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21 September 2012

Reuven Schwencke
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Dear Reuven Schwencke

We refer to your request of 14 August 2012 under the Official Information Act for a copy of the report on the viability of major energy projects in Samoa carried out by David Wright, a management consultant, in late 2011. Our letter of 12 September notifying you of an extension of time to reply to the OIA request also refers.

We are now pleased to attach a copy of David Wright's report, titled "Samoa: Renewable Energy Design Mission".

Some portions of the report have been withheld under section 9(2)(b)(ii) of the Official Information Act in order to protect information where release would prejudice the commercial position of the people or companies who supplied or are the subject of the information. The various redactions are noted in the margins of the document.

Under section 28(3) of the Act you have the right to request the Ombudsman to review this response.

Yours sincerely

Don Will
for Secretary of Foreign Affairs and Trade

Samoa: Renewable Energy Design Mission

Prepared by David Wright, Independent Contractor, based on consultations with members of a Reference Group of stakeholders[1]

Samoa 7 – 11 November 2011

Purpose

The purpose of this report is to assist Samoa and its development partners to make sound decisions on the substantial capital investment and ongoing operating costs involved in renewable energy; ensuring that such investment is both environmentally and economically sound, delivering long term reliable and sustainable energy solutions to the country.

The report assesses the available analytical material on Samoa's renewable options to produce a comparative analysis across such options in order to define the strongest mix of investment, and a clear road-map toward its renewable energy goal.

In addition, the report will assist Samoa to test the market for a private sector approach to supply of biofuel (or other) options and designs a potential programme of support to deliver those options.

A comparative analysis is presented for consideration by the Reference Group highlighting and ranking the strongest investment options or mix of options for Samoa according to criteria.

Key findings and recommendations

1. An investment in renewable energy will produce a hedge against future imported diesel costs as well as contribute to greenhouse gas abatement. However, any contractual arrangements must anticipate the situation that the cost to generate electricity from renewable energy sources may at times exceed the cost to generate electricity from diesel.
2. It would seem prudent to spread the risk with a "balanced portfolio" approach investing in a range of renewable energy options in the almost certain knowledge that some investments will ultimately be more attractive than other renewable energy options.
3. Electric Power Corporation (EPC) as the electricity utility provider must be "kept in the loop" and party to any planned renewable energy options as this is not currently consistently happening. The company must ultimately make the commercial decisions on options chosen, however EPC should keep other members of the Reference Group informed on potential investment decisions. An independent regulatory approach is recommended to determine electricity tariffs given the increasing diversity of sources of generation including the likelihood of private sector investment in power generation.
4. Solar photovoltaic will arguably become a renewable energy of choice internationally over the next five to ten years as the capital cost of installations per kWhr of electricity continues to decrease. An early completion of the "Samoa 400kWp Solar PV Project" is recommended as it will provide a good demonstration of this form of renewable energy. This is an intermittent source of electricity generation (until battery technology is efficient and economical) so does not mitigate the need for

[1] Reference Group of stakeholders from across the energy, finance, environment and agriculture sectors including development partners. In addition, discussions were held with other stakeholders including potential private sector investors.

investment in stand by diesel generation. A watching brief should be maintained on the 1 MW installation currently under construction in Tonga as this will provide a useful benchmark of the challenges in integrating an intermittent source of energy into a diesel generation network.

5. Biomass is currently the most cost effective form of renewable energy as well as the technology ready for commercialisation. It can also be relied upon for base load generation as it is not an intermittent source of energy. Private sector involvement and investment should be encouraged given the technical and commercial viability of this form of renewable energy.
6. Careful due diligence should be undertaken on the commercial implications of the proposed power purchase agreement (PPA) with Biogen3 Samoa Limited given the Deed of Guarantee that has been entered into; in part because of the scale of this initiative to supply a large block of future energy requirements with limited ability to adopt new renewable energy technologies as they become technically and commercially attractive. A Condition Precedent on implementing the PPA should be the completion of the Environmental Impact Assessment (EIA) which leads to regulatory approval to permit the import of the proposed "power millet" energy source.
7. Private sector interest should be ascertained through a contestable Expression of Interest (EOI) or Request for Proposal (RFP) in scaling up and commercialising the demonstration project utilising indigenous biomass on Samoa Trust Estates Corporation (STEC) coconut plantations, as well as the pilot project to produce biodiesel from coconut oil utilising a process developed by the Scientific Research Organisation of Samoa (SROS). These initiatives utilise indigenous biomass and are not reliant on gaining regulatory approval to import new species (power millet or palm oil).
8. New hydro developments should be encouraged as this is arguably the most cost competitive renewable energy option with less environmental impact than some other renewable energy options. The time to complete feasibility studies, construct and commission these developments means that they will not be able to contribute to replacement of diesel generation in the short term.
9. The potential of wind generation is dependent on completing the wind studies and on current information will not be as cost competitive as other sources of renewable energy given the cost of specialist turbines needed in cyclonic regions and relative low wind speeds. In addition this is an intermittent source of energy so cannot be relied upon for base load generation.
10. Geothermal energy potentially is one of the cheapest forms of renewable energy but insufficient information exists to make any recommendations. It would be useful to investigate if any funding exists internationally to undertake preliminary investigation of the potential on Savai'i.
11. Wave and tidal energy is an emerging technology. It is recommended that it is commercially proven elsewhere before considering any investment in this form of renewable energy.
12. Distributed generators are generators located at a home or business (often solar panels) which are capable of generating electricity for that home or business's own use. They are also increasingly of a capacity that will be capable of supplying electricity back into EPC's network that is surplus to their own requirement. It is anticipated that the renewable energy available from these distributed systems will increase significantly over the next five to ten years; and so policies and guidelines should be developed in anticipation of the increasing contribution that they can make to reducing diesel generation.

Terms of Reference

The following renewable energy options have been considered[2]:

- Biomass gasification from power millet
- Biomass gasification from indigenous biomass including coconut residue (husk and shell) and coppiced legume species
- Biodiesel (and / or biofuel blends) manufactured from coconut oil
- Biodiesel manufactured from palm oil
- Solar photovoltaic
- Wind
- Hydro
- Geothermal
- Wave / tidal

A comparative analysis has been undertaken of Samoa's renewable energy options against the following criteria:

- Relative economic merits;
- Technical viability, including whether or not technology is proven and mature, sustainable supply;
- Readiness for implementation;
- Degree of risk and uncertainty;
- Suitability of financing, ownership and regulation arrangements including consideration of economic viability of the private sector and/or State Owned Enterprise provision;
- Potential socio-economic benefit or risk associated with any changes to the related industries e.g. copra or agro-forestry; and
- Overall potential to progress Samoa's goals to reduce reliance on imported fossil fuels and increase its power generation from renewable sources.

Financing arrangements (if known) for each option have been assessed including capital investment costs, operational costs any on-going subsidisation that may be required. Where possible, any areas of insufficient technical assessment have been identified with recommendations on further work required to test particular options.

The comparative analysis is presented in this report with recommendations for consideration by the Energy Reference Group.

[2] Other potential renewable energy options include biogas (from anaerobic digestion), biodiesel from jatropha oil and bioethanol from indigenous species (e.g. breadfruti, cassava, niu kuma) but no information was available when undertaking the comparative analysis.

Electricity Generation

The total production of electricity generated by the EPC in the 2010/11 financial year[3] was 109.0m kWhr, slightly down on demand in the previous year. It is understood that future demand is relatively static over the next few years.

Location/Source	Generation 2009/10 (kWhr)	Contribution 2009/10 (%)	Generation 2010/11 (kWhr)	Contribution 2010/11 (%)
Hydro Upolo	47,737,583	42.9	35,248,194	32.3
Diesel Upolo	51,662,614	46.4	62,709,565	57.5
Coconut Oil Upolo	155,961	0.1	0	0.0
Solar Apolima Island	3,514	0.0	7,826	0.0
Diesel Savai'i	11,794,288	10.6	11,063,970	10.1
TOTAL	**111,353,960**	**100.0**	**109,029,555**	**100.0**

Electricity supply is reliant on diesel generation which accounts for some 55 to 70% of total generation. Hydro generation is an important current renewable source of energy but variable depending on weather conditions and accounting for some 30 to 45% of total generation. EPC has an objective to replace up to around 64m kWhr of diesel generation with generation from the following renewable energy sources:

- Biomass 35 m kWhr;
- New hydro 8-10m kWhr;
- Solar photovoltaic 7m kWhr; and
- Unallocated up to 12m kWhr e.g. biodiesel

Cost of Generation

9(2)(b)(ii)

Hydro generation is the cheapest source of energy. The cost to generate does not significantly vary over time.

9(2)(b)(ii)

[3] Source: EPC Annual Reports 2009/10 and 2010/11.

The direct cost of diesel is the "avoided cost of diesel generation" which is an appropriate cost to compare any renewable energy option against. It will continue to fluctuate and therefore introduce risks to the relative commercial viability of any renewable energy option.

Structuring investment in renewable energy

Most investment proposals assume that the current relative high cost of diesel will continue. This may or may not be the case although it is reasonable to assume that the long term trend of high international oil prices will continue. An investment in renewable energy will produce a hedge against future imported diesel costs as well as contribute to greenhouse gas abatement. However, any contractual arrangements must anticipate the situation that the cost to generate electricity from renewable energy sources may at times exceed the cost to generate electricity from diesel.

In addition relative movement between the costs to generate electricity from different renewable energy options over the long economic life of a renewable energy investment will change. For example, the cost to generate electricity from solar photovoltaic installations currently exceeds the cost to generate electricity from biomass. However, the cost of solar photovoltaic continues to drop and may eventually fall below the cost to generate from biomass significantly impacting on the relative commercial viability over the balance of a 15 to 20 year economic life of the respective renewable energy options.

For these reasons, it would seem prudent to spread the risk with a "balanced portfolio" approach investing in a range of renewable energy options in the almost certain knowledge that some investments will ultimately be more attractive than other renewable energy options.

EPC are progressing two proposals for private sector investment in generation from renewable energy sources (biomass and photovoltaic). In addition, it may be possible to structure other renewable energy options in a way that attracts further private sector involvement or funding while at the same time providing for ongoing research information. This includes the proposal to establish a demonstration facility for gasification of indigenous biomass; as well as the pilot plant for biodiesel production from coconut oil. It is

recommended that the Reference Group consider this approach before determining that such initiatives can only be proven through public sector funding. Contractual arrangements can be structured to ensure that resources are harvested sustainably with adequate protection to the environment, that independent environmental impact studies form the basis for determining whether new species should be introduced, that research information remains in the public domain, while at the same time demonstrating commercial feasibility.

Independent Regulation of electricity tariffs

Independent regulation of electricity tariff setting becomes more imperative with the increasing diversity of sources of generation through private sector investments in Independent Power Producers (IPPs). A regulatory regime is required that balances the interests of consumers as far as tariff and service standards are concerned; against the need of EPC and private sector investors to have certainty over earning a fair return on their investment.

The relative movement between the costs of electricity generated from various renewable energy sources and that generated from diesel will have a fundamental impact on the ongoing commercial viability and the amount of operational subsidies that may be required unless the costs (or benefits) can be passed through to electricity consumers. The development and negotiation of Power Purchase Agreements (PPAs) which are fair to both the project investors (irrespective of public or private sector funds) and EPC is a key risk in considering any renewable energy investment decision.

Some proponents of investment in renewable energy propose arrangements that link the cost of generating electricity from renewable energy sources to a selling price per kWhr that is adjusted to match the relative movement in cost of imported diesel. Linking renewable generated energy pricing to imported diesel costs is considered problematical as it cannot guarantee returns on investment. If diesel costs increase, then the investor in the renewable energy makes windfall profits not necessarily linked to an acceptable return on investment cost and the consumers of electricity do not get the benefit of the relative lower costs of generating (from renewable energy rather than diesel) through lower tariffs. If the cost of diesel falls below the cost to generate from the renewable energy source then the investment is unprofitable and returns cannot be guaranteed to encourage investment.

A negotiated selling price which provides an adequate return on investment with provision for annual cost adjustments should be considered. If electricity produced from renewable energy is more expensive than electricity produced from diesel then EPC would need to recover the additional costs either through the provision of a Community Service Obligation (CSO) by the Government of Samoa (GOS) or pass through of the higher costs to consumers of electricity. Any benefits through the cost of electricity generated from renewable energy being less than diesel in future years could be passed through to consumers in lower electricity tariffs.

The principles that are recommended to be included in any independent regulation include:

- A tariff setting mechanism that provides for:
    - Pass through of direct EPC costs of energy (e.g. diesel, hydro) plus cost of energy purchased from IPPs; and

  - EPC entitled to a specified return on assets providing for allowed operating and overhead costs of an efficient operator with targets set to achieve operating efficiencies (generation and distribution);
- Permit independent power generation (including consumer distributed generation with feed in tariffs);
- Distribution and retail remain exclusive to EPC;
- If Government policy constrains EPC's ability to recover investment or operating costs in tariff then community service obligations (CSO's) should be used to ensure transparency of cost recovery; and
- Consumer service standards (e.g. response time to faults etc.) and system performance standards (e.g. voltage fluctuations / outages etc.) with penalties for non performance.

Power Purchase Agreements

It is crucial that adequate due diligence is undertaken during negotiation of contractual arrangements with given the commercial implications over the long asset life of any investment of up to 20 years. The issues that need to be considered in negotiating a PPA include the following:

- Term of agreement;
- Commencement dates for supply;
- Payment terms and provisions for default on payment including;
  - Price and price movement through the term of agreement;
  - Basis upon which pricing is based (e.g. variable price per kWhr with obligation only to pay for actual electricity delivered into network or including other fixed components irrespective of output);
  - Invoicing and payment;
  - Currency of payment and currency risk;
- Supply conditions including;
  - Obligation to purchase all available electricity (24 x 7) irrespective of network load requirement;
  - Obligation to supply a minimum amount of electricity on a per day or per week or per annum basis;
  - Technical specifications regarding minimum quality specifications (dependent on renewable energy source but may include noise level, output harmonics, voltage/frequency response, power factor etc);
- Responsibility for obtaining regulatory approvals including taxation or import duty concessions;
- Responsibility for determining appropriate location to site generation plant in terms of network requirements;
- Responsibility for acquiring land for site of generation plant;
- Responsibility for operating and maintaining plant;
- Technical aspects of connection to EPC grid including operating parameters;
- Conditions of supply including provision of planned outages for maintenance;

- Provision for non supply and disconnections from grid;
- Site access;
- Metering and meter installation;
- Indemnity and liabilities against damage to each party's assets;
- Buy out options to acquire generation plant during term of PPA, and how the cost of such acquisition would be structured;
- Treatment of carbon credits;
- Insurance;
- Termination and dispute resolution;
- Consequences of termination including provision for payment of "liquidated Damages";
- Sovereign Guarantees / obligations; and
- Governing law.

Reducing system losses

Any regulatory regime should encourage EPC to invest in initiatives that improve the efficiency of operations. For example, EPC generated 109.0m kWhr and billed 89.7m kWhr in the most recent financial year ending 30 June 2011. This equated to a total system loss[4] of 17.7%. This level of losses is not untypical of island networks although the most efficient island networks may achieve total system losses of 13%. Work is underway through the power expansion project to reduce the level of losses through initiatives such as the installation of pre-pay meters and distribution network upgrades. Every 1% reduction in system losses would reduce the cost to generate electricity by around 1 sene per kWhr billed.

Demand Side Management

Initiatives such as the replacement of high pressure sodium street lights with new generation light-emitting diode (LED) lanterns will reduce usage by some 600 kWhr per annum per lantern[5]. New LED lights last for 50,000 hrs or approximately 13 to 14 years at 10 hours usage a night. Initiatives such as this will reduce the demand to generate electricity from diesel as well as renewable sources.

Distributed Generation

Distributed generators are generators located at a home or business (often solar panels) which are capable of generating electricity for that home or business's own use. They are also increasingly of a capacity that will be capable of supplying electricity back into EPC's network that is surplus to their own requirement. It is anticipated that the renewable energy available from these distributed systems will increase significantly over the next five to ten years. The increasing capability of this renewable energy option presents two major policy considerations for consideration by the GoS and EPC:

- Whether own generation from renewable sources should be encouraged as one option of reducing the dependence on imported diesel generation; and if so, the implications for EPC who will still be

[4] System losses measure the difference between kWhr that are billed and kWhr that are generated; taking into account parasitic losses (amount of electricity used by generators generating electricity, line losses (network losses in distributing electricity) and non technical losses (fraud, meter error, meter reading errors etc).
[5] Based on a 100w LED compared to the equivalent 250w high pressure sodium lantern.

expected to provide backup diesel generation capacity when these largely intermittent forms of renewable generation are unable to supply all of the consumer's own requirements; and

- Should surplus electricity be "purchased" into the EPC network; and if so, on what terms and conditions.

It is recommended that a Distributed Energy Guide[6] is developed to assist consumers in planning for the installation of Distributed Generation Systems because if EPC is not aware of what is happening, then the system could be hugely disruptive to the network load requirements in the event that either, the consumer still requires a connection to the grid to supply back up electricity or, arrangements are entered into for purchase of surplus electricity into the network.

It is not unreasonable that EPC develop a policy that provides for:

- Customers who have installed distributed generation may elect to remain connected to the EPC grid for supply of additional electricity from the network, or supply of surplus energy into the network;
- That an application fee is paid to EPC staff to inspect and ensure that any connection to the EPC network is technically approved and presents no risks to EPC staff or other users and operators of the network;
- That customers be charged the greater of, the variable electricity charges for electricity drawn down from the network, or a fixed "Availability Charge"[7] per month, whichever is the greater; and
- Surplus electricity will be purchased at EPC's weighted average variable energy cost to generate electricity[8], i.e. not including EPC network distribution costs, indirect costs and company overheads.

The arrangements for purchase of surplus energy from distributed generation are typically referred to as "feed in tariffs". Some jurisdictions have policies to encourage investment by consumers in renewable energy through pricing of the "feed in tariff" at a similar amount to the charge to customers to purchase electricity from the utility company. The arrangements proposed above do not rely on any subsidisation and reflect the commercial situation to EPC.

Comparative analysis of renewable energy options

The comparative analysis of each of Samoa's renewable generation options for electricity generation is detailed in the tables presented in the annex to this report.

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[6] Tonga Power Limited has developed a "Distributed Generation (DG) Policy Guide and Information Pack" for use by its customers planning installations. The Guide covers all technical aspects of installing and connecting distributed generation with the network in a Pacific Island context where the predominant form of generation is diesel based. It clearly outlines the customer's and utility company's obligations. With minor adaption it would be suitable for Samoa. It is a public document so an approach could be made to Tonga Power to provide a copy of the guide. This would considerably reduce the cost of developing a policy and guidelines.

[7] An "Availability Charge" covers the fixed cost to EPC of having to provide sufficient investment in "stand by" diesel generation to meet the customer's needs when they have insufficient own generation. It should cover the fixed costs of having standby generation available including depreciation and a contribution to other company indirect costs and overheads.

A summary of the overall potential to progress Samoa's goals to reduce reliance on imported diesel and increase its power generation from renewable sources along with recommendations for consideration by the Energy Reference Group is presented in the following table. This table presents a comparative summary of the renewable energy options based on key information provided in the detailed tables. The options are ranked according to an assessment of energy cost[9] and readiness for implementation.

[9] The assessed energy costs are provided from a range of sources, and are the best estimates available at the time of writing this Report. They are not based on a common set of assumptions, and the validity and robustness of the assumptions have not been tested. Actual costs are subject to the specific circumstances in Samoa, although some of the ranges in costs provide for these uncertainties.

Summary Comparative Analysis of Renewable Energy Options

Rank	Energy source / Project proponent	Capacity (MW)	Electricity generated (kWhr)	Energy cost (SAT $ per kWhr)	Litres of diesel saved (litres)	Net energy saving or (additional cost) (SAT $ p.a.)	Readiness for implementation	Recommendations for consideration by Energy Reference Group
1	Solar Photovoltaic (EPC and Government of Samoa utilising Pacific Environmental Community Fund PECF)	0.4	507,000	Grant funded	133,000	9(2)(b)(ii)	• Project underway to construct facility. • Project funding available should allow construction of a larger facility than 400 kWp given current panel costs.	• Encourage construction of facility as will provide good demonstration of potential of this form of renewable energy. • Maintain watching brief on Tonga Power Limited installation of 1 MW facility as will provide useful benchmark of challenges in integrating intermittent source of renewable energy into a diesel generation network.
2	Biomass gasification of power millet[10] (Biogen3 Samoa Limited)	4	35,000,000	9(2)(b)(ii)	9,200,000	9(2)(b)(ii)	• Subject to negotiation of commercial PPA. • Contingent on EIA and regulatory approvals permitting importation of power millet unless alternative energy source imported.	• Consideration given to implication of large block of future energy requirements being committed to one commercial arrangement/technology over long period with minimal ability to adopt new renewable technologies as they become technically and commercially attractive. • GoS undertakes due diligence on terms of PPA to ensure no unintended consequences which obligates GoS under Deed of Guarantee. • PPA conditional on Environmental Impact Assessment (EIA) permitting import of power millet. • PPA structured to ensure contractual commitment to "take or pay" all kWhr produced does not exceed minimum base load requirement (diesel minus hydro). • PPA payment terms structured to ensure payment

[10] Advice subsequently received that GoS Cabinet approval permits Biogen3 to generate from any renewable energy source with priority on use of indigenous material and that PPA has now been signed

							on variable basis of electricity supplied into network (sene per kWhr) with no fixed payment components irrespective of whether electricity supplied into network.
3	Biomass gasification of indigenous biomass including coconut residue (husk and shell) and coppiced legume species (Government of Samoa/STEC)	0.5	2,900,000	9(2)(b)(ii)	760,000	9(2)(b)(ii)	• Ready source of available indigenous biomass on STEC estate. • Sufficient technical information and indication of economic viability to allow decision on establishment of demonstration facility. • Project anticipates public sector funding of demonstration unit and operations.	• Private sector involvement/investment may be commercially viable and could be tested through competitive EOI/RFP; with contractual arrangements structured to ensure technical trial information is in "public domain" in exchange that private sector party(s) has first right to scale up to full commercial operation.
4	Biodiesel generated from coconut oil (Government of Samoa/SROS)	n.a.	5,100,000	9(2)(b)(ii)	1,350,000	9(2)(b)(ii)	• Esterification of coconut oil proven by SROS at a laboratory scale. • Sufficient technical information to allow decision to be made on establishment of demonstration unit. • Accurate process costing and determination of economic viability can only be determined on scaled up batch size. • Note that in addition to above, a further project is about to be initiated by the World Bank, "Substitution of Diesel Fuel with Coconut Oil for Remote Pacific Islands". • Notwithstanding the above, sufficient information exists to take decision now on scaling up to pilot trial.	• Ascertain private sector interest in involvement / investment in a scaled up batch facility through a competitive EOI/RFP. • Confirm more accurate production cost through RFP process as basis for decision as to whether project scaled up.
5	New hydro (Government of Samao/EPC)	3 (Upolu) 4.5 (Savai'i)	10,000,000	9(2)(b)(ii)	2,600,000	9(2)(b)(ii)	• Project feasibility has not been undertaken. • Project funding not confirmed.	• Progress initiative as part of allocation of funding within Power Expansion Project

6	Wind turbine (Government of Samoa/EPC)	2	3,600,000	9(2)(b)(ii)	947,000	9(2)(b)(ii)	• Wind resource assessment being undertaken on Upolu at selected sites to obtain investment grade wind data. • Understand data not available for 2 years.	• Watching brief while wind data is collected over two years. • If wind data proves economics; energy will be produced at a relatively low operating cost as an intermittent renewable energy available at all times of day or night.
7	Solar Photovoltaic (Solar Samoa Limited)	4	7,200,000	9(2)(b)(ii)	1,900,000	9(2)(b)(ii)	• Subject to negotiation of commercial PPA which may not be commercially attractive to private sector investors. • Currently still an expensive form of renewable energy and more expensive than current diesel costs; but photovoltaic costs continue to decrease so no commercial imperative to expedite this investment opportunity (particularly if project proponents expect costs to increase at review points over economic life of investment).	• Some capability in photovoltaic generation recommended but experience can be gained through PECF funded grant if this private sector investment is not commercially attractive to financial partners. • Maintain watching brief on Tonga installation to benchmark performance and costs.
8	Biodiesel produced from palm oil (Pacific Energy Ltd)	n.a.	41,800,000	9(2)(b)(ii)	11,000,000	9(2)(b)(ii)	• Contingent on EIA permitting importation of palm oil. • Industry needs to be established with three year lag to maturity of crops before commencement of oil extraction and biodiesel production.	• Consider project once Environmental Impact Assessment is available. • Careful analysis and consideration is required on project proponent's business case economic benefits as appears to result in net increase in energy costs.
9	Geothermal	2	14,000,000	9(2)(b)(ii)	3,684,000	9(2)(b)(ii)	• Little known about potential geothermal sources of energy so considerable exploration and drilling costs would be incurred to establish if viable energy source was able to be exploited.	• While costs look attractive, insufficient information exists to make any recommendation. • Explore whether potential funding is available to undertake preliminary exploration. • Note similar preliminary cost per unit of electricity to Sili River hydro development. If both were to proceed, Savai'i could be a net exporter of electricity to Upolu if either project included an undersea power cable.

Annex – Comparative Analysis of each Renewable energy Option

Renewable energy source	Biomass - gasification / electricity generation from a high energy content "power millet" hybrid grain.
Project proponent	Biogen3 Samoa Limited. Private company with access to technology and finance. Website: www.biogen3.com
Nature of proposal	Build own operate (BOO) scheme by Company - Independent power producer (IPP) sourcing, processing and generating electricity from biomass for supply to Electric Power Corporation (EPC) under a long term power purchase agreement (PPA).
Project proposal (Capacity)	Original project of 28 MW of generating capacity in three stages; 1st Stage 8 MW (2 x 4 MW generators); 2nd stage 10 MW; 3rd stage 10 MW. Project scaled down to one stage of 4 MW (2 X 2 MW) sized to ensure that kWhr supplied into grid does not exceed grid requirement at minimum load (less available hydro). Generate up to 35m kWhr per annum.
Financing arrangements (Capital and operational)	
Cost of electricity	
Key contractual parameters	
Project status	Environmental Impact Assessment (EIA) to assess bio-security risks of importing power millet. Intent to initially intend to import "glycerol" as feed stock for gasification plant although unclear as to how this is a biodiesel feed stock.
Project evaluation	Economic merits

9(2)(b)(ii)

9(2)(b)(ii)

9(2)(b)(ii)

9(2)(b)(ii)

9(2)(b)(ii)

[11] Advice received subsequent to completing report that PPA is now signed

		Contributes to base load requirement with continuous generation.
	Technical viability	Biomass gasification and generators are a maturing and proven technology.
	Readiness for implementation	Dependent initially on import of glycerol and ultimate establishment of millet cropping in Samoa.
	Degree of risk and uncertainty	Significant contribution to increase power generation from renewable sources although may simply substitute one import for another unless millet permitted as introduced species.
	Suitability of financing, ownership and regulation arrangements	Meets objective as private sector IPP with appropriate PPA. Commitment to long term financial repayments irrespective of future renewable options and diesel prices. Reduces financial constraint for public sector funding of future capital development costs. Current regulatory environment does not anticipate IPP/PPA arrangements.
	Potential socio economic benefit or risks	Creates village employment opportunities. Does not utilise existing indigenous biomass. Potential risk to biodiversity and food self sufficiency if power millet cropping replaces traditional food crops on agricultural/forestry land. Contribution to green house gas abatement.
	Contribution to reliance on imported fossil fuels	Replace up to 56% of Upolu diesel generation or 9.2 m litres of imported diesel.
Recommendations for consideration by Energy Reference Group		Consideration given to implication of large block of future energy requirements being committed to one commercial arrangement/technology over long period with minimal ability to adopt new renewable technologies as they become technically and commercially attractive. GoS undertakes legal due diligence on terms of PPA to ensure no unintended consequences which obligates GoS under Deed of Guarantee. Consider PPA condition precedent upon EIA permitting import of power millet species. PPA structured to ensure contractual commitment to "take or pay" all kWhr produced does not exceed minimum base load requirement (diesel minus hydro). Ensure payment terms are structured to provide for payment on variable basis of output with no fixed payments (e.g. to meet maintenance costs, currency movements etc) irrespective of whether plant produces electricity.

9(2)(b)(ii)

Renewable energy source	Biomass - gasification / electricity generation of indigenous biomass including coconut residue (husk and shell) and coppiced legume species
Project proponent	Government of Samoa/STEC (based on feasibility study for a Biomass Gasification Electricity Plant in Samoa undertaken by Consultants, Small and Medium Enterprise Cambodia)
Nature of proposal	Investigation of the technical and financial feasibility of sourcing indigenous biomass, building, and operating a gasification electricity generation plant. PPA with EPC for supply of electricity.
Project proposal (plant capacity)	Initial utilisation of woody biomass as overgrown coconut plantations on STEC land on Upolu is cleared. Establishment of coppiced legumes alongside replanted coconut plantations. Construction of a 500 KWe installation to demonstrate technical feasibility and commercial viability of sustainable biomass supply and plant operation. Generate up to 2.9 m kWhr per annum (based on feasibility study).
Financing arrangements (Capital and operational)	9(2)(b)(ii)
Cost of electricity	9(2)(b)(ii)
Key contractual parameters	To be determined.
Project status	Development assistance being sought to meet for project development costs including plant capital. 300 ha of STEC land available for supply of biomass and location of gasification plant / generator with network connection to grid.
Project evaluation	Economic merits — Appears to be commercially viable based on project assumptions 9(2)(b)(ii)
	Technical viability — Project indicates sustainable supply of indigenous biomass. Processing gasification and generators are maturing and proven technology.
	Readiness for implementation — Sufficient information on project feasibility available to allow decision on establishment of demonstration facility
	Degree of risk and uncertainty — Adequate biomass is available from the preferred site but the project is sensitive to biomass yields and costs which need to be proven as part of demonstration facility operation. Ongoing sustainability of farming and harvesting biomass from coppiced legumes needs to be proven during demonstration. Technical, operational and economic characteristics of the recommended gasification and electricity generation technology mitigated through contractual requirements for plant to perform according to manufacturer's specifications (outputs, yields, costs).
	Suitability of financing, — Project aligns with energy sector policies to reduce dependence on imported diesel and contribute to greenhouse gas abatement

	ownership and regulation arrangements	through investment in renewable energies. Project indicates that biomass gasification may be commercially viable for private sector involvement / investment as an IPP contracting for supply of electricity to EPC under a PPA.
	Potential socio-economic benefit or risks	Feasibility study considered all significant environmental and social issues although formal environmental assessment intended as part of demonstration unit. • Arable land is not removed from food production through establishment in conjunction with coconut harvesting for food and oil extraction. • Does not impact on natural forest ecosystems. • Provides employment in rural environments. • Water catchment issues can be accommodated through some set aside land in sensitive areas. • Waste water is minimised through recirculation with no external discharge due to recommended gasification technology. • Recommended biogas gasification system is carbon neutral as carbon emissions to atmosphere during the biomass conversion are balanced by the carbon uptake by the plant material grown for fuel. • Exhaust emissions such as sulphur and nitrogen oxides from an internal combustion engine running on wood gas are lower that for engines running on hydrocarbon fuels. • Carbon monoxide emissions accounted for in plant building design to ensure no harmful gas build up. • By product of biomass gasification is ash and char which can be used for charcoal like purposes or added to soil for soil enhancement. • Noise emissions are generally lower than for diesel engines and can be constraint although location on land outside urban areas will mitigate against environmental impact.
	Contribution to reliance on imported fossil fuels	Replace up to 5% of Upolu diesel generation or 760,000 litres of imported diesel.
Recommendations for consideration by Energy Reference Group		Project appears to be technically feasible and economically viable. Project anticipates public sector funding of demonstration unit and operation. If this is the preferred option; then consideration must be given to the public enterprise that manages the development and operation of the demonstration unit. Private sector involvement /investment in the demonstration facility may be viable and could be ascertained through a competitive EOI/RFP process. Private sector involvement could be structured to ensure information required to be collected from demonstration trial is publically available with first right of scaling up facility being given to commercial party.

Renewable energy source	Biodiesel produced from coconut oil.	
Project proponent	Government of Samoa and Scientific Research Organisation of Samoa (SROS).	
Nature of proposal	Development of laboratory scale process (200 litre) for esterification of coconut oil and estimation of processing costs.	
Project proposal (capacity)	Utilisation of whole coconuts or copra for extraction of coconut oil which can be blended as a biofuel with diesel for electricity generation. Esterficiation of coconut oil to biodiesel as a substitute for diesel or for blending with diesel for electricity generation. Purchase of pilot scale equipment for scaled up commercial production. A 5,000 litre batch producing one batch per day over 300 days would have an annual production of 1.5m litre of biodiesel per annum (equivalent to the same calorific value as 1.35m litres of petroleum diesel) thus substituting for 5.1m kWhr of electricity or 8% of generation demand. 1.5m litres of biodiesel production require some 13m coconuts (current production of coconut oil estimated at some 47m coconuts).	
Financing arrangements (Capital and operational)		9(2)(b)(ii)
Cost of electricity		9(2)(b)(ii)
Key contractual parameters	To be determined.	
Project status	Development assistance being sought to meet for project development costs including plant capital. Note that in addition to above, a further project is about to be initiated by the World Bank, "Substitution of Diesel Fuel with Coconut Oil for Remote Pacific Islands". The duration of the proposed project is from July 2011 to June 2013 with a Feasibility Report due 15 months from project initiation. Notwithstanding the above, sufficient information exists to take decision now on scaling up to pilot trial.	
Project evaluation	Economic merits	Laboratory scale trial indicates may be commercially viable at current purchase price of copra for manufacture of CNO. Commercial viability can only be absolutely determined with scaled up pilot facility.
	Technical viability	Blended coconut oil with diesel (biofuel) only an option for older generators and can be incorporated in blends of up to 20%. Biodiesel only able to be used on new generators without voiding manufacturers warranties
	Readiness for implementation	Esterification of coconut oil to biodiesel proven by SROS at laboratory scale. Vehicle with diesel engine running on fuel for over a year without adverse impact on engine. Sufficient information on project feasibility available to allow decision on establishment of demonstration facility.

	Degree of risk and uncertainty	Accurate process costing can only be determined on scaled up batch size. Current project costing indicates marginally more expensive than diesel but costing extremely sensitive to raw material and production costs. Requires additional 15 m coconuts (current CNO demand ca. 47m) and competes with coconut oil (CNO) production for export although CNO is a commodity with fluctuating prices; and view exists that constant market at known price for biodiesel could be a useful hedge. Prices for CNO oil have dropped from high of FOB USD $2,500 per tonne to current selling price of ~~FOB USD~~ $1,300 per tonne.
	Suitability of financing, ownership and regulation arrangements	Capacity exists to collocate biodiesel plant alongside private sector processing of CNO to minimise production costs and prevent undue competition with existing supply chain. Economics likely to outweigh advantages of collocation alongside a biomass plant (because of need to invest in additional extraction machinery) unless biomass gasification / generation plant collocated with existing commercial CNO plant.
	Potential socio-economic benefit or risks	Creates village employment opportunities Utilises existing food resource although not all existing available coconuts are collected.
	Contribution to reliance on imported fossil fuels	Replace up to 8% of Upolu diesel generation or 1.35 m litres of imported diesel.
Recommendations for consideration by Energy Reference Group	Private sector involvement / investment in the scaled up batch facility may be viable and could be ascertained through a competitive EOI/RFP process. Confirm more accurate production cost through RFP process as basis for decision as to whether project scaled up.	

Renewable energy source	Biodiesel – Plantation planting, harvesting and extraction of palm oil for production of biodiesel
Project Proponent	Pacific Energy Limited Samoan registered company with Canadian equity partner which has a 2 billion litre biodiesel plant in China. Website www.pacificenergy.ws
Nature of proposal	Production of biodiesel for supply to transport and electricity sectors as replacement for imported petroleum diesel.
Project proposal (capacity)	Importation of oil palms for developing some 5,500 to 8,600 ha of "unutilised or underutilised" agricultural land and planting of oil palm plantations in various locations (total land suitable for agriculture estimated at between 160,000 and 200,000 ha of which ADB estimate ca. 110,000 ha of unused or under used agricultural land). Palms begin cropping in third year with production of 322 tonnes per annum increasing to 28,000 tonnes per annum (ca. 28m litres) after 10 years of domestic biodiesel. Project intends to replace 60% of imported petroleum diesel with establishment of three oil extraction plants and a biodiesel production plant. 1 litre of biodiesel produced from palm oil will have calorific value of around 95% of petroleum diesel (source: Pacific Energy); therefore 28 m litres of biodiesel could substitute for 26.6m litres of petroleum diesel which is in excess of the total EPC requirements. Pacific Energy recommend blending of biodiesel with petroleum diesel in a 60:40 ratio therefore substituting for up to 11.6m litres of the total estimated EPC requirement of 20m litres of diesel. 11.6m litres of biodiesel is equivalent to the same energy generation as from some 11.0m litres of petroleum diesel or 41.8m kWhr of electricity generated.
Financing arrangements (Capital and operational)	Private sector financing with foreign direct investment spread over a period of five years. GoS approached to provide "a limited sovereign guarantee of project debt in return for a controlling interest in the company which can be amortised in line with debt repayments." Pacific Energy maintain that 'The approach of asking for assistance in the form of guarantees has the advantage of reducing the cost of capital by transferring risk away from the lender while it costs the State nothing in raw fiscal terms. Likewise, the Government's (reducing) equity position means that the progress and operation of the company are completely transparent to it." Pacific Energy selling price modelled on global wholesale price of biodiesel which is assessed at equivalent of SAT $2.63 per litre (exclusive of excise and VAGST). Intent is to sell to Samoan distributor for blending with petroleum diesel (60:40) thus incurring a margin and bringing cost to an estimated SAT $3.17 per litre (inclusive of excise, margin and exclusive VAGST). Pacific Energy is proposing adjusting the excise rates with increase on petroleum products and lower rate on biodiesel to improve the economics. Whilst overall fiscally neutral, impact will be energy cost increase to EPC over first 6 years of operation (unless subsidy provided to EPC) until quantities of biodiesel increase and cost of petroleum diesel increases (model assumes continuing rise in international petroleum prices) relative to cost movement of biodiesel (model assumes continuing increase in cost of petroleum diesel). Also seeking concessional arrangements for import of plant and equipment; as well as arrangements at Apia port for import / export of biodiesel.
Cost of electricity	Assuming cost of SAT $2.92 per litre and blend requires more litres to produce each kWhr (given lower calorific value) of 3.7 kWhr per litre of blend; then effective energy cost is SAT $0.79 per kWhr.
Key contractual parameters	To be negotiated.
Project status	GoS Cabinet Investment Committee considered and advised Pacific Energy of its concerns that importation of palm oil poses to Samoa's environment and its indigenous crops; as well as impact on soil and food crops. Pacific Energy required to undertake an Environmental

	Impact Assessment (EIA) to assess and analyse all potential environmental risks of the palm oil.	
Project evaluation	Economic merits	Utilises unused or underutilised agricultural land for productive crop that will create employment opportunities in rural communities and replace petroleum imports (estimated at 1,600 families working the land and creating another 300 agricultural, industrial and administrative jobs). Oil palm cropping is claimed to have greater productive value (net earnings per ha) than equivalent area of coconut palms. Production of 5,900 litres of oil per ha per year compared to 2,500 of coconut oil per ha per annum. Glycerol by-product (1 tonne per 10 tonnes of biodiesel) which can be refined for use in range of products. Biomass available for gasification / electricity generation. Energy cost increase to EPC of biodiesel blend.
	Technical viability	Palm oil plantation cropping, oil extraction and biodiesel production technically proven in other countries.
	Readiness for implementation	GoS concerned over environmental impact from a bio security and food self sufficiency perspective. Project dependent on EIA assessment.
	Degree of risk and uncertainty	Capability of Company to successfully establish and commercialise large scale palm oil industry although investors have access to expertise from equity partner.
	Suitability of financing, ownership and regulation arrangements	Meets objective as private sector IPP with appropriate PPA. Reduces financial constraint for public sector funding of future capital development costs. Current regulatory environment does not anticipate IPP/PPA arrangements.
	Potential socio-economic benefit or risks	Creates village employment opportunities. Does not utilise existing indigenous biomass. Potential risk to biodiversity and food self sufficiency if palm oil plantations replace traditional food crops on agricultural land or cosonut plantations (as not able to grow other agricultural crops under palm oil plantations). Contribution to green house gas abatement.
	Contribution to reliance on imported fossil fuels	Potentially replaces up to 60% (assuming 60:40 blend) of total imported petroleum diesel for power generation or 11m litres; but at likely overall increase in energy cost.
Recommendations for consideration by Energy Reference Group	Consider project once Environmental Impact Assessment is available. Careful analysis and consideration is required on project proponent's business case economic benefits as appears to result in net increase in energy costs.	

Renewable energy source	Solar photovoltaic	
Project proponent	Government of Samoa / EPC utilising Pacific Environmental Community Fund (PECF)	
Nature of proposal	Development partner funded installation	
Financing arrangements (Capital and operational)		
Project proposal (capacity)		
Cost of electricity		
Key contractual parameters	Detailed requirements outlined in funding documentation	
Project status	EPC has tendered for recruitment of experts to undertake consultancy for the feasibility, environmental impact assessment, system design and specifications of major components, preparation of tender documents and tender management assistance	
Project evaluation	Economic merits	Development grant do demonstrate feasibility and gain experience with this form of renewable energy. Cost of panels decreasing and conversion efficiencies improving (including on cloud obscured days) reducing cost of electricity generated per kWhr. Intermittent source of electricity so back up diesel generation is still required with consequential impact on EPC capital requirements and depreciation charge. High initial capital cost to build installations but once constructed has very low operating costs and long economic life of asset in excess of 20 years with minimal degradation in panel efficiency over time. Cost of ongoing energy "raw material" source (i.e. sunshine) is free. Likely to become a renewable energy of choice within 5 to 10 years as the capital cost decreases and storage battery technologies improve given low operational costs once installed.
	Technical viability	Solar photovoltaic is a proven technology and readily available. Because of Samoa's location to the equator, it has high solar radiation levels despite the incidence of cloudy days. The limitation is availability of land and grid integration aspects. Solar resource not linked to specific locations. Solar has the flexibility to be distributed generation across the network and located near to load and / or the transmission system.

9(2)(b)(ii)

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		Battery storage is still a maturing technology so most systems are intermittent generation thus requiring sophisticated integration into grids alongside other base generation.
	Readiness for implementation	Project underway
	Degree of risk and uncertainty	Intermittent variable source of energy with output only supplied during daylight hours (which does not match evening peak load requirements) hence need for back up diesel generation to meet peak load requirements. Technical constraints on integrating an intermittent form of energy into diesel systems requiring sophisticated control systems and "spinning reserve" of diesel generation to respond immediately to spikes in load as cloud cover moves over panels. The "loss" factor in terms of inefficient diesel generation at sub optimal load is estimated at up to 6% of the potential solar kWhr generated per annum. Impact will be minimal on overall generation given relatively small size of this project relative to overall generation; but becomes more significant as the output of the photovoltaic relative to output of the diesel system increases.
	Suitability of financing, ownership and regulation arrangements	Meets requirements for development partner assistance.
	Potential socio-economic benefit or risks	Requires far less land area (per kWhr produced) than biomass options. Low environmental impact and carbon footprint. Contribution to greenhouse gas emission reduction.
	Contribution to reliance on imported fossil fuels	Replace up to 133,000 litres of imported diesel.
Recommendations for consideration by Energy Reference Group	With very low maintenance, the cost of this renewable energy is directly related to the capital cost of installation. Expedite installation as will provide good demonstration of potential of this form of renewable energy and provide experience during period until economics improve (reduced capital cost and mature battery technology) and larger installations become commercially viable and able to provide base load generating capacity.	

Renewable energy source	Solar photovoltaic	
Project proponent	Solar Samoa Limited Represented by Oloipola Terence Betham Betham and Company A consortium understood to have been restructured recently with equal shareholding held by Equity Energy Solutions (Gary Yost), Terence Betham, and Dr Peter Blood. Have business relationship with Applied Solar Wind Solutions, Australia (ASWS),a private company specialising in solar photovoltaic installations based on panels sourced from a Chinese manufacturing company, CETC-48 Solar Energy Holdings Co., Ltd. http://www.appliedsolarwindsolutions.com.au	
Nature of proposal (capacity)	Build own operate (BOO) scheme by Company – Independent power producer (IPP) sourcing, processing and generating electricity from photovoltaic panels for supply to Electric Power Corporation (EPC) under a long term power purchase agreement (PPA)	
Financing arrangements (Capital and operational)	Private sector financing of development	
Project proposal (capacity)	Intermittent source of electricity (i.e. no battery storage) with solar energy utilising sun tracking solar panels.	9(2)(b)(ii)
Cost of electricity		9(2)(b)(ii)
Key contractual parameters	To be negotiated.	9(2)(b)(ii)
Project status	Company responsible for locating and concluding arrangements for locating panels. Consortium planning to build a factory in Samoa for construction of solar tracking devices for an export order in addition to Solar Samoa requirements.	9(2)(b)(ii)
Project evaluation	Economic merits	9(2)(b)(ii)
	Intermittent source of electricity so back up diesel generation is still required with consequential impact on EPC capital requirements and depreciation charge. High initial capital cost to build installations, but once installed minimal ongoing capital or maintenance costs, the "energy" source is "free" and economic life of asset is in excess of 20 years with minimal degradation in panel efficiency over time. Cost of panels decreasing and conversion efficiencies improving	

[13] See note 10 for indicative return based on current costs and allowing for an investor return on equity

		(including on cloud obscured days) reducing cost of electricity generated per kWhr. Likely to become a renewable energy of choice within 5 to 10 years as the capital cost decreases and storage battery technologies improve given low operational costs once installed.
	Technical viability	Solar photovoltaic is a proven technology. Sun tracking panels increase output per panel but are more expensive than fixed panels. Battery storage is still a maturing technology so most systems are intermittent generation thus requiring sophisticated integration into grids alongside other base generation.
	Readiness for implementation	Still subject to negotiation of contractual terms, supply and construction of panels as well as securing land for location of panels.
	Degree of risk and uncertainty	Financial backing and technical capability of commercial parties. Currently still an expensive form of renewable energy and more expensive than current diesel costs; but photovoltaic costs continue to decrease so no commercial imperative to expedite this investment opportunity (particularly if project proponents expect costs to increase at review points over economic life of investment). Technical constraints on integrating an intermittent form of energy into diesel systems requiring sophisticated control systems and "spinning reserve" of diesel generation to respond immediately to spikes in load as cloud cover moves over panels. Most large scale grid connected photovoltaic installations around the world are only viable with financial incentives.
	Suitability of financing, ownership and regulation arrangements	Meets policy objective as private sector IPP with appropriate PPA. Commitment to long term financial repayments irrespective of future renewable options and diesel prices. Reduces financial constraint to fund capital development cost. Current tariff regulatory environment does not anticipate IPP/PPA arrangements.
	Potential socio-economic benefit or risks	Battery storage technology not mature – expensive and environmental issues in disposal of batteries Otherwise, no particular issues if battery storage is not anticipated
	Contribution to reliance on imported fossil fuels	Replace up to 11% of Upolu diesel generation or 1.9 m litres of imported diesel.
Recommendations for consideration by Energy Reference Group		Some capability in photovoltaic generation recommended but experience can be gained through PECF funded grant if this private sector investment is not commercially attractive to financial partners. Maintain watching brief on Tonga installation to benchmark performance and costs.

Renewable energy source	New Hydro	
Project proponent	EPC	
Nature of proposal (capacity)	A total of up to 10m kWhr has been "allocated" to new hydro capacity as follows Upolo • Vaisigano River (1 MW) • Fuluasou River (1 MW) • Faleseela River (1 MW) Savai'i • Faleata River (0.5 MW) • Sili River (3 – 4 MW)	
Financing arrangements (Capital and operational)	No funding has been identified for these possible projects	
Project proposal	To be determined	
Cost of electricity		9(2)(b)(ii)
Key contractual parameters	To be determined	
Project status	Sili River is "on hold" due to issues associated with access to land in communal title although interest is increasing again in reassessing this project as it has the possibility to supply all of the Savai'i needs. Unlikely though to be constructed in short term.	
Project evaluation	Economic merits	High capital investment cost
	Technical viability	Dependent on geological and terrain issues
	Readiness for implementation	No time soon
	Degree of risk and uncertainty	Land access issues. Potential environmental impacts including stagnant waters creating methane emissions.
	Suitability of financing, ownership and regulation arrangements	Unlikely to be viable as private sector investment requiring development partner assistance.
	Potential socio-economic benefit or risks	Loss of access to communally owned lands a major barrier to developments.

	Contribution to reliance on imported fossil fuels	Replace up to 13% of total diesel generation (Upolu and Savai'i) or 2.6 m litres of imported diesel.
Recommendations for consideration by Energy Reference Group	Progress initiatives as part of allocation within Power Expansion Project for renewable energy projects.	

Renewable energy source	Wind turbine generation	
Project proponent	Government of Samoa / EPC with assistance from Secretariat of the Pacific Islands Applied Geoscience Commission (SOPAC) and the United Nations Development Programme (UNDP)	
Nature of proposal	To be determined	
Project proposal (capacity)	Vergnet are the only known turbine manufacturer supplying turbines in the size range (275 kW and 1 MW) suitable for use in remote and cyclonic areas; able to be lowered to the ground for servicing and for protection during cyclones. The Vergnet GEV 275 MP C turbine has a cut in speed of 3.5 metres / seconds and does not produce the full output (275kW) until wind speeds exceeding 13 metres / second. The cut out speed of the turbine is 25 metres / second. Wind speeds in Samoa are likely to be at the lower end of viability. Optimum wind speeds exceeding 13 metres / second are understood to only be attained between June and August in most areas other than at higher elevations. The annual production of a turbine operating at an average wind speed of 5.5 metres / second will be around 400,000 to 550 kWhr per annum. A 2 MW wind farm could have an annual generation estimated at 3.6m kWhr.	
Financing arrangements (Capital and operational)		9(2)(b)(ii)
Cost of electricity	To be determined but a recent study undertaken in Tonga[14] has assessed the unit cost of electricity generated from an intermittent wind source on a 1 MW wind farm at USD $0.177 per kWhr (SAT $0.41 per kWhr).	9(2)(b)(ii)
Key contractual parameters	To be determined	
Project status	Wind resource assessment being undertaken on Upolu to obtain investment grade wind data	
Project evaluation	Economic merits	Expensive capital cost but relatively low operating cost producing renewable energy at a cost that is competitive with other renewable sources and with diesel. Commercial viability dependent on wind speed. Intermittent source of energy so either requires battery storage or back up diesel generation to provide base load.
	Technical viability	Dependent on wind speed - data to date ca. 4.5 metres per second putting viability at low end of wind speed.
	Readiness for implementation	Unknown until wind data available.
	Degree of risk and uncertainty	High until investment grade wind data available across a range of sites.
	Suitability of financing,	Unlikely to be commercial viable without development partner assistance given cost and output of turbines.

[14] Tonga Energy Road Map 2010 – 2011; Final Report, June 2010

	ownership and regulation arrangements	
	Potential socio-economic benefit or risks	Predicted CO2 savings. Wind turbines have a low land requirement (kWhr per ha) and can co-exist with other sub 2m high agricultural use but cannot co-exist with tall crops such as oil palms, coconuts or forest; and cannot co-exist with residential use because of noise issues.
	Contribution to reliance on imported fossil fuels	Replace up to 6% of diesel generation or 947,000 litres of imported diesel.
Recommendations for consideration by Energy Reference Group	Watching brief while wind data is collected over two years. If wind data proves economics; energy will be produced at a relatively low operating cost as an intermittent renewable energy available at all times of day or night.	

Renewable energy source	Geothermal	
Project Proponent	None	
Nature of proposal	Savai'i consists of a massive basaltic shield volcano constructed along a rift zone with three active volcanoes; Mauga Afi, Aopo and Matavanua. No surface geothermal features are reported although Savai'i and Upolu have well developed rift systems which may provide a suitable environment for prospective thermal reservoirs. GNS[15] compare the similarities of the geological setting in Hawaii (site of Puna geothermal power plant) with Savai'i; and potential for the development of power generation projects associated with deep seated geothermal resources on Samoa. GNS concludes "that Samoa is considered to be a moderate level geothermal prospect. Although no surface geothermal features are observed the existence of an active heat source on the island of Savai'i could be a pointer to geothermal potential. It is understood that a more detailed report was undertaken on the potential but this cannot be located.	
Project proposal (Capacity)	None	
Financing arrangements (Capital and operational)		
Cost of electricity		
Key contractual parameters	Not applicable	
Project status	Not applicable	
Project evaluation	Economic merits	Potentially one of the more competitive sources of renewable energy.
	Technical viability	Technology well developed in other countries.
	Readiness for implementation	Little known about potential geothermal sources of energy so considerable exploration and drilling costs would be incurred to establish if viable energy source was able to be exploited.
	Degree of risk and	Arguably highest of the renewable energy options.

9(2)(b)(ii)

9(2)(b)(ii)

[15] Geothermal Power Potential of Selected Pacific Nations, McCoy-West, A.J., Bignall, G., Harvey, C.C., GNS Science Consultancy Report 2009/180, June 2009, GNS Science.

	uncertainty	
	Suitability of financing, ownership and regulation arrangements	Would inevitably require development partner assistance given speculative nature of project.
	Potential socio-economic benefit or risks	Creation of some employment opportunities.
	Contribution to reliance on imported fossil fuels	A 2 MWe plant producing 14m kWhr could meet all of Savai'i electricity needs replacing some 3.0m litres of expensive (transhipped) diesel and potentially export energy to Upolu (if combined with an undersea transmission cable).
Recommendations for consideration by Energy Reference Group	Given the competitive cost to generate from geothermal energy sources; • Maintain a watching brief, and • Support any potential development partner funded initiative that may be proposed to investigate the potential for geothermal generation in the Pacific Region.	