Clean Power at Home

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Executive Summary

The purpose of this report is to describe and analyze net metering as a mechanism to support the deployment of small-scale, distributed electricity technologies in British Columbia based on renewable energy sources. These are referred to as “distributed renewables” throughout the report. The deployment of distributed renewables offers several environmental, economic, and social benefits that are described in this paper.

Net metering enables individual utility customers to connect on-site generation to the utility grid, feeding excess power back to the grid when it is not needed, and utilizing grid power when consumption exceeds local renewable energy supply. In most programs, a single meter measures the customer’s net consumption of grid power in a billing period, and they are charged for that consumption under regular retail rates. If production exceeds consumption, the customer’s bill is essentially zero. In some instances, utilities may refund customers for excess production in a billing period based on wholesale market prices or avoided production costs.

Net metering programs can make self-generation more attractive for customers by eliminating the need to size systems to meet customers’ exact power needs or install on-site storage and power conditioning devices. Utilities may, depending upon the type of systems installed, benefit from improvements in local area load factors, and receive credit for various social or environmental benefits of such resources (e.g., greenhouse gas reductions). However, utilities have raised concerns about worker safety (e.g., the possibility that net metering sites may continue to feed electricity into the local distribution grid when the rest of the network is down, putting line workers at risk) and possible financial cross-subsidies from other rate payers (e.g., the ability of net metering customers to avoid any fixed costs embedded in bundled retail rates or the lack of time-varying retail rates to reflect hourly, daily or seasonal differences in the cost/value of avoided power).

Net metering programs have been developed in at least 24 U.S. States, two Canadian provinces, Germany, and Japan. Programs have been proposed in several additional U.S. States, and may be required nationally as a result of a proposed Presidential initiative to restructure U.S. electricity markets. The final report of the B.C. Task Force on Electricity Market Reform recommended a net metering program in British Columbia, but no program has been developed to date. Such a program could be implemented via government legislation, a Ministerial directive to government-owned utilities, Special Government Direction to the B.C. Utilities Commission requiring implementation by all regulated utilities, or as a voluntary, customer-driven initiative at individual utilities. The majority of net metering programs in other jurisdictions were initiated as a result of state or national legislation or through public utility commission orders. However, program design has typically been specified by electric utilities.

Net metering is only one of many means for fostering further development and utilization of renewable energy sources. It is a customer-driven mechanism supporting small-scale generation technologies located at customer sites (i.e., distributed renewables)[1].

[1] Other mechanisms for fostering the development and utilization of renewables include, among others: renewable portfolio standards or set-asides; voluntary green pricing; rate- or tax-payer subsidies; and utility-owned and operated distributed renewable energy systems.

Study Purpose

This paper focuses on the costs and benefits of net metering, and the challenges and opportunities for developing effective net metering programs. It does not compare net metering to other means of fostering the development of renewables, or the costs and benefits of fostering different types and scales of renewable resources. A net metering program would support small-scale renewable energy technologies located at customer sites (i.e., distributed renewables such as solar PV and micro-hydro), but would not support medium- to large-scale facilities connected directly to transmission or distribution facilities (e.g., wind farms, biomass plants, or small-hydro).

To that end, the paper addresses the following questions:

1) What is the likely magnitude of distributed renewables that would be supported by a net metering program in B.C.? This is a function of technical potential and likely customer uptake. Customer uptake, in turn, is a function of program design, customer costs, and consumer preferences.
2) What are the potential social and environmental benefits of the program in terms of jobs and GHG emission reductions?
3) How should a net metering program be designed to maximize customer participation?
4) How should utility concerns about worker safety and ratepayer subsidies for net metering best be addressed?

Magnitude of Distributed Renewables Supported by Net Metering

Five types of distributed renewable energy systems were considered in this analysis:

- a 500Watt solar PV system;
- a 10kW wind energy system;
- a 25kW wind energy system;
- a 1 kW micro-hydro system; and
- a 10kW micro-hydro system.

Table E1 summarizes the current range of estimated resource potential from customer systems within British Columbia. The total estimated resource potential for these distributed renewables is 308 to 867 GWh / year, equivalent to roughly 0.5 to 1.5% of BC Hydro’s current annual sales.

Table E1 –Resource Potential of Selected Distributed Renewable Energy Systems

Resource	Average System Size	Customer Type(s)	Technical Potential (GWh/year) (1)
Solar PV	500W	Residential / commercial / agricultural	230-520
Wind Energy	10kW	Agricultural / commercial	25-178
Wind Energy	25 kW	Agricultural / commercial	5-35
Micro-Hydro	1kW	Residential / commercial / agricultural	4-12
Micro-Hydro	10 kW	Agricultural / commercial	44-134
TOTAL			**308 – 879**

(1) The resource potential for each renewable energy source is an estimate of the annual production of electricity that could be generated from that source under a prospective net metering program, regardless of cost. For micro-hydro, the assessment is based on an industry representative's estimate of the number of sites that could be developed in the province.

Actual customer uptake will depend upon system costs, consumer preferences, and program design. A range of potential customer costs was calculated for each system (Table E2). These include capital costs (including the cost of a manual system disconnect switch), installation, electrical inspection, ongoing operations and maintenance, and GST. Capital costs reflect a range of wholesale and retail prices for systems available today, and do not account for potential cost reductions over time as the technologies continue to develop. Monthly payments will be sensitive to financing rates and terms. Financing rates and terms available under BC Hydro's Home Improvement Program were utilized in the base case analysis. The net premium reflects monthly carrying costs less any savings on historical utility bills, assuming that self-generators are credited at current retail rates.

Based on this analysis, the monthly premium for distributed renewables ranges from virtually zero for a 10 kW micro-hydro system to over $800 for large (50 kW) wind systems under current retail rates. For perspective, the annual premium associated with a 500 kW solar PV system would be between one and two times the current average annual bill of a residential customer in British Columbia.

Given the relative cost premium of distributed renewables, actual uptake will depend highly upon consumers' willingness to pay for non-financial benefits. Their willingness to pay, in turn, will reflect consumers' individual attitudes towards environmental protection, early adoption, technology experimentation and leadership, and independence from the grid.[2]

[2] Independence refers to the ability to have a backup power supply. The ability of net metering systems to provide adequate replacement power during sudden and/or extended outages will depend upon the size and type of system installed, the availability of on-site storage devices, and the configuration of islanding protection systems. These issues are discussed in greater detail in the main body of this report.

Customer participation will also be influenced by program design. In general, customer uptake of a prospective net metering program will reflect:

- consumer awareness of net metering options, renewable energy technologies, and financial and non-financial benefits of renewable energy;
- technology availability and cost;
- financing rates and terms;
- ease of implementation; and
- the design of net metering tariffs (which affects potential magnitude of monthly savings on historical utility bills).

The low estimate of customer uptake in Table E3 reflects a level of uptake that might be expected under the following conditions:

- a program that offers a simple net metering tariff with no proactive customer education or marketing efforts;
- capital costs tending to the higher estimates in this paper;
- limited financing options; and
- limited customer awareness of and/or willingness-to-pay for non-financial benefits.

The high estimate of customer uptake reflects a level that might be expected under the following conditions:

- an aggressive and coordinated marketing program (with support from renewable energy advocates), with information widely available via the Internet, utility offices, retail outlets, electricians, tradeshows, magazines, trade journals, among others;
- capital costs tending to the lower estimates in this paper (e.g., through bulk purchasing and distribution channels);
- capital financing at favourable rates and terms;
- technologies widely available, and tested and certified by the utility (under a new product certification label), the Canadian Standards Association, or Underwriters Laboratory (UL) to ensure customer product satisfaction, safety, and reliability;
- equipment designers, suppliers, installers, and maintenance people trained and certified under independent programs;
- simple and favourable net metering tariffs and interconnection standards; and
- widespread customer awareness of and/or willingness-to-pay for non-financial benefits.

These attributes are common to the most successful net metering programs, including those in Japan and in Sacramento, California.

In general, anticipated customer uptake ranges from less than 0.1% of total resource potential in the case of solar PV to between 25% and 50% of total resource potential in the case of micro-hydro.

Table E2 – Customer Costs and Benefits

System Type	Upfront Capital Costs		Equivalent Monthly Financing Costs(1)		Monthly Energy Production (kWh)		Monthly Electricity Bill Savings(2)		Monthly Customer Premium (3)
	Low	High	Low	High	Low	High	Low	High	
Solar PV 500W	$4,572	$9,245	$58	$117	55	58	$3	$4	$54-114
Wind 10kW	$54,198	$57,352	$723	$763	1,095	2,555	$68	$158	$565 – 695
Wind 50kW	$65,927	$69,764	$926	$975	2,738	6,388	$146	$342	$584 – 829
Micro-Hydro 1kW	$3,438	$3,820	$48	$53	365	511	$23	$32	$16 – 30
Micro-Hydro 10kW	$17,141	$19,046	$239	$263	3,650	5,110	$195	$273	$0 – 68

(1) Assumes systems are financed under a similar program as the current BC Hydro Power Smart Home Improvement Program.

(2) The financial savings are assumed to occur as a result of reduced utility power bills.

(3) Premium over and above current electricity bill.

Table E3 – Customer Uptake of Net Metering and Associated Societal Benefits

System Type	Estimated Customer Uptake (# of Systems)		Estimated Annual Production (kWh / yr)		Estimated GHG Reductions (Tonnes / Year)		Estimated Job Creation Benefits (Full-time Equivalents)	
	Low	High	Low	High	Low	High	Low	High
Solar PV 500W	40	2,600	74	4,810	0.03	1.92	4	140
Wind 10kW	10	20	219,000	438,000	87.6	175.2	4	8
Wind 50kW	5	10	274,000	548,000	109.6	219.2	3	5
Micro-Hydro 1kW	375	750	1,971,000	3,942,000	788.4	1,576.8	10	18
Micro-Hydro 10kW	375	750	19,710,000	39,420,000	7,884	15,768	53	94
TOTAL	805	4,130	22,174,074	44,352,810	8,869.63	17,741.12	74	265

Job Creation and Greenhouse Gas Reduction Benefits

Greenhouse gas emissions and employment creation benefits are also summarized in Table E3 under a range of estimates for customer uptake. Considering all distributed renewables together, total GHG reductions would be between 8,900 and 17,700 tonnes, equivalent to 0.3% - 0.7% of BC Hydro's annual GHG emissions in 1997. Job creation benefits would range from 74 to 265 full-time equivalents, although it is uncertain whether all of those jobs would be created in B.C.

This analysis suggests that the largest incremental generation, GHG reductions and job creation benefits would come from micro-hydro installations.

Maximizing Customer Participation

Even among the more than 27 jurisdictions in North America that currently offer net metering, customer uptake has been limited by technical and institutional barriers. These include:

- A confusing array of utility-specific interconnection standards.
- Lack of understanding or experience regarding distributed generation systems among building inspectors.
- Additional (and sometimes arbitrary) permitting and inspection fees for net metering systems.
- Complex customer contracts, with excessive liability and indemnification requirements.
- Low cost grid-supplied electricity prices that do not reflect the full social costs of traditional generating technologies.
- Lack of financing for systems with large upfront capital costs.
- Lack of awareness of program availability and benefits among potential customers.
- Complex or unfavourable tariff structures.

Many of these can be addressed through good program design. Once a decision is made to implement net metering, specific opportunities for improving program uptake include the following:

- Design simple net metering tariffs for all customer-classes that rely on existing bi-directional meters to measure net consumption and credit customers at current retail rates.
- Include a provision that allows customer-generators to carry forward excess generation to the next billing period, for a maximum of one year.
- Establish favourable financing mechanisms for customers purchasing distributed renewable energy systems.
- Draft simplified and standardized contracts for customer-generators that do not require the services of a lawyer and that don't require customer-generators to acquire special liability insurance for their renewable energy systems.
- Develop clear interconnection standards for customer-generators that are presented in layperson terms. Form a consortium of electric utilities, renewable energy practitioners, electrical safety, and WCB representatives to come up with a consensus on specific interconnection standards.

- Educate electrical inspectors, building inspectors, and utility personnel regarding the technical issues surrounding distributed renewables and net metering.
- Certify all technologies through the Canadian Standards Association or equivalent organization.
- Develop training and certification programs for equipment designers, suppliers, installers, and maintenance people.
- Make efforts to internalize the environmental and social costs of conventional electricity supply in market prices to provide better price signals for distributed renewables.
- Publicize the net metering program.
- Develop a renewable energy education program to help build demand for distributed renewables and increase the public appetite for net metering.

Addressing Utility Concerns

Many utilities have resisted net metering programs, mainly due to concerns about lineworker safety (e.g., islanding protection) and potential cross-subsidies from other ratepayers (e.g., recovery of historical fixed costs and time-varying cost/value of power).

<u>Lineworker Safety</u>

There are a variety of islanding protection and prevention options that can be implemented with net metering systems. These include:

- utilizing power inverters with "islanding protection" where power backup capabilities are included;
- utilizing synchronous power inverters which require a grid signal to operate;
- utilizing induction generators without a self-excitation feature or using protection computers with induction generators that have self-excitation; and/or
- installing a manual, lockable, system disconnect switch between the utility meter and the distributed renewable energy system.

These mechanisms have been used to address lineworker safety issues in other jurisdictions.

<u>Financial Cross-subsidies</u>

A key concern among utilities in the province is that net metering will impose a cost burden on other ratepayers. There are three types of subsidies implicit in net metering. First, bundled retail rates typically include fixed costs. By crediting customer generators based on retail rates, they may effectively avoid some of these fixed costs (e.g., fixed T&D costs) although they continue to benefit from them (e.g., standby service). Second, power production from customer-generators that is credited by the utility may coincide with periods of the day or year when power is less valuable (e.g., summer days), yet customer-generators may consume utility power at zero net cost during periods when power is more valuable. Finally, net metering programs may entail additional administration costs that are recovered from all ratepayers, not just program participants. The potential magnitude of these cross-subsidies was not quantified in this study.

There are a variety of options for reducing or eliminating potential cross-subsidies. These include the following:

- Limiting the number of participating customers.

- Using load profiling and time-of-use rates to adjust credits for customer generators.
- Using dual meters to measure both consumption and production and adjusting the credit accordingly.
- Installing time of use meters and applying a time-of use rate to a customer's net consumption.

Except for capping program participation, most of these options would likely increase the cost of net metering and reduce potential customer benefits/uptake.

Some cross-subsidies may be justified on the basis of social and environmental benefits since the program is not intended merely to offer customers options, but to support the deployment of specific technologies. In addition, cross-subsidies are already prevalent in retail rates. For example, most bundled rates reflect average consumption patterns (e.g., load factors) in a particular customer class. Similarly, postage stamp rates inevitably imply cross-subsidies among customers at different locations.

Conclusions

1. *Benefits of Distributed Renewables*. The use of distributed renewables can offer a variety of benefits including environmental benefits such as greenhouse gas emission reduction and local air quality improvements, social benefits such as economic development and job creation, and potential utility/customer benefits such as environmental stewardship and potential cost reductions in non-integrated areas which are currently supplied by diesel.
2. *Benefits of Net Metering.* Net metering could enhance the market for distributed renewables in British Columbia. Net metering facilitates system capital cost reductions, customer utility bill reductions, and technical simplicity, relative to those situations where net metering is not in place. For utilities, facilitating net metering can help to improve public support and customer satisfaction. Net metering empowers people, businesses, and organizations to reduce their environmental impacts, something that retail businesses can publicize to gain customer support. The private-sector focus of net metering could build on the expertise of existing market players for remote and mobile power applications. Finally, the characteristics of distributed renewables are often more conducive to customer installation and maintenance rather than full implementation by utility personnel.
3. *Resource Potential* The total renewable resource potential under net metering is between 308 and 879 GWh/year, about 0.5 – 1.5% of current BC Hydro sales. Financial costs and other barriers would likely limit customer uptake to 3% - 14% of this resource potential. The most economical net metering resource from a customer perspective are micro-hydro installations. Based on the figures from the analysis, these systems would account for more than 98% of likely generation under a net metering program in the province, and would provide between 42 and 85% of the job creation benefits, and 98% of the GHG reduction benefits anticipated under net metering. A net metering program targeting micro-hydro may provide the greatest net customer, utility and social benefits for the province.
4. *Lineworker Safety* As illustrated in other jurisdictions, utility concerns regarding lineworker safety can be addressed through various forms of islanding protection and prevention technologies, including manual disconnection switches. A variety of stakeholders should be involved in establishing reasonable protection standards. Exchanges of information with personnel in other jurisdictions may be required to fully overcome these concerns and improve awareness of protection systems. Education of building and electrical inspectors will also be required.

5. *Cross-Subsidies* It is possible that some cross-subsidization by non-participating customers will occur. Most net metering programs credit customers at existing bundled retail rates. These rates typically include a variety of fixed costs and do not necessarily reflect the time-varying cost/value of grid-supplied generation. However, there are numerous cross-subsidies implicit in existing retail rates. For example, average rates reflect the average load factor of a customer class. Furthermore rates do not vary by location. These cross-subsidies have been generally accepted, either because the cost of eliminating them outweighs the benefits, or because they are acceptable on the basis of social or environmental policy. Although the potential magnitude of cross-subsidies from net metering is unknown at this time, they can be capped by limiting participation in net metering programs. However, it would be useful to estimate upper and lower bounds for the subsidy to better inform stakeholders and policy makers, and allow an explicit judgment of whether the subsidy is justified by the social and environmental benefits.
6. *Customer Uptake*. If a net metering program is implemented in B.C., customer uptake can be enhanced by incorporating the following program elements: simplified rate structures and contracts, transparent interconnection standards, crediting the retail rate for excess generation up to the level of customer consumption within a year, offering financing mechanisms, certifying technologies and installers, educating stakeholders on the technologies and net metering, and making efforts to internalize the environmental and social costs of conventional electricity supply in market prices to provide better price signals for distributed renewables.
7. *Method of Implementation*. Net metering policy could be implemented either through government policy or voluntary utility action. Government policy could take the form of legislation, ministerial directive or special directive to the BC Utilities Commission. Most other jurisdictions have utilized legislation or commission orders. However, the success of a net metering program relies on utility cooperation. If special orders, directives or legislation are to be used, consideration should be given to involving renewable energy professionals, utilities unions, regulators, and other stakeholders in the development of program requirements.
8. *Policy Considerations* This analysis has demonstrated that net metering can provide several benefits to electricity consumers, electric utilities, and society as a whole. The only benefits that were quantified were job creation and greenhouse gas (GHG) emission reductions. The analysis indicates that the employment creation benefits could be large, depending on the magnitude of customer uptake, which is linked to the program design. However, on a provincial basis, the greenhouse gas emission reduction benefits of net metering are small relative to other options. For policymakers to maximize GHG reductions, net metering could be integrated into a broader package of mechanisms to support renewables or facilitate GHG emissions reductions

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Part A: Introduction

Clean Power at Home describes and analyzes net metering as a mechanism to support the deployment of small-scale, distributed, electricity technologies based on renewable energy resources ("distributed renewables") in British Columbia. Net metering enables individuals, institutions, businesses, or governments to connect on-site renewables to the utility grid, allowing them to consume the renewable energy when needed, feed excess power back to the utility when it is not needed (e.g., which causes the electrical meter to run backwards), and utilize utility power when their consumption exceeds the renewables supply (e.g., meter runs forward).

The analysis focuses on the costs and benefits of net metering, and the challenges and opportunities for developing effective net metering programs. It does not compare net metering to other means of fostering the development of renewables, or the costs and benefits of fostering different types and scales of renewable resources. A net metering program would support small-scale renewable energy technologies located at customer sites (i.e., distributed renewables such as solar PV and micro-hydro), but would not support medium- to large-scale facilities connected directly to transmission or distribution facilities (e.g., wind farms, biomass plants, small-hydro). Other mechanisms, described in detail at the end of this section, may be more appropriate to promote these types of centralized renewable energy projects.

To that end, the paper addresses the following questions:

1) What is the likely magnitude of distributed renewables that would be supported by a net metering program in B.C.? This is a function of technical potential and likely customer uptake. Customer uptake, in turn, is a function of program design, customer costs, and consumer preferences.

2) What are the potential social and environmental benefits of the program in terms of jobs and GHG emission reductions?

3) How should utility concerns about worker safety and ratepayer subsidies for net metering best be addressed?

4) How should a net metering program be designed to maximize customer participation?

Renewable Energy Technologies and Resources

Distributed Resources

Distributed electricity supply technologies and resources produce power at a scale that is appropriate for locating at electricity end-use consumers' premises – at people's homes, at businesses, at farms, in offices, or at industrial plants. With these technologies, electricity generation is "distributed" throughout the electricity grid, rather than being centralized. Examples of this type of technology are photovoltaic (PV) solar arrays which generate electricity from solar radiation or micro-hydroelectricity generators which produce electricity from water power.

In contrast, the most dominant source of electricity in Canada is from large-scale, centralized power plants which are often located away from consumers' premises. They are situated near the source of the energy resource which powers them (i.e., hydroelectric reservoir), often involving long extensions of electrical transmission systems to connect them. They are often developed on a large scale to maximize economies of scale in the construction and operation of the plant. An example of a centralized power plant is the 2600 megawatt G.M Shrum Generating station next to the Williston Reservoir in N-E British Columbia.

Distributed resources are becoming increasingly competitive with centralized power sources on a financial basis due to technological innovations, reduced capital costs, reduced maintenance requirements, access to inexpensive energy resources, and other factors. However, the electrical systems in many jurisdictions including British Columbia are still dominated by vertically-integrated[3] electric utilities that have a monopoly on retail market sales of electricity. Many of these companies have investments and expertise in centralized power sources and are slow to consider the adoption of distributed resources.

Renewable Energy Technologies (Renewables)

Renewable energy technologies are used to generate electricity or heat from renewable energy resources such as solar radiation, and the potential energy from rivers and streams, wind power, or biomass. These technologies and resources are referred to as “renewables”.

Renewables can be definedas energy sources with long-term supply characteristics with little chance of resource exhaustion over a human timeframe (e.g., several hundred years). Their utilization need not diminish the availability of the renewable resources upon which they are based. Fossil fuel and nuclear technologies are not considered to be renewables due to their diminishing supply characteristics.

Renewables which generate electricity include the following technologies:

- Solar photovoltaic (PV) modules and arrays.
- Wind turbines and generators.
- Run-of-river micro-hydroelectric turbines and generators with no storage reservoir.
- Reservoir or storage based hydroelectricity facilities.
- Water velocity turbines – for capturing energy from moving water, including vertical-axis tidal generators and run-of-river Darrius turbines. They utilize the kinetic energy of flowing water rather than potential energy due to gravity which is the case for micro-hydro.
- Biomass electricity generation or cogeneration systems – using waste products from the forestry industry or new biomass resources which are grown and harvested in a sustainable manner.
- Landfill and sewage gas electricity generation and cogeneration technologies.
- Electricity generation from combusting municipal solid wastes.
- Geothermal electricity generation and cogeneration technologies.
- Hydrogen fuel cells – if the hydrogen is derived from renewable resources.
- Tidal and wave power technologies.

Our analysis focuses on those renewables which minimize environmental impacts, or in some cases actually improve environmental quality. Some of the environmental objectives that are

[3] Provide electricity supply, transmission, distribution, conditioning, and retail services within one company

important to British Columbians include the protection of anadramous fish species (e.g., salmon), protection of air quality in the lower mainland and communities with pulp mills and mineral smelters, management of greenhouse gas emissions, preservation of parks and protected areas, and maintenance of the aesthetic qualities of the province.

The utilization of some types of renewables is conducive to meeting or enhancing these environmental objectives. However, the development and utilization of other renewables can result in environmental impacts which are incompatible with the achievement of these objectives.

- Reservoir or storage-based hydroelectric projects can permanently change watershed characteristics, threaten salmon spawning or other aquatic organism habitat, or flood lands with impacts on the terrestrial environment.
- Biomass resources may be derived from wood which is not harvested in a sustainable manner. Also, the combustion of biomass creates air emissions which can impact negatively on the local or regional air quality (e.g., PM-10, NO_x, VOCs, SO_x), depending on how it is combusted. Net greenhouse gas (GHG) emissions are negligible in those cases where the biomass resource is renewed because the growth sequesters carbon. In some cases, the development and utilization of biomass plants can help improve local or regional air quality if they divert wood waste products from more environmentally impacting disposal.
- Landfill gas and municipal solid waste technologies rely on the production of consumer waste products (i.e., garbage) which is either landfilled or combusted. The production of certain types of consumer products can cause negative environment impacts. More importantly, enhancing the value of landfill gas or combusting garbage may create a demand for consumer waste products and threaten or slow waste reduction and recycling initiatives.
- The majority of geothermal resources in British Columbia are in undeveloped areas with pristine wilderness characteristics that would be threatened with the development of power generating and transmission facilities.
- With hydrogen fuel cells, a large proportion of hydrogen production in the Canadian market is derived from natural gas with resultant greenhouse gas emissions.
- Large-scale tidal and wave power technologies can threaten estuary habitat and/or have impacts on aquatic life.

There are many types of renewables, but only small scale “distributed renewables” are investigated in this paper, since they are appropriate for net metering. The distributed renewables considered in this paper include the following[4].

- Solar photovoltaic modules and arrays.
- Wind turbines and generators.
- Run-of-river micro-hydroelectric turbines and generators (up to 150kW) with no storage reservoir (although the economic analysis in this paper only considers resources up to 50kW).
- Water velocity turbines (these technologies are not considered in the economic analysis because they are not commercial).

[4] This list also corresponds with the technologies which are eligible for a B.C. government PST exemption for consumer-based renewables, included in Appendix E.

Benefits of Utilizing Distributed Renewable Energy Technologies

The deployment of the distributed renewables in an electricity system can offer several benefits to electricity consumers, communities, and electricity companies. These benefits are not exclusive to distributed renewables, as many large-scale renewables offer similar benefits.

Environmental Benefits

The utilization of distributed renewables can help to alleviate many environmental problems associated with the use of conventional electricity technologies such as large-hydroelectricity, coal, or natural gas generators. They are listed below.

- The utilization of distributed renewables can prevent negative impacts on watersheds and aquatic organisms. Some potential impacts of large-scale hydroelectricity include the alteration of water flow regimes, the diversion of water, destruction of aquatic organism habitat, in particular salmon spawning grounds, and negative impacts on water quality such as increased dissolved nitrogen gases in water. With micro-hydro technologies, both water quality and the physical characteristics of watersheds are virtually unaffected.
- Their utilization prevents negative impacts on lands as can be the case with large hydroelectricity. These impacts can include flooding, making lands adjacent to reservoirs unusable, impacts on riparian areas through changing water flows, and negative impacts on flora and fauna.
- Their utilization does not result in the production of toxic waste products, provided that the manufacturing processes for solar, wind and micro-hydro technologies don’t result in toxic waste outputs. An exception to this is some “thin-film” solar PV modules which are made with compounds of toxic elements such as cadmium or arsenic. However, the majority of the solar PV modules on the market today are based on silicon entirely.
- They do not produce greenhouse gas (GHG) emissions, and as such, their utilization generally results in a reduction of GHG emissions provided they displace fossil fuels. In British Columbia, the current electricity providers generate some of their electricity from diesel oil and natural gas and purchase power from jurisdictions which generate electricity from coal.
- Their utilization can result in a net reduction in emissions of air pollutants that affect local or regional air quality. This environmental benefit is again tied to the reduced consumption of fossil fuel generated electricity somewhere in the province or in neighboring jurisdictions. These emission can include particulate matter, nitrous oxides, volatile organic compounds, toxic hydrocarbons, or sulfur dioxide. The specific impacts of these pollutants can include ground level ozone (i.e., smog), acid rain, or significant health implications for people who inhale significant amounts of those pollutants, or are particularly sensitive to them (e.g., asthma).

Economic Development and Job Creation Benefits

The deployment of distributed renewables creates jobs. On a per unit investment dollar basis and on a unit energy production basis, the deployment of distributed renewables creates more employment than conventional electricity generation technologies.

A study prepared by the Pembina Institute in 1997 for Environment Canada outlined the “person-years” of employment created per million dollars of energy sector expenditure. Large-scale hydroelectric developments in B.C. averaged at 2.6 person-years of employment and natural gas plants in Alberta, 4.0. In contrast, a small hydro or wind energy project created 8 person-years of employment, a biomass plant, 14, solar thermal developments, 28, and demand-side management programs in B.C., 31 person-years.

There is no guarantee that all of these jobs will remain in B.C. A discussion on this issue is included in Part B.

In addition to creating more jobs relative to other energy resources, the development of renewable facilities can contribute to provincial economic development. For example, the Government of Québec, along with its energy regulator, la Régie de l'Énergie, have supported a public investment in large-scale wind energy developments in return for economic development benefits. La Régie has recommended that Hydro-Québec endorse a 50MW/year "set-aside" for wind energy purchases through competitive bids, provided that the wind energy industry establish long-term manufacturing facilities in the job-starved Gaspé peninsula.

Although the facility in Québec involves large-scale wind turbines not appropriate for net metering, a similar case could be built in British Columbia with micro-hydro technologies, as B.C. currently has significant expertise with these technologies.

Electric Utility Benefits

The main benefit to utilities is improved customer perception and support of the utility – that is, customers perceive that the utility is offering customers more choice and that it is supporting environmentally friendly technologies. As electricity markets become more competitive, something potentially around the corner in British Columbia, companies could differentiate themselves by offering products and services other than conventional electricity alone. Support for distributed renewables can be offered as an additional product or service to customers - to gain a competitive advantage, particularly given the popularity of renewables among the general public[5].

The deployment of distributed renewables in regions of B.C. that are not served by the provincial integrated grid but are served by regional or community distribution grids can reduce the cost of serving utility customers, as those customers currently receive subsidized rates that do not reflect their cost of service. The communities of Atlin, Dease Lake, Bella Coola, Bella Bella, Anahim Lake, the Queen Charlotte Islands, and others are currently served in-whole or in-part by high-cost diesel generators. Production of electricity from distributed renewables can help to reduce the operation of those diesel units and thus reduce the utility cost of service.

Distributed renewables may play a greater role in the electricity market in the future as their costs decline and they are made more available in consumer markets. Distributed renewables, with or without net metering, could be used partly or wholly in place of utility-supplied electricity. Existing electric utilities will face competition from electricians, hardware stores, and other energy providers to supply distributed renewables to electricity consumers. By engaging in the deployment of renewables, electricity companies could gain valuable technological and customer service experience for an emerging market.[6]

[5] Electricity consumers have indicated a preference for renewables among competing energy sources when asked to consider environmental aspects of energy production. In the 1998 *Joint Ministries and Crown Environment Poll* commissioned by the Government of British Columbia, solar energy was ranked as the preferred electricity resource, wind power second, and small hydro third, all by a wide margin over natural gas, large hydro, and biomass. The survey did not differentiate between distributed and non-distributed renewables.

[6] Although the benefit of organizational learning is not guaranteed with net metering because it is a customer-driven mechanism, utilities have an option to actually serve the net metering market as is the case

A new market opportunity may arise through the creation and sales of renewable energy credits. Electricity market restructuring legislation in several jurisdictions in the U.S. has required utilities to maintain a "Renewable Portfolio Standard" (RPS) whereby every retail power supplier must acquire renewable energy credits equivalent to some percentage of its total annual energy sales. The States of Arizona, Connecticut, Maine, Massachusetts, Nevada, and Vermont have adopted RPSs, and the proposed Clinton Restructuring policy includes a national RPS of 7.5% for the year 2010[7]. The Clinton policy on net metering is designed to help meet the national 7.5% target[8] along with other renewable energy sources. It is possible that a similar RPS policy could develop in Canada in the future to meet trade obligations with the U.S. If that becomes the case, then net metering could be used as one of many mechanisms to produce and sell RPS credits.

Consumer Independence

Distributed renewables can be used by individuals to derive a large proportion of their own energy needs without impacting on the environment. From another angle, distributed renewables can be designed to provide backup power to the customer if and when the utility grid is down. The public demand for power backup systems has increased significantly in the last two years as a result of the eastern Canadian "ice-storm", the threat of power outages resulting from the "millenium bug"[9], and a perceived reduction in electricity supply reliability associated with wholesale and retail competition in the U.S. and Alberta electricity markets. Power backup provides significant social benefits, and in many cases, financial benefits to customer generators that rely on electricity in their homes and workplaces.

Power backup is not an inherent characteristic of all distributed renewables. All of the systems listed in the analysis in Part B of this report can be designed to provide immediate power backup for a limited number of the customer's loads while maintaining lineworker safety when the grid is down. However, only the 1500W wind turbine includes the ability to do this with no added cost, subject to resource availability. The 1kW PV system can be easily converted into a full backup power system, while maintaining lineworker safety, for the cost of a battery bank (starting at $500). For the other solar PV systems (100W, 500W), the added cost would be of a battery bank and a power inverter which converts battery power to alternating current ($600- $4000). For systems with induction generators, the added cost would be of a battery bank, an inverter, and a "self-excitation" capacitor for the induction generator (minimal cost). To guarantee lineworker safety on these systems, a disconnect switch would need to be installed.

Clearly there are cost implications to converting these systems to include power backup. In many cases, this cost exceeds the capital cost of a small diesel-generator which is the current standard

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with the Sacramento Municipal Utilities District (SMUD) in California (see Appendix B). Also, the market for distributed renewables is small.

[7] http://home.doe.gov/policy/ceca.htm

[8] http://www.energy.com/news/cover/cv041599.asp

[9] The "Y2K" or "Millenium Bug" may cause certain computer software programs to crash on or after January 1st, 2000 as a result of non-robust programming routines that could fail when the year setting in computer clocks changes to 2000 or "00". As many power generation, transmission, distribution services and associated administrative services rely on computers for their function, there is a risk of power system failure after that date. A spokesperson at the Sacramento Municipal Utilities District (SMUD) has verified anecdotally that customer demand for independent solar PV systems has increased as a result of customer concerns on power reliability after January 1, 2000.

for backup power. Thus, in many cases, power backup alone will not justify an investment in distributed renewables, unless a standby power backup is required for computers or other electronic devices which require a constant power source. The Trace Inverters included with the 1000W solar PV and 1500W wind systems are capable of providing uninterrupted power supplies and can also be used for net metering.

Net metering is only one of many means for fostering further development and utilization of renewable energy sources. It is a customer-driven mechanism supporting small-scale generation technologies located at customer sites. Other mechanisms for fostering the development and utilization of renewables include:

- **Renewable portfolio standards or set-asides** – Requirement that a minimum percentage of electricity sold by retailers be derived from renewable resources. Retailers may generate or purchase electricity to satisfy this requirement, or, alternatively, purchase credits from retailers or producers with excess supplies. A variation on this is a required renewable energy “set-aside” whereby a minimum proportion of all electricity generation be derived from renewables.
- **Voluntary green pricing**– In jurisdictions without retail competition, monopoly utilities may offer optional green tariffs that support incremental investments in green technologies (e.g., renewables). In jurisdictions with retail competition, there is evidence that marketers will offer green products as a means of differentiating their supply from other producers. In either case, any cost premium associated with green technologies is paid for by the customers that elect an optional tariff or green supplier.
- **Rate- or tax-payer subsidies** – Subsidies may be provided to support R&D, or to reduce the cost of renewables to market levels. Subsidies may be raised through non-bypassable charges on electricity transmission/sales or through taxpayer funding sources. Subsidies are often tied with other initiatives which foster either customer and/or utility investments in renewables.
- **Utility-owned and operated distributed renewable energy systems** – Some utilities have developed programs to own and operate distributed renewables on customer premises. These systems feed electricity directly into the grid (i.e., are connected on the utility side of the meter). Customers are not net metered and may in fact pay a small premium for the privilege of participating in the program. A good example of such a program is Sacramento Municipal Utility District’s PV Pioneers I Program. These programs seek to leverage the economies possible from bulk purchase and installation of systems, while maintaining control over interconnection and operation of facilities.

Each mechanism tends to support different types and levels of resource investment, and has different implications in terms of the relative costs and benefits for customers, utilities, and society as a whole. None of the mechanisms to support renewables is mutually exclusive. Indeed, they are often implemented in combination, reflecting the relative objectives and constraints in an overall renewable energy strategy.

Net Metering

Definition of Net Metering

Net metering is the practice of using a single electrical meter to measure the difference between the total consumption of utility electricity by a customer and their total generation of electricity from renewable energy resources. It is also known as reverse metering, net billing[10], or power banking. The meter runs backwards when the customer's electricity production exceeds their consumption.

Throughout this paper, the term "customer-generator" is used to refer to the electricity consumer with a renewable energy technology at their premises that is grid-interconnected and capable of doing net metering. The term is also used to refer to the specific distributed renewable energy technology which produces power.

Net metering allows customer-generators to use their excess electricity generation to offset the cost of utility power consumption over an entire billing period or year. They can "bank" the power they generate within the utility system by feeding the grid when excess power is produced and consuming power from the grid at a later time when their production falls below consumption.

Through net metering, customer-generators effectively receive the retail price of utility electricity for any excess production of electricity that is fed into the grid, which would be equivalent to almost 6 cents per kWh for residential electricity consumers in British Columbia. If their net electricity production within a billing period is equivalent or greater than their consumption, the utility bill would be reduced to zero. In some cases, net metering programs allow the customer-generator to carry-forward excess generation into the next billing period, up to a maximum of one year, thus increasing the value of resources which have seasonal characteristics.[11] Alternatively, several other utilities pay a customer-generator for any power production in excess of their total consumption within a billing period or year – at the utility wholesale rate, spot price of electricity, or the avoided cost of power from a new power plant[12]**.** Thus, net metering can have the effect of reducing a utility consumer's power bill, making it zero if their excess production equals consumption, or if the program allows it, making it negative if their production exceeds consumption, in which case they could carry forward a credit to the next billing date or receive a rebate from the utility.

Figure 1 illustrates the structure of a typical net metering installation.

[10] In some cases, "net billing" refers to utility tariff where a distributed electricity supply resource is connected to the utility grid through a second meter and the net consumption of utility power is calculated rather than physically measured, as is the case where only one meter is used.

[11] This feature is included in several of the programs detailed in Appendix B - Toronto Hydro and Ontario Hydro, and in the State of Washington.

[12] Table 1 lists all the programs with that feature under "Treatment of Net Excess Generation".

Figure 1.

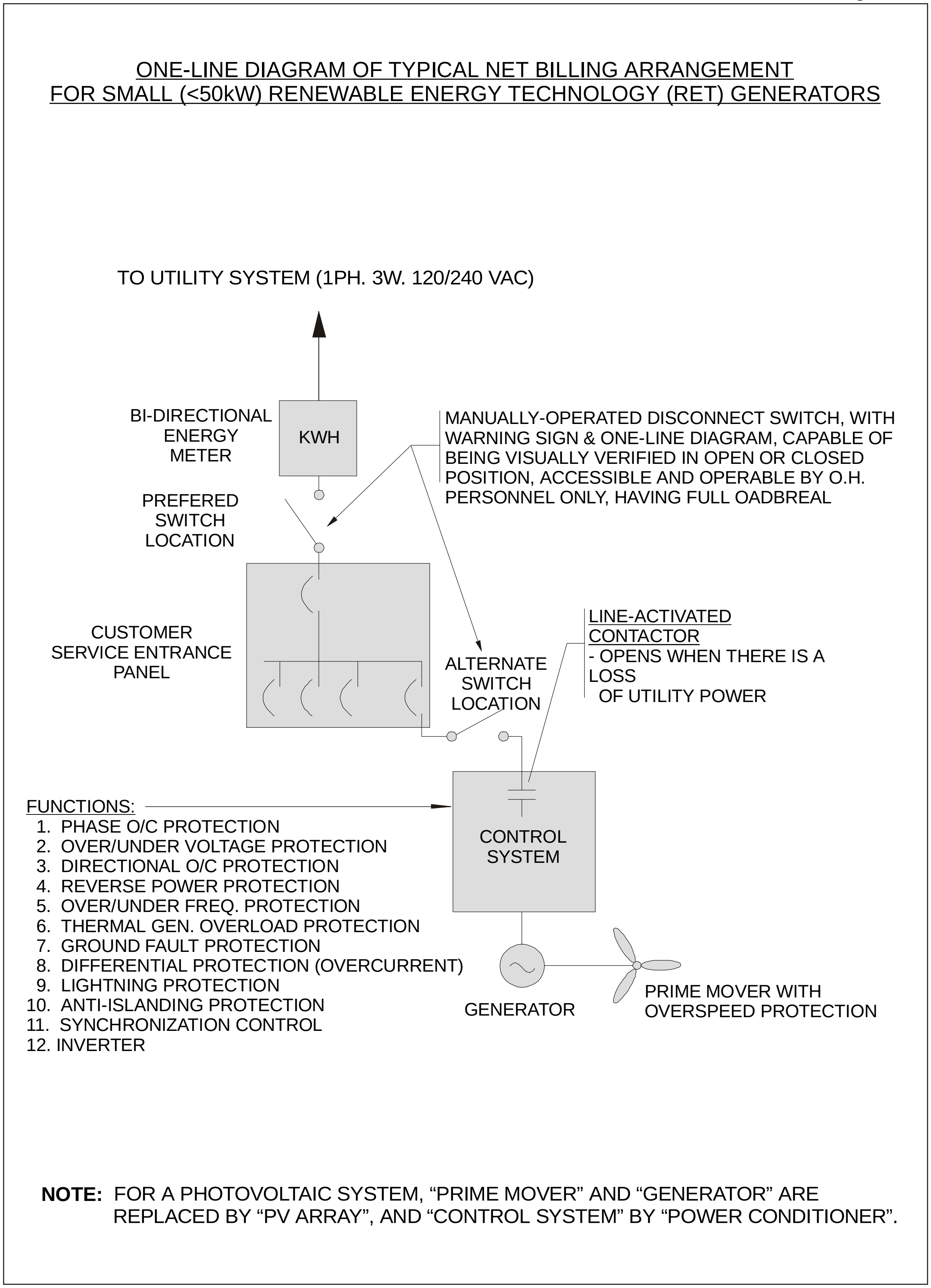

Diagram of Typical Net Metering Arrangement **Source: Ontario Hydro Retail**

Technical Benefits of Net Metering Programs

Net metering programs can offer several benefits to customer-generators. They can reduce the cost of distributed renewables relative to situations where those renewables are not grid-interconnected. The utilization of the existing meter is an important financial benefit of net metering, as the purchase and installation of additional meters poses additional costs. If net metering were not in place, then distributed renewables would be treated like IPPs/NUGs, requiring additional metering equipment. This cost starts from about $350[13].

The ability to interconnect distributed renewables to the grid often reduces their capital cost due to reduced equipment needs. For micro-hydro and wind technologies, the ability to use induction generators significantly reduces capital costs relative to synchronous generators. For distributed renewables that generate power from intermittent resources such as wind and sun, net metering eliminates the need for some storage and/or power conditioning and transforming equipment. This can include batteries, large-scale inverters, and battery charge controllers and regulators. These components can easily double or triple the price of a complete system.

Another way of looking at the benefit on eliminating storage equipment is that net metering provides flexibility to consumer-generators to produce and consume power at different times. Their power consumption patterns can be independent of power production times. This is particularly important when the peak power demand of the consumer is much higher than the average demand (i.e., low load-factor). With net metering, the customer-generator can partly serve consumption needs during peak periods and “bank” power in the utility grid during off-peak periods for use against future consumption. Without net metering, some power production may be wasted if it is not needed at the time it is being produced.

Socio-Economic Benefits of Net Metering

Net metering provides a means for electricity consumers with access to renewable energy resources to significantly reduce their contribution to greenhouse gas emissions and other environmental impacts from electricity consumption[14]. Without net metering, an individual has little opportunity to produce their own power due to the excessive costs and hassles involved with operating two parallel systems – the utility grid system and distributed renewable system – an no opportunity to integrate them[15]. Currently, consumers in other markets have several choices to purchase environmentally-sustainable goods and services such as recycled paper, energy efficient

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[13] See Appendix I.

[14] A 2kW micro-hydro system operating at a 60% capacity factor can produce enough electricity on an annual basis to meet the average household consumption in B.C. without space heating.

[15] The current policy within BC Hydro on distributed renewables is that building owners must install a switch that completely separates grid operations from those of self-generation. In other words, either 100% of the building load is met by BC Hydro, or 100% is met by the distributed renewable, with no combination of the 2 operating simultaneously permitted. This is appropriately in place to protect utility personnel from harm when they are servicing transmission and distribution lines. However, there has been little effort to date to resolve the issue of allowing customers to operate systems simultaneously, even though this has been effectively established in other jurisdictions without harm to personnel. Net metering is one mechanism to allow this, although other approaches may be possible such as a policy on the interconnection of small-scale distributed renewables without net metering.

refrigerators, and organic vegetables, but in most cases don't have an opportunity to do so in the electricity sector[16].

Net metering enables private capital to be directed toward distributed renewables that may otherwise be directed toward luxury goods, entertainment or the purchase of other environmentally-benign goods and services. Numerous individuals have indicated an interest in spending money on distributed renewables for grid-integrated applications[17] but have not been able to because of the lack of a utility policy on the interconnection of distributed renewables.

Net metering can help commercial consumers to improve their customer relations by demonstrating environmental stewardship through the deployment of distributed renewables. This includes "bragging rights" to help differentiate them from their competitors. For example, Mountain Equipment Coop has installed a net-metered 1kW Solar PV system at their store in Toronto and is making that system a focus of some of their marketing efforts to gain customer support. The project also includes several energy efficiency features in the building.

Electric Utility Benefits of Net Metering

Several potential utility benefits of net metering are included below. These benefits are not exclusive to net metering and could be accrued to utilities through other types of programs for renewable energy.

Utilities can enhance their public support and improve customer relations by providing a customer-driven and environmentally-responsible energy solution.

Making net metering available to customer-generators can help to improve electric utility system load factors, although this is very resource and site specific (e.g., if the renewable resource produces power during periods of peak electricity demand). This is typical of micro-hydro technologies in coastal areas that produce power during rainy periods which correlate with the provincial peak demand period.

Utilities may also be able to receive some or all of the credit for the incremental environmental benefits of deploying renewables through a net metering program. These may include greenhouse gas (GHG) emission reduction credits or incremental improvements in local air quality. By paying for the installation of a second meter to measure production from renewables (starting from $350), utilities may be able to market green power to other electricity consumers, and create GHG offsets or other tradable commodities. However, there is uncertainty around the ownership of credits obtained through net metering. In contrast, direct utility investment in renewables would not be faced with the same uncertainty about ownership.

Net metering can reduce the risk of customer bypass in situations where customers would be able and willing to build self-generation even in the absence of power banking.

Finally, net metering of renewables can help utilities gain expertise with distributed electricity generation technologies that they are not familiar with. This expertise will be valuable when, as many predict, distributed resources become the dominant source of electricity.

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[16] An exception is the West Kootenay Power green rate which enables customers to elect a higher rate for green derived resources. Customer uptake has been poor to date.

[17] Personal communication, Robert Mathews, Energy Alternatives regarding the number of customers interested in net metering; Fred Howe, Thomson and Howe Engineering, customer interest; Bud Beebe, SMUD, customer uptake of PV Pioneers II.

Summary of Existing Net Metering Initiatives

Net metering programs have been developed in at least 24 U.S. States, two Canadian provinces, Germany, and Japan. It has been proposed in several additional U.S. States and may be required nationally in the U.S. as a result of a Presidential initiative to restructure the electricity market nationally. In British Columbia, it was proposed under the B.C. Task Force on Electricity Market Reform. Where information is available, these are summarized in Table 1 below. Appendix B contains detailed descriptions of all Canadian initiatives and representative initiatives in the U.S. and overseas.

The majority of the net metering programs have been initiated as a result of state or national legislation or through public utility commission orders. A detailed discussion on different approaches for implementing net metering programs is contained in Part C.

To implement net metering, an electric utility typically develops a new tariff or rate which enables customer-generators to connect distributed renewables to the grid using the existing electrical meter or an additional meter. The utility typically applies a standard residential, commercial or industrial rate for each kilowatt-hour of net power consumption. If net consumption has occurred over an entire billing period, then the electricity consumer will have a balance owing to the power retailer. In contrast, if net production has occurred, the bill will be zero, or in some cases, the electric company may pay a special rate that is lower than the retail rate to the customer-generator for excess power production (e.g., the utility avoided cost of supply, spot or wholesale price).

Some net metering programs determine the net consumption/production on an annual basis. For a detailed description of this mechanism, see the description of the Toronto/Ontario Hydro and State of Washington programs in Appendix B.

Almost all of the net metering programs in Canada and the U.S. specify customer-generator capacity limits, ranging from 10kW to 100kW per system, and in a few cases, statewide limits are imposed (e.g., 0.1% – 0.2% of peak electricity demand within the State).

Table 1 – Summary of Net Metering Programs

See the Internet (http://www.eren.doe.gov/greenpower/netmetering/indesx.html) for links to detailed descriptions of most of the listed initiatives.

Jurisdiction Name	Allowable System Size	Allowable Technologies/Re-sources	Participation Limit	Allowable Customer Classes	Governing Authority	Treatment of Net Excess Generation	Year Enacted
Manitoba Hydro	< 2000 kW	All distributed technologies	None	All utility customers	Manitoba Hydro	Avoided utility cost	1989
Ontario Hydro	< 50 kW	PV solar, wind, micro-hydro, biomass	20 demonstration systems	All utility customers	Ontario Hydro	No financial compensation	1997
Toronto Hydro	< 50 kW	PV solar, wind	Several demonstration systems	All utility customers	Toronto Hydro	No financial compensation	1997
Arizona	< 100 kW	PURPA Qualifying Facilities	None	All customers of IOUs[18] and RECs[19]	Arizona Corporation Commission	Purchased at utility avoided cost	1981
California	< 10 kW	Solar only	0.1% of 1996 peak demand	All State residential consumers	Legislature	Purchased at utility avoided cost	1995

[18] Investor-Owned Utilities.

[19] Rural Electric Cooperatives.

Table 1 – Summary of Net Metering Programs cont…

Jurisdiction Name	Allowable System Size	Allowable Technologies/Re-sources	Participation Limit	Allowable Customer Classes	Governing Authority	Treatment of Net Excess Generation	Year Enacted
Public Service of Colorado Company	< 10 kW	PURPA Qualifying Facilities[20]	None	All utility customers	Public Service Company of Colorado	No financial compensation	1994
Connecticut	< 100 kW (renewables) <50 kW (cogenerators)	PURPA Qualifying Facilities	None	All customers of IOUs, no RECs in State	Public Utility Commission	Purchased at utility avoided cost	1990
Hawaii	< 10 kW	Solar, wind, micro-hydro	0.1% of peak demand	All residential consumers (2 meters required)	Legislature	All generation credited at special rate	1996
Idaho	< 100 kW	All distributed resources	None	All customers of IOUs only	Public Utility Commission	Purchased at utility avoided cost	1980
Indiana	< 1000 kWh / month	PURPA Qualifying Facilities	None	All customers of IOUs only	Public Utility Commission	No financial compensation	1985
Iowa	No limit	Renewable energy only	105 MW	All customers of IOUs	Iowa Utility Board	Purchased at utility avoided cost	1993

[20] Includes cogenerators and all renewable energy technologies.

Table 1 – Summary of Net Metering Programs cont…

Jurisdiction Name	Allowable System Size	Allowable Technologies/Re-sources	Participation Limit	Allowable Customer Classes	Governing Authority	Treatment of Net Excess Generation	Year Enacted
Maine	< 100 kW	PURPA Qualifying Facilities	None	All customers of IOUs and RECs	Public Utility Commission	Purchased at utility avoided cost	1987
Maryland	< 80 kW	Solar only	0.2% of 1998 peak demand	All State residential consumers	Legislature	No financial compensation	1997
Massachusetts	< 30 kW	PURPA Qualifying Facilities	None	All customers of IOUs, no RECs in State	Public Utility Commission	Purchased at utility avoided cost	1982
Minnesota	< 40 kW	PURPA Qualifying Facilities	None	All State electricity consumers	Legislature	Purchased at utility avoided cost	1983
Nevada	< 10 kW	Solar and wind	First 100 customers for each utility	All State electricity consumers	Legislature	No financial compensation	1997
Public Service of New Hampshire	< 25 kW	Renewable energy	500 kW	All residential utility consumers	Public Service of New Hampshire	No financial compensation	1994
New Mexico	< 100 kW	PURPA Qualifying Facilities	None	All customers of IOUs and RECs	Public Service Commission	Purchased at avoided cost with additional flat charge	1988

Table 1 – Summary of Net Metering Programs cont…

Jurisdiction Name	Allowable System Size	Allowable Technologies/Resources	Participation Limit	Allowable Customer Classes	Governing Authority	Treatment of Net Excess Generation	Year Enacted
New York	< 10 kW	Solar only	0.1% of 1995 peak demand	All State residential consumers	Legislature	Annualized purchase at utility avoided cost	1997
North Dakota	< 100 kW	Renewable energy and cogeneration	None	All customers of IOUs only	Public Utility Commission	Purchased at utility avoided cost	1991
Oklahoma	< 100 kW and < 25,000 kWh / year	Renewable energy and cogeneration	None	All State consumers except for municipals	Oklahoma Corporation Commission	No financial compensation	1988
PECO Energy Company, Pennsylvania	None	Solar only	None	All residential utility customers	PECO Energy Company	Purchased at average utility billing rate	1996
Rhode Island	< 25 kW for larger utilities < 10 kW for smaller utilities	Renewable energy and cogeneration	None	All customers of IOUs, no RECs in State	Public Utility Commission	Purchased at utility avoided cost	
Sacramento, California - *PV Pioneers II*	2kW solar PV arrays	Solar only	About 100 systems per year	Residential	Sacramento Municipal Utility District	Purchased at utility wholesale cost	1999
Texas	< 50 kW	Renewable energy	None	All customers of IOUs and RECs	Public Utility Commission	Purchased at utility avoided cost	1986

Table 1 – Summary of Net Metering Programs cont…

Jurisdiction Name	Allowable System Size	Allowable Technologies/Re-sources	Participation Limit	Allowable Customer Classes	Governing Authority	Treatment of Net Excess Generation	Year Enacted
Vermont	< 15 kW or < 100 kW for farm systems	Solar, wind, fuel cells, agricultural waste products	1% of 1996 peak demand	All State electricity consumers	Legislature	Annualized net metering with no financial compensation	1998
Virginia (proposed)	< 10kW	Solar, wind, hydro	0.1% of 1998 peak demand	Residential customers only	Legislature	Power purchase agreement required	1999
Washington	< 25 kW	Solar, wind, micro-hydro	0.1% of 1996 peak demand	All State electricity consumers	Legislature	Annualized net metering with no financial compensation	1998
Wisconsin	< 20 kW	All technologies	None	All IOUs and some RECs	Public Service Commission	Purchased at retail rate for renewables, utility avoided cost for non-renewables	1993

Barriers to the Successful Implementation of Net Metering in Other Jurisdictions and Possible Responses

Customer uptake of net metering has been very poor in several U.S. jurisdictions and Manitoba[21] despite the environmental, social, and potential economic benefits of distributed renewables and net metering.

This section reviews some of the barriers to customer participation in existing net metering initiatives, most notably in the U.S. Where appropriate, potential responses are also referenced.

Institutional Barriers and Possible Responses

Starrs *et al*. (1998) details several institutional barriers that customer-generators must overcome in U.S. jurisdictions, thus limiting investments in renewables. He states that, "… according to one PV equipment manufacturer, roughly four out of five potential customers who are willing and able to pay the $5,000 - $20,000 price for a rooftop PV system that will offset some or all of their electric utility bills end up abandoning their efforts because of unanticipated problems associated with these institutional barriers". He argues that, "… most of the problems arise from the lack of familiarity with the technology among utilities, building code officials, insurers, lenders, and others whose blessing is needed to install and operate even the smallest-scale generating facilities".

There is a lack of uniform utility interconnection standards for net metering. Although the Institute for Electrical and Electronics Engineers (IEEE) has a standard – *IEEE Recommended Practice for Utility Interface of Residential and Intermediate Photovoltaic Systems* (Standard 929-1988 R1991) – utilities sometimes develop their own standards that seem arbitrary to some in the PV industry. "The result is a confusing array of utility requirements … that can add significantly to the cost of a PV system".

A clear solution to this problem is to legislate a standard into place and require all utilities and net metering customers to comply with the standard. Another approach would be to form a consortium of electric utilities and stakeholder groups to voluntarily adopt a standard that works for both customers and utilities.

The enforcement of local building and electrical codes imposes some problems on net metering installations. Although inspections are based on national and provincial electrical and/or building codes, their implementation and enforcement varies significantly at a local level. Also, many inspectors are unfamiliar with distributed renewables and related components such as the direct current (DC) subsystems associated with most solar and wind facilities. Their lack of experience with distributed renewables makes them hesitant to approve such equipment.

A possible response to this barrier is to develop training courses on distributed renewables and net metering interconnections for utility personnel and inspectors (Starrs et.al., 1998). This could be led by key contact people in each jurisdiction that are familiar with the technologies and could be contracted by inspectors at any time. Another potential solution to this problem would be to clarify the role of building and electrical codes, and/or develop inspection standards in net metering legislation. Natural Resources Canada is currently working with a senior engineer at

[21] See Appendix B for information on the uptake in Manitoba.

Ontario Hydro to develop a standard for field inspection of utility interconnected solar photovoltaic systems[22].

Many utilities, building inspectors, and/or permitting authorities charge additional fees on net metering systems that are not commensurate with the scale of the facility. For example, one homeowner in New Hampshire recently testified at a legislative hearing that his utility, Public Service Company of New Hampshire, had imposed a $900 fee to review the specifications for his 900W PV system; had required an additional protective relay ($450) beyond what was incorporated in his inverter; and had required an annual test of the protective relay, for which the customer pays $100. The annual test alone was enough to wipe roughly six months of energy production from the PV system, and the other fees increased the cost of the PV system by 15%. (Starrs et.al., 1998).

A response to this barrier is to ban all extra fees for net metering interconnection in legislation, and/or to form a consortium of stakeholder groups and electric utilities to agree upon a standard fee structure.

Utility contracts for small-scale customer-generators are another source of problems. Starrs *et al*. (1998) explains, "… many utilities have developed 'boilerplate' contracts for the purchase of power from non-utility generators ... designed with $100 million cogeneration facilities or geothermal plants in mind rather than a $5000 wind turbine or PV system. As a result, these contracts often contain complex liability and indemnification provisions that require the involvement of lawyers and other outside experts – for a residential customer with a casual interest in renewable energy, … these costs are likely to be prohibitive". In addition, many utility "boilerplate" contracts require non-utility generators to carry $500,000 or more worth of liability insurance, considerably more than most standard homeowner's policies.

A possible response to this barrier is to develop simplified contracts for small-scale generators such that lawyers are not required. Ontario Hydro has developed one such contract (see Appendices B & C) and Southern California Edison has a two page contract for facilities under 10kW. In addition, utilities should be encouraged to voluntarily drop insurance-related requirements, as small-scale distributed renewables pose little if any threat to utility equipment and personnel, provided that safety provisions are followed (Starrs et.al., 1998).

The State of Washington's net metering legislation (see Appendices B & D) attempts to address some of these barriers by stating in the Act that utilities are prohibited from: imposing any additional requirements beyond those related to safety, power quality or interconnection standards in national electrical codes, IEEE and UL standards; or imposing additional costs beyond those that are in regulated rates; unless the commission approves it after undertaking a public process.

Economic Barriers

Although distributed renewables may be cost-effective for some applications on a purely financial basis, many customers do not install them because of a lack of financing capital. Distributed renewables are capital intensive, with virtually all expended at the time of installation, and few costs being imposed as the system is operated. Currently, the acquisition of financing capital for renewables is very difficult for most prospective customer-generators, as many lending institutions are unfamiliar with the technologies. To address this barrier, governments or utilities

[22] Technical Authority: Dr. Lisa Dignard, EDRL, Varennes, PQ. Author: Per Drewes, Senior Engineer, Ontario Hydro. Drewespl@rd.hydro.on.ca.

could introduce a financing program for distributed renewables or provide guarantees to existing financial institutions to provide financing.

Some argue that the current price of electricity in North America does not reflect the “external costs” associated with the production and transport of that power, in particular, environmental and social costs. For example, greenhouse gas emissions could impose a significant financial cost burden on industrialized countries who are signatories to the Kyoto Protocol in the future, and yet they are not accounted-for today. Also, there are environmental and social costs associated with the generation of electricity from hydroelectric dams, both on watersheds, adjacent lands, and nearby communities.

Distributed renewables are free of those environmental and social costs, and thus, would be more cost effective relative to conventional resources if the costs associated with environmental and social impacts (i.e., externalities) were incorporated into the price of conventional electricity resources. In that case, the cost of utility power would presumably increase, thus making distributed renewables more economically attractive, as the value of their power would increase.

The introduction of net metering is intended to provide an extra financial incentive for the deployment of distributed renewables in return for the environmental and social benefits of power production from distributed renewables relative to conventional energy resources.

Another approach would be to include an “environmental adder” to the price of conventional electricity which reflects environmental and social impacts.

Other Barriers

There is a lack of knowledge about net metering and the benefits of distributed renewables which is also a significant barrier to their deployment.

A response to this is to leverage funding from net metering customers, the government, or utility ratepayers to promote the program and educate the public on the benefits of net metering. Otherwise, program participation will be limited to hobbyists, environmentalists, or “early adopters”.

It is also important that the government and electric industry regulator be supportive of net metering – disseminating information about programs, promoting distributed renewables, and providing a check-and-balance on electric utilities’ policies and practices on net metering. In some cases, if utilities are imposing unnecessary fees or interconnection requirements on customer-generators, the regulator and/or government should respond with ministerial directives or legislation to manage those requirements.

Key Barriers to the Establishment of Net Metering in British Columbia and Possible Responses

In the past few years, several formal efforts have been made in British Columbia by renewable energy, environmental and consumer groups to advocate net metering through hearings at the BC Utilities Commission (BCUC). Also, net metering has been considered as a part of a provincial government climate change strategy process. However, to date, these efforts have not resulted in new policy development which facilitates net metering.

A number of consumers have formally approached their electric utility, requesting permission to connect distributed renewables to the grid through a net metering arrangement. However, both BC Hydro (BCH) and West Kootenay Power (WKP) have consistently opposed net metering in their service areas. They have permitted a small number of their customers to connect distributed renewables in parallel with the electric utility for in-house consumption and/or with wholesale pricing for their excess production.

Spokespeople for the two main electric utilities have consistently identified two principle reasons for opposing net metering – lineworker safety and ratepayer financial subsidies. These issues have influenced net metering policy development, as evidenced by the result of the BC Greenhouse Gas Forum discussion on “Early Actions” in late 1998 which considered the inclusion of net metering, but rejected it as a result of those two issues.

Lineworker Safety

The first barrier is related to lineworker safety and WCB requirements for BCH and WKP transmission and distribution line maintenance procedures. There is a concern that net metered renewables would continue to feed electricity into the grid after the network goes down during power outages, putting lineworkers at risk while they are working on the lines. This is also sometimes referred to as “islanding”, a situation where a customer-generator feeds an electricity load adjacent to its location when that part of the distribution system is down from failure or for maintenance purposes.

The following discussion outlines some of the “islanding” protection or prevention features of typical equipment used with distributed renewables, proven for net metering application. This equipment corresponds with that analyzed in Part B of this paper.

All net metering systems should be individually inspected by the Electrical Safety Branch of the provincial government until which time that authority is satisfied with the safety and performance of grid intertied, distributed renewables. If and when that conclusion is made, safety inspections could be done randomly as is currently the case for electrical work in buildings by owners or electricians.

Islanding Protection with Trace Power Inverters

For some renewables, such as the 1000 Watt Solar PV or 1500 Watt wind systems in Part B, lineworker safety is guaranteed by features in power inverters that convert the DC electricity from the solar modules to AC electricity, such as those developed by Trace Engineering. Their grid-interconnection inverters include “islanding protection” that senses when the utility grid is down and disconnects the customer-generator until the line is operating again. A full description of Trace’s “islanding protection” is listed in Appendix F. Also, information on Pacific Gas and

Electric's acceptance of Trace Inverters for the purpose of net metering is provided in Appendix G.

Micro-Sine Inverters

The smaller solar PV systems (100W, 500W) in Part B include a "micro-sine inverter", also distributed by Trace Engineering, which is physically incapable of producing electricity when the grid is down. This type of inverter is called a "synchronous inverter", meaning that the circuitry requires an external signal to produce power. Thus, these inverters do not require islanding protection – when the utility grid is not operating, these systems will not be capable of producing electricity from the customer generator.

Induction Generators

Induction generators, such as those included with the micro-hydro and the 25kW and 80kW wind systems in Part B, will not generate electricity when the grid is down. They require electrical excitation from the grid to operate. Without excitation current from the utility, a magnetic field cannot be created by the stator winding and therefore the machine cannot generate. Thus, the installation of induction generators does not normally pose a threat to lineworkers when they are working on the grid.

However, self-excitation is possible with systems which include a built-in, self-excitation capacitor. Thus, a net metering program should ban the use of self-excitation, induction generators which include such a capacitor. Alternatively, a protection device by Thomson and Howe Engineering Systems Inc. for induction generators could be installed. The HM Control and Grid Protection Computer prevents islanding or any production of electricity onto the grid when it is down. Information on this product is included in Appendix H.

Synchronous Generators

Another type of generator that could be used with distributed renewables for net metering is a synchronous generator on a wind turbine system. These have been specified with the 1500W and 10kW wind energy systems in Part B for the scenario analysis. Synchronous generators are common for remote power applications with micro-hydro, diesel or wind technologies. They are capable of producing power without being connected to an electrical grid because they use permanent magnets to provide the field magnetism. Thus, in principle, synchronous generators that are grid intertied are capable of producing power when the grid is down, posing a risk to utility lineworkers.

However, the wind energy systems in Part B of this report which include synchronous generators also require a power inverter as they produce direct current electricity. The 1500W wind energy system includes the same Trace Engineering Inverter as that specified for the larger solar PV system (see above), the one with islanding protection. The 10kW wind energy system includes a "synchronous inverter" with similar features as the micro-sine inverter with respect to islanding in that they are physically incapable of producing power when the grid is down.

Discussion About Additional Protection

Utilities across North America require additional safety equipment and procedures to protect lineworkers and other utility personnel where distributed renewables are connected to the grid. An example of this is at the British Columbia Institute of Technology (BCIT) for their solar PV array which has been in place since 1998 for research purposes. The 1 kW solar PV array is connected into the BCIT electrical system in parallel with the BC Hydro system, meaning that it is synchronized with the grid at all times. Technically, the system is identical to a net metering configuration. However, the agreement between BCH and BCIT states that no excess generation is permitted into the system.

The BCIT system requirements include a lockable system isolation switch, installed at a location where BCH lineworkers can access it. After a grid outage, no attempt will be made to reconnect the solar PV system until BCIT has obtained approval from the BCH Lower Mainland Control Centre. The procedure is carefully spelled out in a BC Hydro "Local Operating Order"[23] which is standard for electricity generators. The lockout switch includes two components, an automatic low-voltage shutout relay[24] contained in a lockable box, and a manual lockable disconnect switch for extra security.

Recent work by Per Drewes of Ontario Hydro indicates that these types of switches are not required for small, solar PV systems with certified power inverters. In this work, Drewes states that, "utility interconnected photovoltaic systems with maximum power ratings less than 10kW and using an approved power conditioner [e.g., inverter] do not require an outdoor utility-accessible disconnect switch" under the rationale that, "PV power conditioners with the required islanding prevention schemes are inherently incapable of feeding power without a utility signal. Also, the very small systems cannot supply sufficient magnetizing current to energize local distribution transformers". This report is entitled *Recommended Guidelines for Field Inspection – Utility Interconnected Photovoltaic Systems*[25], a document that may be submitted for inclusion in the Canadian Electrical Code in the future.

However, given that electricity utilities in B.C. are relatively unfamiliar with those distributed renewable energy technologies and systems, it is suggested that manual disconnect switches be included with all prospective net metering applications in the short-term. This may also help to support the achievement of WCB objectives on lineworker safety, although further research is required on this issue.

In sum, the experience from other jurisdictions demonstrates that automatic disconnect switches are not required for net metering applications in B.C., even though one has been installed for the BCIT system. These switches add potentially unjustifiable costs to a net metering system. Lineworker safety is guaranteed by the equipment specified above, and the work of Per Drewes supports that claim for certain types of equipment. As an added layer of security, a manual disconnect switch could be put in place.

Also, it is suggested that utilities invest in net metering demonstration and research systems to gain experience and possibly to certify certain technologies for use on their grid as other utilities have done in the U.S[26].

[23] Local Operating Order No.3T23-93 – BCIT Photovolatic System (BPV).

[24] Cutler Hammer, 15 amp relay, C25DND315.

[25] Submitted to Dr. Lisa Dignard, Natural Resources Canada – EDRL. December, 1998.

[26] See Appendix G.

Ratepayer Financial Subsidy

The second barrier relates to subsidies from all utility ratepayers to the customer who owns the net metered system. The concern is that net metering will impose an unacceptable cost burden on utility ratepayers and that customer generators will gain an unfair advantage as a result of the subsidy.

One form of the subsidy is related to the time value of power in the utility system. The timing of the production of electricity from the net metered technology may not correspond with that of the customer consumption. For example, with solar PV installations in B.C., it is possible that the consumption of electricity will correspond with peak demand periods (i.e., in the evening), while the production will correspond mostly with off-peak demand periods (i.e., during the day). The magnitude of this subsidy depends on the timing of available electricity from the customer generator, the cost of producing electricity during different time periods, the opportunity cost of electricity during different time periods, and the consumption patterns of the customer.

A second form of subsidy from ratepayers is related to the cost of providing capacity to customers through distribution line connections. Residential customers pay for both their capacity connection equipment and energy use through a single energy charge in cents per kilowatt-hour. The fixed costs of capacity equipment are amortized over a period of time which can be translated to an energy charge, assuming that the customer will consume a minimum amount of power. Under net metering, customer consumption inevitably goes down and reduces customers' contributions toward those fixed costs, imposing a cost burden on the entire utility.

The third subsidy is related to the net metering program administration costs. This includes utility personnel time, marketing expenses, and potential liabilities.

There are also several potential benefits that accrue to electric utilities from distributed renewables and net metering.

These subsidies and benefits are not quantified in this paper. Further work is required as outlined in the discussion on Utility Costs and Benefits in Part B.

However, there are four approaches to capping these potential subsidy issues, listed as follows:

1. Limit the number of customer-generators in the jurisdiction through a cap on net metering. This way, the potential subsidies can be capped to ensure that they don't overly burden the utility ratepayers as a whole.
2. Generate an annual load and production profile for the customer-generator and develop an annual charge/rebate to reflect the differences in cost of power consumed and value of power produced.
3. Install a second meter to separately measure renewables production and utility customer consumption and adjust the customer bill to reflect the value of the subsidy.
4. Install a Time of Use (TOU) Meter to continuously measure the amount of power production and consumption during peak and off-peak periods. In that case, the customer bill would be equivalent to: (net consumption on-peak – net production on-peak) + (net consumption off-peak – net production off-peak).

Except for capping program participation, most of these options would likely increase the cost of net metering and reduce potential customer benefits/uptake. The scenario analysis in Part B includes assumes that the total amount of net metered supply in the province is capped at 0.1% of peak provincial demand, allocated among customer-generators on a first-come, first-serve basis, and that each customer-generator is limited to a peak capacity of 150kW. Thus, the scenario analysis incorporates the first approach above to managing the subsidy issue.

Some cross-subsidies may be justified on the basis of social and environmental benefits since the program is not intended merely to offer customers options, but to support the deployment of specific technologies. In addition, cross-subsidies are already prevalent in retail rates. For example, most bundled rates reflect average consumption patterns (e.g., load factors) in a particular customer class. Similarly, postage stamp rates inevitably imply cross-subsidies among customers at different locations.

Part B: Analysis of the Potential Costs and Benefits of a Net Metering Program in British Columbia

Part B summarizes the potential physical, economic, environmental and social costs and benefits of renewables generally and net metering specifically. This section attempts to quantify some of these costs and benefits in British Columbia.

This section is organized in the following components:

- technology and system descriptions;
- resource potential for net metering in British Columbia;
- system costs and financial benefits;
- net metering program analysis assumptions;
- estimate of customer uptake of net metering;
- utility costs and benefits;
- social benefits; and
- summary uptake and benefits.

Technology and System Descriptions

A detailed description of some of the technologies that are suitable for net metering is contained in Appendix A. These include solar photovolataics (PV), wind generators, and micro-hydro generators. Several system configurations are presented for each of these three distributed renewables in Figures 2, 3, and 4. Current system costs in British Columbia are provided in 1998 Canadian dollars, including the following components:

- electricity supply technologies – energy resource converters and generators;
- mounting devices and physical works;
- power conditioning equipment such as inverters and electricity storage devices if required;
- mechanical and electrical controls;
- installation costs at $40/hour – the current market rate in the B.C. independent power industry; and
- other miscellaneous costs including wire, junction boxes, materials, contingency, etc.

The prices exclude any long-distance transmission costs for micro-hydro or wind energy systems that are located far from the customer-generator's premises (< 500 meters).

The specific systems considered for the detailed analysis are:

- the 500Watt solar PV system;
- the 10kW wind energy system;
- the 25kW wind energy system;
- the 1 kW micro-hydro system; and
- the 10kW micro-hydro system.

These five systems are assumed to represent the range of technologies that are likely to be deployed under a prospective net metering program in British Columbia and are thus used to assess the potential costs and benefits of customer participation in a net metering program.

Figure 2 - Solar Photovolatic System Components and Costs

Technology: Photovoltaic Capacity: 100 watt

Components	**Price**
PV Module(s), 100 watt	$900.
Mounting frame	175.
Inverter, 100 watt, 24-50 VDC, 120 VAC, 60 hz	550.
Installation	160.
Miscellaneous @ 10 %	180.

Technology: Photovoltaic **Capacity**: 500 watt

Components	**Price**
PV array, 500 watt	$4300.
Mounting frame	600.
Inverters, (5) x 100 watt, 24-50 VDC, 120 VAC, 60 hz	2600.
Installation	480.
Miscellaneous @ 5 % (very simple hook-up)	360.

Technology: Photovoltaic **Capacity**: 1000 watt

Components	**Price**
PV array, 1000 watt	$8000.
Mounting frame	860.
Inverter, 4000 VA, 34-75 VDC, 240 VAC, 60 hz	5520.
Installation	800.
Miscellaneous @ 10 %	1500.

Figure 3 - Wind Generator System Components and Costs

Technology: Windelectric **Capacity**: 1500 watt (Bergey)

Components	**Price**
Wind generator, 1500 watt	$8,000.
Tower, 25 meters	4,000.
Inverter, 2.5 kVA, 120 VAC (SW2512) w/sm batt	4,800.
Installation - turnkey	3,000.
Miscellaneous @ 10%	2,000.

Technology: Windelectric **Capacity**: 10 kW (Bergey)

Components	**Price**
Wind generator, 10 kW	$24,200.
Tower, 25 meters	9,500.
Inverter, 10 kVA, 240 VAC, 60 hz, 1 phase	7,800.
Installation - turnkey	7,000.
Miscellaneous @ 10 %	4,800.

Technology: Windelectric **Capacity**: 25 kW (Wenvor-Vergnet)

Components	**Price**
Wind generator w/controls, 25 kW	$47,000.
Tower, 25 meters	6,000.
Inverter not required (induction, fixed speed)	
Installation - turnkey	6,000.
Miscellaneous @ 10 %	5,900.

Technology: Windelectric **Capacity**: 80 kW (Lagerway)

Components	**Price**
Wind generator w/controls, 80 kW	$138,000.
Tower, 25 meters	30,000.
Inverter not required (induction, variable speed)	
Installation - turnkey	57,000.
Miscellaneous @ 10 %	22,500.

Figure 4 - Micro-Hydro System Components and Costs

Technology: Hydroelectric **Capacity**: 500 watt (236 l/m @ 27m)

Components	**Price**
Penstock, 7.5mm x 250m PVC	$ 820.
Turbine-generator unit (ES&D Induction 1.5hp)	1400.
Invertor not required	
Installation (except penstock & intake)	480.
Miscellaneous (intake & powerhouse) @ 10%	260.

Technology: Hydroelectric **Capacity**: 1000 watt (126 l/m @ 100m)

Components	**Price**
Penstock, 5mm x 570m PVC	$1100.
Turbine-generator unit (Harris induction 3 hp)	1400.
Invertor not required	
Installation (except penstock & intake)	480.
Miscellaneous (intake & powerhouse) @ 10%	290.

Technology: Hydroelectric **Capacity**: 10 kW (3700 l/m @ 32m)

Components	**Price**
Penstock, 20mm x 480m PVC	$4,000.
Turbine-generator unit (pump-induction)	5,500.
Intertie protection	3,500.
Installation (except penstock & intake)	1,600.
Miscellaneous (intake & powerhouse) @ 20%	2,900.

Technology: Hydroelectric **Capacity**: 50 kW (5600 l/m @ 100m)

Components	**Price**
Penstock, 25mm x 1650m PVC	$35,000.
Turbine-generator unit (pelton-induction, 3 phase)	20,000.
Intertie protection	6,000.
Installation (except penstock & intake)	2,560.
Miscellaneous (intake & powerhouse) @ 20%	12,700.

Resource Potential for Net Metering in British Columbia

A preliminary estimate of the resource availability for renewables in British Columbia is outlined below. It includes wind, solar, and micro hydro resources only. This estimate is of the technical potential – the amount of energy that could be tapped regardless of financial considerations. The estimates all include an upper and lower range, each tied to the five representative systems listed in the previous section.

Potential customer-generators and renewables suppliers will need to do a more detailed assessment for each possible site. The actual resource availability from renewables depends on a variety of factors including:

- For PV – the weather (solar radiation), rooftop orientation and angle, shading from trees and other buildings.
- For wind – the weather (wind speed and climate), wind obstructions.
- For micro-hydro – water and stream availability, vertical drop and water flow in system area, seasonal variation.

Despite all the specific factors that could affect the resource availability of renewables, an effort is made below to assess the annual energy production that may be available from distributed renewables for net metering in British Columbia.

Existing Grid Location and Number of Customers

The existing utility grids are controlled predominantly by West Kootenay Power and BC Hydro. The BC Hydro network is outlined in Figure 5. Distribution networks are connected to each substation along the transmission networks. A black line indicates the boundary of areas where net metering is possible.

The population of British Columbia is approximately 4 million people. The number of people per household in 1993 was 2.64, and is expected to decline to 2.44 by 2014[27]. The current level is assumed to be 2.6 people per household. This translates to 1.54 million households in the province. Some of those households are in areas that are not on the integrated electricity grid or secondary distribution grids, and would thus be inappropriate for net metering.

The total number of commercial and agricultural buildings connections are estimated to be 160,000[28]. This includes institutional, retail, government, agricultural, apartments, and other utility customers.

The number of industrial customers in the BC Hydro system is about 15,000[29].

[27] BC Hydro. 1994 IEP – Appendix D.

[28] Based on the proportion of residential to commercial customers in the West Kootenay Power Unbundled Cost of Service Study (July, 1997).

[29] BC Hydro. 1994 IEP – Appendix D.

Figure 5 – Existing Grid Network Source: B.C. Hydro

Please contact BC Hydro for grid map.

Solar Radiation

Figure 6 outlines the resource potential in the province, indicating several zones of resource potential. Each zone represents the amount of megajoules of solar radiation that impact on a square meter of surface area every day. The energy values range from 8.5 to 13 MJ/m^2/day. However, the majority of the population of British Columbia live in the southern part of the province and on Vancouver Island where the average radiation is about 12 MJ/m^2/day.

The technology to produce electricity from the sun is the solar photovolatic (PV) module (see Appendix A for a description). Solar PV modules are rated for peak sunlight conditions at 1000 Watts per square meter of solar radiation. In order to assess the solar energy output potential, the number of equivalent full sunshine hours at that power rating is required. For example, in Vancouver, the total solar radiation over a year translates to an equivalent amount of radiation if the sun was shining for 3.7 hours per day at an intensity of 1000 W/m^2. In Prince George, the figure is 3.6 hours/day[30].

On the map in Figure 6, the City of Vancouver has 12 MJ/m^2/day, representative of other populated parts for the province. Assuming Vancouver is in the mid-range of resource potentials, then the provincial daily bright sunshine hours is assumed to be 3.6 – 3.8 hours/day.

The number of residences in B.C. was estimated in the previous section to be about 1.5 million. Many of the households that are served by electric utilities do not have access to solar radiation due to shading from nearby buildings or trees. It is only those buildings with some amount of southern solar exposure on their rooftops that could take advantage of the solar resource. It is assumed that about 20% – 40% of the buildings in British Columbia have some amount of solar radiation[31]. Thus, the number of residential buildings which could potentially participate in net metering is 300,000 – 600,000.

The number of commercial buildings in the province was estimated to be 160,000. As commercial buildings are larger than residential dwellings and are generally located in areas with good visual exposure (for customers), it is assumed 40% - 60% of the total customer base could capture some amount of sunlight and participate in net metering. Thus, the number of eligible commercial customers is 64,000 – 128,000.

Among the industrial electricity consumers, it is assumed that about 50% - 70% of these customers have the capability to do net metering, then the maximum number of connections is 7,500 – 10,500.

An estimate of the technical potential for solar PV is provided in Table 2. This assumes that solar PV panels could be installed on 350,000 – 750,000 buildings for net metering purposes, and that the average system size is equivalent to the mid-sized system in Figure 2, 500 Watts peak (excluding all efficiency losses in the inverter and wire).

[30] Energy Alternatives Catalogue. 1998.

[31] Assumes that an average of one-third of buildings surrounding an obstruction (e.g., trees, tall building, mountain) will have solar exposure.

Table 2 – Estimate of the Technical Solar PV Energy Potential

Low Estimate	High Estimate
500 Watts x 350,000 systems x 3.6 hours/day = 630 MWh/day = 230 GWh/year	500 Watts x 750,000 systems x 3.8 hours/day = 1,425 MWh/day = 520 GWh/year

Thus, the theoretical maximum net metering production from solar PV in the province is between 230 and 520 GWh/year. In comparison, the 1997 consumption of electricity in British Columbia was 64,814 GWh[32]. Thus, up to 0.8% of British Columbia's electricity production could be derived from building connected solar photovoltaic sources.

[32] Canadian Electricity Association, Natural Resources Canada "Electric Power in Canada – 1995". 1997.

Figure 6 - Solar Energy Potential

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Wind Power

Figure 7 illustrates the wind energy resource in British Columbia. For the purposes of this report, it is assumed that the majority of the wind energy potential in British Columbia is in coastal communities facing the Pacific Ocean directly – the areas with the darkest colour zone in Figure 7. In these regions, the average wind speed is at least 19 kmh or 5.3 m/s. This is equivalent to a capacity factor of about 15%[33]. For comparison purposes, several sites monitored by BC Hydro in the early 1980s indicated wind speeds around 5.6 m/s for Christopher Point (near Victoria), 6.1 m/s for Sandspit, and 8.2 m/s for Kitkatla (near Prince Rupert). The installed wind turbines near Pincher Creek, Alberta, have capacity factors in the range of 35% - 40% with wind speeds in the upper range of that vicinity[34].

Thus, this study assumes that customer-generator wind turbine sites will have capacity factors ranging from 15% - 35%.

Wind power installations are not practical in large urban areas due to building restrictions, noise concerns, and availability of land. The ideal setting for wind power is on cleared areas with good wind exposure and limited obstructions from adjacent trees, hills, or mountains. The main population centers with grid electricity where this is possible is northwest of Victoria, near Ukulelet and Tofino, near Prince Rupert, in the northern Gulf Islands, Port Hardy area, and on the Queen Charlotte Islands. Only those people with sufficient land to install a wind turbine will be eligible. Assuming that about 100,000 people live in those regions, that 5% - 15% of those populations have sufficient land to install a wind turbine[35], and that 2.6 people live per household, the total number of potential sites is 1,900 – 5,800.

Another potential wind energy application is on agricultural lands or deforested areas in the Cariboo and south Okanagan regions, predominantly in the mid-colour zone of Figure 7. The number of BC Hydro agricultural customers in 1993/94 was about 3000[36]. Assuming about 5% - 15% of those customers have a viable location for wind power, then the number of potential sites is at least 150 – 450. This estimate is excluding opportunities among West Kootenay Power (WKP) and other non BC Hydro utility customers, although the number of customers served by those utilities is small compared to BC Hydro.

An estimate of the technical potential for net metered wind systems is provided in Table 3. This assumes that the 10kW turbine listed on Figure 3 is the one installed for up to 1,900 – 5,800 residential customer-generators at a 15% - 35% capacity factor[37], and that 150 – 450 agricultural sites are developed with the 25kW turbine at a 15% - 35% capacity factor.

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[33] NRCan. “Economic Characteristics of Large Scale Wind Energy Development in Alberta”. 1997.

[34] Ibid. 1997.

[35] This assumption is based on the author’s judgement through experience in these regions that an average of 10% of buildings are on acreage, waterfront, islands, or agricultural lands.

[36] BC Hydro IEP. 1995.

[37] Efficiency losses are imbedded in the capacity factor rating.

Table 3 – Estimate of the Technical Net Metered Wind Energy Potential

Low Estimate	**High Estimate**
10,000 Watts x 15% capacity factor x 1,900 sites x 8760 hours/year = 25 GWh/yr plus 25,000 Watts x 15% capacity factor x 150 sites x 8760 hours/year = 5 GWh/yr TOTAL = 30 GWh/year	10,000 Watts x 35% capacity factor x 5,800 sites x 8760 hours/year = 178 GWh/yr plus 25,000 Watts x 35% capacity factor x 450 sites x 8760 hours/year = 35 GWh/yr TOTAL = 213 GWh/year

Thus, the theoretical potential for wind power production through customer-generators is between 30 and 213 GWh/year. Up to 0.3% of British Columbia's electricity production could be derived from net metered wind power sources. This figure is not reflective of the overall wind energy potential in the province as there are several sites that could be developed by electric utilities or private power producers on a large scale (e.g., several hundred megawatts).

Figure 7 - Wind Energy Potential

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Micro-Hydro Power

Figure 8 illustrates the hydroelectric potential in British Columbia. Micro-hydro potential is very site specific. It depends on the availability of a stream close to a customer's property, sufficient vertical drop in the stream, and sufficient water to drive the turbine and generator. The map in Figure 8 illustrates that the majority of the potential is in coastal areas and in the East Kootenay region.

Potential micro-hydro sites include streams and engineered water works. The potential customer-generators include residential customers who live in rural areas, agricultural and irrigation customers, and municipalities or organizations who control water and irrigation-source facilities that could tap into micro-hydro power. In those cases, municipal water works could provide a source of micro-hydro power – turbines taking the place of pressure reducing valves.

The number of micro-hydro sites in the province is unknown. However, Fred Howe of Thomson and Howe Engineering believes that there are at least 3000 sites in the province with the potential for development. His area of expertise is the Kootenay and Rocky Mountain areas in the eastern part of the province. His estimate reflects experience in those regions, but a vast number of potential sites are also located in coastal areas of British Columbia, and in the coast mountain range. Thus, his estimate might be conservative.

In absence of any other information on micro-hydro resource potential, this paper assumes that his estimate reflects the mid-range of the actual resource potential in the province. Thus, the number of sites is assumed to be between 2000 and 4000 in the province.

The federal government published a report entitled *Small Hydro Projects and Potential Sites in British Columbia*[38] which includes several assessments of potential small-hydro sites in the province. One estimate from Sigma Engineering lists about 650 sites for which pre-feasibility studies for hydroelectricity development have already been completed. In most cases, the listings include only one hydroelectric development per watershed and are all in the range of capacities from 10kW to 50MW, mostly in the 1MW + capacity range. In contrast, several micro-hydro sites can be typically developed within a single watershed and their capacity is between 1kW to 50kW, about a factor of 10 less than the numbers in the federal government report. Thus, the estimate in this paper (on net metering) of 2000-4000 micro-hydro sites is consistent with those results.

An estimate of the technical potential for net metered micro-hydro systems is provided in Table 4. This assumes that half of those 2000-4000 sites are suitable for 1000 Watt systems and the other half are suitable for 10kW systems, both with annual capacity factors of 50-70%[39].

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[38] Prepared by Sigma Engineering. March, 1989.

[39] Energy Alternatives. This includes routine maintenance, annual fluctuations in water energy resources, equipment efficiency, and other factors. The figure is an estimate provided by Robert Mathews of Energy Alternatives.

Table 4 – Estimate of the Technical Net Metered Micro-Hydro Energy Potential

Low Estimate	High Estimate
1,000 Watts x 50% capacity factor x 1000 sites x 8760 hours per year = 4 GWh/yr plus 10,000 Watts x 50% capacity factor x 1000 sites x 8760 hours per year = 44 GWh/yr TOTAL = 48 GWh/yr	1,000 Watts x 70% capacity factor x 2000 sites x 8760 hours per year = 12 GWh/yr plus 10,000 Watts x 70% capacity factor x 2000 sites x 8760 hours per year = 122 GWh/yr TOTAL = 134 GWh/yr

Thus, the estimated potential for electricity production from net metered micro-hydro systems is 48 - 134 GWh/yr. Up to 0.2% of British Columbia's electricity production could be derived from net metered micro-hydro sources. This figure does not reflect the total micro-hydro resource potential in the province as there are several additional sites that could be developed by electric utilities or private power producers, not connected to customer loads.

Figure 8 – Small Hydro Potential

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System Costs and Revenues

This section provides an assessment of the technology costs of systems in British Columbia and the potential revenues that could be accrued through net metering those systems.

Current System Capital and Installation Costs

For each of the three distributed renewables considered in this analysis (ie., solar PV, wind, micro hydro), several system configurations are presented. These were all listed in Figures 2, 3, and 4. A summary of total costs is provided in Table 5.

Operating and Maintenance Costs

For Solar PV, operating costs are zero, as the solar resource is free. Routine maintenance includes snow and leaf removal off of modules, something that can be done by the building owner several times a year. Solar PV systems do not require routine equipment replacement and system warrantees are quite high. Modules have 10-20 year warrantees, and Trace Inverters, 2 years. Trace inverters have a reputation for quality and long-operation[40]. Mounting equipment, typically made of aluminum, should be long lasting provided that the installation is done properly. Thus, maintenance costs are assumed to be zero.

Wind energy systems have zero operating costs as well, as the wind resource is free. However, they have relatively high maintenance costs. Depending on the location where they are installed, they may require blade replacement at least once over the life of generator and tower. Bergey wind turbines have a reputation for quality and durability,[41] however, batteries may need to be replaced routinely. The maintenance costs are assumed to be equivalent to $0.02 per kilowatt-hour of production, double the costs of larger wind turbines that are operating near Pincher Creek, Alberta[42]. This translates to about $440 per year for the 10kW turbine, and $1000 per year for the 25kW turbine.

Customer generators with micro-hydro systems need to pay the BC government a water rental fee of about $0.004/kWh of production[43]. This is comparable with the fees that BC Hydro pays for electricity production from its hydroelectric facilities. Micro-hydro systems require routine maintenance on the penstock (pipeline) intake and outlet. The “trash racks” leading into the penstock require regular leaf and twig removal, and the nozzles leading into the turbine at the base of the penstock may require seasonal adjustment to reflect changes in water flow. Both of those maintenance tasks are assumed to be done at no cost by the customer-generator. In extreme cases, the penstock itself might require maintenance by the customer-generator or a paid professional. This could be as a result of physical damage to it from falling trees or branches, human-induced damage, large rocks entering it, or freezing[44]. Also, the induction generators may

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[40] Personal Communication, Robert Mathews of Energy Alternatives.

[41] Ibid.

[42] Personal Communication, Mike Bourns of Nor’Wester Energy 1997.

[43] Personal Communication, Robert Mathews of Energy Alternatives.

[44] One of the key design characteristics of a micro-hydro system is to avoid penstock pipeline freezing. This can be accomplished by burying the pipe, or placing it in areas that have sufficient snow cover to

require maintenance or replacement over the life of the micro-hydro system. These costs are assumed to be $0.001/kWh over the 20-40 year life of the system for larger systems (e.g., 10kW +) and $0.006/kWh for smaller systems[45]. This translates to about $50 per year for the 1kW system and $260 for the 10kW system.

The costs are summarized in Table 5.

Forecast of Future System Capital Costs of Selected Systems

The capital costs outlined in Figures 2 through 4 represent the costs of a small market for distributed renewables in British Columbia for remote power applications only. Also, the prices do not reflect volume discounts which are common in that market[46] and other markets.

The combination of volume discounts and an expanded market are expected to contribute toward cost reductions under a net metering program, provided that some amount of purchasing aggregation is undertaken. One approach to achieve this type of aggregation is to have distribution utilities purchase multiple systems at once for their customers who have committed to purchasing distributed renewables. However, if customer generators are spread out, and aggregation is not possible, then existing prices are assumed to prevail.

This paper does not investigate potential long-term capital cost reductions which could arise from large-scale distributed renewable energy deployment programs in the U.S., Japan, and Germany (see Appendix B). If these capital cost reductions are facilitated, Canadian consumers will benefit.

An estimate of potential cost reductions for selected systems from Figures 2-4 is provided below.

- Solar PV – 500W System – The potential cost reductions for Solar PV from volume discounts are assumed to be significant, based on actual prices that are currently offered to consumers in Sacramento, California. The local electric utility, Sacramento Municipal Utility District (SMUD) is selling 2kW PV systems for US$5.07/Watt, net of all subsidies[47]. This is equivalent to CAN $7.61/Watt assuming an exchange rate of 1.5. A shipping charge of 5% should be added to this figure. It is assumed that an aggregator in B.C. could achieve these prices under a substantial net metering program which attempts to reduce customer uptake barriers.
- Wind – 10kW and 50kW Systems – Cost reductions from volume purchases are assumed to be minor for wind turbines, in line with a current 5.5% volume discount offered by a major renewable energy company in British Columbia for purchases of 3 or more small wind turbines[48].

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provide insulation. The owners of Purcell Lodge at a high-altitude location in the Rocky Mountains operate a micro-hydro system year round, facilitated by snow cover insulation in the winter months.

[45] Personal Communication, Robert Mathews of Energy Alternatives.

[46] Soltek Solar Energy, a large B.C. solar energy company lists volume discounts of 12% for wholesale purchases of 24 modules or more, compared with the price for 1-4 modules. That same company offers a 6% discount for purchases of 3 or more small wind turbines, and a 5% discount on purchases of 3 or more Trace sinewave inverters. Thompson and Howe Engineering offers a 20% discount for purchases of 2 or more micro-hydro systems.

[47] http://www.smud.org

[48] Soltek Solar Energy dealer price sheet.

- Micro Hydro – 1kW and 10kW Systems – Cost reductions for volume purchases of micro-hydro systems currently vary between 10% and 20% among two companies surveyed[49]. The potential volume discount is assumed to be 10% for the purposes of this analysis.

Cost Summary for Selected Distributed Renewables Systems

The following table includes a summary of system costs, including $100 for an electrical inspection, $200 for a manual disconnect switch, and 7% GST. The "current capital costs" come directly from Figures 2-4. The "potential volume purchase-based capital costs" are derived by applying the assumptions above to the "current capital costs", assuming that an aggregator is participating in the net metering market.

Table 5 – Summary of Technology Costs

Technology Type and Size	500W Solar PV System	10kW Wind System	25kW Wind System	1kW Micro-Hydro System	10kW Micro-Hydro System
Current Capital Costs	$9,244.80	$ 57,352.00	$69,764.00	$ 3,819.90	$19,046.00
Potential Volume Purchase Based Capital Costs	$4,272.11	$ 54,197.64	$65,926.98	$ 3,437.91	$17,141.40
Operating Cost ($/kWh)	$ -	$ 0.02	$ 0.02	$ 0.010	$ 0.005

Financial Benefits of Systems

The installation of distributed renewables can provide financial benefits to customer-generators through reduced power bills.

A financial benefit-cost analysis is summarized in Table 6. The assumptions used for this are as follows.

- Capital costs low / high refers to those numbers in Table 5.
- Equivalent monthly financing costs low / high assumes capital cost financing of each system at the same interest rate and amortization period offered to BC Hydro customers under the Power Smart Home Improvement Program. This includes a 10-year amortization period at a rate of prime plus 2.5% for principals of $5,000 - $9,999, or prime plus 1% for principals of $10,000 or more. The prime rate is currently 6.5%. The monthly payment also includes all operating costs, as listed in Table 5. The low / high refers to the payments required for the low and high ends of possible capital costs.
- Monthly electricity production low / high refers to the monthly electricity production for each of the extremes of the capacity factor or equivalent operating hours.
- Monthly electricity bill savings low/high refers to the savings accrued to the customer-generator through reduced power bills. For the 500W Solar PV, 10kW Wind, and 1kW micro-hydro, the avoided cost of grid power is assumed to be $0.0577 per kWh plus 7% GST. For the 50kW Wind, and 10kW micro-hydro, the avoided cost is assumed to be $0.05 per kWh plus 7% GST[50].

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[49] Energy Alternatives and Thomson and Howe Energy Systems Inc.

[50] In consideration of the approximate residential power rate in British Columbia – the BC Hydro rate is 5.77¢/kWh plus a fixed customer charge and taxes, while the WKP rate is 5.121– 5.905¢/kWh plus a fixed

- Monthly customer premium refers to the net financial investment required by the customer on a monthly basis to cover the costs of the distributed renewables.

Table 6 – Summary Table of Customer-Generator Costs and Benefits

System Type	Upfront Capital Costs		Equivalent Monthly Financing Costs(1)		Monthly Electricity Production (kWh)		Monthly Electricity Bill Savings(2)		Monthly Customer Premium (3)
	Low	High	Low	High	Low	High	Low	High	
Solar PV 500W	$4,572	$9,245	$58	$117	55	58	$3	$4	$54-114
Wind 10kW	$54,198	$57,352	$723	$763	1,095	2,555	$68	$158	$565 – 695
Wind 50kW	$65,927	$69,764	$926	$975	2,738	6,388	$146	$342	$584 – 829
Micro-Hydro 1kW	$3,438	$3,820	$48	$53	365	511	$23	$32	$16 – 30
Micro-Hydro 10kW	$17,141	$19,046	$239	$263	3,650	5,110	$195	$273	$0 – 68

(1) Assumes systems are financed under a similar program as the current BC Hydro Power Smart Home Improvement Program.

(2) The financial savings are assumed to occur as a result of reduced utility power bills.

(3) Premium over and above current electricity bill.

The results of the analysis indicate that only the 10kW micro-hydro system offers short-term net financial benefits. Under both low and high capital cost scenarios, the monthly savings equal or exceed the monthly costs, assuming medium to high electricity production. A sensitivity analysis is described in the next sub-section to determine if these favorable financial attributes are robust to changes in interest rate and amortization period. After the 10 year amortization period is complete, the 10kW micro-hydro system will produce financial savings with minimal operating and maintenance costs for the remaining life of the plant, assumed to be 20-40 years[51].

The 1kW micro-hydro system has strong financial attributes, with monthly power bill savings being between $23 and $32, and costs being between $48 and $53. Similarly, the 10kW micro-hydro system with low production figures has monthly savings of $195 or more, with monthly costs ranging from $240 - $260. Over the 10 year amortization period, the customer-generator will absorb those costs, but following that period, net savings will accrue to the customer to make a financial payback possible over the life of the project.

The solar PV system and all of the wind systems have poor financial attributes. A reasonable payback on investment is not possible. If a government or utility subsidy were made available, as

charge and taxes. The commercial rates for both utilities vary significantly, depending on total monthly consumption and interconnection voltage. It is assumed that the commercial sector cost is 5¢/kWh, including all taxes, consistent with the lower end of the WKP rates.

[51] Personal Communication, Robert Mathews of Energy Alternatives.

is the case in the U.S., Germany, and Japan, it might be possible to improve their financial performance.

Analysis of the Sensitivity of Financial Benefits to Discount Rate and Amortization Period

An analysis of the sensitivity of the aforementioned conclusions to changes in interest rate and amortization period was undertaken. Four scenarios were assessed under the sensitivity analysis. Under the first two, the prime interest rate was lowered and raised by 1.5% to assess changes in monthly payments, with the amortization period maintained at 10 years. Under the third and fourth scenarios, the amortization period was altered to 5 years and 15 years, with the prime interest rate maintained at 6.5%.

The results indicate that the 10kW micro-hydro system continues to provide net financial savings to the customer-generator under both interest rate extremes, assuming medium to high electricity production characteristics.

The financial attributes of the 1kW micro-hydro are not improved sufficiently by changes in interest rate to provide net financial savings to the customer-generator within the 10 year amortization period.

Changes in the amortization period however, did affect the financial characteristics of the 10kW micro-hydro system. Under a 5 year amortization period, the monthly payments were between $378 and $417, while the savings remained at $195 to $273. Thus, the customer-generator will take a financial loss during the amortization period, but a payback on investment is possible after that.

In contrast, under a 15 year amortization period, the monthly payments range between $196 and $215. Thus, even those micro-hydro systems with low production characteristics will demonstrate net financial savings on a monthly basis.

The financial characteristics of the 1kW micro-hydro system appear more favorable under the long amortization period, but are still fall short of providing net financial savings to the customer-generator during the 15 year payment period.

The financial characteristics of the Solar PV and wind energy system changed under the sensitivity analysis, but in all cases, those systems did not provide net financial savings to the customer-generator.

Net Metering Program Analysis Assumptions

This analysis assumes a province-wide net metering program. The assumptions on basic program design are provided in this section, stated in a factual manner.

Eligible Customers and Technologies

- All retail customer classes are eligible for net metering, including residential, commercial, industrial, and agricultural customers.
- Technologies and resources are limited to micro-hydro, wind, and solar PV[52], due to their positive environmental attributes and their potential economic development and job creation benefits. This list of technologies corresponds with the current British Columbia Government PST Exemption on "Alternative Energy Sources"[53].
- Small-scale water velocity turbine technologies for river and tidal applications are not readily available on the market and, as such, are not included in this analysis, despite their positive environmental attributes.
- The peak capacity of the distributed renewable energy systems investigated is as high as 50kW, although there is justification for permitting systems as large as 150kW, reflecting the size of those systems eligible for the B.C. government PST Exemption**.**

Tariff Design

- The net metering rate credits the full retail rate for "net production" up to their level of "net consumption" within a billing period.
- Monthly excess generation within a billing period (e.g., two months for residential customers) can be carried-forward to the next billing period, for a maximum of one calendar year at which time it is reset with no financial compensation to the customer. This arrangement is identical to the approach in the State of Washington legislation and the Ontario Hydro program (see Appendices C and D). This feature is important to the analysis, as the resource potential is expressed in average annual units, even though many of these resources may demonstrate seasonal variations[54].

Legal and Institutional Aspects

- Customers and utilities sign simplified "boilerplate" contracts to establish net metering arrangements without requiring the services of a lawyer.
- Customer-generators are not required to purchase liability insurance associated with net metering or the use of distributed renewables.

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[52] See Appendix A for a detailed description of the technologies included in this analysis.

[53] See Appendix E.

[54] For example, many coastal micro-hydro installations have their peak production during rainy winter months with a significant reduction in power capacity during the summer. In contrast, solar PV systems produce their peak power output in the summer.

- The net metering program is limited to 0.1% of peak demand for British Columbia's system in 1998 – equivalent to about 11.36 MW.[55] Each utility can allow customer-generators to connect distributed renewables for up to 0.1% of its peak demand in 1998, available to customers on a first-come, first-serve basis.

Grid Interconnection Requirements and Costs

- Figure 1 illustrated the configuration of a net metering interconnection with the utility grid. The illustration is for a typical residential sector installation of renewables.
- The main components of the net metering interconnection are the renewable energy source (solar PV, wind, or micro-hydro), power conditioning equipment (inverter or controls), and a disconnect switch if required. The following functions must be performed by the generator, inverter, power control, and/or power conditioning equipment in order to make a grid interconnection[56]:
  - production of 60 HZ AC power;
  - synchronization (frequency) control;
  - "Islanding" protection[57]; and
  - lightning protection.
- For additional lineworker safety, a lockable, manually-operable disconnect switch should be installed between the renewable generator and the utility meter, accessible to utility staff. The cost of this switch is assumed to be $200 installed[58].
- Automatic disconnect switches[59] over and above "islanding protection" are not required[60].
- The net metering interconnection utilizes the existing bi-directional customer meter and customer service entrance panel. However, various options should be made available for metering[61]. From the meter to the utility distribution lines, the configuration is identical to an existing customer interconnection without any net metering.

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[55] Canadian Electricity Association, Natural Resources Canada "Electric Power in Canada – 1995" – gross demand is forecast at 11,364 MW for 1998.

[56] From the list provided by Ontario Hydro Retail for their Net Metering program.

[57] This is a line-activated contactor that opens when there is a loss of utility power and does not reclose for a minimum period after utility power is restored.

[58] Personal Communication, Rick Stevens of Ontario Hydro.

[59] This type of switch is similar to that required at the Solar PV installation at the British Columbia Institute of Technology (BCIT) in Vancouver, where a 1kW solar array is grid intertied with BC Hydro. The specific switch is a "low-voltage relay" which automatically senses if the grid goes down, opens the circuit when that happens, and will not re-close until it is physically switched on by the project authority (BCIT staff) or a BC Hydro employee. The switch can also be locked in an open position for extra security.

[60] A discussion about work on this issue is included in Part A under the heading "Lineworker Safety".

[61] See Appendix I for a discussion on metering options.

- Each customer-generator at each net metering site will pay for the costs of an electrical safety inspection, performed by the Electrical Safety Branch. This is assumed to be $100, reflecting the cost of time and travel of the inspector.[62] If and when the Branch gains confidence in the safety of distributed renewables and power conditioning equipment needed for utility interconnection, then it may choose to do random inspections only under existing inspection programs, thus potentially eliminating the $100 fee.
- Customer-generators are not required to pay any additional connection and/or utilization charges over and above the charges for regular customers and the above costs. Any additional costs associated with the introduction of the net metering rate are absorbed by all utility customers equally and/or the utility shareholders[63].

[62] Personal Communication, Rick Stevens of Ontario Hydro.

[63] This assumption is only made for the purposes of the analysis.

Estimate of Customer Uptake of Net Metering

This section provides an estimate of the number of customers who would participate in a net metering program of the type described at the beginning of Part B if it were available in British Columbia. This is referred to as the “customer uptake” of net metering.

Customer participation will also be influenced by program design. In general, customer uptake of a prospective net metering program will reflect:

- consumer awareness of net metering options, renewable energy technologies, and financial and non-financial benefits of renewable energy;
- technology availability and cost;
- financing rates and terms;
- ease of implementation; and
- the design of net metering tariffs (which affects potential magnitude of monthly savings on historical utility bills).

In a previous section it was demonstrated that only micro-hydro systems have attractive financial characteristics. In contrast, solar PV and wind power investments do not have strong financial characteristics. Thus, customer purchases of these technologies for net metering would be as a result of the accrual of non-financial benefits (see Part A) which are also shared by micro-hydro installations.

The estimate of customer uptake is provided as a range of the possible number of customer connections, differentiated by technology, expressed in two extremes, “high uptake” and “low uptake”.

The low estimate of customer uptake reflects a level of uptake that might be expected under the following conditions:

- a program that offers a simple net metering tariff with no proactive customer education or marketing efforts;
- capital costs tending to the higher estimates in this paper;
- limited financing options; and
- limited customer awareness of and/or willingness-to-pay for non-financial benefits.

The high estimate of customer uptake reflects a level that might be expected under the following conditions:

- an aggressive and coordinated marketing program (with support from renewable energy advocates), with information widely available via the Internet, utility offices, retail outlets, electricians, tradeshows, magazines, trade journals, among others;
- capital costs tending to the lower estimates in this paper (e.g., through bulk purchasing and distribution channels);
- capital financing at favourable rates and terms;

- technologies widely available, and tested and certified by the utility (under a new product certification label), the Canadian Standards Association, or Underwriters Laboratory (UL) to ensure customer product satisfaction, safety, and reliability;
- equipment designers, suppliers, installers, and maintenance people trained and certified under independent programs;
- simple and favourable net metering tariffs and interconnection standards; and
- widespread customer awareness of and/or willingness-to-pay for non-financial benefits.

In order to assess the potential customer uptake of a net metering program in British Columbia, some assumptions need to be made on utility customers' investment behavior with respect to purchasing distributed renewable energy technologies. These assumptions are listed in Table 7.

The actual customer uptake of the Toronto Hydro (TH) and Ontario Hydro (OH) net metering programs is used as a guide for estimating the low customer uptake of solar PV and wind. The TH/OH programs have no financing options available, are not widely publicized or marketed, and do not include accompanying educational initiatives. Also, OH/TH have not certified suppliers or invested funds to facilitate capacity building in the distributed renewable energy sector. Although the retail electricity rates in Ontario are almost double those in British Columbia, they do not sufficiently improve the financial characteristics of the solar PV or wind energy systems to facilitate net financial savings on the part of customer-generators. Thus, the customer uptake characteristics in Ontario are assumed to be applicable to British Columbia.

The low customer uptake estimate for micro-hydro is based on a fixed percentage of the technical potential, given that micro-hydro demonstrates positive financial attributes.

The customer uptake of the SMUD PV Pioneers II program is used as a guide for the high customer uptake estimate of solar PV as that program includes all of the optimal program characteristics outlined above. The SMUD program is explained in Appendix B.

For wind and micro-hydro, the assumptions for the low customer uptake estimate are multiplied.

Table 7 –Assumptions on Customer Uptake

Low Customer Uptake Estimate	High Customer Uptake Estimate
About 40 residential and commercial consumers will purchase solar PV systems for purely non-financial reasons over 5 years[64].	Up to 2600 residential and commercial consumers will purchase solar PV systems for purely non-financial reasons over 5 years[65].
About 15 residential and commercial customers will purchase wind systems[66]. 10 of them will develop 10kW systems and five will develop 25kW systems.	Up to 30 residential and commercial customers will purchase wind systems.[67] 10 of them will develop 10kW systems and five will develop 25kW systems.
25% of the micro-hydro potential will be developed in the province by residential, commercial, agricultural, government or institutional electricity consumers. The remaining potential will not be developed because of lack of awareness of net metering options, consumer transience (frequent moves), unfamiliarity with the technology, implementation costs, the hassle factor, or other investment barriers[68].	Up to 50% of the micro-hydro potential will be developed because of the additional net metering program features. The full potential is still not achieved because of other market failures which preclude all consumers from undertaking sound financial investments.
Industrial sector customers will not participate in net metering programs[69].	Industrial sector customers will not participate in net metering programs.

The expected customer uptake is outlined in the table below for each scenario. Energy production is assessed in kilowatt-hours per year, using the average production characteristics of the distributed renewables. For solar PV, this is assumed to be 3.7 equivalent operating hours per day, wind energy, 25% capacity factor, and for micro-hydro, 60% capacity factor.

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64 The Toronto Hydro net metering program had 6 customer-generators sign up in the first year, among a population of about 1 million people. Using the BC population of 4 million, assuming that the customer uptake is maintained over five years, the estimate for B.C. is 120.

65 This assumption is based on the current uptake of the SMUD PV Pioneers II program which had 175 customers signed up in the first year among 430,000 residential customers. Thus, among B.C.'s 1.5 million homes, one could expect an uptake over 5 years of 175 systems x 5 years x 3 times the population = 2600 systems.

66 Ontario Hydro had 3 wind turbine installations in the first year. The wind regime characteristics are by no means optimal. Given that Ontario Hydro Retail does not serve many urban loads (as they are currently served by municipal utilities), one could assume that the number of rural households served by OH Retail are less than or about the same as those in British Columbia. Thus, this figure is multiplied by 5 to reflect the 5 year analysis period.

67 Double the low customer uptake estimate.

68 Author's assumption.

69 The justification is because: (a) industrial rates are lower than those utilized in the financial analysis; (b) industrial customers face competitive markets for their commodities, thus cannot afford higher discretionary costs than their competitors; and (c) industrial sector electricity consumption typically exceeds the cap on distributed renewables capacity of 150kW, meaning that they would not be "net metering" at all – they are always consuming 100% of the renewable electricity and not feeding any excess power to the grid.

Table 8 – Estimate of Customer Uptake of Net Metering and Annual Electricity Production from Distributed Renewables

Low Customer Uptake Estimate	High Customer Uptake Estimate
Solar PV	Solar PV
40 Systems 500 Watts x 40 systems x 3.7 hours/day Production = 74 kWh / year	2,600 Systems 500 Watts x 2,600 systems x 3.7 hours/day Production = 4,810 kWh / year
Wind Power	Wind Power
15 Systems 10 x 10kW systems and 5 x 25kW systems 10 kW x 25% capacity factor x 10 systems x 8760 hours per year = 219,000 kWh / year 25 kW x 25% capacity factor x 5 systems x 8760 hours per year = 274,000 kWh / year TOTAL = 493,000 kWh / year	30 Systems 20 x 10kW systems and 10 x 25kW systems 10 kW x 25% capacity factor x 20 systems x 8760 hours per year = 438,000 kWh / year 25 kW x 25% capacity factor x 10 systems x 8760 hours per year = 548,000 kWh / year TOTAL = 986,000 kWh / year
Micro Hydro	Micro Hydro
25% of 1500 sites[70] for 1kW system = 375 systems 1 kW x 60% capacity factor x 375 systems x 8760 hours per year = 1,971,000 kWh / year and 25% of 1500 sites for 10kW system = 375 systems 10,000 Watts x 60% capacity factor x 375 systems x 8760 hours per year = 19,710,000 kWh / year TOTAL = 21,681,000 kWh / year	50% of 1500 sites for 1kW system = 750 systems 1,000 Watts x 60% capacity factor x 750 systems x 8760 hours per year = 3,942,000 kWh / year and 50% of 1500 sites for 10kW system = 750 systems 10,000 Watts x 60% capacity factor x 750 systems x 8760 hours per year = 39,420,000 kWh / year TOTAL = 43,362,000 kWh / year
Total Production from Distributed Renewables	**Total Production from Distributed Renewables**
22,174,074 kWh / year	**44,352,810 kWh / year**

[70] Based on the numbers in the resource potential section.

Utility Costs and Benefits

The interconnection of net metered renewables to the utility grid could impose costs on the electrical utility and other ratepayers. A list of these potential subsidies associated with a net metering program were provided in Part A in a section entitled *Key Barriers to the Establishment of Net Metering in British Columbia and Possible Responses*.

The potential benefits of a net metering program to electric utilities and their ratepayers was also outlined in Part A in a section entitled *Electric Utility Benefits of Net Metering*.

A quantification of these potential subsidies and barriers is beyond the scope of this paper. The assessment would have to consider the following factors:

- allocation of transmission and distribution asset costs to residential and general service ratepayers;
- electricity production characteristics of distributed renewables (potentially resulting in benefits or costs to the utility);
- cost and/or value of electricity at different times of the day;
- the electricity consumption characteristics of prospective customer-generators;
- the geographic distribution of prospective customer-generators;
- the administration and marketing costs of a net metering program;
- education programs on distributed renewables;
- the costs and benefits of developing and analyzing demonstration sites for distributed renewables; and
- the value of environmental benefits to the utility and its ratepayers.

If a utility were interested in developing a net metering program, then they would be in the best position to assess these costs and benefits, and should do so as part of a business case for net metering.

If the government or regulator were to impose net metering on the utilities in British Columbia, then they would be presumably doing so because of the social and environmental benefits of such a program, partly estimated in the following section. However, it is important that they compare the relative financial and institutional merits of net metering against other types of initiatives to foster renewables.

Social Benefits

Two specific benefits of the prospective net metering program outlined in Part B are described in this section – greenhouse gas emission reduction and job creation benefits. This assessment is based on the range of potential customer uptake of the prospective net metering program.

Greenhouse Gas Reduction

The environmental benefits of net metering could include greenhouse gas (GHG) emission reduction, improvements in local air quality and reduced impact on watersheds associated with existing large hydroelectric facilities.

For the purposes of this paper, it is assumed that customer-generators are offsetting the construction and operation of new natural gas-fired generating plants. Although 95% of the current electricity supply in British Columbia is from hydroelectricity which produces little or no greenhouse gas emissions, there is little opportunity for expanding that existing supply to meet growth in electricity demand in a cost-effective manner. Also, natural gas plants currently offer levelized production costs (including capital, O&M, and fuel costs) below those of new hydroelectric projects[71]. Thus, it is expected that the vast majority of new electricity supply in the province will be derived from natural gas.

The main environmental impact of utilizing natural gas is greenhouse gas emissions. Other environmental impacts are minor at the point of electricity production[72]. The GHG emissions from a typical combined-cycle natural gas combustion turbine plant, such as the proposed Burrard Thermal expansion, is about 400 tonnes of CO_2 per GWh of electricity produced[73].

The estimated GHG emission reductions that would result from the customer uptake of net metering described above are illustrated in Table 9. These are expressed in tonnes of CO_2. If the particular distributed renewable energy system reduces electricity and heating needs, then it is possible that larger GHG emission reductions can be accrued.

Table 9 – Greenhouse Gas Emission Reductions

Low Customer Uptake Estimate	**High Customer Uptake Estimate**
Annual customer-generator production: 22.174 GWh per year	Annual customer-generator production: 44.353 GWh per year
22.174 GWh x 400 tonnes/GWh = 8870 tonnes of CO_2	44.353 GWh x 400 tonnes/GWh = 17,741 tonnes of CO_2

The GHG emission reduction benefits of 9-18 kilotonnes per year are small relative to other options in the energy sector. For example, a single biomass cogeneration system that was

71 Content from this paragraph is referenced in the BC Hydro 1995 Integrated Electricity Plan.

72 However, the life-cycle environmental impacts of natural gas exploration, extraction, processing, and transportation include deforestation for exploration, road, and pipeline construction and maintenance, local air quality impacts from sour gas in some cases and fugitive methane emissions in the transportation of natural gas. Given that these impacts are difficult to quantify, and that such an effort is beyond the scope of this paper, those aspects are not analyzed in this paper.

73 Source: BC Hydro.

installed in Powell River is expected to reduce about 127 kilotonnes per year, the majority through reduced consumption of natural gas[74].

Job Creation Benefits

Investments in energy supply systems create jobs. Different technologies tend to have different results on employment creation. The Pembina Institute, in a report for Environment Canada (1998), summarized the job creation benefits of alternative energy sector investments. All benefits were equated to permanent full-time equivalent positions per million dollars spent. Some of the results were as follows.

- Solar – 14 full-time equivalents (FTEs).
- Wind – 8 FTEs.
- Micro-hydro – 8 FTEs.
- Natural gas plant – 4 FTEs.

The job creation impacts will depend on the amount of investment monies that will be induced as a result of the program. The total spending and job creation benefits are listed in Table 10 below. For the "low customer uptake estimate", the current retail price of equipment is used, net of GST, inspection fees and the cost of manual disconnect switches. For the "high customer uptake estimate", lower capital costs figures are used, as outlined in Table 2.

Table 10 – Employment Creation Benefits

Low Customer Uptake Estimate	**High Customer Uptake Estimate**
Solar PV	
\$8340/system x 40 systems = \$0.3 million \$0.3 million x 14 FTE/\$1M = 4 jobs	\$3993/system x 2,600 systems = \$10 million \$10 million x 14 FTE/\$1M = 140 jobs
Wind Power	
\$53,300/system x 10 systems x 8 FTE/\$1M = 4 jobs \$64,900/system x 5 systems x 8 FTE/\$1M = 3 jobs TOTAL = 7 jobs	\$50,400/system x 20 systems x 8 FTE/\$1M = 8 jobs \$61,334/system x 10 systems x 8 FTE/\$1M = 5 jobs TOTAL = 13 jobs
Micro Hydro	
\$3,270/system x 375 systems x 8 FTE/\$1M = 10 jobs \$17,500/system x 375 systems x 8 FTE/\$1M = 53 jobs TOTAL = 63 jobs	\$2,933/system x 750 systems x 8 FTE/\$1M = 18 jobs \$15,740/system x 750 systems x 8 FTE/\$1M = 94 jobs TOTAL = 112 jobs

The estimated employment creation benefit of a net metering program is thus is estimated to be between 75 and 265 full-time equivalent jobs. However, there is no guarantee that these jobs will remain in British Columbia. Employment benefits are distributed among the following: research and development; technology manufacturing; system design, sales, and installation; system maintenance. In the case of micro-hydro systems, a large number of jobs could be created in

[74] http://www.gert.org

British Columbia because of the strong existing capacity in all of those areas.[75] In contrast, wind and solar PV manufacturing is currently concentrated in the U.S. and Europe, but design, sales, installation, and maintenance jobs would likely be created in B.C..

[75] See the discussion in Part A.

Summary of Uptake and Benefits

The customer uptake and social benefits of undertaking a net metering program in British Columbia are outlined in the table below.

Table 11 – Societal Benefits of Net Metering

System Type	Estimated Customer Uptake (# of systems)		Estimated Annual Production (kWh / yr)		Estimated GHG Reductions (tonnes / year)		Estimated Job Creation Benefits (Full-time Equivalents)	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Solar PV 500W	40	2,600	74	4,810	0.03	1.92	4	140
Wind 10kW	10	20	219,000	438,000	87.6	175.2	4	8
Wind 50kW	5	10	274,000	548,000	109.6	219.2	3	5
Micro-Hydro 1kW	375	750	1,971,000	3,942,000	788.4	1,576.8	10	18
Micro-Hydro 10kW	375	750	19,710,000	39,420,000	7,884	15,768	53	94
TOTAL	805	4,130	22,174,074	44,352,810	8,869.63	17,741.12	74	265

Part C: Policy Issues

Merits of Net Metering Policy for Supporting Distributed Renewables

This paper is focused on distributed renewable energy technologies (renewables). There are several renewable energy technologies that do not fit into this class, and are thus not considered in this paper.

Net metering is one of several mechanisms that can be introduced to support the development of distributed renewables. It is a relatively straightforward approach that utilities could undertake to support renewables, as the majority of the effort for purchasing and utilizing renewables is on the part of the customer-generators. An alternative approach to promote distributed renewables would be through utility programs which install and maintain technologies at customer premises, similar to the SMUD PV Pioneers I program where residential customers pay US$4 per month for 10 years to have a utility-owned solar PV system installed at their house[76].

Currently in British Columbia, there is neither a net metering program nor a utility-driven program to facilitate the interconnection of distributed renewables, with the exception of the BCIT solar PV demonstration site. Overall, there is no market in British Columbia associated with distributed renewables for grid intertied applications because of the lack of such programs. The West Kootenay Power green rate has, to date, only focused on large-scale wind energy technologies and may focus on non-distributed hydroelectricity.

If policymakers are interested in promoting distributed renewables for grid applications, either a net metering rate or a utility program will need to be introduced. Otherwise, the distributed renewables market will remain stagnant as it currently is for grid applications.

This paper does not take a position that net metering is superior to utility driven mechanisms because there has been no effort here to study those possibilities, nor to assess the disadvantages of net metering relative to those mechanisms. However, there are several considerations outlined below which could be used to build a case for net metering. They are broadly focused on: (1) the merits of the private-sector focus of net metering; (2) that utility benefits for each distributed renewable installation are small relative to other options, but the customer-generator benefits are potentially significant; and (3) that the installation and maintenance of distributed renewables is best undertaken at a grass-roots level rather than by utility personnel.

Net metering is a private-sector, consumer-based mechanism. Currently, an extensive consumer market is established for renewable energy technologies for remote power applications. In British Columbia alone, there are already a number of profitable full service companies that offer renewable energy products and services for remote and mobile power applications.[77] They advertise through their communities, through the Internet, in the yellow-pages under Solar Energy, in trade journals[78], and at tradeshows. These companies have established distribution

[76] http://www.smud.org

[77] Appropriate Energy Systems, Energy Alternatives, Northern Alternative Energy Systems, Powersource, Solar Plus, Soltek, Sovran, Sunfire, Sunwind.

[78] Electrical Line, Cottage Magazine, Home Power, Harrowsmith, Sol, Windsight.

networks in place that could be conducive to promoting distributed renewables for grid applications. The remote power technologies that they are currently promoting include solar PV, small wind, micro hydro, controls, power storage, inverters, and end-use technologies. They have an abundance of experience with the technical aspects of renewable energy for remote power. Although there are some additional technical complications associated with grid interconnection, these companies could quickly gain knowledge on those issues through the publication of clear guidelines for grid interconnection by the utility. In summary, it would be relatively straightforward for those existing companies to serve a potential distributed renewables market through net metering.

From the utility perspective, the benefits of individual distributed renewable energy systems are small as was evidenced in the Part B scenario analysis. Relative to other options in the municipal, transportation, forestry, and industrial sectors, the greenhouse gas reduction and financial benefits are small from distributed renewables. In contrast, the benefits to an individual customer-generator can be quite large – in terms of power savings, financial benefits, social benefits (through recognition for being environmentally conscious citizens), and others.

Also, once in place, net metering imposes little capital or operating expense on the utility. Net metering has minimal impact on core utility business because on-going maintenance is the customer's responsibility.

There are several characteristics of distributed renewables that makes their installation and maintenance more conducive to a customer-based mechanism than a utility-based mechanism.

Solar PV modules and power inverters are small, consumer-oriented technologies, which have "plug-and-play" characteristics, something that a consumer can install on their own without needing the services of an electrician, utility employee, or other professional person. The cost of doing the actual installation is negligible for a building owner, but would require up to one-half a working day per site for a utility employee or sub-contractor. PV systems have no maintenance requirements except to remove snow off of the PV modules in the winter.

Wind and micro-hydro systems should be installed by a contractor, presumably by one of the experienced companies that already serves the remote power market, or by an ticketed electrician. Micro-hydro and wind systems require periodic maintenance that are best done by the customer-generator and would be far too costly for a utility employee or sub-contractor to undertake. Some of these maintenance tasks are outlined in Part B in the section on operating and maintenance costs.

Overall, net metering offers several opportunities for promoting the deployment of distributed renewables.

Net Metering Implementation Mechanisms

Net metering is ultimately offered to electricity consumers through the implementation of an electric utility or retailer rate / tariff which enables customers to intertie distributed renewables to the electrical system and receive financial credit for their excess generation.

However, from a policy perspective, there are a number of approaches that have been undertaken in jurisdictions around that world that have ultimately facilitated the introduction of a net metering rate / tariff. These approaches are broadly categorized as:

1. legislated requirements on all electricity transmission and distribution companies;
2. ministerial directions on crown-owned utilities;
3. utility commission orders and special directives; and
4. voluntary electric utility initiatives, without government policy drivers.

These approaches are all described in the following sections.

Legislated Programs

The recent trend in the U.S. for introducing net metering is through state legislation. Eight states have enacted net metering laws, most of them in the last two years - California, Hawaii, Maryland, Minnesota, Nevada, New York, Vermont and Washington. Legislation is proposed in Virginia and New Jersey. Net metering programs established by state law are applicable to all utilities in the state, regardless of whether a utility is under the jurisdiction of the state utility commission[79].

A variation on this is through national legislation. Net metering has been implemented nationally in Germany and Japan, and is being considered for the U.S. under President Clinton's bill for restructuring the electricity market and reducing greenhouse gas emissions.

The main benefit of this approach is its competitive neutrality. Many jurisdictions are opening their markets to retail competition where customers can choose among a number of retail electricity suppliers including brokers that do not own electricity facilities. Under state-wide legislation, all retail electricity suppliers are required to offer net metering to customers regardless of the market structure, degree of deregulation of the sector, or the individual preferences of utilities.

Another benefit of legislated programs is their potential for limiting additional barriers to the successful implementation of net metering connections. Several barriers are identified in Part A which have hindered net metering programs in various jurisdictions. Recently legislated programs in California, New York, and Washington have explicitly addressed many of those barriers through legislation.

The main disadvantage of the legislated approach is related to the challenges of passing the legislation through the political process, which is often highly adversarial and drawn-out. Certain special interest groups will inevitably oppose net metering due to the potential cost impacts of the policy on the overall system (despite the social and environmental benefits) or the threats that net

[79] Wan, Yih-huei; and Green, James. 1998.

metering poses on traditional vertically-integrated utilities and their conventional electricity supply technologies and resources.

Another disadvantage of this approach is that electric utility staff may not be supportive of net metering and may introduce additional barriers to its successful implementation that the legislation does not address. Thus, it is important that relevant electric utility staff work closely with government to develop the legislation prior to its proclamation.

Ministerial Direction

A Ministerial Direction is appropriate for those jurisdictions that have Crown-owned electric utilities. It appears that Manitoba is an example of a jurisdiction with a ministerial order. In this case, the government requires the Crown-owned, electric utility to offer a net metering tariff without legislation or a special direction to the electricity regulator if one exists.

The main advantage of this approach is the ease of implementation – the government is accountable to all voters, but also has the authority to set policy within the electric utility if Crown-owned or the electricity market as a whole if it is regulated. Thus, if the government cabinet believes that net metering is in the public interest, they may consider requiring net metering.

This approach is possible in the Yukon, Northwest Territories, British Columbia, Saskatchewan, Manitoba (as demonstrated), Québec, New Brunswick, and Newfoundland.

Some disadvantages of this approach are:

- Private or municipally-owned utilities in those jurisdictions are not required to offer net metering under an order, but could be requiring to do so through a special direction to the regulator if it exists.
- Utility staff may not be supportive of the Ministerial Direction and may introduce barriers to the successful implementation of net metering.

Utility Commission Mandated Programmes

Historically, net metering programs in the U.S. were most frequently implemented as a result of public utility commission (PUC) orders following regulatory processes such as stakeholder hearings or PUC special directives. PUC driven initiatives are in place in 14 states including Arizona, Connecticut, Idaho, Indiana, Iowa, Maine, Massachusetts, New Hampshire, New Mexico, North Dakota, Oklahoma, Rhode Island, Texas, and Wisconsin. PUC orders only apply to utilities that are rate-regulated by the PUCs. Since many U.S. states do not rate-regulate rural electrical cooperatives, the net metering option is not available for rural customers unless the rural electrical cooperative voluntarily offers a rate option as do many in Wisconsin[80].

This approach may be possible in British Columbia, Alberta, Ontario, Québec, and Nova Scotia, all jurisdictions which have PUCs regulating the major electric utilities.

The main advantage of implementing net metering through PUC orders is that any stakeholder can launch a complaint to the PUC in order to advocate a net metering policy, and their case will be heard if they are a recognized and credible stakeholder group. However, that does not mean that the PUC will necessarily order retail utilities to implement net metering. That depends on the

[80] Wan et.al., 1998.

outcome of the regulatory process (i.e., hearing or negotiated settlement), the amount of opposition from other stakeholder groups, and the political orientation of the PUC commissioners.

The disadvantages of this approach are as follows.

- PUC processes are often adversarial, highlighting negative aspects of cases rather than working to achieve consensus on a preferred approach.
- The PUC can only order regulated electric utilities to implement net metering – missing many electrical cooperatives, municipal utilities, First Nations utilities, or certain crown-owned utilities.
- A PUC order does not always specify the parameters or requirements for net metering – as such, many electric utilities in the U.S. have imposed cumbersome requirements on customers to do net metering (e.g., see Part A on barriers), in some cases reversing many of the financial and technical benefits of net metering.

Voluntary Electric Utility Initiatives

Several electric utilities have voluntarily offered a net metering tariff without legislation, a Ministerial Direction, or a PUC order. Utilities that have done this include Ontario Hydro, Toronto Hydro, Manitoba Hydro (although probably resulting from a Ministerial Directive), the Public Service of Colorado Company, Public Service of New Hampshire, and the PECO Energy Company.

The advantages of this approach are as follows:

- The utility has access to many marketing tools to encourage customer uptake of net metering (e.g., bill stuffers, customer profile information, mailing lists, decentralized regional offices and human resources, and others).
- The specifications of the program would presumably reflect the technical and administrative requirements of the utility, not externally mandated specifications which could be incompatible with the utility mode of operation.
- The utility could provide or arrange financing to customers to purchase and install distributed renewables.
- The utility could acquire renewable energy credits for emerging renewables markets or for marketing “green power” to non-net metered customers.

A disadvantage of this approach is that the utility may be overly conservative about setting interconnection standards, requiring additional safety equipment, imposing additional charges on net metering customers, or other transactional barriers. Thus, an important element of net metering tariff development is to incorporate stakeholder, regulator, and government feedback, to ensure that utility requirements aren’t overly cumbersome for customer-generators to comply with.

Part D: Conclusions and Recommendations

1. *Benefits of Distributed Renewables.* The use of distributed renewables can offer a variety of benefits including environmental benefits such as greenhouse gas emission reduction and local air quality improvements, social benefits such as economic development and job creation, and potential utility/customer benefits such as environmental stewardship and potential cost reductions in non-integrated areas which are currently supplied by diesel.
2. *Benefits of Net Metering.* Net metering could enhance the market for distributed renewables in British Columbia. Net metering facilitates system capital cost reductions, customer utility bill reductions, and technical simplicity, relative to those situations where net metering is not in place. For utilities, facilitating net metering can help to improve public support and customer satisfaction. Net metering empowers people, businesses, and organizations to reduce their environmental impacts, something that retail businesses can publicize to gain customer support. The private-sector focus of net metering could build on the expertise of existing market players for remote and mobile power applications. Finally, the characteristics of distributed renewables are often more conducive to customer installation and maintenance rather than full implementation by utility personnel.
3. *Resource Potential.* The total renewable resource potential under net metering is between 308 – 879 GWh/year, about 0.5 – 1.5% of current BC Hydro sales. Financial costs and other barriers would likely limit customer uptake to 3% - 14% of this resource potential. The most economical net metering resource from a customer perspective are micro-hydro installations. Based on the figures from the analysis, these systems would account for over 98% of likely generation under a net metering program in the province, and would provide between 42 – 85% of the job creation benefits, and 98% of the GHG reduction benefits anticipated under net metering. A net metering program targeting micro-hydro may provide the greatest net customer, utility and social benefits for the province.
4. *Lineworker Safety.* As illustrated in other jurisdictions, utility concerns regarding lineworker safety can be addressed through various forms of islanding protection and prevention technologies, including manual disconnection switches. Several stakeholders should be involved in establishing reasonable protection standards. Exchanges of information with personnel in other jurisdictions may be required to fully overcome these concerns and improve awareness of protection systems. Education of building and electrical inspectors will also be required.
5. *Cross-Subsidies.* It is possible that some cross-subsidization by non-participating customers will occur. Most net metering programs credit customers at existing bundled retail rates. These rates typically include a variety of fixed costs and do not necessarily reflect the time-varying cost/value of grid-supplied generation. However, there are numerous cross-subsidies implicit in existing retail rates. For example, average rates reflect the average load factor of a customer class. Furthermore rates do not vary by location. These cross-subsidies have been generally accepted, either because the cost of eliminating them outweighs the benefits, or because they are acceptable on the basis of social or environmental policy. Although the potential magnitude of cross-subsidies from net metering is unknown at this time, they can be capped by limiting participating in net metering programs. However, it would be useful to estimate upper and lower bounds for the subsidy to better inform stakeholders and policy makers, and allow an explicit judgment of whether the subsidy is justified by the social and environmental benefits.

6. *Customer Uptake.* If a net metering program is implemented in B.C., customer uptake can be enhanced by incorporating the following program elements: simplified rate structures and contracts, transparent interconnection standards, crediting the retail rate for excess generation up to the level of customer consumption within a year, offering financing mechanisms, certifying technologies and installers, educating stakeholders on the technologies and net metering, and making efforts to internalize the environmental and social costs of conventional electricity supply in market prices to provide better price signals for distributed renewables.

7. *Method of Implementation.* Net metering policy could be implemented either through government policy or voluntary utility action. Government policy could take the form of legislation, ministerial directive or special directive to the BC Utilities Commission. Most other jurisdictions have utilized legislation or commission orders. However, the success of a net metering program relies on utility cooperation. If special orders, directives or legislation are to be used, consideration should be given to involving renewable energy professionals, utilities unions, regulators, and other stakeholders in the development of program requirements.

8. *Policy Consideration.* This analysis has demonstrated that net metering can provide several benefits to electricity consumers, electric utilities, and society as a whole. The only benefits that were quantified were job creation and greenhouse gas (GHG) emission reductions. The analysis indicates that the employment creation benefits could be large, depending on the magnitude of customer uptake, which is linked to the program design. However, on a provincial basis, the greenhouse gas emission reduction benefits of net metering are small relative to other options. For policymakers to maximize GHG reductions, net metering could be integrated into a broader package of mechanisms to support renewables or facilitate GHG emissions reductions.

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Appendix A - Technology Description

The renewable energy generation technologies (renewables) or systems that are appropriate for net metering are briefly described in this section. Given that technologies change so frequently, it was felt that a more detailed investigation is inappropriate. In Part B, several generic systems are outlined along with current pricing.

Each is associated with a specific renewable energy resource, specifically solar radiation, wind energy, and water power. For each renewable energy source, the configuration of a generic system is described as well, including necessary interconnection equipment.

The main reference for these descriptions is Energy Alternatives (1998).

Solar Photovoltaics with Inverters

Photovoltaic (PV) modules convert solar radiation into direct current (DC) electricity They consist of solar PV cells wired together on a thin panel. There are no moving parts in PV modules and little maintenance is required. They are very modular (easily expandable), portable, and durable. They have a long warrantee as well (10-25 years).

PV modules produce electricity in proportion to the amount of sunlight falling on them. Modules' power output, electrical current and voltage is usually rated for standard solar radiation conditions – about 1000 Watts of radiation per square meter of surface area impacted at 25°C. For example, a typical module on the market with dimensions of 52" x 23" x 1.5" will produce 4.7 amps at 17 Volts DC (about 80 Watts) in those sunlight conditions.

There are a few variations of the modules with respect to dimensions, power output, and the type of solar cell:

- Dimensions range from 1-4 ft long by 1-2 ft wide. They are usually less than 2 inches thick.
- They are typically wired in a configuration that results in a nominal voltage of 12 or 24 volts and power output of 5 – 120 Watts. This range is ideal for remote power use, battery charging or for providing a component of a net metering system. All modules produce direct current power, although some PV companies are selling modules with integrated inverters on their backside. It is possible to connect several modules together to form an array. The largest solar array in the world, in Munich, is 1,1016 kW, presumably containing about 10,000 solar PV modules.
- The types of cells which make up PV modules include: single-crystal silicon cells, multicrystalline silicon cells, amorphous silicon cells, and other thin-film cells:
  (1) Single crystal silicon cells are extremely thin wafers cut from a single silicon crystal. These are the most efficient solar cells and have a life expectancy exceeding 25 years.
  (2) Multicrystalline silicon cells are extremely thin wafers cut from multiple crystals grown together in an ingot. They are slightly less efficient than single crystal cells and thus require more surface area to produce a given amount of electricity. They are also less expensive.
  (3) Amorphous silicon cells are made by depositing a micro thin layer of silicon onto a sheet of glass or other substrate. These are the least efficient and typically only last 5-10 years before their output begins to diminish. They can be mounted on flexible backing.
  (4) Other thin films are similar to (3) above, but use materials other than silicon.

PV modules are usually installed on rooftops of buildings using mounting frames, usually facing south in the northern hemisphere, at an angle that is perpendicular to the sun at noon. Midday is the approximate time that the solar radiation is at its daily peak. It is also possible to integrate PV cells/modules within building materials – rooftop shingles, wind materials, cladding, or other products. Finally, some utilities have installed centralized PV power plants in areas with substantial solar radiation although that is not suitable for net metering.

PV modules are fragile but highly reliable. Because solar radiation is not available at night, net metering is ideally suited to PV systems, as excess power can be produced and banked during daytime hours and consumed at night.

Solar PV systems require an inverter which converts the DC power coming from the solar module/array to 60HZ alternating current (AC) power that can be integrated and synchronized with the grid. The availability of inverters in North America that are appropriate for using with PV-grid interconnections are limited to sizes of 100 Watts, 2500 Watts, 4000 Watts, and 5500 Watts.[81] However, multiple inverters can operate in parallel, giving customers more flexibility. The inverter must provide multiple functions for a successful grid interconnection. These are listed in the grid interconnection requirements in Part B. If the inverter doesn't contain all those features, additional control or power conditioning equipment is required.

Wind Generators with Inverters

Wind generators convert moving air into electricity – catching it with blades (like aircraft wings), transferring that motion to a rotating shaft, and driving a generator that produces electricity.

Wind generator ratings varies from 100 Watts to more than one megawatt. The ones appropriate for net metering start at 1500 Watts up to about 80 kW. The power rating refers to the maximum power output under ideal wind conditions, usually around 28 mph (45 kmh). However, wind generators don't output their peak power at all hours of the day. The wind will inevitably fluctuate – resulting in a lower than 100% "capacity factor" for the output of the wind generator. The capacity factor refers to the amount of electricity that the wind system produces over a given period of time compared to its potential if it were running at full output all of that time[82]

The "capacity factor" refers to an equivalent percentage of time that the generator is producing its maximum output, considering the wind energy resource and maintenance down time. Thus, it may be producing its full power potential for part of the year, and none at other times of year, but all energy production in a year can be translated to a single capacity factor that reflects the average. Wind generators' capacity factors range from 15% to 40%.

Other than size and power output, wind technologies vary mostly in the type of generator they use.

Larger wind turbines use induction generators that produce 60HZ AC power directly to the grid with fixed speed generators. Others working with adjustable speed drives (inverters) can rotate at different rates to reflect different wind conditions, operating more efficiently than fixed speed generators because they are able to tap into energy sources at lower wind speeds.

[81] The 100 Watt and 4000 Watt inverters can be used directly with a PV array, without a battery, and provide maximum power-point tracking from the PV array – adjusting the voltage to maximize the amount of power (watts) feeding the grid. The other inverters require a small battery bank to stabilize the voltage coming from the PV array (12-14 volts).

[82] Nick Sagrillo. Home Power Magazine #65, 1998.

Smaller wind turbines produce DC power (12-48 Volts), requiring a small battery to smooth out the power production and an inverter to produce 60 HZ AC power. The inverter produces AC power and synchronizes with the grid.

The combination of the generator, inverter in some cases, and/or control system must perform the functions listed in Part B on grid interconnection requirements.

Wind generators are typically installed in locations with average wind speeds greater than 8 mph (13 km h) and where wind impacts are visible through vegetation deformation. Turbines are usually mounted on towers above objects which can have detrimental impacts on wind speed and /or create turbulence such as buildings, trees, hills, etc. Installation requires structural skill and knowledge. Wind energy technologies require some maintenance- replacement of bearings and periodic maintenance /cleaning of the blades.

AC Micro-Hydro

Micro-hydro systems produce power from the gravity-induced movement of water in streams. The majority of smaller systems produce electricity via a “impulse turbine” that runs a generator to produce 60 HZ AC power.

Micro hydro systems include the following components:

- Intake structure – a simple diversion structure in a stream such as a weir allows water to flow in and debris (twigs, leaves, etc.) to float/settle.
- Pipeline – water is carried downhill via a pipeline that is rated for the pressure of water (varies with the vertical drop in the system) – made from PVC, polyethylene, steel, aluminum or other piping.
- Turbine – at the end of the pipe a wheel is turned from the force of the water. This turbine is typically made of a bronze alloy material. Pelton turbines are like spoons on a wheel while turgo turbines are larger and more rounded, used for higher water volume conditions. Turbines can utilize the water pressure from as little as 10 feet of vertical drop (head) to a thousand feet.
- Water control nozzles – different turbine nozzles are often used to adapt to changing water conditions or variations in power demand. On a seasonal basis, nozzles will need to be adjusted to reflect different water flow regimes.
- Generator – the generator produces electricity via a rotating shaft attached to the turbine. Induction generators are typically used for net metering systems, requiring grid-provided electrical excitation to operate.
- Intertie protection – an electronic device maintains power quality and provides islanding protection for large micro-hydro systems.

Micro hydro systems can produce any range of power outputs, from 50 Watts to hundreds of kilowatts or more. The power production varies directly with the product of the head (vertical drop) and water flow (the volume of water per unit time).

Routine maintenance on intake trashracks/screens and equipment bearings is necessary.

Appendix B - Detailed Descriptions of Certain Initiatives

Ontario Hydro / Toronto Hydro

Ontario Hydro (OH) established a net billing (same as net metering) pilot project in 1997 and Toronto Hydro (TH) followed with a virtually identical pilot. Appendix C includes the program materials.

The main objective of the OH program is, "… to help Ontario Hydro Retail understand the operation of small-scale distributed generation with the existing electrical system". It is part of OH's Renewable Energy Technology Program. Another objective is as follows – "working with the renewable energy industry in Ontario, and representative associations, Ontario Hydro is assisting in the development and marketplace acceptance, of renewable energy technologies" (renewables).

The characteristics of the pilots include the following:

- Eligible technologies and resources include photovoltaic solar, wind, micro-hydro (OH only), and biomass (OH only).
- Maximum renewables system size of 50 kW peak.
- Customers are given a choice of three different metering options, including: keeping their existing meter only and having it run backwards when generation exceeds consumption, installing a second meter to measure excess generation (more accurately measures the net production than under the single meter option), or the utilization of time-of-use meter(s) which keep track of net generation and consumption for different demand periods (i.e., peak versus off-peak). The costs of purchasing a new meter are covered by the customer (regular meter - $350 installed, TOU - $600 installed).
- Maximum of 20 systems in the OH pilot.
- In both, the selection of the interconnections is up to the discretion of the utility.
- Five year contract with OH, 2 year contract with TH.
- An extensive safety program has been developed, including the following requirements:
  - the customer power system must automatically disconnect from the grid if the network goes down (built-in with most inverters, inherent with induction generators);
  - the customer must provide an outdoor lockable manual disconnect between their system and the utility grid, located at the point of interconnection, which is used to establish a visually open safety clearance for Ontario Hydro personnel working on the grid;
  - each system must be reviewed by an Ontario Hydro Electrical inspector prior to its interconnection with costs covered by the customer (approximately $100); and
  - full signage must be put in place at each customer site to ensure that lineworkers are aware of the presence and configuration of the system.
- All equipment must meet one of the following certification standards: Canadian Standards Association (CSA), Underwriters Laboratories (UL), Warnock Hersey, or MET.
- The net metering option adopts customers' current electricity rate (e.g., residential retail rate) with energy charges (approximately 10¢/kWh for residential) and a regular service charge of $15.

- Both programs offer annual net metering. Customers are able to "bank" electrons in the grid for a whole year rather than just a specific billing period (e.g., two months). Thus, at the end of the year, the total net production is subtracted from total net consumption to determine the amount owed to or from the customer, if any. The bi-monthly bill uses an annual "profile" of the customer's expected "net" consumption (or "net" production) which is adjusted at the end of the year when the "net" production or "net" consumption is determined.
- Customers do not receive a payment for negative excess generation (if the total annual net electricity production exceeds on-site consumption).
- Both utilities have developed and disseminated extensive marketing materials.
- A standard contract has been developed between customers and the utility (Appendix C).

Both programs have experienced a reasonable customer uptake in their first year. It is important to recognize that OH does not serve many urban customers, as there are approximately 350 municipal utilities in the province (including TH) which serve those loads.

The Ontario Hydro program has at least six connections, including the following:

- A 80 kW Lagerway wind generator, restricted to 50 kW, installed by the Blind River municipality (partly using extra monies from a redevelopment fund that resulted from the closing of a uranium mine in the Elliot Lake region).
- A 50 kW Atlantic Orient Canada wind generator, at the Town of Blind River marina.
- A small-scale solar PV in a rural setting.
- A 400 Watt (average) solar PV installation.
- A micro-hydro development in the Town of Blind River.
- A wind and solar system (including solar shingles) to power parking lot lights at the Kortwright Centre for Conservation northwest of Toronto.

The TH program has included six solar PV installations in the City of Toronto. In the future, the Toronto Renewable Energy Cooperative may be installing a wind turbine that may make use of the program.

<u>Contacts:</u>
Jeannette Boyer – Renewable Energy Program Manager – Ontario Hydro – 416-506-5238.
Joyce McLean – Green Energy Services Manager – Toronto Hydro – 416-591-4686.

Manitoba Hydro

Manitoba Hydro (MH) has a full net metering program. The MH program does not focus exclusively on renewables but rather all, "Non-Utility Generation" (NUG) including cogeneration. The program has been in place since 1989 as an *Administrative Directive* from the Senior Vice-President of Energy Supply. One of the objectives of the program is to demonstrate to customers that MH is proactively supportive of private power generation in the province.

The program has the following features:

- MH will pay for NUG purchases as follows:
    - for purchases less than 2,000 kW, at the same rates that MH charges its own customers for similar service; or

  - for purchases equal to or exceeding 2,000 kW, on the basis of avoided system cost or value as determined by the Corporation.
- NUGs will be connected to the MH system only if:
  - It is properly synchronized, meets MH system standards for frequency and voltage controls and is provided with fault protection and switching equipment satisfactory to MH; and
  - The facility and the energy and power produced satisfies MH standards in respect of public, employee and equipment safety.
- An electrical inspection is required before interconnecting systems.

The MH program currently has only two connections. The first is a small wind generator with a capacity of less than 1 kW on a farm. The second is a pulp mill using woodwaste energy for about 1/3 of their industrial requirements and feeding excess power back into the MH grid. A potential third project is a flare gas project.

Clearly this program is not successful given that the program has been in place for ten years, and the customer uptake has been very weak. Some possible problems with the program that have contributed to its poor response could be as follows:

- lack of customer interest in customer-owned electricity generation.
- the lack of promotion of the program.
- low avoided electricity costs - the lowest electricity prices in the continent - 5¼ ¢/kWh for residential customers and 2.5 ¢/kWh for industrial customers.
- cumbersome utility interconnection requirements – treating distributed renewables on a similar line as large-scale cogeneration equipment with similar interconnection standards.

<u>Contact:</u>
Ed Zaleski – Division Manager, Distribution and Transmission – Manitoba Hydro –
204-474-3777.

Government of the United States

The U.S. Secretary of Energy recently sent legislation to Congress to implement retail competition throughout the United States, including a provision to require net metering in all jurisdictions. Components of Section 403 of the Comprehensive Electricity Competition Act on net metering include the following[83].

- Eligible resources are solar, wind, geothermal, and biomass with a peak generating capacity of 20 kW or less.
- Net metering would allow consumers to offset purchases of electric energy from their supplier with electric energy generated by small, on-site renewable generating facilities and delivered to the distribution system.
- All retail electric suppliers need to offer net metering if a customer requests it.
- Individual States can impose additional requirements such as a cap limiting the amount of net metering available in the State.

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83 http://home.doe.gov/policy/ceca.htm

A news report claims that the net metering component of the legislation to restructure the electricity industry is designed to help meet the 2010 goal of 7.5% of retail electricity from non-fossil sources. Equipment needs standards to allow interconnection to the grid, and the issue is under study by the Institute of Electrical and Electronics Engineers[84].

Sacramento Municipal Utility District (SMUD) – PV Pioneers II

The PV Pioneers II program in Sacramento, California operates like a net metering program for solar PV systems. The typical system size installed is 2000 Watts. They have a home retrofit program for people to install solar PV systems on their existing homes, and a new home program that is promoting the deployment of solar PV shingles on new homes. Participating customers own the solar PV systems, and are able to sell any surplus power back to the utility (net metering). SMUD purchases and installs the solar PV systems and arranges for electrical inspections. SMUD will also provide financing for the customers' costs of the solar PV systems at a rate of about 9¼% – 9½%. SMUD will also arrange for maintenance or repairs of the PV system, for both warranty and out-of-warranty items.

The utility provides a subsidy to customers for about half of the cost of a 2 kW solar PV system and installs the system on behalf of customers. The total budget for the subsidy is currently US$37 million, funded mostly through a wires charge on all utility sales for "public good programs". A customer's cost to buy a typical 2000 Watt system that would provide about half of the annual energy needs an average SMUD customer, is about US$4,740 ($2.37/Watt). While the full cost of such a system is US$10,140 ($5.07/Watt), SMUD reduces the cost by contributing a buydown of $5,400.

The SMUD program is designed so that, "… as real system costs fall and the public goods buydown decreases, a real self-sustaining market will be established … SMUD customers can enjoy the benefits of the reduced prices expected outside the program in 5 or 6 years, today."

The uptake has been outstanding. In less than a year, 175 customers have signed "letters of intent" to purchase and install solar PV systems, although the utility is still arranging the bulk purchase of solar PV panels.

Under their PV Pioneers I program, about 1000 people applied each year to have solar PV systems installed at their homes for US$4/month with an option to purchase the system at the end of their 10 year commitment. However, SMUD was only able to install 450 systems in the last 5 years because of institutional limitations in their program.

Contact:
Bud Beebe – Sacramento Municipal Utility District.
916-732-5254.

Washington State

Washington State enacted a net metering law in March 1998. The full text is included in Appendix D. Under the new law, all electric utilities in the state are required to offer net metering programs to customers who have installed small generating systems that use solar, wind and hydropower.

Specific features of the legislation entitled, *an Act Relating to net metering for certain renewable energy systems*, include the following:

[84] http://www.energy.com/news/cover/cv041599.asp

- That the legislature finds it in the public interest to encourage private investment in renewable energy resources, stimulate economic growth of the state, and enhance the continued diversification of the energy resources used in the state.
- Net metering systems are facilities for the production of electrical energy which:
  - use solar, wind, or hydropower as a fuel;
  - have a generating capacity of less than 25 kW;
  - are located at the customer-generator's premises;
  - operate in parallel with the electric utility's transmission and distribution facilities; and
  - are intended primarily to offset part or all of the customer-generator's requirements for electricity.
- The utility shall offer to make net metering available to eligible customers-generators on a first-come, first served basis until the cumulative generating capacity of net metering systems equals 0.1% of the utility's peak demand during 1996.
- The utility should allow net metering systems to be interconnected using a standard (existing) kWh meter.
- The utility can charge the customer-generator a minimum monthly fee that is the same as other customers in the same rate class, but is not permitted to charge the customer-generator any additional standby, capacity, interconnection, or other fees or charges.
- The mechanics of the billing are as follows:
  - The utility measures the net electricity produced or consumed during the billing period:
  - If net electricity consumption exceeds net production, the customer will be billed for the net consumption in accordance to normal metering practices.
  - If net electricity production exceeds net consumption, the customer will be billed the flat customer charge and will be credited for excess kWhs generated during the billing period with the credit appearing on the next bill.
  - At the beginning of each calendar year, any remaining unused kWh credits will be granted to the utility, without compensation to the customer-generator.
- The customer must provide all equipment necessary to meet applicable safety, power quality, and interconnection requirements established by the national electrical code, the national electrical safety code, IEEE, and UL.

Contact:
Nancy Hirsh – Northwest Conservation Act Coalition, Seattle, Washington

Wisconsin[85]

In Wisconsin, net metering was initiated by a utility commission order with no state legislation backing it up. Net metering is authorized by the Public Service Commission of Wisconsin (PSCW) Order 6690-UR-107, effective January 1, 1993. The order applies to all utilities under the jurisdiction of PSCW. Rural electric cooperatives in Wisconsin are not rate-regulated by PSCW, and technically they do not have to

[85] From Internet reference: http://www.eren.doe.gov/greenpower/netmetering/index.html.

offer net metering to their customers. However, Wisconsin rural electric cooperatives often follow Commission's rulings voluntarily, and several rural electric cooperatives are offering net metering to their customers.

Wisconsin's net metering applies to customer-owned electric generation facilities that are rated at 20 kW or less, regardless of energy sources. If a customer has more than one generator, the sum of all generators' ratings cannot exceed 20 kW. In that case, customers have to enter a parallel generation contract with the utility.

The utility's electric meter is permitted to run backward when the customer is generating electric power to feed into the utility grid. If the amount of energy supplied to the utility exceeds the amount of energy consumed, the customer will receive a credit on his/her monthly bill equal to the net excess kilowatt-hours of energy received by the utility multiplied by the Energy Credit Rate. Any credits to the customer shall be reduced by the monthly customer charge of the standard applicable rate schedule.

For customers with a time-of-use rate, a second time-of-use meter has to be installed, and the on-peak purchases and sales will be netted separately from off-peak purchases and sales. For renewable resource generators, the energy credit rate is the customer's retail rate. For nonrenewable resource generators, the energy credit rate is the utility's avoided cost (PG-2 rate)

Germany

Solar and wind power are supported by government legislation across Germany and many utilities are offering net metering to their customers.

The 1990 *Electricity Feed Law* (Stomeinspeisungsgesetz) demands that any electricity generated from wind, solar, hydro, waste fuels or biomass be bought by the public electricity utility at fixed rates equivalent to 90% (for wind and solar) of utility revenue – e.g., 90% of the retail electricity rate (Groscurth, 1996).

The German government has also committed to installing 30,000 PV solar systems in the country by the year 2010, requiring a strong commitment from all electricity sector players to achieve that objective.

Germany currently has the largest installed capacity of wind power in the world, with almost 2,000 MW peak, although the majority of those systems are wind farms, not using net metering.

Also, German utilities have also been aggressively pursuing installations of PV solar systems. For example:

- BayernWerk[86] has recently commissioned a 1,016 kW PV array at the Munich Convention Center – the largest array in the world – and have 2.8 MW of installed PV throughout their service territory.
- RWE AG[87], the largest utility in Germany, and one of the seven largest in the world, has two PV power plants – 340 kW and 360 kW.
- VSE AG offers a 2500 DM subsidy for customers that install a 1kW PV array[88].

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[86] http://www.bayernwerk.de

[87] http://www.rwe.de

[88] http://www.vse.de

Japan[89]

The Government of Japan announced an aggressive policy to promote the development of PV solar facilities in the country, including a sizable capital cost rebate and a target of installing 70,000 PV systems in the country by 2010.

In 1994, the Ministry of Industry and Trade (MITI) announced the rebate – purchasers will receive half of the capital cost of PV systems up to a generating capacity of a 3 kW peak. The budget for this rebate started at ¥2 billion in 1994 and has since risen to ¥14.7 billion in 1998. All grid-intertied customers have a net metering arrangement with their local utility. The target national generating capacity through the program was set at 185 MW peak. The subsidy is paid to the installer. The subsidy will be phased out by the year 2001.

The program started off supporting only residential systems. In 1997, the government expanded the program to include owners/developers of housing complexes as well (presumably net metered). In 1998, the program expanded to support local government efforts to develop PV solar systems in government buildings and throughout their communities with additional subsidies to residents. Local governments installed 527 PV solar systems with a capacity of 2,867 kW by 1998.

Some examples of electric utility initiatives with PV solar technologies and net metering include:

- Kansai Electric (Osaka) had 1,454 customers doing net metering by the end of 1997, all receiving the full retail rate for their net electricity production[90].
- Tokyo Electric has 700 kW of installed PV solar capacity in 1998[91].

89 http://www.nef.or.jp/english/moniter/moni1.htm

90 http://www.kepco.co.jp

91 http://www.tepco.co.jp

Appendix C – Ontario Hydro Net Billing Program Literature

Appendix D – State of Washington Legislation

Appendix E – British Columbia PST Exemption for Alternative Energy Sources

Appendix F - Trace Engineering "Islanding" Protection on Inverters

All of the SW series inverter/chargers include the following protective systems. These systems are used to protect the inverter and the installer/operator/utility personnel from hazardous conditions. The standard protection is as follows:

- Grid shorted-Normally, when the utility power fails, the inverter momentarily tries to power the entire neighbourhood. This condition looks like a short circuit to the inverter and causes it to reach the overcurrent protection setting and shuts off. It then opens its internal relay and disconnects from the utility grid. This protective system operates instantly. (Under four milliseconds).
- Grid open-The inverter can tell when there is no current being delivered to the grid and it will disconnect. This is used when a disconnected switch is opened or the power line which feeds the installation is cut. This protective system may require up to one second to respond.
- Islanding-This occurs when the grid has failed and the "neighbourhood" that the inverter is powering requires the same amount of power that the inverter can supply. This balanced condition is often called "islanding". The islanding detection circuit checks the grid condition on each cycle. The inverter watches the utility grid and waits for it to rise a couple of volts before it begins to invert again. This is done on each cycle when SELL mode is activated. Typically, disconnection is achieved in a few cycles after the utility has failed. If a large electric motor is connected, it may provide enough generator capacity that the inverter thinks the grid is still connected. This can fool this protective system. Two additional protective systems are provided to handle this condition over/under frequency and over/under voltage detection.
- Over/Under Frequency-Since the inverter is locked onto the frequency of the "Islanded utility grid, the frequency of the system will drift out of regulation in a short amount of time during an islanding condition. This protective system may require up to one second to respond. The inverter will shut off disconnect after the frequency exceeds +/- 1 hertz of the normal frequency.
- Over/Under Voltage-Since the inverter does not regulate the voltage of the utility grid while selling power into it, the AC voltage will drift out of regulation in short amount of time during an islanding condition. This protective system may require up to one second to respond. The inverter will shut off and disconnect after the voltage exceeds +/- 10% of the nominal AC voltage.

Each SW series inverter/charger is individually tested to ensure operation of the islanding protection system. A signed certificate by the test technician of the test results are included with each unit.

Appendix G – Pacific Gas and Electric's Letter of Approval of Trace Inverters for Grid Interconnection

Appendix H – Thomson and Howe Engineering Systems Inc. – Single Phase Control and Protection Module for Intertied Induction Generators

Appendix I – Metering Options

At least three different types metering arrangements can be employed for net metering systems as outlined below.[92] The first is the one typically installed at residential connections in British Columbia. As such, the existing metering infrastructure is sufficient for the successful implementation of a net metering arrangement between a customer-generator and a utility.

1. Utilize the standard customer meter that can operate in two directions. This meter measures the electricity consumed by the customer from the utility and the electricity produced by the customer-generator that is exported to the utility grid. The latter measurement is less accurate as it has not been calibrated to the same extent as the former measurement. The meter automatically subtracts the excess energy produced by the customer-generator from the power consumed to measure "net" usage.
2. Utilize the existing meter to measure flows of electricity from the utility to the customer. Install a second meter to measure the flows of electricity from the customer-generator to the utility grid. The utility reads both meters and bills the customer for net consumption – subtracting the reading on the second meter from the incremental reading on the first to determine "net" usage. This is sometimes called net billing. The cost of an additional meter is approximately $350 installed[93].
3. Utilize a single new meter that records both power inflows and outflows. These sophisticated meters can also function as time-of-use meters, measuring power consumption at different times of day including during peak and off-peak power demand periods. The cost of a time-of-use meter with programmable buckets to measure electricity production / demand during different billing periods (i.e., peak, shoulder, off-peak) is about $350 plus installation[94].

[92] Based on the list provided by Ontario Hydro Retail for their Net Metering program.

[93] West Kootenay Power. 1998.

[94] Ibid.