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RENEWABLE ENERGY OPPORTUNITIES Indo-Pacific

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Executive summary

The Australian Department of Foreign Affairs and Trade (DFAT) is seeking to identify Australia's strengths in clean energy (solar, wind and other renewable technologies) and to understand opportunities for the Government and DFAT to pursue overseas clean energy outcomes, particularly in the Indo-Pacific.

This report provides an overview of Australian capability based on consultation with industry representatives, drawing on other DFAT work on renewable energy capability, and Entura's own experience working in this field.

The areas of most obvious capability can be categorised as:

- Solar energy and storage combinations including feasibility, design, construction and commissioning
- Education and training
- Remote area power solutions including: systems concept, feasibility, design, delivery/implementation
- Hydropower development and operation
- Enabling technology and assembly such as batteries, inverters
- Power system integration
- Network development and upgrading including super-grid, mini-grid and smart grid
- Wind energy development and implementation
- Ocean energy technology development
- Engineering and professional services expertise for identification ,design, implementation, or for owner's due diligence of project viability or performance
- Economic and financial management, risk management, and renewable energy policy and planning.

Other, perhaps less obvious expertise includes :

- Software for measurement and modelling of resources, development viability, design or performance data
- Regulatory experience and know-how
- Sustainability and industry good practice guidelines (including HSE)
- Standards and certification

Many of the Indo-Pacific nations have set ambitious policy targets for uptake of renewable energy, either in response to climate change or as an opportunity to provide increased energy security and affordability. While many of these programs are in the early stages, it is becoming clear that the proposed schedules are unlikely to be achieved, largely due to a lack of coordinated access to capabilities of the type listed above. Given Australia's strengths in these areas, there is a clear opportunity for DFAT to assist in bringing these to the market.

Key opportunities for DFAT include:

- Funding and fostering a regional or bilateral capability program using Australian expertise.
- Fostering networks through hosting regional or bilateral forums and missions that bring together Australian companies with relevant customers and partners in the region (e.g. Indonesia, Mekong, or The Philippines).
- Foster collaboration between Australian small and medium sized enterprises (SMEs) with similar or complementary expertise to allow them to present a stronger offer on strategic or larger scale projects in the region (particularly where such projects will be more attractive to competitors from other regions).
- Supporting attendance of relevant government representatives of advanced economies in the region at a Greenbank forum hosted by CEFC to share knowledge and build capability for developing similar mechanisms.
- Promoting the establishment of a specific clean energy testing facility where national and international researchers/developers test their equipment or solutions at the facility for a fee.
- Expanding internal knowledge about the clean energy sector and supporting a proactive approach to match business with opportunities in the markets.
- Bilateral support to improve the regulatory system and the standards will not only promote Australian capability to come through and deliver but it also assists Australia to be more competitive in the global market.
- Australian development assistance directed at clean energy sector including network improvements to support renewables integration.

Consider existing partnerships and programs that can be a vehicle for support in this sector and in the Indo-Pacific and subregions, e.g. looking into joining other mature economies to support third parties such as joining New Zealand to support renewable deployment in the Pacific.

Contents

1. Renewable energy opportunities in Indo-Pacific

Energy demand is increasing as economies grow and yet many communities still do not have access to reliable electricity. According to the World Bank, over 1 billion people are still without access to electricity, concentrated in Sub-Saharan Africa (55%) and South Asia (34%) but including countries in South-east Asia and the Pacific. With climate change squarely on the global agenda, water availability and quality is also a critical issue and often goes hand in hand with multiple purpose water resource developments, including hydropower. Energy and water are fundamental to the agricultural sector and to reducing poverty and improving quality of life.

Water, energy and food security are, therefore, important for developing and mature economies alike; however it is in the less developed countries that it is driving multi-purpose energy and water infrastructure projects, together with the expansion into renewable energy resources and off-grid remote renewable power schemes. The international market for energy and water services, therefore, shows strong growth in the medium to long-term.

Renewable energy (excluding large hydro) accounted for 48% of new generating capacity installed globally in 2014, and the share of renewables in global electricity generation increased to 9.1%. Further, there has been a continuous spread of renewable energy into new markets, with US$131.3bn invested in developing countries in 2014. Countries from the Indo-Pacific that invested over US$1bn in the 2014-15 financial year included Indonesia and India, with The Philippines and Myanmar in the US$0.5 – 1bn range. By the end of 2015, renewable capacity in place was enough to supply an estimated 23.7% of global electricity, with hydropower providing about 16.6%. For the first time in history, total investment in renewable power and fuels in developing countries in 2015 exceeded that in developed economies. The developing world, including China, India and Brazil, committed a total of USD 156 billion (up 19% compared to 2014).

While much of the above development has focused on large scale renewable systems, it has driven (and often been driven by) substantial cost reductions in technology. This cost reduction has opened up a whole range of other markets, including Indo-Pacific, where more distributed systems are required.

Renewable energy is inherently suited to distributed energy systems because the resource is available on site. It does not require the costly roll out of major electricity transmission systems associated with centralised fossil fuel generation, and avoids potentially expensive and higher risk transport of fossil fuels such as diesel, as would be required in a non-renewable distributed system. These factors can make renewable energy a more economically attractive energy solution in many developing nations. Awareness of this, in conjunction with the threats posed by climate change, has led to the development of renewable energy policies in many nations in the Indo-Pacific region.

1.1 Pacific region

The Pacific region faces a unique set of energy challenges. Its limited supply of domestic fossil fuel resources has led to a historical dependence on imported fuels and a corresponding vulnerability to fluctuating energy prices. At the same time, outdated power infrastructures, geographical constraints, small populations, and limited generation capacity lead to high electricity tariffs (or costly subsidies), transmission and distribution losses, and low electrification rates.

The population of some 14 independent Pacific island states is spread across tens of thousands of islands, many of which are home to less than 100 people. Access to infrastructure, including electricity, is limited outside of urban centres. It has been estimated that 70 percent of Pacific islander households do not have access to electricity, which is equivalent to access rates in sub-Saharan Africa, despite higher income levels. Pacific SIDS (small island developing states) face unique challenges in expanding access to electricity, given that their populations are spread across so many islands. Access to electricity is a key influencer for education outcomes (ability to study in evenings) as well as economic progress (levelised cost of energy).

For these populations, off grid and mini-grid systems are the most likely solutions rather than traditional “big grid” options. Even on some larger islands, sparse populations can make these solutions attractive.

Access to electricity is widespread in countries with relatively higher income levels such as Palau, Cook Islands, and Fiji. In a number of micro-states all households have access to electricity, such as in Nauru, albeit often with severe availability or reliability issues. Energy poverty in the Pacific is concentrated in three countries: Papua New Guinea, Solomon Islands and Vanuatu. These countries account for 84 percent of the population of all 14 independent SIDS in the Pacific, and have very low levels of access to electricity. The electrification rate in all three countries is lower than that of other countries with similar levels of GDP per capita.

In response to these challenges, many Pacific island nations are targeting a scaling-up of renewable energy to off-set high diesel prices and seeking on and off grid solutions for improved power access, quality and efficiency. Renewable based electricity production can reduce overall generation costs and associated consumer prices which burden these countries and limit economic development. Demand side energy efficiency is forming part of the strategy and efficient technologies will also be important for success.

Most Pacific island nations have set ambitious renewable energy targets as part of plans to reduce the diesel reliance and build climate change resilience. With heavy reliance on outside funding and limited capability in-country, the road to implementing these ambitions has already been long and in many ways troubled.

Aid agencies and multi-lateral financing organisations are directing funding to these nations for climate change adaptation and resilience. Some larger, more mature economies have larger scale generation and network plans utilising hydropower, geothermal, wind and solar resources.

The funding in the Pacific for renewable energy systems and climate change adaptation and resilience has been growing. For example, ADB and WB commitments are over US$235m for current or in the in pipeline projects, 50% of which is renewables, 25% water supply and flood protection, 10% hydropower and dams and 6% transmission. These projects also require grid related services, including smart grid opportunities, and funding support is being directed to this area as well.

The following sections describe the situation in regards to renewable energy in each of the pacific nations where significant renewable development opportunities exist. Fundamentally, these highlight the following points:

- There is strong support for renewable energy in the pacific, because of the need to address climate change and energy security, and to address high electricity costs.
- Renewable resources, most commonly solar or wind, have reasonably good availability at all sites.

- Opportunities exist to support implementation and construct systems that provide full renewable generation for villages with small populations (<500 people) where the cost of diesel is high. For such locations, the economic business case for renewables is generally viable and improving.
- Opportunities also exist to support implementation and construct wind and solar plants where they will provide low penetration into existing larger grids.
- High value-add opportunities exist to support planning and implementation, technology solutions, and construction of systems that offer integration of higher penetrations of renewable energy in larger grids.

1.1.1 Cook Islands

The high cost of electricity is a barrier to economic development and in the Cook Islands, where electricity prices are among the highest in the Pacific. It had been estimated that supplanting diesel power with renewables can reduce the cost of generation by up to 40%.

In response to this, and the need to establish a firm position in response to climate change and energy security, in 2011, the local Government issued the Cook Islands Renewable Energy Chart, which sets a target of supplying 100% of inhabited islands with renewable energy by 2020 (50% by 2015). The 50% target has been achieved with support from the New Zealand Government to implement mini-grids in 6 islands in the Northern Group (out of a 12 populated islands in the Country). It should be noted that as defined by the Government of Cook Islands, the 50% target means 50% of islands. However, in terms of total energy demand, renewable energy contributes only about 13%.

In January 2016, the President estimated that the country would achieve 80% renewable by the end of 2017 as solar-battery mini-grids are constructed on four islands in the Southern Group. In terms of total energy demand, the contribution of renewable energy when these systems are complete will be under 20%.

The Cook Islands provides an excellent case study in some of the different scales of systems:

- All of the systems implemented to date (and proposed for 2017) are for island populations of 50-500 people. These are remote sites with very high cost of diesel transport. The systems implemented are relatively simple, and use proven, off-the-shelf technology. Nevertheless, the projected cost savings of the renewable energy systems compared to diesel generation, based on actual construction costs, are very modest, and much less than the early estimates of 40%.
- For the remaining two islands, population and electricity demand is much higher: Aitutaki has more demand than all the existing systems combined, and demand on Rarotonga is almost an order of magnitude higher than Aitutaki. Larger demand means regular shipping, and the cost of diesel on these islands is close to half that on the outer islands. Thus, these islands require a much leaner installation to maintain or improve the cost of energy for consumers. This means customised solutions and tight integration and control. While solar installed on Rarotonga to date[1] has more than achieved around the predicted 40% reduction in the cost of generation, this is only because the penetration is low. As renewable penetration increases, the cost of generation will also increase.

[1] Which contributes about 11% of the 13% renewable energy contribution to total demand achieved to date.

The paradox here is at the heart of challenges faced in developing high penetration renewable energy solutions in mini-grids. This is discussed in detail in Section 2, but essentially, Cook Island has achieved the 'easy wins' – relatively simple small scale systems with a high threshold cost of energy, and low penetration renewables in the larger mini-grids where the threshold cost of energy is lower.

To achieve the 100% renewable target on Cook Islands by 2020 will require renewable energy contribution to increase by about 80% in 3 years. This is technically feasible and the Cook Islands are very well placed to achieve this with a detailed plan, funding allocations, and a mature electricity utility. Nevertheless, this will require substantial ramp-up in capacity and represents a significant challenge on a range of fronts.

1.1.2 Federated States of Micronesia (FSM)

In its National Energy Policy, the FSM established the priority to "improve the life and livelihoods of all FSM citizens with affordable, reliable, and environmentally sound energy". And set the goal of meeting 30% of its generation needs with renewables by 2020 and 70-100 per cent by 2050.

The power generation system on Weno Island (home to the capital of Chuuk, and the second most populated island in the FSM) is severely outdated and is limiting effective delivery of government services and thereby the quality of life of the inhabitants and impedes economic development.

Yap is one of the four states within the FSM, and is currently almost 100% dependent on imported diesel for electricity generation. Although the main island enjoys a 97% electrification rate and stable power supply, oversized diesel generators result in low generation efficiency, and import dependence exposes Yap's economy to fluctuating fuel prices.

In 2013, the Federated States of Micronesia and the Asian Development Bank (ADB) initiated the Yap Renewable Energy Development Project (YREDP) to reduce Yap's dependence on fuel imports. The project will diversify the Yap States energy mix through the introduction of an 825-kilowatt (kW) wind farm and 300 kW of grid connected solar, consisting of 11 solar systems from 30 to 160 kW on the rooftops of seven government-owned buildings. Two high-speed diesel generators will also replace the existing, aging assets unsuited to the fast response times required with this level of renewable integration. A fully automated Integration and Control System will balance and maintain the quality of the energy supply to meet the 2.2 MW load for the 7000 people living on Yap Proper, maximising renewable energy penetration to the island. Upon completion the power system will be capable of providing up to 70 per cent instantaneous renewable energy penetration, contributing an average 17 per cent of the annual energy production. The projected diesel displacement volumes are in the order of 113,600 gallons per annum or a fuel saving of more than $500,000 annually.

Procurement and construction of most of the proposed systems for Yap is now underway. The three year timeframe (2013 till 2016) is typical for the implementation timeframe to allow planning, feasibility studies (including environmental and social impact assessment), land acquisition, procurement, detailed design, equipment lead times and installation. While shorter timeframes are possible (and often the basis of planning), these are rarely achieved without increased cost or reduced opportunity for local participation.

1.1.3 Kiribati

Kiribati also depends on imported oil products to meet the vast majority of it energy needs. This dependency makes Kiribati extremely vulnerable to oil price volatility and leads to high energy costs that place a burden on local development. As a collection of low-lying, isolated islands, Kiribati is also vulnerable to the impacts of climate change, including rising sea level, increased storm strength and frequency, and disruptions to rainfall patterns, where rain remains the main source of fresh water in Kiribati.

Kiribati currently has a low rate of access to electricity, with only 44% of the total population connected to the national grid. In addition, 36% of the rural outer islands population have access to rural energy services such as solar home systems and small diesel generators. There is wide disparity between the economic conditions in the capital, Tarawa, and the outer islands, where a lack of economic opportunities and persistently lower standards of service delivery, particularly in health, education, water and sanitation is causing urban migration.

Biomass is estimated to constitute around 43% of the gross national energy supply and is used for cooking and copra drying. Solar PV is used in the outer islands, but accounts for less than 1% of national energy consumption.

In 2009, the Government of Kiribati established a National Energy Policy with a vision of Access to Sustainable, Reliable and Affordable Energy Services. With the support of IRENA in 2013, it has cooperatively conducted a Renewable Readiness Assessment (RRA) that examined the status and prospects of renewable energy deployment in the country, identified issues that need urgent attention or promotion, and defined concrete actions. Fossil fuel reduction targets were set taking into account differences between the energy systems of the three major island groups and ranged from 45% to 60% reduction from power generation together with energy efficiency improvements.

In 2015, the 500 kWp Tarawa solar farm was commissioned contributing about 10% renewable energy towards demand in the capital. As with the other islands described previously, this is an important but positive step, which has taken time to achieve in-spite of the relatively low complexity of low penetration renewables.

1.1.4 Fiji

Fiji's newly revised sector policy sets the target of 99% renewable generation by 2030 and a 100% electrification rate by 2020. Achieving these goals will require investment in the order of $760 million over the next ten years, as well as increased regulation in Fiji's electricity sector.

Currently, the Fiji Electricity Authority (FEA) is the sole entity authorized to generate, transmit, distribute, and sell electricity in the power sector. Although the Fiji Commerce Commission approves tariffs, the manner in which tariffs have been established has not offered the long-term certainty and predictability that private investors would prefer.

According to the ADB, Government priority actions in the energy sector include:

- expanding the role of the private sector in power generation, including the partial privatization of FEA
- increasing the role of non-FEA renewable energy via small-scale systems
- restructuring regulatory arrangements to improve transparency and accountability and to remove possible conflicts of interest.

Fiji has implemented some wind power generation. While wind energy is naturally variable, it can offset diesel use when the turbines are generating. This has resulted in a 15-20% reduction in diesel use FEA is conducting detailed mapping in order to attract private investors.

Fiji is also planning for more widespread roll-out of mini-grids for isolated populations, particularly on remote islands. This highlights again a common theme amongst Pacific Nations, where renewable energy development commences with low penetration renewables in large grids, and isolated mini-grid systems. These are the projects that can generally be expected to be feasible, and are relatively simple to implement.

1.1.5 Marshall Islands

The Republic of Marshall Islands (RMI) is heavily reliant on diesel but has significant renewable resources and, in 2009, adopted a National Energy Policy and Energy Action Plan, which committed a 20% renewable energy goal for total generation mix by 2020. RMI is currently in the planning stages for this commitment, and has recently tendered for consulting services to support this planning process. It is likely that this will result in construction of significant renewable energy resources within the next three years.

Yet RMI has committed emissions reductions only in its official Intended Nationally Determined Contribution and has not specified a renewable energy target.

Achieving this goal will require considerable investment in the power system, which is not designed for renewable generation. A JICA funded project concluded it could only accommodate 11% renewables, well below the target. Typical issues limiting high renewable penetrations may include ratings of distribution system components, including protection, or simply minimum generator loads. These can frequently be addressed through grid stabilisation and storage technologies, so the barrier is likely to overcome.

1.1.6 Nauru

In Nauru, an under-maintained, inefficient and failing power system creates significant issues in relation to security and reliability of supply. In 2014, Nauru's total nominal electricity generation capacity was 12.9 MW. However, available capacity in the same year was only 3.70 MW against a peak power demand of about 10.75 MW.

Significant infrastructure, capability development and institutional strengthening is required to support the country with stabilising the current power supplies and building toward new renewables. The ADB is supporting the Nauru Utilities Corporation with system improvements as well as policy reform.

1.1.7 Niue

The Government of Niue has made a commitment to achieve 80% renewable electricity generation by 2025. Niue is the largest coral atoll in the world and while it is less threatened by rising sea levels, the Government is keen to reduce reliance on diesel and to cut emissions. Almost all the country's electricity is generated from diesel and fuel imports account for more than 15% of the country's GDP. Electricity prices in 2013 ranged from AU 57c to 80c per kWh.

The main focus of Niue's energy transition will be on solar power; the potential of other renewables such as wind power, biomass and wave energy will be investigated. Given the current electricity prices, low renewable energy contribution will present a good business case, however, high levels of renewable energy may be difficult to justify and are likely to rely on reductions in technology cost.

1.1.8 Palau

Like other Pacific island nations, Palau is heavily reliant on imported fossil fuels with 99.7% of the electricity generated in that way. Palau had previously committed a target of 20% of electricity from renewable sources by 2020. It has since committed, in its Intended Nationally Determined Contribution (November 2015) to 45 per cent renewable energy by 2025 along with a 22% energy sector emissions reduction below 2005 levels by 2025 and a 35% energy efficiency target, also by 2025. Progress towards these targets has not been identified.

According to the INDC report, Palau will need considerable additional installed capacity, including the 5MW of solar already planned (two or more solar projects plus additional roof-top solar) plus an additional 10 MW to power the water sector. Palau will also have to work to reduce transmission and distribution losses.

1.1.9 Papua New Guinea

Papua New Guinea (PNG) has just 12% of the population connected to the power grid, and the transmission and distribution infrastructure standard creates severe reliability issues for those that are connected in urban areas. For example, the capital of Port Moresby is plagued by power outages. The Port Moresby grid has historically been supplied by renewable energy from the Rouna 58.75 MW hydropower plant; however, heavy demand and inadequate maintenance has led to unreliable power supply and increased dependence on diesel fuel for generation.

The lack of reliable, and affordable access to electricity is cited as a key barrier to economic growth in both urban centres and rural communities. A number of projects are underway by PNG Power, several with ADB assistance to increase generation and support renewal of grid infrastructure.

The Government of PNG, through its Department of Petroleum and Energy, has laid out three primary goals in its Electricity Industry Policy. The policy seeks to

- improve access to electricity,
- improve the reliability of electricity
- ensure that power is affordable for consumers.

Most recently, in March 2016, PNG became the first country to formally submit the final version of its national climate action plan (called a “Nationally Determined Contribution,” or NDC) under the Paris Agreement. The Government’s ambition to transition to 100 percent renewable energy by 2030 is now the country’s official climate plan.

PNG has good hydropower resources and active programs to develop the resource, largely supported by the Asian Development Bank. A number of hydropower projects are under development. However, locational factors mean that the vast majority of remote villages (for instance, in the Western Province) cannot access electricity from these projects. Nevertheless, these villages are likely to be suitable for remote renewable power systems to improve electrification rates .

1.1.10 Samoa (Independent State of)

Samoa’s power grid serves 95% of the total population, with the remainder generating electricity from small diesel or solar systems. However, high system losses and voltage drops have resulted in poor reliability and quality of electricity supply.

The Government has recognised that reliable electricity services are vital for promoting private sector investments to diversify the economy and achieve sustainable economic growth. Diversifying Samoa's energy mix and supplanting diesel generation with clean, indigenous renewable energy also forms part of EPC's investment goals. A 100% renewable energy target was set for 2017 based on 30% from hydropower, 30% from solar power, 20% from wind power and 20% from biomass and waste. Samoa has committed to this target through to 2025, conditional on receiving international assistance to maintain the contribution.

Hydropower, wind and solar projects have been implemented in the push toward this goal. Hydropower is the largest source of renewable energy and accounts for about 20% of total generation. Utility scale solar has included the 2.1MW Faleata Racecourse solar facility (with expansion planned to 5.2MW) and 3.1MW facility at Faleolo International Airport.

As peak demand grows at about 3% annually, the central challenge for Samoa's lone utility—the Electric Power Corporation (EPC)—is to ensure sufficient generation and transmission capacity while improving the quality and reliability of electricity supply. To date, the rapid implementation of renewables has created concerns about grid stability and over-commitment to commercial arrangements with Independent Power Producers (IPPs), which will be a key challenge for EPC.

1.1.11 Solomon Islands

The Solomon Island has an electrification rate of around 12- 16% and all grid-connected power is currently generated by diesel. This leads to one of the highest tariffs in the Pacific at $0.76/kWh in January 2016, which creates significant barriers to economic growth. Electricity grids are only in place in urban centres, with access to electricity in rural areas estimated at just 4 %.

The Government is targeting 50% renewable energy generation by 2020. At the end of 2014, the share was approaching 11%. Increasing uptake of grid-connected renewable energy provides opportunities to lower generation costs and extend electrification to portions of the population who are not currently served. This process has commenced with five ADB funded solar-diesel hybrid systems that are planned to be installed at different sites, and will replace between 66% and 87% of diesel generation in the five selected provinces.

The ADB is also supporting the Solomon Islands Electricity Authority with the installation of a hydropower generation plant on the Fiu River to replace an existing diesel plant, and by extending the distribution network to peri-urban households. Meanwhile the World Bank has been involved in the development of the 15MW Tina River hydropower plant with a 58m high dam, which has since been taken on by SIEA and seeking private investment when the World Bank interest rates estimates significantly impacted viability.

1.1.12 Tonga

Tonga comprises five island groups—Tongatapu, 'Eua, Ha'apai, Vava'u, and Niuas—and has a total of 176 islands. Although 89% of households on Tonga have access to grid electricity, 90% of power generation relies on imported diesel. High diesel prices combined with geographical isolation create high generation costs and high prices for consumers.

The Government of Tonga has set a target of reducing fossil fuel imports for power generation by 50% by 2020 and 70% by 2030. The strategy to achieve this is set out in the Tonga Energy Roadmap 2010–2020. Renewable energy and energy efficiency improvements are key elements of this strategy.

Tonga estimates that around 25% of its energy uses is from biomass, predominantly in cooking but also in fish drying. Kerosene and LPG also feature as fuel for cooking. The solar energy resource is estimated to be very good, although likely impacted to some degree by local climatic effects on larger islands where clouds form due to rising air currents. IRENA reports that there may be potential for tidal energy on the main island of Vava'u.

The ADB's 'Outer Island Renewable Energy Project' is supporting this goal by constructing solar generation systems on nine of Tonga's outer islands, which will result in a preliminary capacity of 1.32 MW. The project is helping Tonga to build photovoltaic systems into existing grids, rehabilitate and improve energy efficiency among distribution networks, and install photovoltaic systems into community-owned minigrids. The project is also increasing knowledge among appropriate staff and institutions. Funding will also be directed to strengthen O&M capacity and for electricity grid upgrades.

Electricity infrastructure will require considerable investment for improvements, not least because of impacts from the January 2014 cyclone that reportedly damaged 90% of Ha'apai's distribution lines, 40%–70% of electricity poles, 65% of transformers, 90% of transformer structures, and 95% of streetlights. Distributed renewable energy would potentially provide greater renewable contribution without expensive grid transmission costs.

1.2 South East Asia

South-east Asia has large populations, high energy demand growth and gaps in existing infrastructure (e.g. interconnections, transmission lines, substations) and capacity.

Malaysia (Sarawak) has an ambitious program to develop 20,000MW of hydropower by 2020. Thermal projects still dominate but there is a growing interest and investment in small and large hydropower, solar, and limited wind power projects.

Selected areas in the region have good wind energy potential. Based on a World Bank-AAEP study, there are good to excellent wind resource areas for large-scale wind generation that can be found in the mountains of central and southern Vietnam, central Laos, and central and western Thailand, as well as a few other locations. Furthermore, coastal areas of southern and south-central Vietnam show exceptional promise for wind energy both because of strong winds and their proximity to population centers.

1.2.1 Indonesia

The current rate of rural electrification in Indonesia is 84 % (2014) with a target of 97% by 2019. Challenges include geographical conditions, proximity of power source to load centre, and an archipelago environment. There is high demand for power infrastructure, with 8.8% per year increase in line with economic and population growth.

Facing potentially drastic electricity shortages over the medium term, the government introduced a series of Fast Track Programs to accelerate power generation. The first phase introduced in 2013, Fast Track Program I (FTP-I) was focused exclusively on bringing coal-fired power plants online, of which just 5,707 MW out of the 9,975 MW have been delivered. The second phase, FTP-II, planned for increases in geothermal power (4000MW), hydropower (1,753 MW), coal gasification (64 MW), gas (280 MW), in addition to a bulk of coal power (3,000 MW), but like FTP-I is facing severe delays.

In its Long Term Electricity Plan (RUPTL) for 2015-2024, the government introduced a third Fast Track Program (FTP-III) which will add 35GW of energy developments by 2019. The majority of additions from FTP-III will be coal-fired power plants (56% of the total additions), followed by gas (36%), hydropower (4%), geothermal (2%) and other energy sources (2%).

In combination, the three FTPs aim to bring 42 GW of generation online by 2019. The significant demand in the country and the immediate tine-frame for commissioning has prioritised thermal over some of the renewable plans. Similarly, there is a drive to deliver on geothermal generation which also has a faster lead time to commissioning/generation output. The primary reason for this thermal focus is the high demand and, due to experience, fast turn-around for implementation. The costs are also very competitive but, as experience grows, this will change and the case for renewables will become stronger.

Geothermal is the highest priority because of the large reserves in country and the scale of generation that can be added more quickly than other technologies. Hydropower is also a priority as it is a familiar technology and there is also high resource potential.

Indonesia is also seeking smarter energy solutions for new developing regions to support the directive to process minerals locally and to reduce the diesel subsidies. There is a focus on new developing regions such as Kalimantan, Sulawesi, Sumatra, and Papua. The Government is driving improvements to the investment climate and there is strong opportunity for Equity/EPC models, including government to government approaches.

To meet this challenge, Indonesia is receiving increased funding from Multilateral Development Banks. However, they will require significant foreign investment to realise their goals. World Bank funding to Indonesia includes $4.3bn allocated to projects (active and pipeline) in power and water sectors.

The power generation sector is currently dominated by the State Owned Entity, PLN, which control around 77% of generating assets in Indonesia including through subsidiaries such as PT Indonesia Power, Pembangkit Jawa Bali, and PT PLN Batam. The private sector is expected to play a larger role in the energy sector. Recent laws have ended PLN's legal monopoly over Indonesia's power generation, transmission and distribution, and created the legal basis for the private sector to enter each stage of the power sector. As by way of example there are 45 geothermal power projects allocated for IPPs in the FTP-II and another 6 allocated for PLN.

To accelerate foreign investment, the Investment Coordinating Board (BKPM) has a mandate to simplify the process, reducing the need to negotiate with multiple government departments and State-owned Enterprises. The investment rules have also been reformed to encourage foreign investment. Foreign ownership is generally limited to 95% for investments in the production, transmission and distribution of electricity (including O&M of electrical power / geothermal installations). Indonesian electricity generation projects smaller than 1 MW installed capacity are currently closed to foreign investments, whilst small scale (1-10 MW) are open, but only through local partnership. Large-scale projects (>10 MW) can now have up to 95% foreign ownership.

The Government is promoting an Electricity Investment Scheme utilising the following mechanisms:

- Engineering Procurement and Construction (EPC) contracts offered to private sector, with finance from state-owned utility Perusahaan Listrik Negara (PLN)
- Public Private Partnerships (PPPs) between the Government and Independent Power Producers (IPPs)

- Policy incentives, such as feed-in tariffs, subsidies and tax relief to facilitate an increase in new renewable energies into the current energy mix.

Geothermal

Indonesia is said to possess the world's largest geothermal resources. Its 28,000 MW of potential represents 40% of the world's total geothermal potential. Indonesia's current installed capacity for geothermal is 1,300 MW, ranking it third in the world behind the US and the Philippines but still representing a mere 4% of its potential. Recognizing the benefits of geothermal energy in terms of energy security and environmental sustainability, the government has prioritized geothermal in its generation expansion plans. Under the Fast Track Programs, geothermal will account for over 1 GW of new power by 2019 and 4.8 GW by 2024, mostly from IPPs. A clear comparison on levelised cost of energy is not apparent but form the Indonesian Government's perspective the huge resource, combined with relatively fast construction and commissioning makes Geothermal a high priority in the renewable energy mix

Hydropower

Indonesia's hydro potential is estimated to be 75,624 MW, but its installed capacity, at 3,649 MW, is less than 5% of this potential. The greatest portion of these resources are located outside the main Java-Bali system and concentrated in areas that still have very low power demand and low electrification rates, including Sumatra, Sulawesi, Papua and East Kalimantan. Larger reservoir-based hydropower projects, including pumped storage hydropower plants, are well suited to supply peaking power in high power demand regions of Java, whereas small run-of-the-river hydropower projects would be well suited for provinces in rural and eastern Indonesia.

Solar

Most of Indonesia lies close to the equator with good solar resource year-round. The country's current installed solar capacity is low (27.23 MW) relative to its potential, but PLN has plans to scale up solar capacity before 2020, particularly to displace isolated diesel power. These plans include 140 MW of solar PV by 2015 and 620 MW of solar power plants by 2020 (including solar thermal power plants).

Wind

It was long thought that Indonesia had limited advantage for wind power generation, but recent experience show that wind potential might be as high as 9 GW. Indonesia's windiest regions also tend to be the least populated (e.g., eastern islands, which lack transmission infrastructure capable of sustaining large wind farms), so wind power opportunities would be limited to small- or medium-sized projects installed with turbines capable of power generation under lower wind speeds.

Biomass

Indonesia has significant potential for biomass energy generation from agricultural residues including rice husk, bagasse, rubber and especially palm oil. About 150 million tons of biomass is produced in Indonesia per year, equivalent to 470 gigajoules (GJ) of energy. The total potential for biomass-based electricity generation could reach around 50,000 MW, which includes biomass derived from forestry, agriculture, and estates, particularly the palm oil plantations of Sumatra. Despite such potential, just 61 MW of biomass-based power plants were operating on-grid as of February 2012. While expansion to 544 MW capacity by 2014 was planned, it is unclear if this has been achieved.

Biofuel

Indonesia has high potential for biofuel, particularly given the country's status as the world's largest producer of palm oil. Biofuel trials in Indonesia mostly focus on first-generation biofuels (starch, sugar, animal fats or vegetable oil), with Indonesia's high crude palm oil (CPO) production viewed as a viable way to reduce oil imports using biofuel. Second-generation biofuels (from biomass) and third-generation biofuels (from algae) may have higher resource availability, but these technologies are still in research and development stages. Several companies have also begun using fast-growing and high-yielding crops such as cassava, Jatropha and sweet sorghum for biofuel production.

Energy Efficiency

There is significant potential for energy savings in Indonesia. The 2005 National Energy Conservation Master Plan (Rencana Induk Konservasi Energi Nasional, or RIKEN) identified an energy saving potential of 15-30% in the industrial sector; 25% in commercial buildings; and 10-30% in the household sector. An update to the RIKEN drafted in 2014, still awaiting approval, is expected to establish a new energy savings target or 17%.

1.2.2 Timore Leste

Power sector development is a key driver of economic growth and poverty reduction in Timor Leste. The Government has successfully increased electrification rates from 22% to 71% during 2003-2014, and reportedly possesses sufficient installed capacity to connect all households and meet peak residential, commercial, and industrial demand for the coming decade. Most power production is from diesel and heavy fuel oil.

Electricidade de Timor Leste (EDTL) is the vertically integrated monopoly generator and distributor of electric power in areas served by its limited grid system, and in isolated areas served by EDTL diesel generators. EDTL faces serious financial constraints because of the chronic non-payment of electricity invoices. Commercial losses have recently run at 50 to 60 per cent of power generated. Donors, in particular Australia, Japan, Portugal and Norway, have been subsidizing EDTL's losses. Improvements to electricity services will, therefore, impose considerable financial burden on the state into the future.

Small scale solar installations have been part of the rural electrification process and are not only improving electrification rates they are assisting with improved health outcomes with the reduction of issues arising from inhaling smoke and kerosene fumes, as well as educational outcomes as children can study at home.

1.2.3 The Philippines

Renewable energy accounted for 26.44% of The Philippines' total electrical energy needs in 2013. Plants include small hydro, wind and pumped storage hydropower projects. Major wind projects include the 150 MW Burgos Wind Farm and the 33MW Bangui Wind Farm.

In October 2015, The Philippines pledged to reduce greenhouse gas emissions by 70% by 2030. At that time, the Department of Energy had approved a total of 616 renewable energy projects. Hydro power led with a total of 344 projects and 7.39 GW capacity having been approved by the agency.

The Energy agency also approved 105 solar power projects with 2.55 GW capacity, 65 biomass projects with 255 MW capacity, 52 wind energy projects with 3.35 GW capacity, 46 geothermal projects with 750 MW capacity, and 7 ocean energy projects with 26 MW capacity. A number of these projects were selected under the Government's feed-in tariff policy which led to a significant response from prospective project developers who urged the government to expand the scope of the policy to cover additional capacity. The agency had under its consideration a further 272 projects representing just over 5 GW capacity.

By the end of 2014, renewables accounted for 29% of electricity generation. In May 2016, President Aquino signed a resolution for urgent and comprehensive review of the country's energy policy aimed at reducing dependence on coal and to facilitate a faster shift to renewable energy. The Philippines also has potential for larger scale generation utilising hydropower, wind and solar resources.

Power transmission and network infrastructure and system requirements are also increasing to support the new generation and electrification goals. For example, the utility company, Meralco of The Philippines announced that the Energy Regulatory Commission (ERC) approved P15.466 billion (US$838.6m) in capital expenditure for its 2016 grid expansion projects. The capital will fund the utility's projects aiming to expand its power generation portfolio and digitisation of networks and facilities.

The projects will include the replacements of transformers, expansion of substations, installation of prepaid meters and deployment of an advanced metering project for commercial customers.

In 2015, the Phillipines' largest electricity distributor had announced that it plans to spend a large part of a US$32 million budget on smart grid technology in 2016.

The Philippines is actively encouraging private investment in the country, including for renewable energy, providing an attractive feed-in-tariff scheme. According to the World Bank, in 2012, 538 MW of renewable energy projects with private participation reached financial closure in the country, with total project costs of USD 1,008 million.

The Government has a focus on Public, Private, Partnership (PPP) models and recent transaction activity amongst concession holders is increasing along with the need for technical and financial due diligence services.

The most active investor in renewable energy was Korea Water Resources Corporation of Korea, with 246 MW, or USD 441 million in financed projects.

Small Hydro was the most active technology, totaling 120 MW in pipeline, and 246 MW or USD 441 million in financed projects.

In March 2016, the World Bank approved $67 million in financial assistance for two renewable energy guarantee programs that are aimed at new renewable energy and remote access to electricity. The guarantee provided by the World Bank will help reduce risks of commercial lending to electric cooperatives.

1.2.4 Mekong countries

The Mekong countries (Cambodia, Laos, Thailand, Vietnam, and Myanmar) all have significant renewable energy potential with hydropower and solar projects planned to support expected economic growth. As an example, the rapid industrialization of Vietnam has led to a demand for electricity that has grown by 10 percent in the past decade. Given that demand is expected to increase at an even faster rate over the next 20 years, Vietnam has started looking at renewables as a possible solution. To support this, transmission and power system needs are also increasing. Aid and loans remain critical for implementation of many projects, although private developers are taking a number of projects forward as well as the Government projects. The ADB has aroundUS$10bn of active and pipeline of renewable energy and climate change projects in the Mekong countries (incl. ~55% water supply and irrigation, 13% hydropower and dams, 25% transmission).

Recognizing the potential and considering the cost competiveness of solar PV, Vietnam has begun energy reforms and opened the sector to private investment. Both local and foreign companies have started taking advantage of this untapped market. Construction on the first solar power plant (19.2 MW) began in August 2015 at a cost of US$36.12 million and with the potential to produce 28 million kWh a year (at a cost of energy of around US$140/MWh). Another project recently announced involves a US$650 million investment by a South Korean firm on a 300MW plant..

Many countries in the region are driving renewable energy investment through feed-in-tariff (FiT) schemes with long tenure Power Purchase Agreements (PPAs) to raise investor confidence. For example, in Malaysia, FiTs have been in place since 2011, providing power producers 21 year' PPAs for PV and mini hydro and 16 year' PPAs for biomass and biogas. Malaysia also established the Green Technology Financing Scheme (GTFS) which can provide up to 60% Government finance. Local investment rules still represent some barrier to foreign investment.

The significant resource opportunity, and the government plans for new generation in these emerging or re-emerging economies can create a policy lag, as developers and investors crowd in on concession opportunities and Governments find themselves behind in terms of policy and regulatory frameworks, governance, and system and network planning. The infancy of these systems and regulatory mechanisms leaves governments at risk of poor quality projects (many of them BOOT (Build, Own, Operate, Transfer) that won't meet sustainable development outcomes.

In Thailand, the EGAT (Electricity Generating Authority of Thailand) plans to increase its power generated from renewable energy resources from the current 560 MW to between 1000 MW and 2000 MW by 2036. Currently EGAT produces close to 40 % of electricity in the country.

Water management planning and dam safety is also a priority following serious flood events in Thailand and Malaysia in particular. Understanding rainfall, river flows and flood risk is all part of adapting to climate change impacts and building resilience. Hydrologic data collection, management and modelling services can support better planning and risk mitigation.

Again, training and capability development and institutional strengthening are required to support these governments on their significant renewable energy and climate change related programs.

1.3 South Asia

In the South Asia region (including India, Nepal, Bhutan, Bangladesh), there are large populations, high energy demand and gaps in existing infrastructure and capability to deliver.

Meanwhile, energy demand is growing and "energy access to all" continues to be a key government driver. World Bank data shows India is leading global electrification rate improvements but around one third of people without access to electricity (263 million) are in India. These trends are likely to continue over the next decade.

There are significant hydropower development programs underway in those countries that will deliver major generation capacity, although not all these result in electrification in remote areas. Small scale hydro, solar and wind projects are also of significant scale in the region.

1.3.1 India

India's demand for electricity has been growing at a rapid rate and is expected to grow further in the years to come. As per the International Energy Agency (IEA) publication on World Energy Statistics 2013, India ranks 5th in electricity production and 110th in the per-capita consumption of electricity.

The Government of India is targeting around 89 GW of additional generation capacity under the 12th (2012–17) and around 100 GW under the 13th (2017–22) Five-Year Plans. The expected investments in the power sector during the 12th Plan (2012–17) are US$223.9bn. Investment in renewable power projects (excluding hydropower projects > 50 MW) increased in 2014 by 14%, (totalling US$7.4bn), as political uncertainty was alleviated after the Indian general election and accelerated depreciation for wind projects was restored in May 2015.

In support of this objective, the Government plans to create a fund to provide long-term finances to hydropower developers. There is a tangible shift in policy focus on the sources of power. The Government is promoting hydropower, other renewables and gas-based projects, as well as the adoption of clean coal technology.

Opportunities include:

- The Government plans to invest Rs 2 trillion (US$32.61bn) in solar and wind power projects in the deserts to compensate for India's depleting fossil fuel reserves.
- India and Nepal have signed the power trade agreement. The agreement will be effective for the next 25 years and deals with power trade, cross-border transmission lines and grid connectivity.
- The Ministry of New and Renewable Energy has initiated a scheme for setting up of 25 Solar Parks, each with the capacity of 500 MW and above, to be developed over the next 5 years in various states.
- Indian Renewable Energy Development Agency Ltd has signed a MoU with the US Exim Bank with respect to cooperation on clean energy investment.
- The Government of India's UDAY scheme plans to augment the transmission capacity and improve efficiency through infrastructure improvement, smart metering and tracking of losses.

1.3.2 Other countries

Stable governments in India and Nepal are bringing positive private investment climate and the financial sector is promoting energy export Public Private Partnerships (PPPs).

Funding agency support is extremely high in India and Nepal with over US$22bn in services including 42% water supply, management, irrigation and flood protection, 38% transmission, 13% hydropower and dams, and 3.5% renewables.

In November, 2015, neighbouring Bangladesh has set a renewable-energy capacity target of roughly 3.2GW by 2021, including 1.74GW of solar and 1.37GW of wind power.

Bhutan has an ambitious hydropower development program of 10,000 MW by 2020 (around1/3 under construction) and is strongly connected with India through financing and electrical interconnectors.

Also in the region, Sri Lanka has a renewable energy target of 20% by 2025 (530MW new wind and small hydro projects).

1.4 Discussion

There are several key themes identified across almost all countries planning for the uptake of renewable energy:

- Strong support for renewables is tempered by a need to deliver cost effective solutions.
- Currently, feasible projects are dominated by either large scale grid connected projects, low penetration renewables in small to medium sized grids, and mini-grids for small, remote communities. These represent the bulk of current opportunities. Despite the relative simplicity of these solutions, they still require detailed and comprehensive planning and development, typically requiring about 3 years lead time.
- Higher penetration renewables is achievable, but requires expertise and high value add services considering technical and commercial drivers to effectively plan a viable solution.

Entura have also observed some other common themes, which are not necessarily evident in the country profiles:

- In many cases, there is limited in-country capacity to provide the necessary services for renewable energy development. This is not limited to technical specialisation, but also includes project management, finance, legal and other support services that are necessary to support rapid influx of investment.
- There is a lack of consistency in information and thus understanding of the opportunities and risks in developing renewable energy. Estimates of the potential capital costs or savings on cost of energy often vary by up to 100% (for a given country, from different reports published within a year of each other). And this has a substantial impact on the capability of policy makers to establish practical yet challenging targets.
- In many countries, progress towards targets is moderately behind schedule. In the few examples that have tried to accelerate faster (e.g. Samoa) difficulties have been experienced in managing the technical and commercial integration of renewables with the grid.
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2. Technical barriers to uptake of renewables

Two of the key questions impacting on renewable energy opportunities are:

- What are the renewable energy technologies with the best prospects for deployment?
- What are the technical barriers to renewable energy uptake?

The answer to these two questions is intertwined, complex, and site dependent. To break this down, it is useful to start from the perspective of the power system requirements that need to be delivered. There are typically two requirements:

- Supplement or replace an existing, functional grid or mini-grid power supply. This may be undertaken if there is an economic benefit, or as a result of energy policy (often aligned with an intended economic benefit).
- Provide electrification in an area which otherwise has none. In such situations, a lower level of service may be acceptable compared to the expectations of a functional grid or mini-grid power supply. A lower level of service covers factors of availability of power supply, capacity to meet demand, and reliability. An example may be a minimal supply sufficient for refrigeration of medicines, water pumping and evening lighting. However, an electrification project may also offer a fully functional mini-grid with 24/7 electricity supply to meet the forecast demand of a village.

In many ways, the second scenario is a simpler one, as it allows holistic consideration of the economic impacts of different levels of service, depending on the available generating resources. In the first scenario, it is often difficult to compromise existing levels of service (even marginally) in order to provide a more economic optimum solution, making for challenges. As such this discussion will focus on addressing the first scenario, on the basis that greenfield solutions (the second scenario) can typically be implemented as a subset of this approach.

To generate energy renewably, there are essentially three technologies that are suitable for this region: hydro, wind and solar photovoltaics[1] . Biomass also has an important potential role in the larger nations such as Indonesia, provided it can be sustainably managed. Solar thermal hot-water is also generally suitable, though does not typically form a major part of the energy mix or contribute to electricity supply. Other broad categories of renewable technology that are mature, but are not typically suitable are as follows:

- Bioenergy (aside from specific opportunities in South East Asia): land area and management requirements typically mean the environmental impacts are disproportionately high to the energy derived[2].
- Concentrating solar thermal: insufficient resource

[1] Plus geothermal in Hawaii and some parts of Indonesia.

[2] Also, waste-to-energy solutions have some potential, but in most cases the waste resource is insufficient to make a significant contribution to energy supply, and these projects are best suited to waste disposal.

- Geothermal: no resource at most sites
- Ocean energy (only moderately mature): high cost and maintenance requirements (has possible application in larger scale economies)

There are also a whole range of alternative technologies that have not yet reached maturity or mainstream. While it has been our experience that such technologies are rarely suitable, such technologies may play a role where they do not form a core role in the electricity supply, and where all risk is on the proponent (i.e. where a well-constructed power purchase agreement, PPA, is in-place).

For hydro, wind and solar, there are various factors that affect their suitability. Solar is the most broadly applicable technology due to almost universally available resource (albeit at only moderate levels due to relatively high cloud cover), modularity, robustness and low maintenance costs. Most typically, PV will be fixed tilt, though tracking systems may be suitable where O&M can be managed effectively. Medium scale wind turbines (~200 kW) are also commonly suitable, though they are typically more site constrained to due to resource availability (coastal regions or elevated areas and ridgelines). In some countries with greater technical capacity, industrial resources and land area, large scale wind may be also be applicable. It has been our experience that constraints on sites suitable for wind power mean that wind can contribute less to the total energy demand than solar in most countries, though night-time generation from wind is an important part of an energy mix.

Hydropower, may include storage or run-of-river technology. It is the most site specific, but also has the greatest potential to deliver high contributions of renewable energy (and almost all larger grids with high renewable contributions incorporate significant amounts of hydro generation). Opportunities for new hydro are more limited (and potentially have higher environmental impacts) but should not be discounted. Indonesia, Philippines, Solon Islands, Samoa and others are investigating and implementing hydropower projects

However, aside from large scale hydro storage, these 'suitable' generation technologies require careful integration to run a grid, and it is the knowledge and management of this that is the major barrier to renewables in the Pacific. Renewable generators are intermittent, and do not (yet) provide all of fault current, spinning reserve, or inertia, all of which are necessary functions of a reliable electricity grid. These functions can be provided by other enabling 'enabling' technology including batteries. Control of the functions of various technologies in these systems is paramount. The need for enabling technology depends on the mix of generation technologies located in any individual grid.

The simplest first step for transitioning to renewable energy is just to add renewable generation to an existing power system, thus reducing load and fuel consumption of the conventional generators. This is typically very cost effective, and attractive for IPPs and grid operators alike. It is for this reason that low penetration renewables feature in current projects in the Indo-Pacific (and elsewhere). The potential to achieve higher contributions of renewable energy is determined by site specific conditions (including resource availability, population, existing infrastructure and cost of fossil fuels) that impact on project economics. Technically, there are solutions available to reach very high (including 100%) renewable contribution at any site. These solutions use combinations of generation technology, storage and other enablers to provide full grid functionality at increasing levels of renewable energy contribution. The key challenge, and the area where Australia has outstanding capability and experience, is innovation in the application of new and conventional technologies to provide the most cost effective solutions for specific sites. This includes utilising unique combinations of technologies, and developing understanding and operational experience in the latest capabilities embedded in OEM equipment (such as wind turbine generators and solar inverters).

There are still typically economic limitations on the level of renewables that can practically be achieved, though viable levels are increasing rapidly. This is particularly being aided by the cost reduction, modularisation and additional power capabilities available in battery energy storage systems. However, there are other innovations that have been proven in Australia such as solar inverters and wind turbines with advanced grid support functionality, low load, high speed diesel generators, solar forecasting systems, and dynamic to provide spinning reserve and manage spinning frequency. And underlying all high penetration renewables are advanced control and automation systems.

One example solution, which has been effectively demonstrated by Hydro Tasmania on King Island, is to use sophisticated control schemes and a suite of conventional technology to provide a more cost effective way to integrate high renewable penetrations. This solution effectively allows conventional generators to operate at low load, or go completely off-line, without significant storage. Under this approach, wind and solar can contribute up to around 45% of total energy demand, and can include a mix of the following technologies:

- Energy efficiency.
- High speed (diesel) generators (to enable quick response to changes in wind / solar output), preferably with low load capability.
- Control system (to manage integration, and curtailment of different technologies).
- Resistors or other controllable load (to manage short term excess renewable generation).
- Demand management (to curtail schedulable loads).
- Flywheels or similar (to provide inertia with higher penetration of wind or solar).
- Storage (high power) (to add more flexibility and control with fluctuation in load and renewable generation).

To achieve very high levels of renewable energy contribution will ultimately require high capacity storage of excess renewable generation for later use (e.g. solar for night-time use). Batteries are the most likely candidate to support this requirement; however, their viability will depend on the cost of conventional generation (fuel price) and the continuing decline of battery price. Other storage technologies such as compressed air energy storage are showing promise, but need to mature before being considered suitable.

Despite the above described opportunities for integrated technology solutions to reach high renewable energy contributions, it is exactly this area that is the major barrier for higher renewable contributions in the Indo-Pacific. This is still a complex area, requiring significant underlying skill sets and experience, which is not widely available in the Indo-Pacific (or elsewhere). There is also considerable potential to get it wrong – if inefficient investment decisions for high capital cost items are made, or long term contracts for unstainable tariffs are locked in, there can be considerable technical and economic impacts. Australia has a considerable opportunity to leverage its leadership status to address these barriers, grow capacity and embed a leadership position in this space.

There are a range of other important constraints that impact deployment of renewable generators in the Pacific. These include:

- Lack of suitable land for installation of renewable generators (or land tenure issues).

- Cultural and environmental impacts due to scarce land.
- A consistent and comprehensive set of technical standards.
- Capacity issues of local utilities, governments and staff:
    - One of the key issues is simply the administrative capacity to process these projects. This includes project management and document control, financial administration, and processing of safeguards requirements. In many governments, access to local staff with these capabilities is limited and substantially constrains volume of projects than can be implemented (particularly where ramp-up / down is required).
    - Similarly, experienced technical staff are limited and typically constrained by their existing commitments. Again, ramp-up/down is a big constraint.
- Lack of awareness of the techno-economic constraints on renewable energy development (effectively the constraints defined above). In particular, setting tariffs that do not fully account for the long term costs of enablers for high renewable contributions, or committing to renewable installation to levels that exceed grid stability thresholds, are frequent experiences reflect a lack of awareness of the complexities and constraints of renewable energy development.

3. Australian Capability

Australia has a wealth of natural resources for renewable energy, including high solar insolation, excellent wind resources and long coastlines with high wave power densities. In line with global growth trends, the Australian industry is set for ongoing growth, supported by long-term policies driving increased adoption and technology development (DFAT Renewable Energy Industry Capability Report).

Australia has significant capability in the clean energy sector in a number of areas across key renewable energy technologies including wind, solar, hydropower and hybrid remote area systems. Capabilities include:

- professional and engineering services,
- education and training,
- technology research, development, and testing,
- components design and assembly[3],
- software for project planning management or performance assessment,
- enabling technology such as batteries.

The following sections summarise this capability as seen by the Australian industry through a number of semi-structured interviews.

3.1 Education, training and capacity building

Australia is highly regarded throughout the region for the quality of its education offered through various universities and institutes. As noted in DFAT's Renewable Energy ICR, Australia's universities and research organisations produce world-leading solutions for the renewable energy industry. Australia is rated fifth in a ranking of the world's top 200 universities by five key subject fields. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) ranks in the top one per cent of the world's scientific institutions in fifteen research fields.

A number of universities in Australia provide degrees and post graduate study in engineering, renewable energy technologies and deployment. These include:

- Charles Darwin University
- Deakin University
- Latrobe University
- Murdoch University
- RMIT
- Swinburne University of Technology
- University of Adelaide
- University of Newcastle
- University of NSW
- University of Queensland
- University of Western Australia

[3] Though capacity in component design is limited to a few specialised systems

Many international students who have studied such courses in Australia are now in senior positions in energy utilities throughout Asia.

There are also some RTOs (registered training organisations) and other organisations that deliver vocational level courses, short term professional development and / or capacity building to participants from the region or delivered in the region. These include:

- Canberra Institute of Technology
- Chisholm Institute
- Entura Clean Energy and Water Institute
- Global Sustainable Energy Solutions
- TAFEs
- CSIRO

Education and training capability covers the full gambit of knowledge and skills required for such projects from small scale solar to large scale and across all renewable energy technologies:

- resource assessment
- engineering design
- economic and financial analysis
- risk assessment and risk management
- project construction and scheduling
- network integration
- systems control
- environmental management and sustainability
- solar installations
- performance assessment
- technology assessment
- project management
- business case development
- procurement and contracting
- commissioning
- technology integration
- transmission and distribution
- health, safety and environment policies and systems
- asset management and maintenance
- refurbishment and upgrade

Further, there are several organisations in Australia that can support governments and utilities with strategy, business management, and leadership development support to lift capability to implement such programs and deliver on their renewable energy visions.

3.1.1 Opportunity

People capability is a critical success factor in developing and implementing clean energy programs in the Indo-Pacific. Education and training services can continue to be an export from Australia to countries in the region where ambitious renewable energy targets and programs are planned and where existing capability to develop, implement and maintain renewable energy assets is limited. Previous experience of “technology dump” leaving un-maintained, under-optimised electricity infrastructure in place has been a problem in the Pacific in particular and is a focus of aid investment.

There is strong potential for Australian support to countries (either bilaterally or regionally) with capability development services that to support the planned growth in renewable energy in those places.

Australian Government (including DFAT) could focus investment and effort into bilateral or regional capability programs utilising Australian institutions. Reminiscent of the “old” Colombo Plan, Australia could continue to have a significant influence on the capability of its neighbours and to do so with a focus on the clean energy sector would bring mutual benefits, diplomatically and economically.

3.2 Solar energy

Over 1.51 million small-scale solar power systems were installed across Australia as at the end of 2015; accounting for 16.2 per cent of the country's clean energy generation and producing 2.4 per cent of total electricity. This put Australia among the top 10 countries for newly installed solar PV in 2015, with capacity the equivalent of one solar panel per inhabitant.

Large-scale solar PV uses the same technology as rooftop solar panels – specially fabricated semiconductor crystals that convert light from the sun into electricity. Another type of large-scale solar technology is concentrated solar PV (CPV). CPV uses lenses or curved mirrors to concentrate a large amount of sunlight onto a relatively small solar PV array. At the end of 2015, Australia had 19 operational solar projects larger than 1 MW in size, including 17 solar farms which use photovoltaic technology and two solar thermal plants – a total of 217 MW of potential generating power. Another large project, the 56 MW Moree Solar Farm by FRV, was launched in early 2016.

Concentrated solar thermal (CST) technology uses lenses and reflectors to concentrate sunlight, heating a fluid such as water or oil and producing steam to drive a turbine.

The advantage of concentrated solar thermal technologies is that they provide a dispatchable energy supply – that is, their power output can be adjusted based on grid demand. This makes them more flexible than traditional solar PV plants. However, the current challenge is the additional costs for the technology (relative to standard PV) which means that it is yet to prove a cost-effective option.

As there is no longer any manufacturing of solar PV panels in Australia, many have a perception that there is no specific solar capability. This is possibly compounded by the rise of other countries leaping ahead of Australia in terms of MW installed solar energy. China, Japan, US, Germany are far ahead on these leader boards now.

Photovoltaic design innovation happens at locations like the University of New South Wales' School of Photovoltaic and Renewable Energy Engineering. Internationally recognised for its research in photovoltaics, the University has held the record for the most efficient silicon solar cell for over two decades.

Australian organisations invented solar energy technologies including evacuated tubes as well as concentrating solar technologies such as the Compact Linear Fresnel Reflector. Current development efforts are focused on next generation technologies such as flexible solar cells and the delivery of direct solar thermal energy to industry. Companies such as Raygen Resources are improving plant efficiency and construction costs for concentrating solar projects.

Capability in solar, especially in combination with storage capability and know-how, still represents a strong opportunity for Australian export. Capability is varied across the project life cycle and includes:

- Research and development capability such as UNSW (solar cell research) and CSIRO.
- Commercial testing.
- Certification system for installers, managed through the Clean Energy Council.
- Solar installation know-how - including resource monitoring and measurement, system sizing and design, construction(including civil and electrical design), and project management.
- Accreditation systems for solar installation and design.
- Standards and certification for solar power systems, modules and inverters.
- Large scale solar project management and grid connection.
- Due diligence and project financing services.

Australia has a range of innovative products under development. For instance, RayGen Resources Pty Ltd is the inventor and manufacturer of an innovative PV Ultra technology which is poised to capture a substantial portion of the growing international energy market. RayGen's solar power system utilises a powerful solar module to convert concentrated light directly into electricity. The 2kW PV Ultra module is over 1000 times more powerful than, and twice as efficient as, normal photovoltaic (PV) panels. In most cases, such innovative technologies are too early in their lifecycle to be considered a major feature in Australia's solar capability. However, commercialisation opportunities for such innovation are limited and highly competitive, and strategic targeting and support for such opportunities potentially has significant value.

There is also component design capability that might go under the radar such as Clenergy that provides solar mounting systems to international markets. The products are manufactured in China but the Australian operations is maintained and is effectively the international office. Clenergy has a Japanese presence and is currently expanding into India and South America.

3.2.1 Opportunity

Opportunities are essentially divided into support of implementation of existing commercial products, and opportunities for new innovations. In the first category, the maturity of Australia's solar sector is widely recognised (and in some instances, such as the Philippines, is used as a model for regulatory development to support renewables). Australia has developed the capability to develop, finance and manage the implementation of safe, robust and quality solar plants (including all aspects of quality assurance and certification). Bringing this respected capability to the international market, particularly through value-add services such as training, certification and capacity building, is an important opportunity. With the right drivers in place Australia has the capability to build capacity in training and accreditation of installers, regulation, quality assurance and other certification frameworks. Key organisations with this capability include the Clean Energy Council and Global Sustainable Energy Solutions (GSES).

Australia's solar generation capacity is still dominated by the residential / small scale market. There are limited larger EPC providers that can target large or even medium scale solar power installations in the Indo-Pacific region. Small and medium sized enterprises (SMEs) that have developed through the residential and commercial markets, and have outstanding capability, may lack the financial capacity or large scale project experience to qualify for implementation of solar, or solar hybrid projects particularly where aid funding thresholds are in place. There may be an opportunity for DFAT to foster strategic alliances of such SMEs to target international opportunities in the Indo-Pacific, to build project experience and capability of multiple SMEs.

In addition to growing capability in the residential, commercial and industrial sectors, Australia has recently built significant experience in the roll-out of major utility sized PV systems, supported through ARENA, CEFC and the RET. For countries where there is sufficient land space, demand and policy support for large scale solar, this is an important opportunity to capitalise on this experience, either directly through competing as EPC or IPP suppliers, or by bringing this capability to assist through regulatory and standards support or owner's engineer type roles.

Solar technology innovation has historically received limited commercialisation support in Australia. Many developers of such technologies view emerging markets, such as those discussed here with their access to grant funding or incentive schemes, as candidates for combined funding and commercial product demonstration. However, in most cases, this represents a significant risk to the client, and conventional technologies dominate. However, support of such technologies through development of a dedicated test and certification facility may be an avenue to support commercialisation of technologies. Development of such a facility would be strongly supported by the very skills and capability in R&D that has driven new research in this sector. A facility of this nature could also be used for testing and verification (on a fee for service basis) of international equipment or solutions . This may be another way to capitalise on the reputation and experience of Australia. If it was established close to remote areas, local communities may even benefit from the outputs from test generating systems.

Also on the innovation front, there is an opportunity to assist in cross fertilisation of R&D with those nations with manufacturing capability. For instance, R&D leaders such as UNSW's Australian Centre for Advanced Photovoltaics, or RayGen Resources, could potentially benefit from bi-lateral partnerships to improve design and manufacture of solar cells elsewhere in return for favourable pricing for manufactured product imported by Australian companies.

3.3 Remote area power systems

Australia has world leading experience in the application of hybrid renewable energy power systems for on and off-grid scenarios utilising wind, solar, bio-diesel, and conventional diesel combinations. A considerable number of remote and island community applications have been developed or are under implementation now; several with ARENA funding. The most common technologies are solar and/or wind with diesel.

Carnegie is promoting integration of consistent wave energy into a mix of renewable technologies such as solar and wind, as well as with battery storage, desalination, existing diesel and control systems. Carnegie's first such project, with WA based partner Energy Made Clean, is the Mauritian Wave and Microgrid Design Project.

The high penetration experience, as exampled by Hydro Tasmania's hybrid station on King Island, is world leading and provides a significant export opportunity in terms of experience, know-how and solutions capability (i.e. in designing and implementing systems using fit for purpose technology and leading control systems and penetration know-how).

The role of storage and other enabling technologies are important including, for example, using synchronistic generation (from fly wheels), batteries, and resistors; all of which has been practically applied in a number of projects in Australia particular in remote communities (including mining, rural, desert, or island communities). Storage (most obviously in form of batteries) will be a major part of solutions going forward and solar energy with battery storage is now considered a dominant future solution for clean energy in Australia and its neighbours.

Examples of capability in this area include:

- Carnegie
- Cat Projects
- Entura
- Ergon Energy
- Greensync
- Hydro Tasmania (Hybrid Offgrid Solutions)
- IT Power
- Redflow (batteries)

3.3.1 Opportunity

There could be an opportunity for Australian Government support for the development of an industry around storage system fabrication/assembly. Batteries in Hydro Tasmania projects, for example, are imported from Japan and the USA which are not low cost manufacturing economies. One interviewee noted that companies are currently importing components and assembling in Australia and he pondered whether this could grow significantly and replace the car manufacture industry. Batteries, fuel cells, inverters can also be used in vehicles which means the future domestic market is also larger.

Many of the countries in Indo-Pacific region are seeking on and off-grid renewable energy options for remote islands or regions, including mini-grid and larger grid situations. Examples include Indonesia and Pacific island nations, the former already commencing the “1000 islands” project with ADB support. This creates significant opportunity for Australian companies with the relevant engineering and implementation experience. Promotion of this capability through bilateral support would assist Australian companies to gain a foothold in those markets. Competition comes from large companies such ABB, a Swedish-Swiss multinational corporation headquartered in Zürich, as well as French, Japanese, and Korean companies.

A technology test and demonstration centre would also be of significant value here. It would provide an opportunity to conduct factory acceptance testing of battery storage technologies prior to deployment on site (a capability not widely available, and a major commercial risk for procurement of batteries). It would also provide capability for testing of integrated grid stabilisation systems for remote grids.

3.4 Software (across technologies)

Australia has a number of examples of demonstrable or emerging capability in software development, implementation and support which can be a critical element in the clean energy sector from site identification to operation and maintenance.

This expertise has been world leading in resource mapping (for example CSIRO/WindLab, Fulcrum 3D); network planning and smart grid design (Greensync, Energy Exemplar); scheme optimisation and performance modelling (Greensync); energy efficiency and machine productivity; demand side management (Entura ADMS, Energy Exemplar); network modelling (Energy Exemplar)

3.4.1 Opportunity

Australian capability in software development and application can be exported globally and is not generally hindered by uncompetitive cost of labour (such as in manufacturing) and sits well with visions for innovation and a smart economy.

3.5 Networks

Australian renewable energy generators have grown up within a major national electricity market, which in itself embodies significant capability and knowledge transfer potential for the region. Many providers in the sector are familiar with market influences and mechanisms that affect project viability and operations.

Further, there is considerable capability in understanding the integration of different types and scale of renewable energy generation into existing grids, formulating systems for small or mini-grids and including the demand side management aspects of electricity supply and infrastructure management.

As noted in DFAT's Renewable Energy ICR, Australia is home to leading technology companies, such as GreenSync, Reposit Power and GoZERO Energy which are integrating renewable energy into existing networks. These companies are all alumni of the Australian Technologies Competition and are delivering smart grid solutions that manage network data, provide demand and capacity management solutions and deliver optimised energy solutions for households, factories, suburbs and remote communities. Other companies are looking at hybrid solutions where renewable energy can be seamlessly integrated into legacy generation systems to enable changes to be made more gradually (see also section on software).

Capability can be broadly categorised in the following way:

- Network master-planning
- Network system reviews and augmentation
- HVDC cables/super grids planning, design
- Mini-grids for islands and other remote area electrification
- Power system modelling for generation integration
- Distributed energy systems design/management
- Protection schemes
- Transmission and distribution infrastructure planning
- Demand side management

3.5.1 Opportunity

Australian power engineering design firms have considerable expertise, experience and know-how that can and is exported to other countries. Most of the countries mentioned in the Indo-Pacific region have considerable network challenges where they have inadequate or antiquated electricity infrastructure that needs significant refurbishment and expansion in order to cope with the integration of additional renewables and to improve network efficiency for improved security and availability of supply to consumers.

These challenges are significant and, in most cases, require significant government investment or outside funding, in order to execute improvements. Australian development assistance in this area could focus on Australian capability to deliver and incorporate a knowledge transfer/capacity building element.

As noted above the national electricity market is a complex and Australia's successful model is of great interest to our neighbours who are in the infancy of consideration around utility privatisation and electricity markets. Sharing of this expertise may be a welcome bi-lateral contribution. Utilising Australian training and development expertise (including AEMO) would provide additional economic benefits in Australia.

3.6 Regulatory

Australia is a leading economy in the region with mature regulatory frameworks and financial, legal and management consulting services industry. Whilst the domestic industry may lament stronger, stable policies to support renewable energy sector, there is no doubt capability in policy and experience with regulatory instruments, guidelines, tariffs, and standards is available for transfer through export services and/or bilateral commitments. This includes advice on policy benchmarks, regulatory frameworks and market instruments, as well as technical and project standards that guide quality development for sustainable outcomes into the future. Beyond this, Australia has significant reputation and experience in high quality health, safety and environment systems that play a part in construction and commissioning of renewable energy projects in particular.

As noted above, the NEM framework and associated mechanisms may be a case in point. Further there are accreditation and certification systems such as for solar installations and a halted version for wind farm installations led by the Wind Energy Association at the time (now Clean Energy Association).

Australia (through Hydro Tasmania and Entura for example) has had a key role in global sustainability guidelines for both wind and hydropower development having had key drafting roles in the International Hydro Power Association Guidelines and Assessment Protocol as well as the World Wind Energy Association Guidelines. This capability and experience was also applied to formulating the Clean Energy Association's Good Practice Wind Guidelines and the National Wind Farm Development Guidelines.

3.6.1 Opportunity

Regulatory frameworks often lag vision and commitment on renewable energy or struggle to keep pace with foreign investment interest (for example in emerging economies with highly prospective project opportunities like Laos, Myanmar, and Cambodia). A strong framework and associated standards or guidelines to steer market development, project assessment, concession agreement process and selection, risk management and governance is important to guide the development of the sector and to ensure quality projects for the governments (as many of them are BOOT).

As one interviewee stated "Australian companies will succeed where the quality bar is high" so Australian Government to Government support to improve the regulatory system and the standards that apply, will not only promote Australian capability to come through and deliver but it also assists Australia to be more competitive in the global market.

Linked to this is master planning. Other countries, such as China, are successfully liaising at the bilateral level and providing resource assessment and master planning services/reports to then identify the most prospective projects they will negotiate rights to take forward and meanwhile providing the national Government with data that can be used to attract other developers. Germany and Denmark have used a similar approach in the wind industry and then Siemens and Vestas have come in behind with turbine deals for identified projects.

3.7 Hydropower

Australia has over 120 operating hydro-electric power stations with a total annual generation of almost 20 GWh around 40% of Australia's electricity generation. The foundations of the sector were laid through the development of two significant undertakings: the Snowy Mountains Hydro-electric Scheme and Tasmania's hydro-industrialisation. The expertise built through the development and ongoing operation of these schemes is now delivered globally through engineering organisations SMEC and Entura.

There is a strong narrative in the hydro industrialisation journey of Australia in particular Tasmania, that can be shared with our neighbours and expertise and know-how exported to support their activities. This is relevant for major economies such as Malaysia, Indonesia, Myanmar, India, Nepal and Bhutan that all have major hydropower programs as well as a number of other nations where smaller scale hydropower will be important in their energy mix, including building small hydro into existing infrastructure to add value in water infrastructure systems (as Entura identified for Durban City Council in South Africa with REEEP funding see details).

Our expertise covers a full array of expertise and across the project life-cycle. Understanding the ongoing operational and eventual refurbishment decades on, is particularly attractive for nations just commencing their hydro journey and especially in the context of government programs for BOOT (build own operate) schemes that are developed on the basis of a 20-30 year commercial life and then transferred to Government for longer term. The risk is high of these governments receiving high maintenance, less profitable schemes on transfer that have not been designed and built with the long-term in mind. Stronger regulatory frameworks and governance over concession rights would assist these countries to minimise their own government risk and also provide stronger incentive for Australian developers, services providers and investors to be involved and be competitive.

Capability includes:

- Options, feasibility design and due diligence services
- Sustainability guidelines and assessments
- Construction supervision
- Operational best practice including asset management, dam safety, automation
- Hydropower pumped storage.

3.8 Wind

Wind power is currently the cheapest source of large-scale renewable energy. It involves generating electricity from the naturally occurring power of the wind.

In 2015, Australia's wind farms produced 33.7 per cent of the country's clean energy and supplied 4.9 per cent of Australia's overall electricity during the year.

Five wind farms became operational in 2015, adding 196 turbines and 380 MW of generating capacity. These additional projects took the Australian wind industry to a total of 76 wind farms with a combined capacity of 4187 MW, made up of 2062 turbines.

Australia therefore has good experience in identifying and developing wind energy projects and this experience can be exported. Capability includes:

- Turbine compliance/testing to Australian standards with improvements added into production more generally (e.g. Goldwind)
- Wind site resource mapping/prosecting (e.g. Windlab and engineering consulting firms)
- Wind farm layout design
- Sustainability/industry good practice guidelines
- Operational performance and management
- Balance of plant construction and commissioning
- Maintenance
- Electrical substation design and construction
- Network integration.

3.8.1 Opportunity

Along with other mature renewable energy technologies, wind is likely to have a role in the energy mix for many nations in the Indo-Pacific region. Small scale wind combined with solar is an effective solution for pacific countries and larger scale wind is underway in larger economies with appropriate resource.

Australian expertise and experience, particularly in engineering design and technical and commercial due diligence is already exported and could be further.

Promotion and matching of Australian expertise in regional and bilateral discussions will assist in raising awareness of this capability.

3.9 Ocean energy

Oceans make up 70 per cent of the earth's surface and twice a day, every day, the water level of the sea rises and falls in response to tidal influences, creating powerful and reliable water currents.

Located many metres below the ocean's surface, tidal energy turbines are strategically located to maximise the tidal flow to turn the turbine blades and efficiently generate 100 per cent green energy.

Tidal turbine technology is undergoing constant development to improve its performance and Tenax Energy is committed to using the most advanced technology based on both environmental and operational performance. Other companies using different technologies include Carnegie Wave Energy Limited that is now nearing the end of its commercialisation phase with the development and delivery of its CETO 6 product generation which will target utility scale and island applications. The Garden Island project will feature several CETO 6 units located 8 to 15 km offshore. It is expected to be fully operational in 2017. BioPower Systems' BioWave technology is also deployed at pilot sites in

Tasmania and Victoria, utilising biomimicry to create an efficient system which can survive storm events; and Bombora Wavepower that has integrated coastal protection and energy generation into a single seawall solution.

3.9.1 Opportunity

Ocean energy companies in Australia are already pursuing international opportunities as despite the significant resources, the environment has yet to be conducive to truly establish the market with demonstration and commercialisation. Carnegie is developing market opportunities in the UK through its 100% owned subsidiary and Tenax has been involved in a joint venture in Indonesia to advance opportunities for ocean energy project development, as well as development discussions in The Philippines.

Bringing together universities and technology developers along with investors and utilities in the region may provide a catalyst for further network and collaboration opportunities

Supporting ocean energy development to full commercialisation through ARENA or CEFC or other mechanisms would build foundations for a strong contribution to Australia's electricity into the future and strengthen the capability to share the technology and experience in the region.

Marine renewable energy is a trade matter for many countries. Trade agreements are in place between UK and Canada, Scotland and Canada, UK and China, and Scotland and Japan. This means the Trade Ministers of the respective countries have marine renewable energy on their annual trade agendas. DFAT could consider Scottish International, UK DTI and others as best practice on which to model similar approach. It would certainly add an extra dimension to the work Australian ocean energy companies are undertaking overseas. For example, the Carnegie Wave project in Mauritius or Tenax in Indonesia and Philippines.

Further, Australia could lead the development and knowledge transfer of ocean energy in the tropical zone. Testing has been in temperate waters and there is opportunity to explore how to adjust for higher temperatures for implementation through the tropics.

3.10 Geothermal

Geothermal energy uses the earth's natural internal heat to generate electricity and heating. Geothermal energy may be stored in granite rocks (often called 'hot rocks') or trapped in liquids such as water and brine (hydrothermal process). Although Australia has no volcanic structures, there is significant potential for geothermal energy to be extracted using hydrothermal and hot fractured rock processes.

With sources being remote from any demand loads, commercialising projects has been challenging. The successful Habanero Pilot Plant run by Geodynamics in South Australia's Cooper Basin in 2013 provided some cause for optimism, but the remote nature of the site has made it challenging to find customers for the resources. In 2016 Geodynamics will plug all its remaining geothermal wells in the Cooper Basin and complete remediation activities.

The South Australian Centre for Geothermal Energy Research (SACGER) at the University of Adelaide is aiming to find prospective geothermal resources without drilling, so as to maximise the national benefits and possibilities for geothermal energy development, at significantly reduced costs. They are creating the Australian Structural Permeability Map, to determine the areas of the Australian crust that have the best in situ permeability, and offer the best opportunity to extract energy from the subsurface for both geothermal and gas sectors

The Australian Renewable Energy Agency (ARENA) has been involved with seven projects, most of which ended in the early investigation phase. Five of these are now closed and two were completed. Its international geothermal expert group found that utility-scale generation from geothermal projects was not expected to be commercially viable by 2020. The technology was only expected to become competitive with traditional fossil fuel power generation by 2030 with the help of a high carbon price and in the most favourable scenario for cost reductions.

3.10.1 Opportunity

Geothermal energy provides considerable energy in places such as New Zealand, Indonesia and The Philippines. These countries will need assistance in such projects. The strength of capability in New Zealand would suggest they are well placed to export expertise to the neighbouring region.

3.11 Biofuels and biomasss

The Biocube Corporation.The BioCube™ is a compact, transportable and affordable biodiesel processor within a 20 foot sea container. It can produce inexcess of 1.5 million litres of high quality biodiesel from a variety of waste and renewable feedstock oils, such as waste vegetable oil (WVO) from restaurants, canola, crude palm oil (CPO), soya, corn, coconut, pongamia and tallow. It can run off-grid on the biodiesel it produces, or on-grid where electricity is available.

Given suitable feedstock, biodiesel produced by the BioCube meets stringent ASTM quality standards and can fuel any modern diesel engine. The BioCube has undergone field tests since November 2009 (in Papua New Guinea). Extensive trials have been conducted along with research partners Queensland University of Technology (QUT) at their bioenergy facility in Mackay, QLD since 2010 and at Olds College, Alberta since 2012. BioCubes now operate with different customers across four continents; Asia, Oceania, Africa and North America.

3.12 Waste to Energy

Waste –to-energy, the conversion of organic waste that would typically go into landfill into energy, is another opportunity that is attractive particularly for land constrained nations. Waste-to-energy typically contributes little to electricity supply, but is very important in managing waste and reducing landfill. There are many Australian companies providing waste to energy through capturing methane from landfill, however, of more interest, particularly for the Pacific, are companies such as New Energy Corporation, that convert waste to energy without landfill.

Those Australian companies looking for international opportunities are typically aware of suitable sites, however, there is strong international competition and support through access to key decision makers can provide value.

3.13 Project implementation

Australia has strong capability in planning scheduling and implementing renewable energy projects from small scale to larger scale across technologies. Many countries in the Indo-Pacific region are challenged with the capability and capacity to see their renewable energy visions come to life. The capability for financing, procurement and contract management, project management, risk management and so on is often below that required for successful delivery. Australian engineering and legal and management professional services firms, as well as construction based companies have ability to support project implementation – across the whole life-cycle.

3.13.1 Opportunity

Directing Australian Government aid or other funding to Australian companies that can provide such advice and capability could deliver sustainable outcomes for those countries. Linked with capability and training programs mentioned elsewhere in this report, there is potential to make a significant contribution.

An Australian funded Project Management Office in the Pacific, might be a way to coordinate regional assistance for project implementation, ensure quality and standards, and lift local capability.

3.14 Financing

Australia's mature financial market has developed innovative financing models that enable non-traditional projects to be delivered. Community-financed energy projects and power purchase agreement structures where renewable energy projects are financed by a third party have provided opportunities for further deployment.

Capability is strong in more traditional financing arrangements, although these may not be particularly unique globally.

The Clean Energy Finance Corporation has been a successful undertaking combining strong policy objective with a commercial filter. The CEFC formalised participation the Greenbank Network at COP21. The six participating green banks are CEFC, Connecticut Green Bank, Japan's Green Fund, Malaysian Green Technology Corporation, UK Green Investment Bank, NY Green Bank. These are mature economies with existing capabilities and CEFC has a mutual knowledge sharing exchange with others in this network. Malaysia is probably the least developed green bank but is also well on its way.

The purpose of the CEFC is to facilitate financial flow, not be it, so it is always a balance to stimulate investment and support deals without coming into conflict with, or crowded out other financial institutions.

CEFC is restricted under legislation from involvement in offshore projects but is able to support Australian companies with export expansion if they are head quartered in Australia.

3.14.1 Opportunity

Lessons from the process of establishing the CEFC and its initial operation are likely to be of interest to some countries in the Indo Pacific as a model for creating similar financial backing to a clean energy sector.

The CEFC would only really be replicable in countries that have relatively mature economies with some level of privatisation and which already have large scale financing processes and indigenous financial institutions in place and including foreign banks; for example Indonesia, The Philippines. In smaller economies grants and aid funding is required to support project development and there is not the scale or pipeline of projects to support a CEFC type facility and unlikely to be able to finance such projects in an affordable way for those countries. They are also unlikely to have the financial/lending capability and capacity to establish and operate free from political interference.

Replication would need to consider key principles such as:

- The level of maturity (and size) of local financial markets
- The structure of energy markets
- The process that countries might undertake to create a 'CEFC-like' entity is important (transparency and governance)
- Recruiting both technical and commercial resources. For example, staffing (including at Board level) of the CEFC was intentionally drawn from energy and finance. In that way, the team has a very unique combination of energy and technology assessment as well as investment and finance experience.

Key principles from creation of the CEFC include independence, the application of a commercial filter to investments and flexibility in design of products (debt and equity). These are all somewhat connected and particularly relevant in an emerging market context.

There is an opportunity for DFAT to become involved in CEFC activity at a Greenbank Network forum that can be hosted in Australia or in the region. It is likely that Australia will play host within the next two years. CEFC representatives suggested that DFAT could sponsor participants from relevant governments to attend. In this way, the principles and lessons can be shared and from which adaptations can be made that reflect the local political and economic environment. CEFC has been involved in, for example, Australian Indonesia Commercial building forum and contributed to an OECD report and a staff exchange program with the UK. Thus it is already involved in knowledge transfer activities internationally.

Legislative change could provide opportunity for CEFC to be involved in offshore projects, perhaps particularly in those involving Australian companies, however they would still need to be economic. Encouraging a role for CEFC in facilitating inbound international investment may also help strengthen the local market to be more export ready.

3.15 Roles for DFAT

A number of roles and opportunities have already been touched on in earlier sections of this report. In addition, consultation in the industry highlighted some other possibilities more generally for DFAT (including Austrade). For completeness these are noted below.

3.15.1 Domestic market

- Support Australian R&D and commercialisation to prove technology and solutions
- Implement demand management as demonstration and clean energy on major Government infrastructure
- Encourage ways to facilitate inbound investment to shore up new technologies or implement renewable projects

3.15.2 International market entry/penetration

- Introductions, networks and trade missions “with coordinated follow-up”
- Local partner identification and screening to support market entry
- Coordinated and proactive matching of opportunities with Australian companies. A number of examples from industry mentioned other agencies that appear to do this well (see next point). An example given was that just 5 hours after the submarine contract was signed with DCNS, the French embassy was telephoning companies looking at ocean energy opportunities in Australia and Pacific. Leveraging off the size of the contract. Another example given was NZFAT contacting a developer the next day after a remote area power project was announced for Cooper Peedy.
- Presence at international events with advocacy for Australian capability (i.e. as more common with mining sector) use UK (DTI) NZ (events, renewables focus, $$ in projects), Canada, France, Germany, and Japan as models.
- Advice and support about doing business in particular countries, including local office establishment, tax or regulatory issues, business model advice – share learnings and information for other companies

3.15.3 Clean energy capacity building program

- Invest in a regional or bilateral clean energy capability program to be delivered by Australian institutes from professional development, vocational, and degree options.
- Key target partner countries – this could be like the “old” Colombo Plan perhaps?

3.15.4 Implementation

- Regional coordination office to leverage other agency activity, remove duplication, and fasten implementation (i.e. Pacific as noted above)
- Foster Government to Government arrangements that bring opportunities for Australian companies i.e. Australia-Indonesia or Pacific nations like Cook Is, Samoa, Solomon Islands, PNG, Fiji
- Work with other key countries to assist with renewable energy goals of a third country. For example New Zealand has made significant commitments in the Pacific, perhaps this could be done together with Australia utilising the mechanisms they already have in place but still providing opportunity for Australian expertise.
- Link with IEA programs and fund participation in sub tasks etc.
- Raise awareness of international frameworks to support deployment of Australian technology.

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4. Existing partnerships and programs

4.1 Mission Innovation

Australia is a member of Mission Innovation. The 21 partners have each pledged to seek a doubling in their governmental and/or state-directed clean energy research and development investment over five years, reaching around a combined $30 billion per year by 2021. Could this be a mechanism to implement other support/investment as identified in this report?

4.2 Global Climate Change Alliance+

The Global Climate Change Alliance + provides EU support to developing nations. This is perhaps a model idea for DFAT to consider. Also the Alliance has supported projects in Timor Leste, PNG, Vanuatu and Solomon Is, as well as Myanmar, Cambodia, Laos, Nepal and Bhutan so they are active in this region. Could Australia join in?

http://www.gcca.eu/about-the-gcca/what-is-the-gcca

4.3 Global Climate Partnership Fund (GCPF)

The GCPF is an innovative public-private partnership dedicated to mitigating climate change through a reduction of greenhouse gas emissions in emerging and developing markets. It is based out of Luxemburg.

http://gcpf.lu/

4.4 World Bank, EU and Australian Government program for Maldives Oct 2015

Could Australia replicate with DFAT, ARENA? ADB and other? in Pacific country/ies?

http://www.worldbank.org/en/news/press-release/2015/10/06/maldives-eu-australia-climate-change-partnership

4.5 PNG's – Climate Plan NDC under Paris Agreement

PNG was the first country to finalise its nationally determined contribution. Is their potential for Australian support PNG to realise its goals? There could be significant opportunity involved in renewable energy projects and network upgrades for Australian expertise to deliver.

http://www.wri.org/blog/2016/03/papua-new-guinea-first-country-finalize-national-climate-plan-under-paris-agreement

4.6 Renewable Energy and Energy efficiency Partnership – REEEP.

REEEP is funded by a group of European donors and is headquartered in Austria. It funds projects across globe including the Indo Pacific region. Could Australia direct some of its aid budget to REEEP as a donor and/or influence priority themes/regions?

http://www.reeep.org/

4.7 IRENA – programmes and tasks.

DFAT could consider funding to assist Australian parties and subtask leaders to deliver on identified projects.

http://www.irena.org/

4.8 Corporate Sourcing of Renewables

http://www.cleanenergyministerial.org/Our-Work/Campaigns/Corporate-Sourcing-of-Renewables#5735

4.9 Queensland Government and Colorado

Interesting partnership provided for information.

http://statements.qld.gov.au/Statement/2016/6/1/premier-and-colorado-governor-hold-talks-on-innovation-renewable-energy-partnerships