BC Remote Community Integrated Energy Project (BCRCIE): Lasqueti Community Integrated Energy Project Public Final Report

Summary of Project: Installation of two high-penetration photovoltaic (PV) solar/diesel/battery hybrid off-grid electrical systems on Lasqueti Island, along with a prototype "smart control" system for generator scheduling and monitoring systems for educational and research purposes.

Total Project Cost: $453,461.26

Project Completion date: March 31, 2016

Executive Summary: The project involved installation of two separate high-penetration photovoltaic (PV) solar/diesel/battery hybrid off-grid electrical systems (42 kW PV capacity at False Bay School and 13 kW PV capacity at Judith Fisher Health Centre) on Lasqueti Island. The project demonstrates the technical and economic feasibility of PV combined with battery storage to reduce diesel use in small off-grid systems. Preliminary performance shows that the expected reduction in diesel consumption (relative to a diesel-only system with battery storage) is about 60% (False Bay School) to 70% (Judith Fisher Health Centre). Several years use will be necessary to confirm these savings.

The project includes a prototype installation of a "smart control" system for generator scheduling to optimize use of solar and minimize use of diesel within the hybrid system. Initial results indicate the prototype system will work well within its limited scope. This system will need further R & D to be ready for up-take by other communities, but the potential looks good.

The project includes a comprehensive monitoring system to display and record system performance data for educational and research purposes. These web-accessible systems will provide a teaching tool for a renewable energy education program that False Bay School hopes to begin offering, and a source of detailed data that will be essential for further refinement of the generator scheduling computer as well as other possible research projects on remote off-grid solar/diesel hybrid systems.

The project demonstrates that solar PV can displace 60 to 70 % of the use of diesel for electrical power in a remote off-grid system, subject to climate variables. The project highlights the need for better control systems than are currently commercially available to efficiently integrate diesel and PV use in a hybrid system, and demonstrates the potential of the prototype system installed.

Project Description:
False Bay School (FBS):

- *134 solar PV modules, 315 watts each, total 42kW PV*
- *150 kWh lead-acid batteries.*
- *5 SMA Sunny Boy solar AC inverters*
- *4 SMA Sunny Island off-grid inverters*

Judith Fisher Health Centre (JFHC):

- 48 solar PV modules, 275 watts each, total 13 kW PV,
- 150 kWh lead-acid batteries.
- 2 SMA Sunny Boy solar AC inverters
- 2 SMA Sunny Island off-grid inverters

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Background & Objectives:

Lasqueti Island is a remote island in the Georgia Strait east of Vancouver Island with a population of about 400. Lasqueti has no Hydro grid, no natural gas piping, and no car ferry. Regular transportation to Lasqueti is by passenger-only ferry, crossing about 17 km of water from Vancouver Island. Supplies of gasoline, diesel and propane arrive by a tank truck carried on a landing barge from Vancouver Island.

The Lasqueti community has a high level of interest in and knowledge about renewable energy technology including solar (photovoltaic, thermal hot water and passive building heat), wind, micro-hydro, and wood heat. These technologies are generally used on a small-scale basis, with each installation serving one or two individual homes. There is generally also a high level of awareness about energy conservation through efficient lighting, appliances and devices, and an overall life philosophy of avoiding excessive consumption of resources.

False Bay School (FBS) on Lasqueti Island is a rural two-classroom school, providing K-8 education. Enrollment is around 20 students. The building is about 4000 square feet in floor area. FBS was built in 1952 and equipped with a diesel generator for electrical power and an oil-fired boiler for building heat. Prior to the project, the generator was run for about 12 hours each day, powering the loads during school hours and re-charging batteries.

The heat system was converted to propane more than 20 years ago. The original heating system ran on passive hot water wall-mounted convectors. An HVAC upgrade around 2004 added three air handlers with electric powered circulation fans and two exhaust fans. The HVAC system was designed without considering the exceptionally high cost of electrical power on Lasqueti. A reverse osmosis water filtration system was also added around this time. Although the building was expanded in the 1980’s, there has been little upgrading of the building envelope. Low levels of insulation, many air leaks, and single-paned windows are still in place.

Two teacher residences were built adjacent to the school in the 1990’s and these are also powered from the diesel generator. Each teacher residence is heated by its own propane-fired forced air furnace.

At some point, School District 69 (SD 69) entered an agreement with Telus (BC Tel at the time) whereby SD 69 provides power to Telus to operate the islands “land line” telephone system. Under that agreement, SD 69 provided about 10 to 12 hours of power connection each day, in exchange for Telus paying a fixed percentage of the fuel bill. Telus has their own batteries which power the phone system at night.

In 2009, Reid Wilson, the head teacher at FBS, became increasingly concerned that the complete reliance on fossil fuel energy at FBS was inconsistent with the Lasqueti community’s values of environmental stewardship and social justice. Reid approached the Islands Trust (local government) and the Lasqueti Community Association for help in raising funds for renewable energy. Doug Hopwood, a long-time Lasqueti resident, and the parent of a FBS student, offered to help by developing a fund-raising strategy and writing some grant proposals. Fund-raising began in the spring of 2009 with the FBS students collecting pledges for a challenge of hiking to the top of Mount Trematon (the highest point on Lasqueti). This activity raised approximately $1000 in 2009, and was repeated in 2010 and 2011. This "seed funding" eventually grew to the final project budget of over $400,000. A brief summary of the development of the total funding package follows:

- 2009, 2010, 2011 – False Bay School students fundraising seed funding efforts
- 2009 - "Solar for Schools" grant for solar hot water (but analysis showed a poor return on investment for solar hot water. Solar PV looked better, but we needed money to collect data and start planning
- March 2011 - VanCity/Real Estate Foundation Green Building grant – primarily used for monitoring and feasibility during the Community Energy Planning Process with the remaining amount put towards this specific project
- November 2011 – Remote community Implementation Program funding through the Fraser Basin Council, and invitation from BC Ministry of Energy and Mines to join "BC Remote Communities Renewable Energy Project" and access to NRCan ecoEII funding.

The project was initially planned as a single integrated renewable heat and power system, combining solar PV, wind, and/or micro-hydro to minimize diesel use, as well as biomass heat and heat recovery from the diesel generator. The project was planned to serve False Bay School, the two teacher residences and Telus (all located close to the school) as well as the Lasqueti Fire Hall, Recycling Centre, and the planned (but not yet built) Health Centre, located about 200 metres from the school.

The intent was to combine several renewable energy technologies into a single integrated system. For example, Lasqueti Island residents have found it works well to combine micro-hydro energy with PV, because most stream on Lasqueti flow in the winter months when solar output is low. Similarly, the waste heat from the diesel generator could be utilized for building heating, and would be available mostly in the winter months.

An additional innovation was planned to fund the project in part by community investment, in which community members would invest in the project and be re-paid through savings in annual fuel costs.

During the period 2009 through 2011, a lot of work went into broad high-level diagnosis of the current energy system at False Bay School and associated buildings, along with exploration of the potential and feasibility of the full spectrum of funding mechanisms, energy conservation measures, and renewable energy technologies that might be used.

By early in 2012, the ecoEII funding was approved in principle, which along with other funds already secured provided an adequate budget to implement an ambitious and innovative project. However, a series of long delays ensued in developing the necessary chain of Contribution Agreements for the ecoEII funding to be disbursed (Canada – BC; BC – Islands Trust; Islands Trust - School District 69). This meant that the final planning and implementation stages were quite limited despite the length of time between the initial concept of the project and actual installation.

In the mean time, major turnovers of personnel at every level of SD 69 meant that plans and/or agreements reached early in the process needed to be re-established by the time the project moved towards implementation.

In the end, some of the innovative aspects of the project as originally planned were not brought through to completion. The reasons included ta number of funding delays, rushed completion deadlines, personnel turnover, administrative issues, and technical issues

Partners / Collaborators / Technology Providers / Contractors:

Partners and Collaborators

False Bay School staff, students and Parents Advisory Council (PAC)

- FBS staff and students provided the initial impetus for the project, based on a sense of environmental ethics, social justice, and leading by example. Students helped with early fund-raising efforts. The PAC served as banker for the funds raised by students.

BC Sustainable Energy Association and the Solar BC Program

- Solar BC provided an early grant that helped to build funding momentum. Solar BC was accommodating in allowing us to shift the funding from solar hot water to P..

Vancity/Real Estate Foundation of BC Green Building Program

- Vancity and REFBC provided a grant under the “Green Building Program” that was essential in funding the data collection and feasibility studies during the community energy planning process that were necessary for project conception with the remaining amount used towards this specific project.

Fraser Basin Council (Remote Community Implementation Program)

- Fraser Basin Council provided substantial funding through the RCI program, and very patiently accommodated the project delays and complexities.

The Province of British Columbia (BC Ministry of Energy and Mines)

- The Province was very supportive in helping to access project funding and managing the project.

Natural Resources Canada (ecoENERGY Innovation Initiative)

- The ecoEII program provided the largest portion of the funding for the project.

Islands Trust

- Islands Trust supported the project both by contributing funds from the Community Action on Energy and Emissions initiative ('Solar Communities') and by serving as the financial administrator for all of the supply and construction contracts to complete the project.

School District 69

- SD 69 was the main project partner for the 42kW solar PV installation at False Bay School as part of the Lasqueti sub-project. SD 69 contributed substantial capital funding towards the project.

Lasqueti Community Association

- The Lasqueti Community Association (LCA) served as the grant recipeint for both the RCI and Green Building grant funds for the project.

Lasqueti Last Resort Society

- Lasqueti Last Resort Society was the project partner for the 13 kW solar PV project at the Judith Fisher Health Centre as part of the Lasqueti sub-project. The Last Resort Society contributed substantial capital funding and in-kind support towards the project.

Contractors

Reid Wylde Engineering
- Eric Smiley of Reid Wylde Engineering provided advice and consultation over many years in the feasibility analysis, economic analysis, and preliminary design of the False Bay School PV system.

Hakai Energy Solutions
- Hakai Energy Solutions completed final design and installation of the False Bay School PV system.

Small Planet Energy
- Small Planet Energy completed final design and installation of the Judith Fisher Health Centre PV system.

Selection of Technology:

Table 1 provides a summary of technologies considered for the project, both those that were implemented and those that were not.

Table 1. Overview of technologies

Energy Technology	Evaluation and Implementation
Solar PV Electrical Energy	***Evaluation*** Initial analysis with RET Screen, and more detailed follow-up analysis with HOMER and a variety of custom-made modeling and analysis tools clearly showed Solar PV's technical and economic feasibility. Modeling also was necessary for sizing of PV arrays and the batteries. Accurate load profile data was necessary. ***Implementation*** 13 kW of PV has been installed at JFC and 42 kW at FBS. Both systems are Solar/Diesel hybrid with lead-acid battery storage, off-grid inverters and AC-coupled solar inverters.
Wind Electrical Energy	***Evaluation*** An anemometer was installed near the top of the 30 m tall Telus radio tower adjacent to False Bay School. Wind speed and direction data were logged from Sept 26, 2011 to November 16, 2011, after which time water entered the connections on the data cable and further data became corrupted. However, the data logged was enough to establish that the site had poor potential for wind power, due to attenuation of wind speed by local topography and forest cover of the surrounding area. ***Implementation*** Not implemented, primarily because the specific site is not well suited for wind power.

Micro-hydro Electrical Energy	***Evaluation*** After determining that wind power was not a promising option, the option of a micro-hydro installation on a nearby stream was explored. Micro-hydro was technically feasible. A system costing about $60,000 to install would save about 2400 litres of diesel per year, worth about $3800.00, giving a simple pay-back period of about 15 years. However, agreements would have been required for occupancy of two separate private land properties as well as a public road right of way. Obtaining a water license would likely have been complicated by the existence of a community water system drawing from Hadley Lake. ***Implementation*** Not implemented, primarily because of administrative issues (complexity of building a project spanning multiple land ownerships) and perceived bureaucratic hurdles (water licensing).
"Smart Controls" of Hybrid Electrical System	***Evaluation*** One of the challenges of a solar/diesel hybrid electrical system with batteries is to ensure that the system operates to optimize the solar input and minimize fuel consumption by the generator. In practical terms, this comes down to how the generator is programmed to stop and start. The SMA inverters are capable of starting and stopping the generator, but only on the basis of a limited suite of criteria. Luckily, there were individuals in the Lasqueti community with a background in electrical engineering and computer programming to help design a prototype generator scheduling system. ***Implementation*** A simple generator scheduling computer has been installed and programmed that will • Read weather forecasts from internet • Calculate expected PV output • Look up (or learn) typical daily load profiles • Read parameters from Sunny Island (e.g., SOC) via Web-box Modbus • Determine optimum generator start/stop times • Alter Sunny island parameters to cause generator start/stop The system installed is intended as a prototype "proof of concept". There was no time between completion of PV installation and the project completion date to allow for development of a fully developed and refined operational system.
Biomass (Wood-burning) Heat System	***Evaluation*** Investigations were conducted into the use of boiler burning chips (which turned out to be unavailable on Lasqueti) or solid wood fuel (cord wood) which is available on Lasqueti for about $300 per cord. However, the labour cost of feeding a boiler with solid fuel was expressed as a potential concern. Accordingly, a feasibility study was completed on both a pellet boiler system (which could feed fuel automatically) and the use of heat pump technology (by request). The conclusions were considered favorable regarding the financial and environmental viability of a pellet boiler system but not favourable for a heat pump system. However, for various reasons, a decision was made to not to proceed with the pellet boiler option at that time. ***Implementation*** Not implemented.
Heat Pump	***Evaluation***

System	A heat pump was not proposed as part of the project, but a feasibility study was completed which showed that a heat pump would not be cost effective due to the fact that the heat pump would have to be powered by diesel-generated electricity during most of the heating season. ***Implementation*** Not implemented, due to technical and economic infeasibility of a heat pump reliant on diesel electricity (it would be more efficient to burn the fossil fuel directly for heat).
Solar Thermal Energy	***Evaluation*** Solar thermal energy was initially considered for FBS, but detailed modeling and analysis showed a poor return on investment. • Solar thermal could be used to displace propane for domestic hot water, but FBS has only a small demand for hot water (there are no showers in the school) so the necessary investment would be slow to pay off. • Solar thermal could also be used to displace propane for building heating, but there is a poor match between timing of available sunshine and the heating needs of the building. • A wood-burning heating system (pellets or solid wood) would be a much more effective and economical alternative to the current propane-burning heating system. ***Implementation*** Not implemented, due to technical and economic infeasibility. (Low demand for hot water, and poor match with existing hydronic building heating system).

Innovation:
In the end, some of the innovative aspects of the project as originally planned were not brought to completion. The reasons included a number of funding related delays, rushed completion deadlines, personnel turnover, administrative issues, and technical issues.

High-penetration of PV in an off-grid institutional energy system

- Both of the PV arrays that were installed as part of this Project are large enough to meet 60 to 70% of annual demand. This project demonstrates that PV can be the primary energy source for off-grid systems (given similar or better insolation). This innovation can be readily replicated, depending only on qualified personnel to complete initial high-level system diagnosis and project planning.

Prototype generator scheduling computer

- The prototype system installed demonstrates the feasibility of improving fuel efficiency, reliability, convenience, and battery life in an off-grid PV/diesel/battery system by advanced controls that factor in weather forecasts, demand forecasts and current conditions. This innovation will require further R&D in order to be replicated.

PV array tilt and orientation matched to load profile

- Conventional PV design guidelines generally recommend orientating arrays to maximize annual (or in some cases seasonal) energy harvest, which is almost always achieved by orienting arrays due south. However the load profile at FBS is heavily weighted to early morning, so it made sense to orient one of the arrays (Array A) roughly 45° east of south, so that early morning loads can be fed directly from PV without the significant losses associated with battery cycling. Even though the SE-facing array may produce less primary energy than it would if it faced due south, its effective end-use energy harvest (and diesel use reduction) is greater. This innovation (actually common practice in small single-home off grid systems) can be readily replicated but requires careful analysis based on the actual load profile

Leadership and education

- The FBS school PV system is intended to be used a teaching resource for use in specialized courses, workshops, tours, etc. The detailed monitoring system in place supports this use.

Outcomes:

- CO_2 emissions from burning diesel for electrical power reduced by about 28 tonnes/year (from about 42 to 14 tonnes/year).
- Reduced noise from generator, fewer fuels spills and impacts associated with exploration, extraction, transport and refining of diesel fuel.
- Reduced operating costs (direct fuel costs, diesel generator maintenance and capital replacement costs).
- Increased reliability of electrical power system at FBS
- Prototype “smart control” of diesel generator scheduling computer offers strong potential for an important R & D advance in the efficiency and reliability of PV/ diesel hybrid systems with battery storage.
- Demonstration of feasibility of 60 to 70 % reduction in diesel use in remote off-grid communities by installing solar PV.
- System design and monitoring system create a good opportunity for renewable energy education.
- The project fostered a sense of accomplishment for the Lasqueti Island community and particularly the FBS students who were involved in the fund-raising.
- The power system at Judith Fisher Health Centre supports many positive health and social outcomes for the community.
- Canadian companies were used as much as possible, and gained operational experience in PV installation.

Project Reflections:

What worked well:

- Community-based initiative, support from community
- Both installations completed to high standard of workmanship, on-time and on budget.
- Support from many organizations
- Partnership with Lasqueti Last Resort Society
- Start with a high level diagnosis of the whole energy system, using real energy consumption data and a range of modeling tools, and considering the full spectrum of possible renewable energy technologies.

What didn’t works so well:

- Prolonged and complex funding agreements, delays and uncertainty
- Multiple personnel changes
- No funding for energy demand reduction
- Restriction to use the funding only on energy supply rather than on demand reduction
- Lack of skilled consultants for high-level diagnosis and planning

The experience with the False Bay School part of the project was that there are many specialist consultants (mostly with some degree of association with suppliers or installers) but few generalists who understand the full range of renewable technologies and how they can fit with conservation and efficiency. Moreover, energy system planning is not only a technological challenge but requires a good understanding of the social, financial, and administrative aspects of planning, including community consultation and coordinating multiple organizations and parties with diverse mandates, objectives, and procedures.

Plans for future/potential replication:

Educational program

- False Bay School is interested in developing an educational program around renewable energy using the FBS system as an educational tool

Advice to other remote communities

- Start with a high-level diagnosis of the whole energy demand and supply picture. Seek consultants who are broad generalists, have nothing in particular to sell, understand off-grid living, and who are committed to low carbon footprint solutions.
- Look at opportunities for demand reduction and management. Time of day shifting of loads may be critical for off grid systems with batteries. Build support and awareness in the community around demand reduction opportunities.
- Allow time for thorough planning. Build relationships and partnerships. Be patient and persistent.

Links:

Sunny Portal Web-site

- https://www.sunnyportal.com/Templates/PublicPageOverview.aspx?plant=7e16fc7f-9da3-4a30-8735-c87af1e7bf10&splang= (or go to "sunnyportal.com", click on "Publicly available PV systems" and search for "fbs".

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Photos/Graphics/Schematics:
Please see attached photo of the installation at FBS School below as well as additional photos, schematics and technical specifications in the accompanying PowerPoint presentation.