Micro-hydroelectricity in Solomon Islands – Current Status October 2010

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Abstract

82% of Solomon Islanders reside in rural areas predominantly in village groupings. The majority of villages are located near to rivers for supply of drinking and washing water. The mountainous nature of the majority of the country offers significant potential for renewable electricity generation through the use of micro-hydroelectric technology. However, only nine systems exist, and of these only six have proven reliable. It is suggested micro-hydro has the potential to supply the significant bulk of Solomon Islands' electricity needs. However, it is argued that current international donor transparency procedures associated with feasibility studies have created an environment that stalls developments.

Keywords

Micro-hydroelectric; rural energy; rural enterprise; Solomon Islands; renewable energy; Pelena; Solomon Islands Government; Ministry of Mines, Energy, & Rural Electrification; feasibility studies, transparency.

Introduction - the nation

Solomon Islands is a sovereign nation with a population of approximately 500,000[1]. An archipelago of 992 islands stretches 1500 kilometres in a south-easterly direction from the southern tip of Bougainville Island in Papua New Guinea to the northern border of Vanuatu[2].

The World Bank[3] estimates 81.7% of Solomon Islanders reside in rural areas (2009) compared to 49.7% globally (11% for nearby Australia & 56% for China). Since 1960, World Bank data indicates Solomon Islands is urbanising at a rate of approximately 2.55% per decade. This compares to the faster global urbanisation rate of 3.57% per decade for the same period.

The United Nations' *Human Development Index* (HDI) provides a composite measure of three basic dimensions of human development: health, education and income. Solomon Islands' HDI in 2009 was 0.492 which gave the "country a rank of 123 out of 169 countries with comparable data" with Australia ranking first. "The HDI of East Asia and the Pacific as

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[1] The last official census report was produced in 1999 recording a population at that time of 409,042. Various estimates have suggested a likely 2010 population of approximately 0.5M (eg World Bank estimate of 523,170 http://data.worldbank.org/country/solomon-islands. Accessed 1 October 2010). A more recent national census was conducted in November 2009 however official results were not available at the time of writing. *(Author's postscript: The Solomon Star Newspaper reported on 12 November 2010 that provisional census results from the 22/23 November 2009 census indicated a population of 515, 870.)*

[2] From Solomon Islands Visitors Bureau website. www.visitsolomons.com.sb Accessed 1 October 2010. *(Author's Note: Distance figures rounded to 1,500km from an apparent 900 mile conversion as published. The definition of an 'island' is unknown and this author suggests the total number of 'vegetated landmasses surrounded by water' would probably exceed 1,000 based on some incomplete assessments by this author from recent satellite images.)*

[3] World Bank Databank. Accessed 6 October 2010.

a region increased from 0.391 in 1980 to 0.650 today, placing Solomon Islands below the regional average."[4]

The current life expectancy at birth, according to the UNDP, is 67.0 years and the mean years of schooling of adults is 4.5 years.

A recent study commissioned by RAMSI [5] indicated 15.6% of Solomon Islanders had access to mains electricity in 2009, an increase from 12.7% in 2007. In 2009, 8.5% of the population indicated use of solar-derived electricity, although the type or size is not stated. 4.8% indicated they used a private generator (assumed to be fuelled by petrol or diesel) and 3.7% used some other, undefined, supply of electricity. Therefore, in total, 32.7% of the population indicated access to some form of electricity with the majority of this from private generation. This compares with an estimated global access to electricity of 75.4%[6].

In summary, the significant majority of people of Solomon Islands live in villages, and these villages are spread out across many islands over great distances. There is little access to modern energy sources and the nation is regarded globally as a 'developing' country.

Micro-hydro – the technology

There are various hydroelectric configurations dependant on the quantity of water available, pressure (head) supplied to the turbine, and required rotational speed to match generator electrical output requirements.

Fundamentally, hydroelectricity is the extraction of *energy* from the falling of water as that water travels downhill from mountains to ocean.

No water is consumed in the process and properly designed systems do not pollute the water.

The energy cycle of hydroelectricity relies fundamentally on solar energy. The heat from the sun evaporates water from the earth's surface to later fall as rain at higher elevations. The opportunity for hydroelectricity generation is achieved as the water falls to lower altitudes.

Micro hydroelectric systems are predominantly 'run-of-river' systems whereby there is limited, if any, water storage. Figure 1 below shows two types of hydro arrangements.

As water flows downhill in the pipeline (penstock), pressure increases due to gravitational effects. At the end of the penstock, this pressure is 'dropped' across the turbine and in doing so the 'pressure-energy' or 'potential energy' is converted to 'rotational energy' or 'kinetic energy'. Mechanical coupling between the turbine and generator results in the generation of electrical energy.

Different turbines have different efficiency characteristics for the conversion of the pressure-energy of the water into the kinetic-energy required to rotate the generator (or alternator). For the same power output, the lower the pressure, the physically larger the turbine must be

[4] United Nations Development Program (UNDP) International Human Development Indicators. From http://hdrstats.undp.org/en/countries/profiles/SLB.html accessed 1 October 2010.

[5] '*People's Survey 2009*' Produced by ANU Enterprise Pty Ltd, Canberra. Published by Office of the Special Coordinator, Regional Assistance Mission to Solomon Islands (RAMSI)

[6] Based on an assumed 2005 world population of 6.5 billion and "1.6 billion people did not have access to electricity" [in 2005] from *"The Energy Challenge for Achieving the Millennium Development Goals"*, United Nations, 2005. (*Author's comment: The difference between those that have a reliable, regular, and sufficient electricity supply, and those that simply have the potential to access an electricity supply is not known in these figures.)*

to accommodate the higher flowrates. This can present challenges for engineers specifying equipment when they have limited access to available turbines. This issue has been largely addressed by Pelena Energy through the design of a range of micro-hydro turbines that have significant commonality of parts and wide range of operation, as demonstrated through the success of the majority of micro-hydros in Solomon Islands.

There is some debate about what power levels constitute a 'micro-hydro'. This author suggests the following:

- Pico Hydro: Less than 2kW
- Micro Hydro: 2kW to 250kW
- Small Hydro: 250kW to 5,000kW
- Large Hydro: greater than 5,000kW (5MW)

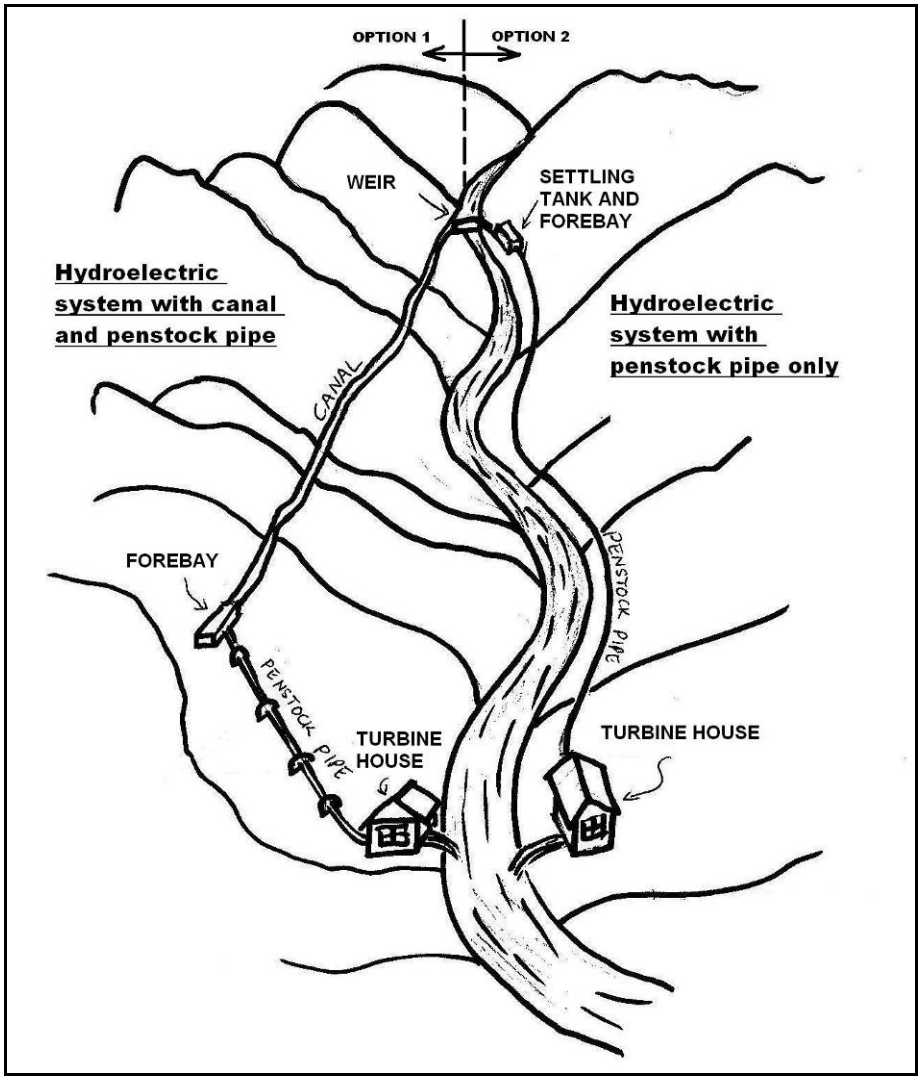

Figure 1: Two types of hydro arrangements. The left option uses a canal with pipeline (penstock) and the right option uses a pipeline (penstock) only.

Micro-hydro in Solomon Islands – current state

There are currently nine hydroelectric systems in Solomon Islands with no system greater than 150kW. Six are operational and these are all community owned with five implemented by the Australian NGO, Apace[7]. Two government-operated systems are "suspended" due to technical and landowner issues. The remaining & oldest micro-hydro system, at Atoifi Adventist Hospital, has experienced frequent technical problems and is currently undergoing further repairs.

It is possible some early mission stations used water for the generation of electricity for radio communications and/or lighting during the 1900's. However, none remain and the history of their operation, if any, has been lost.

Figure 2 below details current micro-hydroelectric sites in Solomon Islands and Table 1 below details current and decommissioned hydros in Solomon Islands.

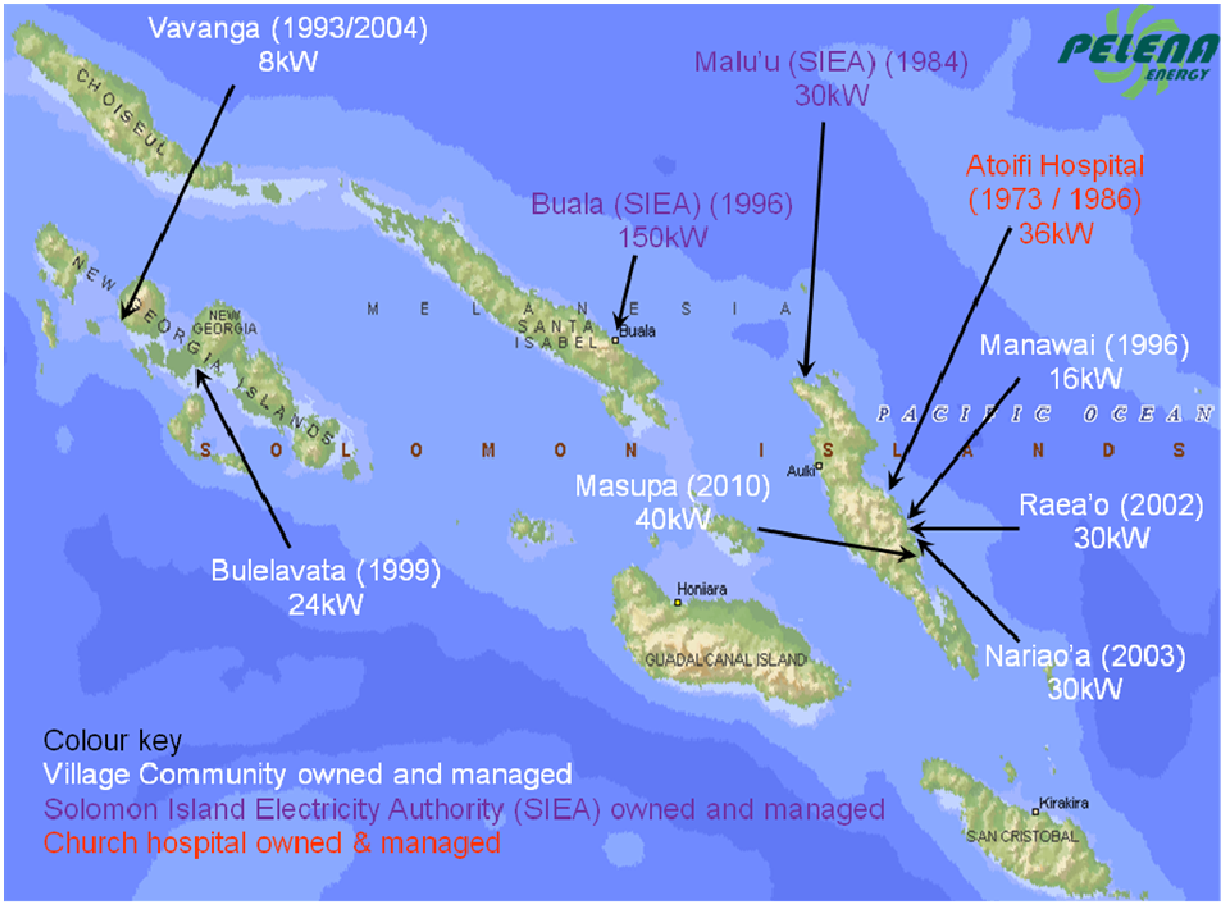

Figure 2: Micro-hydroelectric systems in Solomon Islands as at October 2010. *(Background map from Encarta)*

[7] Apace (Appropriate Technology for Community and Environment, Inc) was an Australian based Non-Government Organisation (NGO) formed in the mid-1970's. In 2002 it changed its charitable status and became the *Apace Village First Electrification Group* (Apace-VFEG) and continues to work in partnership with communities in primarily a support role.

Year built	Site	Ownership	Turbine & manufacturer	Typical output	Status (October 2010)
1973	Atoifi[8]	Adventist Hospital	Pelton - Gilkes	30kW	*Ceased operation 1980(?)*
1986			Pelton – Hydro Systems	36kW	Under repair
1983	Iriri[9]	Community	Pelton - Apace	3kW	*Ceased operation 1997*
1984	Malu'u[10] (Manakwai)	SIEA (Gov't)	Crossflow – SKAT[11]	16kW	Suspended (Land & technical issues)
1993	Vavanga[9]	Community	Crossflow - Apace	2kW	*Ceased operation 2001*
2004			Pelton - Pelena	8kW	Operating
1995	Manawai[9]	Community	Pelton - Canyon	16kW	Operating
1996	Buala[10] (Jejevo)	SIEA (Gov't)	Pelton - Andritz[11]	150kW	Suspended (Technical issues)
1999	Bulelavata[9]	Community	Crossflow - Pelena	24kW	Operating
2003	Raea'o[9]	Community	Pelton - Pelena	30kW	Operating
2004	Nariao'a[9]	Community	Pelton - Pelena	30kW	Operating
2010	Masupa[9]	Community	Pelton - Pelena	40kW	Operating

Table 1: Micro-hydroelectric systems in Solomon Islands as at October 2010. Shaded rows indicate decommissioned systems.

In 2009, a local Solomon Islands' company, Pidgin Holdings, began to stock a range of Chinese-manufactured turbines of power ratings less than 10kW. It is understood a number of the units were modified to improve electrical safety. No successful installations are known to this author.

This author is aware of a number of donations of very small (<300W) hydro turbines during late 1980's & 1990's. The author has no knowledge of any successful installations and the whereabouts of the equipment today is unknown.

Studies

No complete study has been undertaken to determine the micro-hydro potential of Solomon Islands. However two studies are worthy of note.

The first is a JICA[12]-funded study for power development in Solomon Islands in 1999-2000. It was largely a desktop study. An original copy of the study has not been sourced, but it has been reported elsewhere that the study "identified nearly 330 megawatts (MW) of hydroelectric potential on seven islands."[13] It is likely most sites focused on micro to small hydro systems.

[8] Details obtained through personal records plus discussions with operators, particularly, the late Mr Ray Jack.
[9] Personal records and visitations
[10] Correspondence with Solomon Islands Director of Mines, Energy, and Rural Electrification.
[11] Unconfirmed
[12] Japan International Cooperation Agency
[13] *Situation Analysis Report – Solomon Islands*, Australian Water Research Facility 2006

The second study was conducted over a number of years during predominantly the 1990's by the Australian based NGO, Apace. The study was confined to the Western Province due to resource support by that province's provincial government and was conducted under the *Western Province Rural Electrification Program* (WPREP). This author understands over 130 villages were identified through site assessments as suitable for micro-hydro development in the Western Province alone.

Various studies have been conducted around Honiara for large scale hydro development, including Lungga, and more recently a study for the Tina River Hydro. It is understood in recent times that at least six sites have been short listed along the Tina River with expected power generation in the range of 20MW to 60MW. Presently, 100% of Honiara's electricity supply is produced from imported diesel fuel.

The success of the majority of currently operating micro-hydroelectric systems in Solomon Islands is significantly due to the efforts of the Australian based NGO, Apace, and its work in developing procedures and technologies to allow access to the technology by the rural people of Solomon Islands. Iriri was the first of Apace's hydro projects in SI. Unfortunately, as is common with pioneering work in the engineering sector, investigators & researchers often chose to compare the small community-run hydro systems with large government or commercial operations in other countries. Whilst these authors may have intended to focus on the technology, their general lack of cultural awareness resulted in a flurry of personal criticism of the community which remains to this day. Most communities with hydros have therefore retreated from promoting the technology for fear of unsubstantiated attacks from outside researchers.

In 1986 a postage stamp set was issued to celebrate the country's first community hydro at Iriri. The Iriri project was officially opened by the Premier of Western Province, Francis Billy Hilly and the national Minister for Energy & Natural Resources. A copy of the stamp set can be seen below in Figure 3. It is understood that the Minister of Energy commented during the opening that the energy output of the Iriri project could only be surpassed by the burning of the massive quantity of reports generated by foreign consultants relating to the country's energy matters.

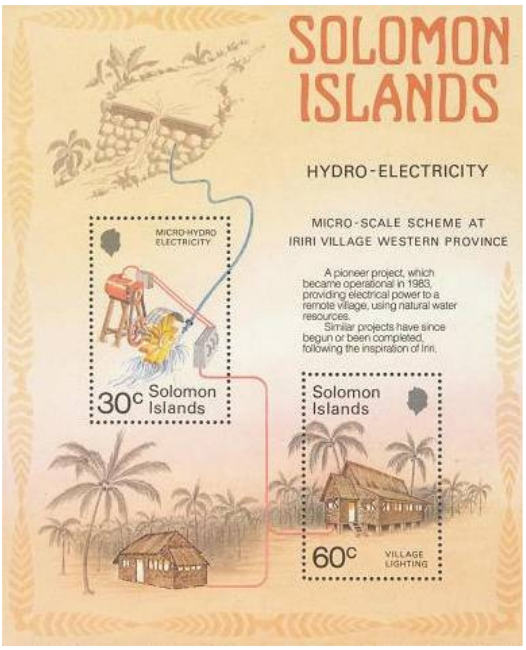

Figure 3: In 1986 a postage stamp set was issued to celebrate the opening of the first village micro-hydroelectric system in Solomon Islands by then Premier Francis Billy Hilly & national Minister of Energy & Natural Resources. Unfortunately, the enthusiasm at the time did not create a wave of momentum for other projects.

Opportunities

It is highly likely that Solomon Islands will never have a single integrated electricity grid network due to the many islands and deep oceans between. However, the climate and geography of the country is ideally suited to the development of independent power systems and multi-generator mini-grids.

Substantial in-country capacity exists for rapid roll-out of micro-hydro systems. The most recent 40kW hydro was constructed in only 13 days[14] using only community labour and trained technicians and supervisors. Since 1999, five hydroelectric systems have been constructed. All have used Pelena Energy turbines, and all continue to operate well. The commonality of spare parts such as bearings, belts, and grease types, plus access to credit, has contributed to this unprecedented reliability.

The process of implementing small scale, independent power generation units has proven to be significant in addressing landowner issues. On occasions the construction of community projects has been interrupted by local elders to announce publicly the importance of these projects for current and future generations. On occasions, this author has been asked to video these ceremonies to provide a permanent record for all future generations.

Present developments

In 1996, the German Government (GTZ) supported the study of three (3) mini-hydropower schemes in the Solomon Islands. GTZ supported the construction of the Jejevo (Buala) Hydropower scheme (Santa Isabel Province), but did not fund the construction of the Huro and Rualae Mini-Hydropower Schemes in Makira and Malaita Provinces respectively. Consultants have recently been engaged to re-evaluate these projects.

Pelena Energy has been in negotiations with the Solomon Islands Government to privately fund & develop micro-hydro systems in various parts of the country. These projects would be based around the community construction model with income generating and partnering with Pelena Energy for technical and management support. Negotiations are continuing.

Constraints

Over the past decade, an average of one hydro installation has occurred every two years. Various programs, organisations, political and policy initiatives have invested considerable effort to increase rural electrification, with little tangible results.

This report does not attempt to provide a thorough explanation for the lack of hydro development. However, from the perspective of a private technology developer and implementer, the following constraints have been identified by this author for the development of micro-hydro in Solomon Islands:

- Excessive international funding for feasibility studies *instead* of actual projects;
- Excessive awarding of feasibility consultancies to foreign engineering firms instead of local institutions and organisations;
- Engineering designs extracted from foreign projects where infrastructure services are greater than in Solomon Islands. These designs are flawed in the context of the

[14] A video documentary of the 13 day construction can be viewed on YouTube by searching "Masupa Hydro"

logistical demands of Solomon Islands. The designs are inappropriate and commonly not funded due to the high cost, as determined from restrictive international tendering processes with little scope for input from experienced local designers;

- Transparency procedures that discriminate against those with the expertise and demonstrable know-how;
- Lack of incentives for private investment in the electricity market of Solomon Islands, particularly for locations outside of the traditional jurisdictions of the government-owned Solomon Islands Electricity Authority (SIEA);
- Perception, particularly by the dominant aid industry, that the only path for rural electrification is through aid funding;
- Undermining of government departments, agencies, and authorities by foreign aid organisations & foreign government programs such that trained Solomon Island engineers and technicians are frequently consigned to token management positions and never gain practical training opportunities;
- A distinct lack of understanding of the rural areas by foreign aid organisations and foreign governments because of an enthusiasm to remain in the confines of Honiara.

Note that local capacity or technology availability are specifically *not* regarded as constraints for the development of micro-hydro in Solomon Islands.

Case Study – Masupa hydroelectric Project

In 2008 the Minister for Mines, Energy, and Rural Electrification contacted this author's company, Pelena Energy, to request a quote for a micro-hydro project at Masupa, Malaita Island, Solomon Islands. Engineers from the Ministry had assessed the site and provided details for flowrates & head. The Minister explained that only Pelena had the experience, capacity, and in-country expertise to complete the project.

Pelena Energy subsequently provided a qualified quotation based on a range of parameters such as head, flowrate, penstock type and length, weir design, distance from the nearest wharf, etc. Pelena was able to do this because of the technology it had developed and the diversity of application.

The quotation was accepted and the Pelena Energy team consisting of this author plus trained Solomon Islanders visited the site. On arrival it was determined that the chosen river was unsuitable and could not be developed.

Discussions with the community including further explanation of the technology resulted in a number of other site assessments concluding with a suitable site for development of a 40kW hydro.

The design was substantially completed on-site during this first site visit. This was largely possible due to Pelena's standard designs for weirs, turbines, turbine houses etc. This step of on-site design is essential in this author's opinion for the development of micro-hydros in remote locations. Mainstream Western engineering design dictates that the design must occur off-site with data collected from one discipline and assessed by others. This results in excessive costs and time delays.

The community was provided a list of materials to collect during the following months including sand and gravel for concreting and sawn timber for formwork and framing. The location of the weir, settling tank, and turbine house were identified and staged digging of the penstock trench commenced. This is part of the community's contribution to the project.

The Pelton turbine was manufactured in Pelena's workshop in Australia and performance tested with all electrical control equipment at Pelena's testing facility. All equipment was packed and shipped to Honiara. The Ministry arranged shipment to Masupa and once all equipment was on site, Pelena representatives returned.

Over 13 days, the system was constructed including the installation of an income-generating freezer room for ice making and food storage. A video of the construction of the project can be viewed on YouTube by searching on "Pelena Masupa".

Significantly, this project including feasibility, design, construction, & training cost less than recent internationally-tendered feasibility studies in the Melanesian region for projects of a similar size.

Reports from the community are positive with indications youth are returning to the community from Honiara because opportunities now exist for income generation at the village.

Figure 4: Various photos from the 13-day construction of the Masupa Hydro in Jan/Feb 2010.

Recommendations for micro-hydroelectric development in Solomon Islands

1. Communities provide main construction resources through manual contribution (avoid foreign teams and expensive machinery).
2. On-site design focus (not foreign design office using designs based on infrastructure-rich project locations).

3. Technicians - community based with access to in-country support (avoid city-based support teams as transportation and communication infrastructure is poor).
4. Women involved in all design, construction, and operational aspects (essential).
5. Metering of all electricity usage with possible minimal energy allowance for resource owners. This encourages entrepreneurial income generation activities.
6. Primary funding for income generation, *not* lighting (2nd stage).
7. Government to encourage private sector investment in rural electrification by allowing private sector generation, distribution, & retail sale in rural areas.
8. Direct funding to proven in-country experts to construct, not study. (Avoid cycle of expensive foreign feasibility studies frequently leading to no project because designs are inappropriate and expensive to implement & maintain).
9. Preference for suppliers that have a proven track record specific to Solomon Islands.
10. Engage engineers and technicians from government ministries, departments, and agencies to experience the practical design and development of the hydros.

About the Author

Peter Lynch is a professional mechanical engineer and Managing Director of Pelena Energy, an Australian based company founded in 1998. Peter's introduction to micro-hydro occurred in 1990 when he joined an Australian based NGO, Apace, as a volunteer. Apace's focus was on rural development in Melanesia through electrification and food security. Witnessing repeated limitations of commercially available technologies installed in rural areas, Peter jointly formed Pelena with his partner, Salena Bryce. The focus was to design and manufacture technologies that were suited to *both* infrastructure-rich and infrastructure-poor countries. Additionally, appropriate support services, such as credit facilities, were developed to sustain the rural installations. There are presently five Pelena hydroelectric turbines installed in Solomon Islands. The first was commissioned in 1999, and all remain operational; a record unmatched. Focusing on rural infrastructure technologies, Peter has been intimately involved in the development of other technologies such as coconut as a fuel, water transportation, and village income generation projects. Pelena Energy is unique in that it has a strong sustainability focus often attributed to NGO's, but has a for-profit constitution. This arrangement often conflicts with transparency & conflict-of-interest demands of donors, but is increasingly being applauded by others because of the demonstrable sustainability and enthusiasm for Pelena's products and services. Peter lives in rural NSW, Australia.