish Passage and Protection: The fish passage and protection criterion is designed to ensure that, where necessary, the facility provides effective fish passage for riverine, anadromous and catadromous fish, and protects fish from entrainment. For riverine, anadromous and catadromous fish, a facility must be in compliance with both recent mandatory prescriptions regarding fish passage and recent resource agency recommendations regarding fish protection. If anadromous or catadromous fish historically passed through the facility area but are no longer present, the facility will pass this criterion if the applicant can show both that the fish are not extirpated or extinct in the area due in part to the facility and that the facility has made a legally binding commitment to provide any future fish passage recommended by a resource agency. When no recent fish passage prescription exists for anadromous and catadromous fish, the facility must demonstrate either that there was a recent decision that fish passage is not necessary for a valid environmental reason, or that existing fish passage survival rates at the facility are greater than 95% over 80% of the run.

4. Watershed Protection: The watershed protection criterion is designed to ensure that sufficient action has been taken to protect, mitigate and enhance environmental conditions in the watershed. A certified facility must be in compliance with resource agency and Federal Energy Regulatory Commission (FERC) recommendations regarding watershed protection, mitigation or enhancement. In 2002 and after, a facility must demonstrate that it has sufficiently protected, mitigated or enhanced environmental conditions in the watershed through meeting one of four requirements for watershed protection, all of which involve either protecting, mitigating or enhancing watershed land or spending or dedicating funds for conservation purposes.

5. Threatened and Endangered Species Protection: The threatened and endangered species protection criterion is designed to ensure that the facility does not negatively impact state or federal threatened or endangered species. For threatened and endangered species present in the facility area, the facility owner/operator must either demonstrate that the facility does not negatively affect the species, or demonstrate compliance with the species recovery plan and receive long term authority for a "take" (damage) of the species under federal or state laws.

6. Cultural Resource Protection: The cultural resource protection criterion is designed to ensure that the facility does not inappropriately impact cultural resources. Cultural resources must be protected

[44] http://www.green-e.org

either through compliance with FERC license provisions, or through development of a plan approved by the relevant state or federal agency.

7. Recreation: The recreation criterion is designed to ensure that the facility provides access to the water and accommodates recreational activities on the public's river. A certified facility must be in compliance with terms of its FERC license or exemption related to recreational access, accommodation and facilities. If not FERC-regulated, a facility must be in compliance with similar requirements as recommended by resource agencies. A certified facility must also provide access to water without fee or charge.

8. Facilities Recommended for Removal: The facilities recommended for removal criterion is designed to ensure that a facility is not certified if a natural resource agency concludes it should be removed. If a resource agency has recommended removal of a dam associated with the facility, labeling is not allowed.

Appendix B – Life-Cycle Value Assessment (LCVA) Process

Description of LCVA

The Pembina Institute has developed a unique and effective methodology to ensure that the major environmental and economic impacts of a purchasing decision, a design option, a process technology selection choice, or a policy instrument are fully considered across the full life cycle of a product or production system.

Life-cycle Value Assessment (LCVA) has been created and refined by the Pembina Institute in cooperation with several of Canada's leading energy companies throughout the course of the past five years. LCVA is a decision-making tool, a design improvement tool and an analysis methodology. The real business value of LCVA comes from its ability to develop better financial and better environmental information and bring these together for designers and decision-makers.

What is LCVA?

LCVA uses a systematic methodology to identify, quantify and analyze the environmental, financial (and if desired, social) implications of each of the activities involved in producing and consuming a product or service. This process can unearth opportunities to improve the technical design, upgrade operating procedures, or substitute processes and materials in order to reduce costs and reduce environmental pollutants and other impacts.

LCVA is:

- an environmental and financial analysis tool;
- a business analysis tool;
- a design improvement tool;
- an environmental impact minimization tool; and
- a pragmatic merger of environmental life-cycle analysis, business financial value assessment, and systems (process) engineering design improvement.

What's Involved in Using Life-cycle Value Assessment?

The LCVA methodology is applied across six different steps: Goal Definition; Scoping; Inventory Assessment; Impact Assessment; Design Improvement; and Reporting.

The **goal definition** clearly defines the decisions to be made, the questions to be answered, and the actual products or production systems to be analyzed and compared on the basis of equivalent provision of service to the consumer.

Scoping consists of clearly mapping out the life-cycle flow of activities involved in production, use and disposal, and organizing these activities into discrete and convenient units of analysis, referred to as unit processes.

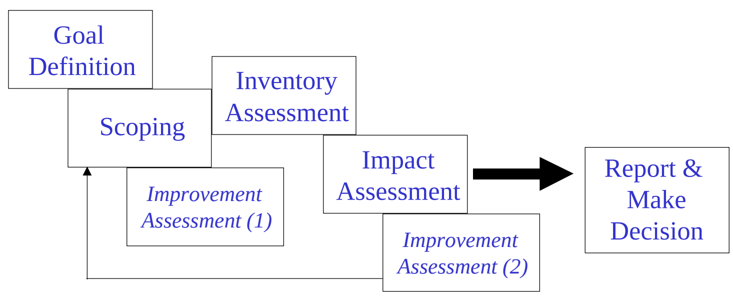
The **inventory assessment** involves collecting and validating data to quantify the inputs and outputs within the life-cycle stages selected for analysis. The data is compiled and modeled to provide aggregated results for various scenarios and systems to answer the key questions outlined in the LCVA goal definition.

The **impact assessment stage** involves assessing the results in terms of their environmental and financial impacts and significance. This step considers the relative change in total environmental loadings and the sensitivity of exposed areas, along with capital and operational costs.

Design improvement is a series of steps taken in tandem with the four main analysis stages. Done fully, it ensures that a systematic and serious effort is made to find opportunities to reduce the financial and environmental impacts of various technologies, process activities and material supply choices across the full life cycle.

Report preparation is the synthesis and summary of results, along with development of conclusions and recommendations. These are compiled in a report or presentation to the decision-makers that are responsible for project approval, selecting options, or making any other decisions that triggered the LCVA in the first place.

LCVA Methodology



Levels of Effort for LCVA

Life-cycle value assessment can be conducted by one person and take only a few days for a small, straight-forward decision in which good data is available, and the issues are well-focused. LCVA can also consist of a multi-disciplined core LCVA team working with project engineering groups and business analysts off-and-on over a six-month period or longer for the planning and approval of a large and complex project.

Life-Cycle Value Assessment and Life-cycle Analysis

Organizations such as SETAC (The Society for Environmental Toxicology and Chemistry), the Canadian Standards Association and now the International Organization for Standardization (ISO) with its new ISO 14000 series on environmental management standards, have increased awareness of an environmental analysis methodology referred to as Life-cycle Analysis (LCA).

Conventional LCA generally fails to incorporate socio-economic issues essential to business decision making. LCVA addresses this by incorporating key socio-economic indicators such as capital and operating costs and job creation.