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Deploying Solar Powered Microgrids on Small Island Developing States:

Breaking Through the Barriers to Realize the Benefits

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Introduction and Summary of Findings

Today, the majority of Small Island Developing States (SIDS) rely on imported diesel fuel to generate electricity on the islands.[1] This reliance on diesel exposes SIDS to multiple challenges. First, the fuel must typically be transported great distances at great expense and the resulting electricity tariffs can be staggeringly high. In 2010, for instance, when global oil prices were higher than they are today, some Pacific SIDS reported tariffs above $1.00 per kilowatt-hour[2]—roughly 10 times the average price in the United States.[3]

SIDS's reliance on diesel presents serious energy security consequences as well: when oil prices spike, SIDS's utilities can find themselves unable to afford the fuel needed to keep their generators running[4] and severe weather events can make it impossible to deliver fuel. Finally, as part of their efforts to demonstrate leadership in international climate negotiations, many SIDS have set ambitious renewable energy targets that are at odds with their continued use of diesel.[5]

Solar powered microgrids appear to offer a significant opportunity for SIDS to lower their electricity costs and improve their energy security, while also advancing their climate objectives. The cost of solar photovoltaic (PV) installations has fallen dramatically in recent years.[6] The costs of battery storage systems, which make it possible to integrate high penetrations of PV without jeopardizing reliability, have dropped significantly too.[7] In light of this progress, and the extremely high cost of fossil generation on SIDS, the case for transitioning to solar power should be clear.

Yet, thus far, relatively few islands have made the switch. On October 1, 2015 the Guarini Center on Environmental, Energy and Land Use Law at New York University School of Law (NYU) convened a daylong workshop to examine the extent to which solar powered microgrids could help SIDS achieve their energy goals, and to explore strategies to overcome obstacles standing in the way. The workshop, which was co-hosted by SolarCity, provided a chance to conduct detailed conversations with representatives from the national utilities of the Cook Islands, Palau, the Republic of the Marshall Islands, and the Seychelles about their islands' power sector and policy goals. Experts from the international development community, including the World Bank, the Asian Development Bank, and the United Arab Emirates' Ministry of Foreign Affairs, the Clinton Climate Initiative, Rocky Mountain Institute, Carbon War Room, International Renewable Energy Agency, and various academic commentators lent their perspective to the conversation as well.

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[1] LINUS MOFOR, MIREI ISAKA, & HERB WADE, INTERNATIONAL RENEWABLE ENERGY AGENCY, PACIFIC LIGHTHOUSES: RENEWABLE ENERGY OPPORTUNITIES AND CHALLENGES IN THE PACIFIC ISLANDS REGION: MARSHALL ISLANDS 3 (2013).
[2] *Id.*
[3] U.S. Energy Information Administration, Electric Power Monthly, August 2015, *available at* http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a.
[4] Matthew Dornan, *Renewable Energy Development in Small Island Developing States of the Pacific*, 4 Resources 490, 495 (2015).
[5] *Id.* The four SIDS represented at the workshop exemplified this trend: Palau and the Marshall Islands have each pledged to meet 20% of their demand with renewable energy by 2020. Palau Energy Policy Development Working Group, Strategic Action Plan Energy Sector (2009) *and* GOVERNMENT OF MARSHALL ISLANDS, NATIONAL ENERGY POLICY AND ENERGY ACTION PLAN (2009). The Cook Islands aims to produce 100% of electricity from renewable sources by 2020. OFFICE OF THE PRIME MINISTER, COOK ISLANDS RENEWABLE ELECTRICITY CHART 8 (2011), As for the Seychelles, the state set a somewhat less ambitious target – 15% by 2030 – but is on track to meet the target by 2020. Haijira Amla, *Secyhelles Should Reach Renewable Energy Target Ten Years Early*, SEYCHELLES NEWS AGENCY, SEPT. 29, 2015.
[6] Studies released by Massachusetts Institute of Technology and the International Renewable Energy Association in late 2015 estimated that the average capital cost per watt from utility scale solar installations fell by 70% between 2008 and 2014 and by 80% between 2009 and 2015, respectively. MASSACHUSETTS INSTITUTE OF TECHNOLOGY ENERGY INITIATIVE, THE FUTURE OF SOLAR ENERGY (2015) *and* INTERNATIONAL RENEWABLE ENERGY ASSOCIATION, RENEWABLE POWER GENERATION COSTS in 2014 (2015).
[7] *See generally*, LAZARD, LAZARD'S LEVELIZED COST OF STORAGE ANALYSIS – 1.0 (2015).

The workshop indicated that there is indeed a compelling economic case for SIDS to move away from fossil fuels, towards systems in which PV plays a major – if not dominant – role in generation. In fact, modelling presented at the workshop indicated that adding at least 35% PV to the generation mix would lower the cost of producing electricity on each of the six islands examined. On half of the islands, data indicated that the local utilities could add over 90% of PV to the generation mix and still cut costs. Part I of this report presents an overview of the relevant case studies, including the modelling assumptions used.

Despite the great potential of microgrids hold, the workshop also revealed a number of challenges that need to be overcome before SIDS can reap the full benefits these systems offer. The "Top Ten" such challenges, and potential strategies for overcoming them, are presented in Part II below. It is our hope that this document will help guide other SIDS that may be considering adopting solar powered microgrid solutions in their territories.

Part I – Case Studies

A. Overview

Participants at the workshop examined case studies of potential microgrid projects on six islands within the four nations represented. The islands were: Kayangel (Palau), Ebeye (Republic of Marshall Islands), Wotje (Republic of the Marshall Islands), Aitutaki (Cook Islands). Mangaia (Cook Islands), La Digue (Seychelles). Each case study explored the economics of installing SolarCity's "GridLogic" microgrid system. GridLogic systems combine a ground-mounted PV array, battery storage, and backup generators with a sophisticated control system to provide a free-standing, low-carbon power system. Renewable resources other than PV, such as wind power, can be incorporated into the system as well, and the total proportion of renewable versus non-renewable energy can be varied to accord with local meteorological conditions and policy objectives. The various components of a GridLogic system are represented in Figure 1.

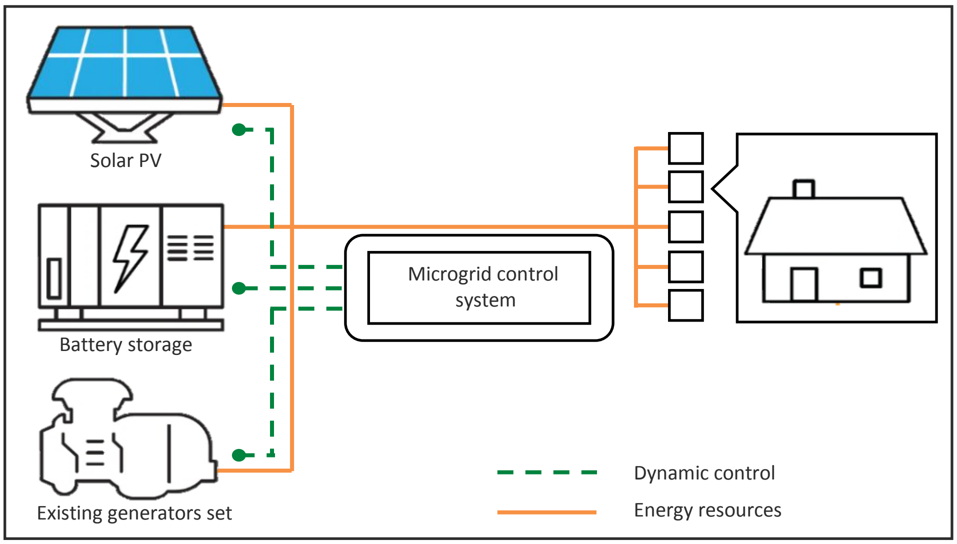

Figure 1

The overarching goal of case studies was to determine whether the GridLogic system, as an example of a solar powered microgrid, could help the islands achieve their objectives of reducing the cost of electricity in their territories and increasing the penetration of renewable energy resources. All six case studies indicated that GridLogic could further these objectives. Specifically, modelling performed for the case studies found that installing GridLogic systems in which PV provided a minimum of 35% of electricity consumed would reduce the levelized cost of electricity (LCOE) below that provided by existing diesel-based systems.

SolarCity analysts and engineers performed all modelling for the case studies with source data provided by the energy experts from each nation.

B. Assumptions

The following assumptions were used in models created for the case studies:

Levelized cost of electricity (LCOE): The comparative economic benefits of renewable energy microgrids can be quantified using an internationally recognized metric known as the Levelized Cost of Energy (LCOE). This metric is used by energy experts in industry and academia to compare the costs of energy generation across different technology types.[8] This metric is especially useful when comparing renewables versus diesel, as the

[8]Govinda Timilsina, Lado Kurdgelashvili, Patrick A. Narbel, *Solar Energy: Markets, Economics and Policies*, 16 Renewable Energy Reviews 449, 453 (2012).

two technologies have very different cost structures (renewable technologies have high upfront capital costs and low operating costs, while diesel technologies have low upfront capital costs and high operating fuel costs).

In modelling performed for these case studies, the LCOE was calculated as follows: LCOE = Capital Expenditure + Net Present Value of Operating Expenditure / Total Generation Over Project Life. The relevant equations for diesel and renewable systems were therefore:

- Diesel LCOE ($/kWh) = Net Present Cost (Fuel Cost + Generator Replacement) / Total Generation Over Project Life[9]
- Renewable LCOE ($/kWh) = Net Present Cost (Capital Cost + Financing Costs + Operating & Maintenance + Battery Replacement Cost) / Total Generation Over Project Life[10]

Cost of capital: A standard Weighted Average Cost of Capital (WACC) of 4% was used for all case studies. While this WACC may seem low given the perceived risk of investing in SIDS[11] there is a significant amount of development funding available to help de-risk appropriate renewable energy investments in SIDS.[12] In light of this funding, workshop participants expressed confidence that a 4% WACC was reasonable and likely even conservative for the proposed projects.

Diesel costs: In calculating the LCOE of diesel generation, case studies assumed local fuel costs as reported immediately prior to the workshop on October 1, 2015. Importantly, however, global oil prices fell by approximately 50% in the 12 months prior to the workshop, making fuel prices unusually low.[13] The comparative economic advantage for renewable generation versus opposed diesel generation would increase considerably if fuel prices return to previous levels.

Operations and Maintenance escalator: The case studies presumed a 3% escalation in O&M costs for renewable energy systems.

Storage: The case studies assumed use of a lithium ion storage system produced by Tesla with a useable life of 10-years with accounting for degradation.

Replacement of parts: It was assumed that diesel generators and solar inverters would be replaced after 15 years.

C. Findings

The case studies examined during the workshop were set in islands that differed widely in terms of geography, population density, current electricity prices, and load curves. Yet a key finding was common to all cases studies: even given today's usually low diesel prices, introducing high penetrations of PV – between 35% and 97% of total generating capacity – would reduce the cost of electricity on each island examined. Synopses of the case studies are presented bellows.

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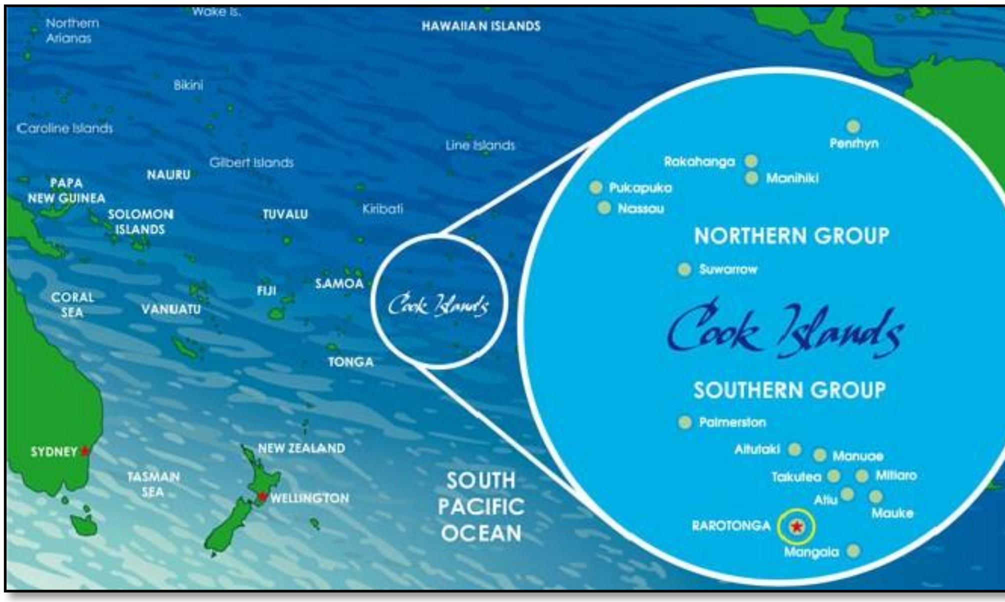
[9] Existing generator financing costs and O&M were omitted from calculations (a conservative assumption).
[10] The project life for renewable systems was set to 30 years.
[11] Janosch Ondraczek, Nadeja Komendantova, & Anthony Patt, *WACC the Dog: The Effect of Financing Costs on the Levelized Cost of Solar PV Power*, 75 RENEWABLE ENERGY 888, 893 (2015).
[12] Among others, the Asian Development Bank, the Japan International Cooperation Agency, the Global Environment Facilities, and the United Arab Emirates have each committed considerable funds to financing renewable energy projects on Pacific and Indian Ocean SIDS and utility representative from both the Marshall Islands and the Seychelles described having previously been awarded grants from the UAE to purchase renewable energy systems.
[13] In October of 2015, crude oil was trading at approximately $45 a barrel, which is roughly 50% lower than it had been one year earlier.

Cook Islands

The Cook Islands is an archipelago of 15 islands in a remote corner of the South Pacific Ocean, approximately 2,000 miles northeast of New Zealand. There are 15,000 inhabitants of the state, with 12,000 residing on the main island of Rarotonga. Back in 2011, the Cook Islands established a target of producing 100% of their electricity from renewable resources by 2020[14] and have already made strides towards that goal by converting the islands in the northern chain to renewable energy systems (principally solar). The NYU workshop examined opportunities for transitioning two islands in the southern chain – Aitutaki and Mangaia.



Aitutaki: Aitutaki is a 4,448-acre island approximately 160 miles north of the capital Rarotonga. At present, 2,194 people live on Aitutaki, which makes it is the second most populous island in the Cook Islands. The primary industry on the island is tourism.

Today, all electricity on Aitutaki is produced by a diesel-based system and peak power load on the island is 580 kW. Demand is spread fairly evenly throughout the day, however there is a slight peak around 7pm. Using the assumptions in Part II.B, the LCOE of diesel generation was found to be $0.36 per kWh.

In light of the state's ambitious renewable energy target, a Cook Islands representative at the workshop explained that their aim for the Aitutaki case study was to find a project with the best economics in which renewable resources produce at least 50% of total generation. Modelling performed by SolarCity indicated that the optimal solution for Aitutaki from cost perspective was for renewable energy to account for 63% of total generating capacity, which exceeds the island's minimum threshold.

[14] OFFICE OF THE PRIME MINISTER, COOK ISLANDS RENEWABLE ELECTRICITY CHART 8 (2011), *available at* http://www.mfem.gov.ck/images/MFEM_Documents/DCD_Docs/Renewable_Energy/Cook_Islands_Renewable_Electricity_Chart_-_Final_April_2012.pdf

Summary of Proposed Solution (Aitutaki)	
Solar Photovoltaic Capacity (kW DC)	1,000
Wind Capacity (kW)	550
Battery Energy Storage Capacity (kWh) (EOL)	550
RE Proportion	63%
Land Requirement (acres)	4
Diesel LCOE	$0.36
RE LCOE	$0.27
Blended Diesel & RE LCOE	$0.30

** Based on Current Diesel Fuel Cost

Specifically, the optimal solution was found to be to install 1,000 kW of PV capacity, 550 kW of wind capacity, and 3,800 kWh of battery storage.

LCOE for the renewable energy in the proposed system was estimated to be $0.27, 25% less than for the current diesel generation. The blended renewable energy and diesel LCOE for this system was estimated to be $0.30 per kWh, which represents a savings of around 15%.

Notably, SolarCity also modelled a scenario without wind in which PV provided all the renewable energy in the system. Although this scenario also reduced the cost of electricity, the savings were more modest; with 55% PV capacity installed, which was found to be the most cost-effective amount, the LCOE of renewable energy was estimated to be $0.30—a 17% savings over diesel generation. At current fuel prices, the blended LCOE in this scenario is $0.34, which represents a 6% savings.

Mangaia: Mangaia is a 12,800-acre island in the southern chain of Cook Islands, approximately 130 miles to the south of the capital Rarotonga. The island is sparsely populated, with only 744 inhabitants. Currently, there is no significant economic activity on Mangaia, but the government aims to develop the island as an eco-tourism destination in the not-too-distant future. Given the desire to promote eco-tourism, Cook Islands representatives seek a solution for Mangaia in which renewable energy accounts for at least 95% of total generating capacity.

Summary of Proposed Solution (Mangaia)	
Solar Photovoltaic Capacity (kW DC)	400
Battery Energy Storage Capacity (kWh) (EOL)	1,100
RE Proportion	95%
Land Requirement (acres)	1.5
Diesel LCOE	$0.52
RE LCOE	$0.37
Blended Diesel & RE LCOE	$0.38

** Based on Current Diesel Fuel Cost

Typical peak load on Mangaia is 106kW, however it increases to 168kW during holiday periods. Daily demand peaks in the mornings, around 8am, and then again in the evenings, between 8 and 9pm. As with Aitutaki, the island presently relies on diesel to meet its electricity needs. The LCOE of diesel generation was estimated to be $0.52 per kWh.

SolarCity's modelling indicated that Mangaia could minimize its electricity production costs by replacing 95% of generating capacity with PV. The proposed system combined 400 kW of PV with 1,100 kWh of battery storage, which requires 1.5 acres of land. The LCOE for the renewable energy in the system was $0.37 per kWh, which is 28% less than the LCOE of diesel generation on the island. The blended renewable energy and diesel LCOE for the system was estimated to be $0.38, which represents a 27% savings below current costs.

Marshall Islands

Ebeye: The Republic of the Marshall Islands is a Pacific island nation about midway between Hawaii and Australia. The tiny island Ebeye is 89 acres in area and is home to 9,614 people, which makes it one of the most densely populated places on earth.[15] The economic engine of the island is the local U.S. military base, which was established in the aftermath of World War II.

Currently, electricity production on Ebeye is exclusively diesel-based and is owned and operated by the Marshalls Energy Company (MEC), which is wholly government owned. The electrical grid on the island is an isolated system that produces approximately 16,000 MWh per year, with a peak load of approximately 2,100 kW. Demand on the island typically peaks around 8pm. A Marshallese representative at the workshop explained that Ebeye frequently experiences blackouts due to fuel delivery delays. The LCOE of diesel generation was estimated to be $0.22 per kWh. Marshallese representatives indicated that their overriding objective in considering any potential power system overhaul was to lower the levelized cost of electricity on the island.

Summary of Proposed Solution (Ebeye)	
Solar Photovoltaic Capacity (kW DC)	3,800
Battery Energy Storage Capacity (kWh) (EOL)	3,800
RE Proportion	35%
Land Requirement (acres)	11.4
Diesel LCOE	$0.22
RE LCOE	$0.16
Blended Diesel & RE LCOE	$0.20

** Based on Current Diesel Fuel Cost

Modelling performed by SolarCity indicated that, the least-cost solution for Ebeye would be to replace 35% of Ebeye's current diesel generation with PV. The proposed hybrid system would be comprised of 3,800 kW of PV and 3,800 kWh of battery storage. The LCOE from the renewable portion of the system was estimated to be $0.16 per kWh, making the blended LCOE for diesel and renewable generation for the system approximately $0.20 per kWh – more than 25% savings compared to diesel generation alone.

The biggest challenge for the proposed project was to identify sufficient land for the renewable system, which requires about 11 acres. To overcome this obstacle, Marshallese representatives proposed installing the majority of PV capacity on a nearby area called Nene and transferring the power to Ebeye via an existing distribution line.

[15] UNITED STATES MILITARY ACADEMY, EBEY 2023: COMPREHENSIVE CAPACITY DEVELOPMENT MASTER PLAN, CENTER FOR NATION RECONSTRUCTION AND CAPACITY DEVELOPMENT 2 (July 2012).

Wotje: Wotje is a 2,021-acre island to the North of the capital island of Majuro. Once home to a sizeable Japanese military base, today only 900 people inhabit the island. The primary industry on the island is copra production. There is also subsidence fishing and hunting.

The island has peak power load of 90 kW. There are two peak demand periods on an average day, the first is between 10 and 11am, and the second between 8 and 9pm. Wotje currently relies entirely on diesel for its power generation. Due to its remoteness, the unsubsidized fuel cost on the island is exceptionally high – even in the current context of low global oil prices - and the LCOE of diesel generation on the island was estimated to be $0.89. Unsurprisingly, a Marshallese representative at the workshop stated that the chief objective for the any potential new power project was to lower the cost of producing electricity on the island.

Summary of Proposed Solution (Wotje)	
Solar Photovoltaic Capacity (kW DC)	400
Battery Energy Storage Capacity (kWh) (EOL)	2,000
RE Proportion	93%
Land Requirement (acres)	1.33
Diesel LCOE	$0.89
RE LCOE	$0.39
Blended Diesel & RE LCOE	$0.40

** Based on Current Diesel Fuel Cost

Modelling prepared by SolarCity indicated that Wotje would minimize costs by installing 400 kW of PV and 2,000 kWh of battery storage. With this configuration, PV would provide 93% of the island's total generating capacity. The LCOE of renewable energy in the system was estimated to be $0.39 and the blended renewable and diesel LCOE approximately 40 cents - less than half the island's current LCOE from diesel generation alone. As the Marshallese representative explained at the workshop, the economic advantage provided by the PV system "is clear."

Palau

Kayangel: Palau is an archipelago of over 500 islands in the Western Pacific Ocean. Kayangel, the focus of this analysis, is a small island of 240 acres in the northern chain of Palauan islands. The island has a population of 138 spread across 5 villages.

Today, Kayangel receives all of its power from a diesel-based power plant that is owned and operated by the Palau Public Utility Commission ("PPUC"), a wholly government-owned entity. The small powerplant employs 6 operators. Peak power load on the island is 33kW and PPUC has to purchase approximately 18,000 gallons of fuel per year to keep the system running. At current fuel costs, the LCOE from diesel generation was estimated to be $0.37.

Summary of Proposed Solution (Kayangel)	
Solar Photovoltaic Capacity (kW DC)	100
Battery Energy Storage Capacity (kWh) (EOL)	100
RE Proportion	53%
Land Requirement (acres)	0.33
Diesel LCOE	$0.37
RE LCOE	$0.34
Blended Diesel & RE LCOE	$0.35

** Based on Current Diesel Fuel Cost

The Palau Public Utility Commission (PPUC) is searching for options to reduce Kayangel's dependence on diesel fuel. Apart from the tremendous expense of diesel throughout Palau – fuel accounts for 70% of PPUC's operating costs – Kayangel's pristine environment is extremely vulnerable to damage from fuel leaks. According to the Palauan representative at the workshop, even a 60 gallon spill could have serious consequences for the local environment. Kayangel's reliance on diesel also makes the island extremely vulnerable to weather related service interruptions. Just one week prior to the workshop, stormy weather had prevented fuel deliveries, forcing PPUC to shut the generators off and let the island go dark.

In light of these challenges, PPUC aims to implement a new power system that incorporates as little diesel generation as possible while also reducing costs. To achieve this goal, SolarCity proposed installing 100kW of PV capacity, which constitutes 53% of total generating capacity, and 100 KWh of battery storage. The proposed PV installation requires one-third acre of land, which could easily be accommodated on Kayangel. The LCOE from the renewable system was determined to be $0.34 per kWh with a blended renewable and diesel LCOE for the system of $0.35, which is $0.02 (5%) below the current LCOE from diesel.

Seychelles

***La Digue**:* The Seychelles is a group of 115 islands in the Indian Ocean off the coast of East Africa. The case study presented at the workshop focused on the island of La Digue, which lies approximately 30 miles to the north of the capital island Mahlé and has a population of 2,761.

Peak load on La Digue is 1,307 kW and demand peaks in the evening hours, between 7 and 8pm. At present, the majority of electricity consumed on La Digue is produced by a diesel-based power plant on an adjacent island called Praslin and transmitted to La Digue via undersea cable. The LCOE for diesel generation was estimated to be $0.36 per kWh at the time of the workshop and the government will only consider implementing a renewable energy solution that can produce cost savings.

La Digue presents some unusual challenges and opportunities from an energy planning perspective. The primary industry on the island is tourism and as part of a strategy to increase tourism further, the government aims to make La Digue the "eco-capital" of the Seychelles. Accordingly, the government wants to produce 100% of electricity used on the island from renewable sources. Problematically, however, there is only limited land available on the island on which to site renewable energy assets because two-thirds of the territory has been designated a nature reserve, meaning it is off-limits for PV installations, and the remaining land is heavily developed. Given the limited available land, rooftop installations, which are generally less cost-effective than larger ground-mounted arrays, will have to be utilized to achieve the island's renewable energy goals.

SolarCity's modelling indicated that La Digue could produce up to 97% of electricity used on the island from renewable sources and still lower the island's LCOE. However, the modeling results showed that, given today's low fuel prices, La Digue could not produce 100% of its electricity from renewable resources without increasing the levelized cost of electricity, largely because doing so would require a significant investment in excess generation and battery capacity.

SolarCity modelled the economics of two potential scenarios for La Digue in which renewable energy provided 97% of generating capacity. The first scenario considered a closed-loop system in which solar energy produced on the island can only be consumed orstored locally, with generation that exceeds storage capacity limits being wasted. In the second scenario, excess solar generation is sold to nearby Praslin via the undersea cable. Both scenarios are predicted to produce cost savings as compared to diesel generation. However, the magnitude of savings is considerably larger when excess generation is sold to Praslin versus not (36% versus 6%, respectively). Summaries of the economic and technical specifications of each scenario are presented below.

Summary of Proposed Solution (Solar + Storage)	
Solar Photovoltaic Capacity (kW DC)	8,000
Battery Energy Storage Capacity (kWh) (EOL)	20,000
RE Proportion	97%
Land Requirement (acres)	24
Diesel LCOE	$0.36
RE LCOE	$0.34
Blended Diesel & RE LCOE	$0.34

** Based on Current Diesel Fuel Cost

Summary of Proposed Solution (Solar + Storage + Sell Excess)	
Solar Photovoltaic Capacity (kW DC)	8,000
Battery Energy Storage Capacity (kWh) (EOL)	20,000
RE Proportion	97%
Land Requirement (acres)	24
Diesel LCOE	$0.36
RE LCOE	$0.23
Blended Diesel & RE LCOE	$0.23

** Based on Current Diesel Fuel Cost

Summary of Economic Findings

To summarize, each case study found that introducing a hybrid solar powered and diesel microgrid would produce cost savings, even given the low fuel costs of 2015. A summary of table of the comparative economics of the two types of systems is presented in Figure 2 below.

Island	Current LCOE (Diesel)	Blended RE & Diesel LCOE from Propoposed Hybrid Grid	Percent Saved
Wotje	$0.89	$0.40	55.1%
La Digue w/ sell back	0.36	0.23	36.1%
Mangaia	0.52	0.38	26.9%
Aitutaki	0.36	0.30	16.7%
Ebeye	0.22	0.20	9.1%
La Digue w/o sell back	0.36	0.34	5.6%
Kayangel	0.37	0.35	5.4%

Figure 2

Part II – Deployment Challenges and Proposed Strategies for Overcoming Them

As mentioned in the Introduction, although solar powered micgrogids appear to offer great economic and energy security benefits to SIDS, deploying the technology in these states can be quite challenging. Broadly speaking, the workshop revealed two categories of challenges that can complicate efforts to deploy solar-powered microgrids. First, there are "upstream challenges" that emerge as parties try to build the requisite stakeholder support for the projects and create project economics. Examples of these challenges include securing financing, engaging the private sector, and ensuring alignment between the utility and government. Second, there are "downstream challenges," which may arise as SIDS try to construct or maintain the systems. The section below considers the most prevalent challenges in each category, as well as suggested strategies for surmounting them.

Upstream Challenges

A theme that runs throughout the upstream challenges is the difficulty of procuring low-cost capital. Development banks and other forms of development assistance often hold the key to securing low-interest financing. To enlist these funders' support, it is important that SIDS identify private sector partners who have a strong track-record of pursuing similar projects and that the parties jointly create detailed proposals that highlight all possible efforts to mitigate risk. One of the key features of a careful risk mitigation strategy is to engage all stakeholders – from local landowners to foreign insurers – early in the project development process so that projects presented to financing partners are truly shovel-ready.

Challenge #1: Aligning Governments and Utilities

Even in states with publicly owned utilities, utilities carry out their responsibilities independently and may have different concerns or preferences than the government does. In particular, utilities tend to be chiefly concerned with maintaining the safety and reliability of the grid and more averse to taking on the risks of new technology. Outside technical advisors may be helpful in designing strategies to mitigate the risks and assuage utilities' concerns. But it is also essential that governments develop a renewable energy strategy for the state together, co-authoring documents where appropriate and jointly evaluating proposed solutions such as microgrids early in the deliberation process. This will ensure that both parties are invested in the outcome and steer the project in a direction that responds to each party's unique concerns.

Challenge #2: Securing Development Bank Support

Development banks represent an important, stable source of relatively low-cost capital. In many cases, development banks are willing to loan money at rates significantly below what SIDS could secure in the private markets. Accordingly, securing development bank funding may be critical to a project's financial viability. One participant observed that development banks often prefer well-defined, shovel-ready projects. Approaching a development bank with a project that can be commenced in the near future can therefore increase the chances of successfully securing financing. Partnering with entities that have a strong track record and have successfully pursued similar projects in the past may also help to convince a development bank of the project's viability. Similarly, where possible, project developers should assist SIDS representatives to prepare documents for financing partners in a manner that demonstrates that the project has been well-designed and all parties have minimized risks. Finally, developing a plan for technology and skill transfer to island inhabitants may also help convince the development bank of the project's positive impact on the local population.

Challenge #3: Engaging the Private Sector

To date, private sector investment in SIDS has fallen short of expectations. Investors have been discouraged by the perceived risks of taking on these projects and the lack of transparent data regarding SIDS energy systems. The high debt to GDP ratio of certain SIDS, particularly in the Caribbean, has also made it difficult to finance projects with debt. To overcome these challenges, experts at the workshop recommended that SIDS governments openly publish energy market data, which would enable more private companies to evaluate whether they have suitable renewable energy solutions to offer. They also encourage private sector companies to directly engage with development bank officials to help devise appropriate financing arrangements.

Challenge #4: Building Scale

The small scale of most renewable energy projects on SIDS makes it challenging to attract private investment. Small market size may translate into low financial returns and, given the need to craft bespoke financing and legal arrangements for each project, transaction costs could swallow the potential savings. One way to mitigate these concerns would be to bundle projects, either within one country or across multiple ones. Technical advisors at the workshop pointed to an initiative to pool geothermal projects in the Eastern Caribbean as an example of the type of cross-border cooperation that could provide a model for future microgrid projects. Notably, these advisors cautioned that a private sector actor may need to be involved to effectively bundle projects. In the past, SIDS governments and utilities working alone have struggled to implement effective bundling strategies, they explained.

Challenge #5: Acquiring Sufficient Land

The ground-mounted solar arrays on which solar powered microgrids depend require sizeable plots of cleared, flat land. These plots can be difficult to come by, particularly in the more densely populated mainland islands, and lease rates for available plots can be extremely expensive. In addition, the common property regimes that pervade the Pacific Islands may impede project development because of the difficulty of forging consensus among the community members. Moreover, experts at the workshop noted that certain development banks, including the Asian Development Bank, will not lend to projects that require the exercise of eminent domain to be implemented. To get around these difficulties, project leads must engage local communities early in the project development pipeline to ensure broad support for moving forward.

Challenge #6: Procuring Insurance

SIDS's unique characteristics also present challenges for adequately insuring a microgrid project. Many potential insurers lack experience working in SIDS and are therefore uncomfortable with a project that might otherwise easily secure insurance in a more familiar context. Engaging a partner with whom the insurer has worked before can help overcome this challenge. In addition, involving an insurer early in the process can provide guidance on the likely cost of insurance, which can then be considered when evaluating the project's financial feasibility. Early involvement of an insurer can also enable a project manager to adjust the project in order to address its hardest-to-insure aspects.

Downstream Challenges

Once the decision has been made to move forward with a microgrid project, SIDS will need to navigate a range of technical, operational, and logistical challenges to ensure that the construction process proceeds according to plan and the system is well-maintained. The most common such challenges, and potential strategies for successfully managing them, are presented below.

Challenge #7: Integrating Pre-existing Distributed Generation

Microgrids will often partially replace existing conventional generators, some of which may have a significant useful life remaining. These generators can provide a valuable source of dispatchable generation. Thoughtfully incorporating them into the microgrid can help reduce the project's cost. In many cases, the utility or government will have taken on significant debt in order to purchase these generators, and will have relied on the revenue from the generators' output to service that debt. These financial commitments must be considered when determining the microgrid's financial impact on the local utility, the government, and, ultimately, the ratepayers.

Challenge #8: Training Specialized Workforce

Many SIDS lack local labor forces with the specialized skills needed to operate and maintain renewable energy systems. Development banks, non-governmental organizations and potentially even renewable energy developers themselves may be able to help build local capacity through targeted training programs and knowledge sharing initiatives such as regional workshops. If multiple SIDS develop projects in tandem, there may also be opportunities to pursue joint training initiatives and/or build a mobile regional workforce.

Challenge #9: Managing Construction Logistics

SIDS present a series of unique logistical challenges for any construction project. Specialized personnel and material must be transported to the main islands and, from there, transported to the construction site, which can be a significant distance away. Shipments between the islands are often infrequent. One participant observed that it is imperative to ship all necessary materials at the same time. Otherwise, a project can be put on hold for months while awaiting a shipment of critical parts. In addition, it is important to consider that many islands, especially more remote islands, will lack developed shipping facilities. Another participant described a project for which all materials had to be transported ashore by small watercraft over several hundred feet of coral reef. Needless to say, anticipating this challenge, and packing material accordingly, was critical to successfully completing that project.

Challenge #10: Allocating Predicted Savings

As previously noted, case studies examined at the workshop indicated that SolarCity's GridLogic microgrid solutions would lower the levelized costs of electricity on each of the islands examined. This presents a tremendous opportunity for SIDS economies but also raises complicated policy questions regarding the extent of rate relief that should be granted to reflect forecast savings. Working together with development bank officials and other technical advisors, SIDS will need to craft an approach to benefit sharing that balances consumers' desire for rate reductions against the need to maintain sufficient liquidity for maintenance and repairs.

Part III – Concluding Reflections

The NYU workshop provided compelling evidence that solar powered microgrids can help SIDS reduce their electricity costs, while taking a major step towards achieving their climate and energy security goals. To be sure, challenges remain that will complicate efforts to deploy microgrids widely throughout SIDS. But with careful planning, and cooperation with trusted partners, there are strong grounds to believe these obstacles can be overcome.