IS RENEWABLE ENERGY ECONOMICALLY VIABLE? THE CASE OF THE SOLOMON ISLANDS

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The renewable energy business challenged conventional utility companies' hold on electricity generation. Francesco Venturini, CEO of Enel Green Power, said:

> *"Renewables are completely a different energy business. Nuclear plants take at least 15 years to plan and commission. Most large-scale power plants require 5 years to commission. On the other hand, wind generation facilities were put up in less than one year, so our renewable energy business requires a very different pace of activity"* (Innovation @ ENEL 2016).

Small-scale hydroelectric plants, solar panels, and wind farms constructed in the developing world were less costly than conventional solutions and enabled quicker self-sufficiency in power. Renewable executives and the World Bank agreed that developing countries were ideal customers of renewables because dependency on oil imports threatened a country's sovereignty (Mitchel & Klassen 2006). Renewables' relatively short turnaround time provided immediate improvement in living standards and commerce for developing nations.

George Baker had served as the Vice President for Community Wind at the Island Institute at the Fox Islands. The Fox Islands were located on Maine's coast in Penobscot Bay, near Rockland. The two largest islands were North Haven and Vinalhaven. The Solomon Islands and Fox Islands were both archipelagos. The scattered geography created similar logistic challenges

The authors developed the case for class discussion rather than to illustrate either effective or ineffective handling of the situation. The case and its accompanying instructor's manual were anonymously peer reviewed and accepted by the ***Journal of Case Research and Inquiry, Vol. 8, 2023***, a publication of the Western Casewriters Association. The authors and the ***Journal of Case Research and Inquiry*** grant state and nonprofit institutions the right to access and reproduce this manuscript for educational purposes. For all other purposes, all rights are reserved to the authors. Copyright © 2023 by Seung Hee Choi and Mark A. Doughten. Contact: Seung Hee Choi, The College of New Jersey, 2000 Pennington Rd, Ewing Township, NJ 08618, choi@tcnj.edu.

for providing consistent electricity access for the full-time residents at affordable rates. See Exhibit 1.

Solomon Islands and Fox Islands were both archipelagos. The scattered geography created similar logistic challenges for providing consistent electricity access for the full-time residents at affordable rates. He volunteered for the Fox Islands Wind project, and acknowledged that strong community support was critical for a project's success. Baker's method included first building a healthy relationship with the community, for example by hosting open town hall meetings with the renewable project as the subject. Since Fox Islands were seasonal, both year-round and summer residents were present at the meeting. Residents were concerned with the potential noise generated from large wind turbines. Baker responded with an illustration of a wind turbine and the total distance to a resident. His diagram illustrated the noise sources, propagation paths, and receivers. Baker guaranteed that the details of the project were effectively presented. He reflected that town hall meetings had helped him to build a relationship with Fox Islands' residents and thus to make progress in renewables. Baker established credibility in the community; residents visited him personally to voice their grievances. The relationship allowed Fox Islands Wind to finance $1.5 million from the National Rural Utilities Cooperative Finance Corporation (CFC) for the 20% down payment on wind turbines. In the Fox Islands, a healthy relationship with the community helped facilitate a cost-effective approach to renewable energy.

The Solomon Islands and Renewable Energy

The Solomon Islands faced high fuel import costs associated with conventional energy that limited the developing nation's economic development. The Solomon Islands decided to address the energy challenge through widespread adoption of renewable energy in order to reduce energy costs and increase access to electricity.

In an early phase, independent firms conducted research into different renewable energy techniques and assessed their effectiveness. Fortunately, there was a large potential in the

Solomon Islands for renewable energy, both from mini-grid generation and large-scale supply to the main grids. Solar photovoltaics captured a significant amount of energy during daylight. The estimated solar irradiation was 5.5 to 6.5 kwh/m2/day. The Solomon Islands Electricity Authority (SIEA) decentralized the electrical grid by constructing miniature grids with solar photovoltaics. As a result, widespread outages from technical errors, maintenance, and environmental disasters were minimized. However, the existing solar system was unsustainable. The primary reason was a lack of battery recycling procedures to reuse the material efficiently and reduce purchases of new batteries. Also, there were no guidelines on maintaining solar infrastructure, and no trained technicians.

The technically complex renewable sources were challenging to research and develop because the SIEA and the Ministry of Mines, Energy, and Rural Electrification (MMERE) lacked technical skills to produce cost-effective biofuels. The additional funding provided through the government and the World Bank helped alleviate some issues. The Solomon Islands required comprehensive renewable energy training to mitigate the risk associated with the present infrastructure and to reduce costs. For example, coconut oil as a substitute for diesel was used to power generators; coconut oil slowly reduced dependency on imported fuel. SIEA expanded coconut oil diesel supplements for power generation; however, this required additional funding. The transition to renewable coconut oil was, however, a high upfront cost.

There were limitations to the renewable energy potential of the Solomon Islands. The most daunting issue was inefficient land acquisition and regulation. The SIEA streamlined distribution extensions and miniature grids while simultaneously updating the current regulatory framework. The system planning and project management in SIEA and MMERE needed the capacity to develop appropriate policies and regulations. A streamlined approach reduced costs associated with acquiring land and working with the community at large.

Considering cost efficiency and economic feasibility, the optimal renewable sources for the Solomon Islands were hydro and solar power (Solomon Islands Government 2014). The

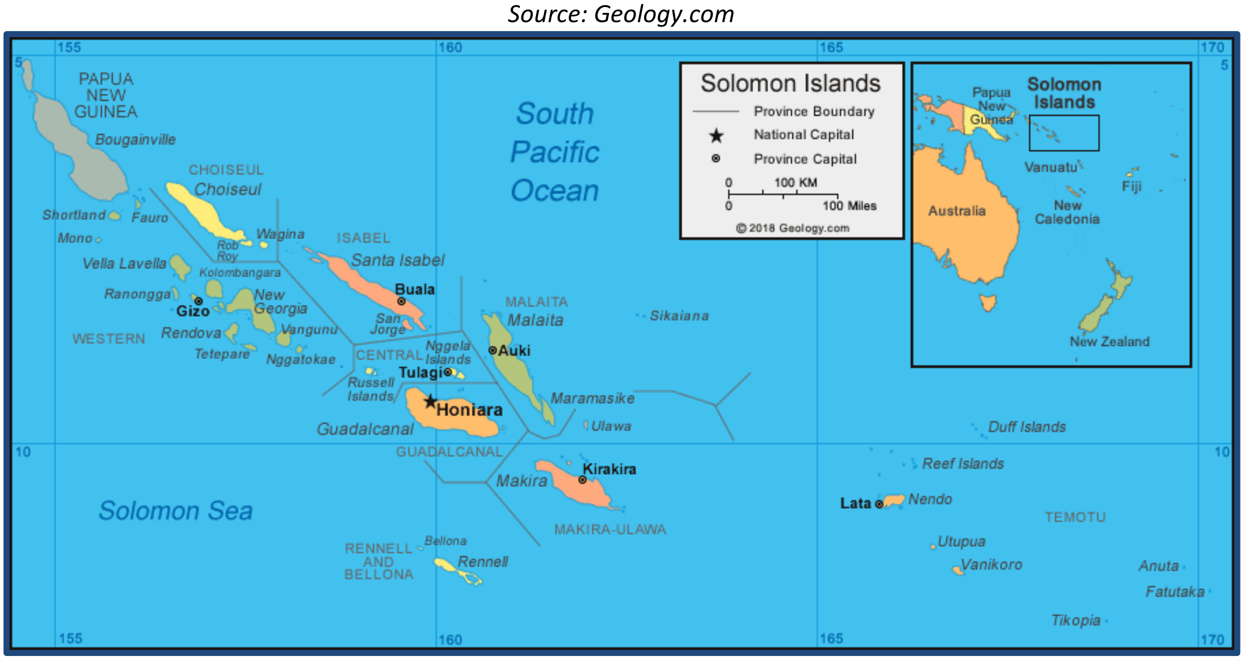
Solomon Islands had year-round river flows and consistent exposure to sunlight. The Japanese International Cooperation Agency conducted a study to estimate the total hydroelectric potential, and concluded it was 326 MW (Solomon Islands Government 2014). Comparatively, the existing diesel grid capacity was 28 MW. The largest project Solomon Island had commissioned to generate renewable energy was the Tina River Hydropower Project in Guadalcanal.

Background Information

Geography

The Solomon Islands were in the South Pacific Ocean and consisted of roughly 996 islands. The six main islands were Guadalcanal, Malaita, Isabel, Choiseul, and New Georgia. The total population of the Solomon Islands was 515,870, and roughly 80% of residents lived in rural communities. The population quickly increased from 1999 to 2009 with an average annual growth of 2.3% per year (Solomon Islands Government 2014). See Exhibit 1.

Exhibit 1. Geography of Solomon Islands
Source: Geology.com



The scattered islands were a logistical challenge because deliveries were decentralized. SIEA transported the equipment and fuel through planes and boats, which was costly for the utility company and ultimately the Solomon Islands people. Infrequently, SIEA used self-sustaining miniature grids to mitigate expensive import costs. The transition from fossil fuel generation to renewable energy generation on the Honiara and Auki grids improved energy affordability and the SIEA's financial performance (Solomon Islands Government 2014).

Economy

The Solomon Islands' economy was a mixed subsistence sector that the population was dependent on for livelihood; the country relied on limited material imports. The large-scale commercial enterprises dominated a limited monetized sector; these sectors straddled rural and urban spaces. The mixed subsistence sector included household production for self-consumption and surpluses were sold to local and urban markets. The monetized sector included commercial enterprises and organizations involved in production, manufacturing, and the service industry.

The Solomon Islands' dollar performed erratically against major currencies for over a decade with a slight appreciation in 2011. In the same year, a strong performance in commodities grew the economy by 10.7% in real terms. The non-forestry and non-mining sectors also contributed to overall growth; the agriculture, telecommunications, transportation, construction, and fisheries sectors boosted the sector. The economy was severely limited because of the small access to affordable energy in the country. A transition to renewable energy from diesel stimulated economic production since small businesses came to obtain reliable electricity and therefore increased production. In 2017, the World Banked published a short film titled *"Powerless: The Challenge Facing Businesses in Solomon Islands."* The film included interviews with local business owners who described firsthand the economic impact of unreliable electricity on their operations (https://youtu.be/xkphTxzhSJY).

Utility Company

The Solomon Islands Electricity Authority (SIEA) was a state-owned enterprise responsible for electric power generation and distribution to all provincial and rural centers. The SIEA had sole authority to provide electricity under the Electricity Act (Solomon Islands Government 2014). In 2014, the Solomon Islands were entirely dependent on imported refined petroleum fuels for energy generation. The grid generation capacity was 28 MW and was entirely diesel generation. The cost of electricity was relatively high, $0.85/kWh for households and $0.91/kWh for commercial customers. As a benchmark, the cost for energy in neighboring countries such as Australia was $0.33/kWh and Fiji was $0.22/kWh. In addition, the SIEA had a national tariff; in early 2013, the retail tariff was $0.86/kWh for domestic consumers and $0.92/kWh for commercial or industrial consumers (Solomon Islands Government 2014). The fuel price was automatically adjusted for the differentiating price of diesel fuel and the frequent fluctuation was dependent on the international oil market. See Exhibit 2.

Exhibit 2. SIEA Tariff April 2013

Source: Investment Plan for Solomon Islands, May 2014, Solomon Islands Government & Ministry of Mines, Energy and Rural Electrification

Category	SI$/kWh	USD/kWh
Domestic	6.19	0.86
Commercial $ Industrial	6.65	0.92
High Voltage Tariff	6.47	0.90
Minimum Charge ($/month)	20.00	2.79

The Solomon Islands Electricity Authority had a Board of Directors responsible for charting the Company's strategic direction, objectives, policy guidelines, and monitoring progress. The Board reviewed corporate objectives and operating budgets. There were three Board Sub-Committees: (1) Audit, Finance, Risk and Governance; (2) Technical; and (3) Human Resources, that were responsible for providing the Board with recommendations.

The Board steered the Solomon Islands Electricity Authority towards renewable electricity generation through infrastructure projects such as solar and hydroelectric. In parallel, the

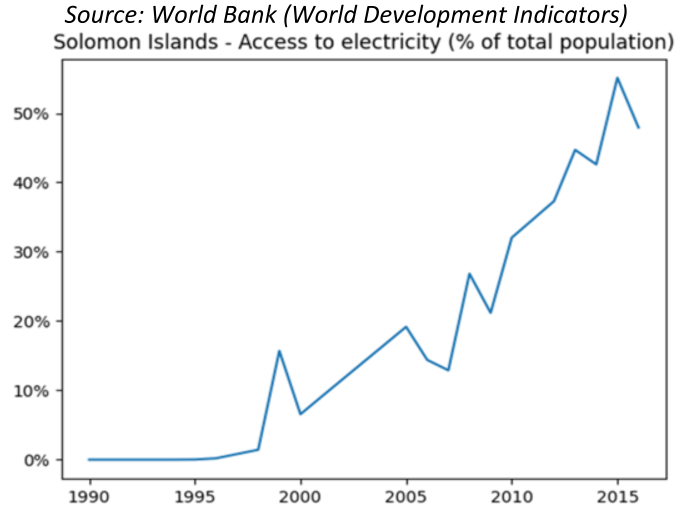
Board screened foreign investments based on the Board's core values. When deciding on a project, the Chairman and Directors were thinking critically about the impact to the country as well as their own fiduciary responsibilities.

Access to Electricity and Future Demand

Most of the households in the Solomon Islands used kerosene lamps as the main power source. The remaining households were connected to the electrical grid or solar. Despite governmental efforts, electricity access in the Solomon Islands remained extremely low. SIEA had a difficult time supporting the high cost of diesel generation and distribution in provincial regions. See Exhibit 3.

Exhibit 3. Percent Access to Electricity Households

Source: World Bank (World Development Indicators)



The Lungga diesel power plant was the main electricity provider in Guadalcanal, whose capital and main city was Honiara. Historically, Honiara suffered from power shortages, especially during peak demand periods. The Solomon Islands needed to increase the power supply to accommodate increasing business and residential demand. The goal was to alleviate the peak SIEA demand on diesel systems and backup diesel generating plants (Exhibit 4). Unfortunately, the need for further investment in diesel power generation was prolonged for more than a decade.

Exhibit 4. Projected Power Demand (kW Peak)

Source: Investment Plan for Solomon Islands, May 2014, Solomon Islands Government & Ministry of Mines, Energy and Rural Electrification

System	2012	2013	2014	2015	2016	2017	2020	2025	2030
Honiara	14,241	14,739	15,254	15,787	16,338	16,908	18,745	22,257	26,427
Noro/Munda	410	424	439	455	470	485	540	641	761
Gizo	450	466	482	499	516	534	592	703	835
Auki	360	373	386	399	413	427	474	563	668
Buala	72	75	77	80	83	86	95	113	134
Kirakira	62	64	66	69	71	73	82	97	115
Lata	88	91	94	98	101	104	116	138	163
Malu'u	30	31	32	33	34	35	39	47	56
Tulagi	92	95	99	102	106	110	121	144	171
Total Demand	15,805	16,358	16,929	17,522	18,132	18,763	20,804	24,703	29,330
Compound Annual Growth Rate	3.49%								

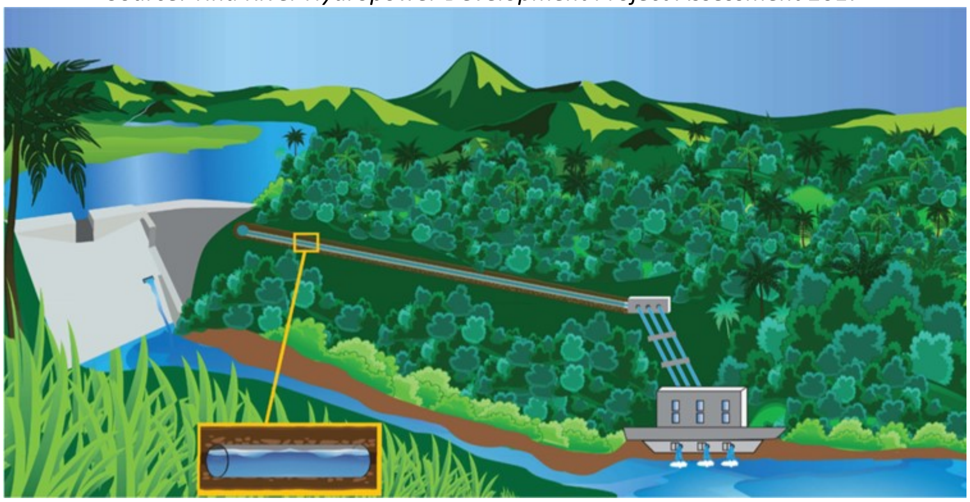
Alternative Energy Sources

Tina River Hydropower

In the Solomon Islands, most villages were located near rivers that supplied drinking and washing water (Lynch 2010). Proximity to rivers provided the residents with a unique opportunity to leverage natural resources for electricity. The Tina River was located 30 km Southeast of Honiara at the upstream end of the Ngalimbiu River Basin in Central Guadalcanal. The feasibility study of the Tina River hydropower scheme started in 2010 and closed in 2014, and several sites were studied for the optimal environment and social factors to determine the location for a hydropower facility along the river (Solomon Island Government 2019). See Exhibit 5.

Exhibit 5. Solomon Islands Tina River Hydropower Development

Source: Tina River Hydropower Development Project Assessment 2017



The Tina River Hydropower Project (TRHDP) sought to develop a 15-20 megawatt run-of-river hydropower plant to generate electricity for the capital, Honiara, through a Public Private Partnership. The project was the first major hydroelectric project in the Solomon Islands and would provide a total annual output of 78.35 GWh (Solomon Island Government 2019). The objective of the project was to supply affordable power to the existing electrical grid in Honiara and the adjacent regions, displacing the existing costly and unreliable oil-fired diesel generators. The electrical supply barely satisfied the demand in Honiara for business and residential consumers. TRHDP would reduce dependency on the current diesel system and the political dependency on fuel. See Exhibit 6.

Exhibit 6. Tina River Hydropower Project Main Characteristics

Source: Environment and Social Impact Assessment, Tina River Hydropower Development Project (TRHP), August 2017, Solomon Islands Government & Ministry of Mines, Energy and Rural Electrification

Project Cost	
Full scheme (extension of the powerhouse)	US$133.3 Million
Unit cost for the Project	US$165 to 185/MWh
Diesel energy unit cost (Lungga power station)	US$330 to 400/MWh
River Hydrology	
Mean flow at dam	11.5m$^{3/s}$
Tina catchment area	150km^2
Catchment area above the dam	125km^2

The electricity price in Guadalcanal was among the highest in the Pacific region due to the extremely costly diesel fuel used to generate electricity. Fuel costs for conventional energy fluctuated between $0.17 kWh and $0.57 kWh. In fact, Guadalcanal had abundant hydropower potential that could help the country reduce its dependency on oil, manage uncertainties inherent with oil markets, and lower the cost of electricity production.

The Government of the Solomon Islands was planning to fund the TRHDP with the assistance of the World Bank and the European Investment Bank. The hydropower project allowed the Solomon Islands to develop trusted relationships with the international banking community. The government would benefit from learning the process to facilitate future funding efforts for large-scale infrastructure projects. Supplemental funding was necessary for the developing country; the country could not meet the financial requirements itself. The renewable energy project had high upfront costs with low operational costs in the following years. The TRHDP met increasing electricity demand required for existing industry, business, and residential consumers, as well as drawing in new foreign investments to the Solomon Islands.

Solar Power Development Project

Since the Solomon Islands was on the equator, there was considerable opportunity for solar energy. Solar irradiation was estimated at 5.5 to 6.5 kwh/m2/day. At the time, there were no grid-connected solar farms in the Solomon Islands, only several small-scale projects called solar home systems (SHS). The Government had funded small projects in partnership with China, Italy, and Turkey. The focus was providing solar lighting for rural based schools including boarding schools and rural clinics.

In September 2012, the Government launched a 2-year pilot program that installed SHS for 2,000 households in the country. Japan funded the project, and the 2009 national census estimated that 21.2% of the national population had some form of household based solar system. The Asian Development Bank financed $2.24 million for the Solar Power Development Project; its goal was to decrease the cost of generating electricity with diesel fuel and reduce greenhouse gas emissions. The solar and battery systems replaced 66%-87% of diesel generation in five provinces: Kirakira, Lata, Malu'u, Munda, and Tulagi. The batteries were critical for intermittent demand. A key component of the project was training the Solomon power technicians, specifically in operating and maintaining solar systems. See Exhibit 7.

Exhibit 7. Lata Site Location

Source: Asian Development Bank. (April 2016). SOL: Solar Power Development Project

There were several advantages of solar power in the Solomon Islands. The first was that solar energy was available in most provinces, even remote inland areas. Again, the Solomon Islands was on the equator and had access to year-round sunlight. Solar panels were 50% cheaper than they had been in years before, making the decision cost effective. There were, however, some constraints including the difficulty finding a private vendor for maintenance, lead acid battery disposal, and a poorly developed cash economy in some parts leading to difficulties in upfront payments by households.

Quantitative Evaluation - Economic Viability

Renewable energy projects had a 10-year loan payback period. The utility industry had compared fixed and operational costs of alternative and conventional energy to aid strategic decision-making. Wind and hydrogen systems were $23,000 per kW and an average diesel generator at $345 per kW fixed cost. The operational costs were estimated at 1.5% annually for the wind and hydrogen system and 2.5% annually for the diesel system. Furthermore, a renewable energy system could redeem green certificate credits for about 0.017 kWh per year. The higher fixed cost for renewable energy was balanced by the relatively low operational cost and free fuel. The Solomon Islands sourced low-cost debt from the international community to help finance the high upfront costs associated with renewable energy. Financially, the Solomon Islands' conversion from conventional energy to renewable energy was supported through the *"Levelized Cost of Energy"* approach.

In 2017, Lazard supported and financed research into the cost of wind and solar (Lazard 2017). The report showed the decrease in the price per megawatt-hour in renewable energy from 2009 to 2017; renewable energy costs fell below conventional energy methods (Lazard 2017). The price per megawatt-hour for utility-scale solar decreased below conventional energy. Based on Lazard's research, the Solomon Islands would benefit financially from more affordable renewable energy.

Levelized Cost of Energy (LCOE)

Many industry analysts and researchers already acknowledged the *"Levelized Cost of Energy"*(LCOE) as one of the major standard measures for comparative analysis of different energy technologies on a standard $/MWh basis. The measurement encompassed sensitives such as cost of capital, geography, and fuel costs. Furthermore, LCOE considered the usage, characteristics, and applicability of different generation technologies, considering factors such as location requirements and constraints, dispatch capability, and land and water requirements. See Exhibit 8. According to Lazard, the LCOE was efficient to:

- Measure values across the longer term, showing projected life cycle costs;
- Highlight opportunities for tribes to develop different scales of projects (facility, community, or commercial);

- Inform decisions to pursue projects on an economic basis, compared to utility rates;
- Acknowledge most renewable energy projects have zero fuel costs (with biomass being the possible exception).

Exhibit 8. LCOE Formula

Source: Lazard's Levelized Cost of Energy Analysis – Version 11.0, November 2017

$$LCOE = \frac{Sum\ of\ cost\ over\ lifetime}{Sum\ of\ electrical\ energy\ produced\ over\ lifetime}$$

The Solomon Islands government and SIEA provided the relevant information on the Tina River Hydropower Project (TRHDP) including the investment expenditure, electricity generation, and project date in the Environment and Social Impact Assessment in August 2017. The adjustable inputs included the selected discount rate, the Solomon Islands' interest rate on World Bank loans, the operation and maintenance expenditures and the growth rate, the life of the system, and fuel expenditures. A relatively low LCOE would provide supporting evidence that renewable energy in the Solomon Islands was financially efficient.

Qualitative Evaluation

Regulatory Environment

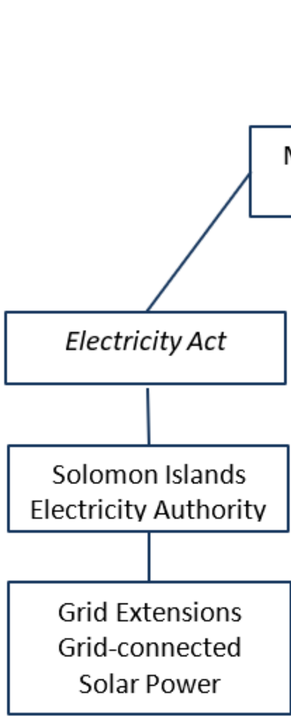
A division in the Ministry of Mines, Energy, and Rural Electrification (MMERE) was responsible for energy policy, renewable energy for development, and project implementation. The Solomon Islands had the National Energy Policy Framework 2007 to outline the broad policy direction for the MMERE (Solomon Islands Government 2014). In 2013 and 2014, the legislation was revised. A relevant clause in the revised draft was a 50% renewable energy target for 2020, and the emphasis to reduce Greenhouse Gas Emissions. The goal was cost-effective renewable energy sources that satisfied the energy demand of the country.

Furthermore, fuel storage and handling were encompassed in the Petroleum Act (Solomon Islands Government 2014). The legislation enforced the annual re-licensing of fuel storage facilities; in reality, there was no regulation for biofuels. According to the Investment Plan for the Solomon Islands, the Energy Division has five core objectives:

1. Formulate and implement national energy policy and monitor and evaluate its impact;
2. Plan, coordinate and assist in the implementation of energy projects across the energy sector and between ministries and related agencies;
3. Provide the government and energy-related agencies with expert advice and analysis on energy matters;
4. Act as the focal point for all petroleum matters;
5. Act as the convener and facilitator of the national energy coordinating.

Most importantly, the Electricity Act provided a legal framework for the establishment of a state-owned, vertically integrated utility to supply the urban and provincial centers with electricity. In 1982, the Act was amended to align with utility practice at the time and permit the SIEA to expand. The jurisdiction expansion provided the SIEA and the MMERE with the authority to direct the utility company toward renewable energy. The regulatory environment was outdated in the Solomon Islands and focused more on regulating fossil fuels than renewable energy. The weak regulatory environment increased uncertainty for businesses and foreign investors alleviating the cost of borrowing to finance projects such as the TRHDP. See Exhibit 9.

Exhibit 9. Ministry of Mines, Energy and Electrification Organization Chart



Communities

The SIEA and MMERE faced difficulties in acquiring land to develop since the clans and tribes owned most of the land. The children inherited rights to the land and the official title to the land was either registered or customary. The Solomon Islands government recognized that all customary land was owned, usually in a lineage group. The registration process was slowly standardized and guaranteed property boundaries through laws. It became more attractive for investors - local and foreign - since it allowed ownership of fixed-term estate in registered land. According to government filings, roughly 88% of the land was customary and 12% was registered (Solomon Islands Government 2014). Solomon Island officials had to persuade the community to forfeit the necessary land for TRHDP through town hall meetings and workshops. The goal was to educate the community on the material, which was a lengthy and costly process for the SIEA.

TRHDP and Solomon Island authorities hosted workshops to meet with the communities in person and present general information on the potential impact of renewable projects. The communities affected by dam construction and operation activities, landowners who had customary rights in the project-affected area, and downstream communities were present at the workshops. Together, the two groups drafted mitigation measures to ease pressure in the area near the construction zone. The objective of the workshops was exchanging information on the TRHDP and receiving feedback on the community's concerns. The mitigation measures were tailored to the local tribes and clans to establish a healthy relationship with the community and transparent communication with the community.

Looking Ahead: Self-Sustaining Grids

In the Solomon Islands, the Tina River Hydro Project and Solar Power Development Project were promising sources of cost-efficient energy. The completion of these projects displaced existing diesel generators. The goals outlined in the 2017 Annual Report for SIEA were the following:

- Increase focus on the development of the Tina River Hydro Project;
- Complete the route survey and options for analysis for the 66kV transmission lines;
- Complete the assessment of the 50-meter easement and its proposed valuation for the above lines;
- Provide input into the drafting of the Power Purchase Agreement and associated schedules.

The Solomon Islands had a bright future with renewable energy and self-sustaining electrical grid construction. The alternative sources of electricity could stimulate economic and societal development through an affordable approach to electrical generation.

Decisions

Learning from the successful case in the Fox Islands led by George Baker, the Solomon Islands needed leadership from decision-makers who had a vision, a healthy relationship with the community, and who could facilitate a cost-effective approach to renewable energy. The individuals were board members, strategic advisors of the SIEA's executive board, and even tribesmen. They partnered to set feasible and strategic directions by identifying opportunities, limits, and risks to the Solomon Islands' energy future. The investigation was based on economic, geographical, regulatory, societal, and environmental perspectives. Some of the selected projects were considered with in-depth comparative analyses. Measuring the economic feasibility of the Tina River Hydropower Project compared to the Solar Power Development Project was a starting point. In addition, the strategic recommendations needed financing to facilitate and complete renewable energy development. Most importantly, there was a clear understanding of the human resource demand on the community. Like George Baker, the decision-makers acknowledged that strong community support was critical for a project's success.

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Appendix A. Glossary

Units	Definition
GWh	Gigawatt-hour
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hour
MWh	Megawatt-hour
MW	Megawatt

Appendix B. Renewable Energy

Advantages	Disadvantages
Solar Panels	
• Portable • Installation • Lightweight	• Cleaning • Sunlight • Batteries
Biomass	
• Recycle plant material • Sourcing fuel • Carbon neutral	• Technical facility • Carbon emissions • Fuel crop production
Turbines	
• Deployable in the ocean • Scalability • Maintenance	• Wind speed fluctuation • Community complaints • Ecosystem implications
Hydroelectric	
• Consistent resource • Design • Easily adopted	• Technical facility • Carbon emissions • Upfront investment

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