Micro-hydroelectricity in Solomon Islands: 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 rivers. The mountainous nature 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 that micro-hydro has the potential to supply a significant part of Solomon Islands' electricity needs. However, it is argued that the current international donor transparency procedures associated with feasibility studies have created an environment that stalls developments.

Introduction - the nation

Solomon Islands is located in the tropics of the southern hemisphere in the south-west Pacific Ocean approximately 1,700km to the north-east of Australia. It is a sovereign nation with a population (2009) of 515,870. The 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.

The World Bank estimates that in 2009, 81.7% of Solomon Islanders resided in rural areas compared to 49.7% globally (11% for nearby Australia & 56% for China) (World Bank Databank, Accessed 6 October 2010). 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. According to the World Bank (2010: 78), in 2009 the GDP was US$657M.

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 ranked it 123 out of 169 countries with comparable data; Australia ranked first. The HDI of East Asia and the Pacific as a region increased from 0.391 in 1980 to 0.650 today, 'placing Solomon Islands below the regional average' (UNDP, 2010). 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 (2009) indicated that 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%.

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. The nation is regarded globally as a less-developed country.

Micro-hydro in Solomon Islands – Current State

There are currently nine hydroelectric systems in Solomon Islands. No system is greater than 150kW. Six are operational and these are all community owned with five implemented by the Australian NGO, APACE[1]. Two government-operated systems are 'suspended' due to technical and landowner issues. The oldest remaining micro-hydro system, at Atoifi Adventist Hospital, has experienced frequent technical problems and is currently undergoing further repairs.

It is possible that 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

[1] 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.

any, has been lost.

In 1996, the German Government (GTZ) supported the study of three mini-hydropower schemes in the Solomon Islands. GTZ supported the construction of the Jejevo (Buala) Hydropower scheme (Santa Isabel Province), but it 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 and 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.

Error! Reference source not found. below details current and decommissioned hydros in Solomon Islands.

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 that a number of the units were modified to improve electrical safety. No successful installations are known to the author. This author is aware of a number of donations of very small (≈300W) hydro turbines during late 1980's & 1990's, but has no knowledge of any successful installation. The whereabouts of the equipment today is unknown; no records of these exist in the Ministry.

Studies

No complete study has been undertaken to determine the total micro-hydro potential of Solomon Islands. However, a number of studies are presented below.

APACE-WPREP 1995-2001: This program was conducted over a number of years during 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). Over 130 villages were identified through site assessments and pre-feasibility studies as suitable for micro-hydro development in the Western Province alone. It is understood that the details of these studies reside with the Australian NGO, APACE-VFEG and have not been publicly released.

Table 1: Status of Micro Hydroelectricity Systems in Solomons, Oct., 2010

Year	Site	Ownership	Turbine/manufacturer	Output	Status: Oct 2010
1952	Fauabu (unconfirmed) [2]	Melanesian Mission	Turgo - Gilkes	10kW	*Not operational*
1973	Atoifi[3]	Adventist Hospital	Pelton - Gilkes	30kW	*Ceased operation 1980(?)*
1986			Pelton – Hydro Systems	36kW	Under repair
1983	Iriri[4]	Community	Pelton - Apace	3kW	*Ceased 1997*
1984	Malu'u[5] (Manakwai)	SIEA (Gov't)	Crossflow – SKAT[6]	16kW	Suspended (Land & technical issues)
1993			Crossflow - Apace	2kW	*Ceased 2001*
2004	Vavanga[4]	Community	Pelton - Pelena	8kW	Operating
1995	Manawai[4]	Community	Pelton - Canyon	16kW	Operating
1996	Buala[3] (Jejevo)	SIEA (Gov't)	Pelton - Andritz[4]	150kW	Suspended (Technical issues)
1997	Ghatere[7]	Community	Crossflow	8kW	Incomplete and damaged
1999	Bulelavata[2]	Community	Crossflow - Pelena	24kW	Operating
2003	Raea'o[2]Error!	Community	Pelton – Pelena	30kW	Operating
2004	Nariao'a[2] Error!	Community	Pelton – Pelena	30kW	Operating
2010	Masupa[2] Error!	Community	Pelton – Pelena	40kW	Operating

(Shaded rows indicate decommissioned systems.)

[2] Current available information regarding this unit is restricted to the manufacturer's supply details from 1952 being that the purchaser was 'Coates & Co. Pty Ltd Melanesian Mission'. It is not certain that the turbine was installed. The author assumes that the turbine purchased in 1952 from Gilkes was installed at Fauabu (based on Gilkes' purchaser records and the author's correspondence with James Tedder, District Administrator in Solomon from 1952 to 1974. Mr Tedder recalls hearing of a 'Melanesian Mission' hydro at Fauabu in 1952. The author intends to further investigate.

[3] Personal records plus discussions with operators, particularly, the late Mr Ray Jack.

[4] Author's personal records and visitations

[5] Correspondence, Director of Mines, Energy, & Rural Electrification, J Korinihona.

[6] Unconfirmed.

[7] This experienced various set-backs including a tsunami destroying village wiring, and a damaged turbine due to an unauthorised attempt at commissioning. Various attempts to revive the system were unsuccessful. During the ethnic tension period (2000-01) many remaining critical components were removed without authorisation. The author remains optimistic that the system can be revived, but a path forward remains unclear. A replacement turbine from a new turbine supplier remains in storage.

JICA Master Plan 2000

The Japan International Cooperation Agency (JICA) funded a study for power development, including hydro, in Solomon Islands in 1999-2000. Whilst the study team visited a number of sites, the overwhelming majority of the team's identified potential hydro sites were assessed from desktop or 'map studies' using area/contour/rainfall methods[8]. The report states: 'A total of 130 potential hydropower sites are identified in the Solomon Islands, with a total hydro potential amount of 326 MW including Lungga and Komarindi hydropower projects and other previous studies'. A summary of sites identified in the report are listed in Table 2 below.

Table 2: Hydro Sites Identified by JICA (2000)

	Islands	Number of Sites	Micro Hydro (kW)	Mini Hydro (kW)	Small Hydro (kW)	Total (kW)	Remarks kW / site
1	Guadalcanal	49		1,210	236,100	237,310	4,800
2	Malaita	23	90	2,700	28,000	30,790	1,300
3	Santa Isabel	6		610	4,100	4,710	800
4	New Georgia	23	320	4,840		5,160	200
5	San Cristobal	12	20	371	25,500	25,891	2,200
6	Choiseul	15	140	2,030	20,030	22,200	1,500
7	Santa Cruz	2	50	260		310	200
	Total	130				326,371	

SPREP 2004

SPREP produced a report in 2004 - *Pacific Regional Energy Assessment 2004: an assessment of the key energy issues, barriers to the development of renewable energy to mitigate climate change, and capacity development needs to removing the barriers: Solomon Islands National Report Volume 12*. This report covers a number of renewable energy technologies including hydro. The hydro component of the report generally refers to the JICA report. It also noted that 'the government developed a database of over 100 sites for possible small hydro development, of which 62 have an estimated overall capacity of 11 MW'.

[8] It is the view of the author that in various parts of Melanesia, the area-rainfall-contour approach is subject to high error. Whilst the lack of long term site-specific rainfall data is acknowledged, and catchment areas are often reasonably determinable from available topographical maps, head measurements are often highly inaccurate due to the photographically-derived contour maps used. These maps are based on assumed tree heights. This approach in highly vegetated mountainous areas frequently hides areas of relatively high head suitable for micro-hydro development. Modern vegetation-penetrating radar technologies offering true ground profiles is an exciting development in this area, but presently such data is not in the public domain.

Pacific Islands Energy Policy and Strategic Action Planning, 2006

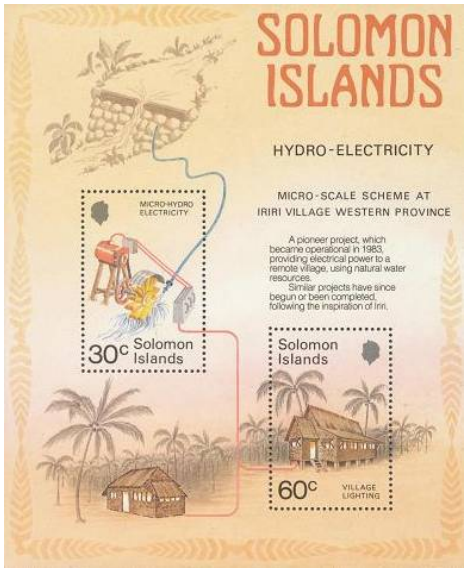
The Pacific Islands Energy Policy and Strategic Action Planning (PIEPSAP) and Solomon Islands Department of Energy produced the report *Review of Solomon Islands Electricity Act and Rural Electrification Framework - Final Report.* In relation to micro-hydro, this report generally references much of the information detailed in earlier reports about possible sites. References are made to a number of Acts relating to the development of hydros, such as the River Waters Act. Where this report differs from earlier reports is that one of the authors visited and reported on a number of the community hydro systems in the Western Province. Unfortunately in relation to the specific communities visited, the report contains a number of technical and historical errors which are unfortunately now in the public domain.

Various studies have been conducted around Honiara for large scale hydro development, including Lungga and Komarindi, and more recently a study for the Tina River Hydro. It is understood in recent times that at least six sites have been shortlisted 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 researching 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 and researchers often chose to compare the small community-run hydro systems with large government or commercial operations in other countries. Whilst the focus of these comparisons may have been on the technology used, the 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 in Figure 1. It is understood that the Minister for 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 1: The 1986 Postage Stamp Issue



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 in between. However, the climate and geography of the country are 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[9] 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 temporarily suspended 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. The relevance and importance of such acts cannot be underestimated.

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 paper does not attempt to provide a thorough explanation for the lack of hydro development. However, from the perspective of a private technology developer & implementer, the following constraints have been identified by the 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 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

[9] A video documentary of the 13 day construction of the Masupa hydro can be viewed on YouTube

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 or supportive input;
- 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 the 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 during this initial site visit 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 the 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 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 work 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 *Pelena Masupa*.

Significantly, this project including feasibility, design, construction, and 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 that youths are returning to the community from Honiara because opportunities now exist for income generation at the village. Since commissioning, electricity supply has been reliable with no reported breakdowns. Plans are afoot to develop stage two of the system to reticulate electricity to the nearby communities.

Fig 2: Pictures from the Construction of Masupa Hydro, Jan-Feb 2010

Recommendations for micro-hydroelectric development in Solomons

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). Income generation allows for future purchase of spare parts, maintenance, and possibly lighting. In the experience of this author, lighting delivered at stage one of the project does not encourage income generation activities because it results in the immediate saving, not generating, of income through typically kerosene replacement.

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.

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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.