Climate Investment Funds

SREP/SC.20/6
December 18, 2018

Meeting of the SREP Sub-Committee
Ouarzazate, Morocco
Friday, February 1, 2019

Agenda Item 6

SREP INVESTMENT PLAN FOR KIRIBATI

PROPOSED DECISION

The SREP Sub-Committee, having reviewed Document SREP/SC.20/6, *SREP Investment Plan for Kiribati*, endorses the investment plan as a basis for the further development of the projects and programs foreseen in the plan and takes note of the request for a total of USD 4.7 million in SREP funding, including

- USD 3.7 million grant for the project entitled *South Tarawa Renewable Energy Project* (Asian Development Bank); and

- USD 1.0 million grant for preparation of the project entitled *South Tarawa Renewable Energy Project* (Asian Development Bank).

The Sub-Committee approves USD 1.0 million grant for preparation of the project entitled *South Tarawa Renewable Energy Project* (Asian Development Bank).

The Sub-Committee requests the Government of Kiribati, in the further development of the proposed project, to take into account comments made at the meeting and any additional written comments submitted by Sub-Committee members by February 15, 2019, and to respond in writing to questions raised during the meeting and in subsequent written comments.

The SREP Sub-Committee reaffirms:

a) that all allocation amounts are indicative for planning purposes and that approval of funding will be on the basis of high-quality investment plans and projects, subject to the availability of funds; and

b) its agreement that with the endorsement of the investment plan, the projects identified therein can enter the SREP pipeline. Recognizing that the SREP currently does not have sufficient resources to fund all projects in the pipeline, the Sub-Committee encourages the Government of Kiribati and the relevant MDB to seek other funding sources to support the implementation of the investment plan and the project.

Scaling Up Renewable Energy in Low Income Countries

Investment Plan for the Republic of Kiribati

Government of the Republic of Kiribati
November 2018

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Table of Abbreviations

ADB	Asian Development Bank
AUD	Australian dollar
CNO	Coconut oil
CSO	Community Service Obligation
EPU	Energy Planning Unit
GCF	Green Climate Fund
GDP	Gross domestic product
GHG	Greenhouse gas
GIS	Geographic information system
GoK	Government of Kiribati
IMF	International Monetary Fund
IP	Investment plan
IRENA	International Renewable Energy Agency
ITP	ITPower Consulting
KIER	Kiribati Integrated Energy Roadmap
KIESP	Kiritimati Island Energy Sector Program
KOIL	Kiribati Oil Company
KSEC	Kiribati Solar Energy Company
LCCA	Life cycle cost analysis
LCOE	Levelised cost of energy
LED	Light-emitting diode
MDB	Multilateral development bank
MFAT	Ministry of Foreign Affairs and Trade
MFED	Ministry of Finance & Economic Development
MISE	Ministry of Infrastructure and Sustainable Energy
MLPID	Ministry of Line and Phoenix Islands Development
M&E	Monitoring and Evaluation
MW	Megawatts
NDC	Nationally Determined Contributions
NTF	National Task Force
OS	Options Study
O&M	Operations and maintenance
PEC	Pacific Energy Community
PPA	Power Purchase Agreement
PUB	Public Utilities Board
PV	Photovoltaic
RE	Renewable Energy
RO	Reverse osmosis
SHS	Solar home system
SOE	State-Owned-Enterprise
SREP	Scaling-Up Renewable Energy Program
WB	World Bank

Ms. Mafalda Duarte
Head, Climate Investment Funds
1818 H Street, NW
Washington DC 20433

RE: Submission of the Kiribati Scaling-Up Renewable Energy Program Investment Plan to SREP Subcommittee

Dear Ms. Duarte,

We hereby submit Kiribati's Scaling-Up Renewable Energy Program (SREP) Investment Plan to the SREP Subcommittee for endorsement. The Government of Kiribati greatly appreciates the financial support provided by SREP and the technical support from the multilateral development banks such as the World Bank, Asian Development Bank, and European Commission, as well as the Ministry of Foreign Affairs of New Zealand to develop the SREP Investment Plan for Kiribati. Endorsement of the Investment Plan will lead to better reliability and quality of electricity access in Kiribati while reducing our dependence on imported fuel.

The Investment Plan is inline with the Kiribati Vision 20: 2016-2036 (KV20) which is a long term blueprint for Kiribati that aims to transform Kiribati to a healthier, wealthier and peaceful nation. KV20 addresses Government's objectives outlined in our Climate Change Policy (2018) and Energy Policy (2009), which both seek to promote sustainable renewable energy development; the Kiribati Development Plan for 2016-2019, which seeks to increase I-Kiribati's access to high-quality and climate-resilient infrastructure; and the Kiribati Integrate Energy Roadmap, which is the country's medium-term strategy document that sets out our targets for renewable energy. Importantly, the Plan will contribute to delivering on Governments commitments in our Nationally Determined Contributions to the United Nations Framework Convention on Climate Change, to reducing the country's greenhouse gas emissions by 48.8 per cent and fossil fuel consumption by 45 per cent in South Tarawa and 60 per cent on Kiritimati Island by 2025.

Kiribati is blessed with excellent solar potential across all of our islands. Solar photovoltaic generation accounts for a small but growing share of the country's electricity generation. With successful implementation of the SREP Investment Plan, solar and other renewable technologies will become the dominant sources of energy in our country. Solar and wind energy combined with energy storage and energy efficiency will be the driving force for achieving our targets.

This Investment Plan identifies the technologies and projects that are best suited to meet Government's objectives. It outlines the steps that need to be taken to implement the projects as well as the financing modalities that will ensure affordable, cost-effective energy for I-Kiribati people.

The projects proposed in the Investment Plan will contribute to the economic and social development of Kiribati. It will create employment and reduce our imports of diesel fuel. These projects will also be environmentally sustainable. Their operation relies on renewable sources that do not emit pollution. The projects therefore represent a promising alternative to diesel generation that currently powers most of our country.

The Government has consulted with development partners, private organisations, and civil societies to ensure inclusion of all relevant stakeholder and to build consensus during the drafting of this Plan.

The Government of the Republic of Kiribati is grateful for the SREP's support for this Investment Plan. The Government looks forward to working with our development partners to successfully implement the programs and activities outlined in the Plan.

Yours sincerely,

Honorable Dr. Teuea Toatu

Minister for Finance & Economic Development

CIF Focal Point

Executive Summary

The National Task Force, an interministry working group led by the Ministry of Infrastructure and Sustainable Energy and the Ministry of Finance and Economic Development, has prepared this SREP Investment Plan for the Republic of Kiribati. The World Bank, Asian Development Bank (ADB), European Union Commission (EU), and New Zealand's Ministry of Foreign Affairs (MFAT) have supported the extensive analysis for the Investment Plan. Consultations with many government ministries and representatives from civil society have also provided input.

The Plan presents the Government of Kiribati's (GoK) strategy for addressing the country's energy security problems and contributes to global efforts to mitigate climate change through low-carbon, renewable energy investments. It describes the GoK's vision for leveraging SREP and development partner funds to remove barriers that have thus far inhibited private sector led renewable energy development and will reduce Kiribati's reliance on fossil fuels.

If implemented, this Investment Plan will demonstrate that Kiribati is an attractive market for renewable energy development. The scaling-up of renewable energy will also contribute to better reliability and quality of electricity access in Kiribati, and thereby introduce opportunities for greater, more productive uses of energy that will improve the lives of all I-Kiribati.

1.1 Brief Country Overview

The Republic of Kiribati is an island country in the Pacific Ocean that comprises 32 coral atolls and one raised coral island. Its atolls are divided into the Gilbert, Phoenix, and Line groups. Roughly 90 per cent of Kiribati's total population (114,395) resides on the Gilbert Islands, of which about 50 per cent live on the capital island of South Tarawa. Most of the remaining population, about 6,500 I-Kiribati, reside on Kiritimati Island. Kiribati's population is growing quickly: by 2026, it is expected that South Tarawa's population will double. The population growth rate on South Tarawa is 4.4 per cent, twice the rate of population growth in other parts of the country, due in part to high internal migration to the capital. The fertility rate among I-Kiribati women is 4.1.

Poverty in Kiribati is high relative to other Pacific Island countries. Poverty tends to be concentrated in the Southern Gilbert Islands and South Tarawa. Unemployment is also high (31 per cent), and even higher among women (58 per cent). Gender inequalities are present in the public and private sectors, and within the home.

The country's climate vulnerabilities exacerbate Kiribati's demographic and socioeconomic challenges. Most of its atolls are only two metres above sea level, making them vulnerable to rising sea levels and increased incidence of extreme weather such as drought and storms. Sea levels are expected to rise by 5-15cm by 2030, and 20-60cm by 2090. This increase will heighten the impact of storm surges and coastal flooding, which can result in land erosion, loss of biodiversity, physical damage to infrastructure, human displacement, and increased scarcity of food and water.

1.2 The Context for SREP Involvement

Kiribati faces two important challenges in the energy sector: (1) an overdependence on expensive fossil fuel imports and (2) insufficient reserve generation and energy storage capacity to cope with increasing intermittent generation from renewable energy resources.

Overdependence on Expensive Fossil Fuel Imports

Reliance on imported fossil fuel (52 per cent) and coconut and palm oil residue (42 per cent) has been steadily increasing over the last few years.[1] The residential sector is the largest energy consumer. Households mostly rely on biomass (77 per cent), fuel wood and wood waste (10 per cent), and petroleum products (10 per cent combined). Electricity makes up only three per cent of household energy consumption. I-Kiribati primarily use wood and kerosene for cooking since liquefied petroleum gas is more expensive. Most households on South Tarawa (71 per cent) and Kiritimati Island (85 per cent) have access to electric lighting, but that lighting is often minimal, inefficient, and expensive.

The power sector consumers almost half (49 per cent) of the imported diesel. The reliance on imported diesel results in high electricity costs. Average electricity tariffs in Kiribati are among the highest in the Pacific, behind the Solomon Islands and Cook Islands. In 2017, the Public Utilities Board (Kiribati's state-owned electricity utility on South Tarawa) spent USD 6.1 million (57 per cent of total expenditures) on diesel and lubricant. The Ministry of Line and Phoenix Development, which is responsible for power generation on Kiritimati Island spent USD 667 684 (76 per cent of total sector costs) on fuel for electricity generation.

Insufficient Reserve Generation and Energy Storage

There is enough generation capacity on South Tarawa and Kiritimati Island to meet current demand, but grid reliability is a serious concern as the percentage of intermittent generation increases in line with Government's goals to reduce its reliance on fossil fuel generation. Substantial repairs, large capital replacements (such as generation assets), and fuel shipments take a long time to procure because of Kiribati's remoteness, reliance on development partner funding, and lack of back up generation assets. As a result, the state-owned utility Public Utilities Board (PUB) conducts load shedding to cope when catastrophic events, such as generator failures, occur. The GoK hopes that continued investments in renewable energy, energy storage, and distributed technologies that shift load can improve the country's energy security by increasing the reliability of the grid, while reducing fossil fuel consumption.

1.3 Renewable Energy in Kiribati

The GoK views investments in RE as a key strategy to addressing its energy sector and climate change challenges. It has prioritised sustainable RE development in all energy sector, climate change, and economic development policies such as the 2009 Energy Policy, the Kiribati Integrated Energy Roadmap (KIER) from 2016-2025, the Nationally Determined Contributions, the Kiribati Development Plan for 2016-2019, and the Kiribati 20-Year Vision 2016-2036 (KV20). The KIER includes fossil fuel reduction

[1] IRENA, "Kiribati integrated Energy Roadmap: 2016–2025," (August 2016).

targets (23 per cent on South Tarawa and 40 per cent on Kiritimati Island), which must be accomplished by scaling-up renewable energy. The Nationally Determined Contributions (NDC) includes a greenhouse gas (GHG) emission reduction target of 48.8 per cent by 2025.

The GoK has already deployed some utility-scale photovoltaic (PV) solar with the support of international development partners. As of 2017, solar PV serves 9 per cent of load and makes up 22 per cent of generation capacity on South Tarawa. On Kiritimati Island, 11 per cent of generation capacity consists of solar PV. Substantial amounts of technical potential particularly in solar (554MW) and wind (1.1MW) remain, and if exploited can help the GoK meet its targets. There are however, constraints to further RE development such as a weak institutional, legal, and regulatory framework; limited availability of financing; affordability concerns; and grid stability issues that must first be addressed.

SREP funds can be used to address these barriers. These funds can be used to secure multilateral development bank (MDB) and other donor commitments for technical assistance to Kiribati's energy sector to overcome barriers such as a weak institutional, legal, and regulatory framework. SREP funds in combination with MDB grant funds can also be used to lower the costs of technology and financing for RE projects. The success of SREP supported projects can ultimately serve as a catalyst to further scale up RE. If, and when the GoK is ready to liberalise its energy sector, SREP projects and technical assistance would demonstrate Government's preparedness for private sector participation.

1.4 Proposed Investment Program

Potential renewable energy resources were evaluated and prioritised using national and SREP criteria. National criteria reflect the GoK's strategic objectives to increase energy security and reduce its fossil fuel consumption. Many SREP and national criteria overlap; including building more renewable energy capacity, increasing access to electricity; supporting more affordable and competitive renewable energy technologies; and supporting technologies that are financially and economically viable. SREP criteria includes wider social benefits such as impacts on gender, the environment, and economic linkages.

The prioritisation exercise has identified two projects where the Government has requested SREP support: The South Tarawa Renewable Energy Project and the Kiritimati Island Electricity Access Project. These SREP projects represent phase I in Government's two phase RE Investment Plan.

Components in the South Tarawa Renewable Energy Project include:

- Investment in 4.1MW of solar PV and 1.9 MW (2.6 MWh) of energy storage
- Technical assistance for transaction advisory, feasibility studies, RE integration study, institutional, legal, and regulatory framework support to create an enabling RE framework and strengthen local capacity to manage and procure independent power producers (IPPs).

Components in the Kiritimati Island Electricity Access Project include:

- Investment in distribution network rehabilitation and expansion on Kiritimati Island
- Technical assistance for an electricity demand study, and institutional support and capacity building to improve the operational and financial sustainability of the power sector

SREP (phase I) investments will help the GoK achieve 69 per cent its 2025 KIER target to reduce fossil fuel consumption by 23 per cent on South Tarawa, 40 per cent of its NDC GHG reduction targets and expand electricity access on Kiritimati Island. Table 1.1 presents the financing plan for the SREP projects. It shows the proposed grants from SREP and the anticipated amounts from MDBs and other donors. It is expected that USD 3.7 million of SREP funding will catalyse nearly three times as much investment from other sources.

Table 1.1: Kiribati SREP Indicative Financing Plan

Phase I	Total	SREP***	ADB**	Other donors	Private sector	GoK*
South Tarawa Renewable Energy Project	**USD million**					
Investment in PV and energy storage	10.7	3.7	5	2		
Subtotal	10.7	3.7	5	2	0	0
SREP Leverage	1:1.9					
Kiritimati Island Electricity Access Project	**USD million**					
Electricity demand study	0.3					0.3*
Investment in distribution network rehabilitation and expansion	3.4					3.4*
Project preparation (feasibility studies, institutional support and capacity building program)	1					1*
Subtotal	4.7	0	0	0	0	4.7
Total	15.4	3.7	5	2	0	4.7
Total SREP Leverage	**1:3.2**					

Notes: *The EU is in discussions with the GoK on the exact scale and scope of the support that will be offered to Kiritimati Island for sustainable development under the EDF 11 envelope. Funds may be put towards general budgetary support, technical assistance, and/or infrastructure investment. Because the discussions are still ongoing the funding amounts provided here are meant to be indicative.

**The ADB is in discussion with the GOK on potential additional funding for SREP (Phase I), and possibly for Phase II. The SREP Phase I funding amount and size of the infrastructure project are therefore indicative and will likely increase upon confirmation of funding increase by Q1 2019 and start of project preparation.

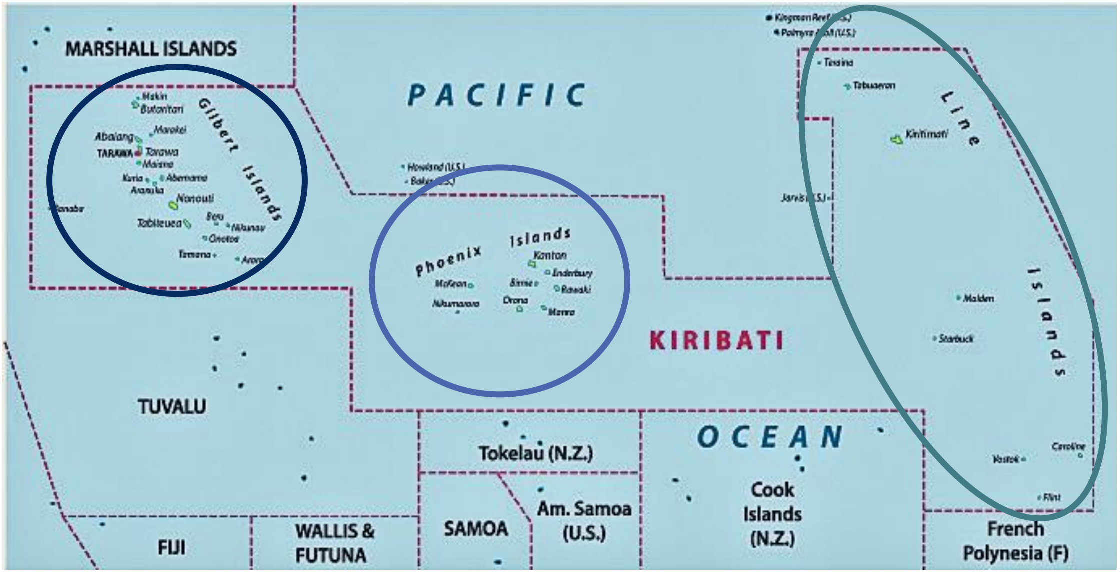
*** Excludes Investment Plan Preparation Grant (IPPG) of USD 0.3 million and Project Preparation Grant (PPG) of USD 1 million

Phase II of the GoK's RE Investment Plan will build on the SREP program (phase I) by using improvements in the RE legal and regulatory framework, local capacity, and understanding of future demand needs (especially on Kiritimati Island) to substantially scale up private sector led RE investments to meet 2025 KIER and NDC targets. Phase II projects will likely include additional investments in grid-connected solar and energy storage on South Tarawa and Kiritimati Island. The GoK plans to seek financing support for projects in Phase II from MDBs, the EU, bilateral donors, and the Green Climate Fund.

2 Country Context

The Republic of Kiribati is an island country in the Pacific Ocean. It is the only country to reside in all four hemispheres because of the geographical dispersion of its islands. Its islands are spread over 3.5 million square kilometres of the Pacific Ocean, of which only 800 km^2 is land area, comprised of 32 small coral atolls and one raised coral island. Its atolls are divided into three island groups: Gilbert, Phoenix, and Line. Kiribati has a hot and humid tropical climate. Temperatures vary only one per cent seasonally and range daily from 25 to 32 degrees Celsius. Figure 2.1 shows a map of Kiribati.

Figure 2.1: Island Groups in Kiribati and Population 2015



Source: National Statistics Office, Kiribati Ministry of Finance, "2015 Population and Housing Census," 2016.

Map: GoK, “KIER,” 2016.

Demographics

Kiribati has a population of 114 395 people.[2] Ninety per cent of the population resides on the Gilbert Islands, of which approximately half live on the capital island of South Tarawa. Most of the remaining population lives on Kiritimati Island (6 456 people), which is part of the Line Islands.[3] Population growth has increased on South Tarawa as people from outer islands migrate to its cash economy.[4] The share of the urban population has risen more than 10 per cent since 1990.[5] In 2010, population growth on South Tarawa was 4.4 per cent, double the country’s total population growth rate of 2.2 per cent. At this pace, the population on South Tarawa will double by 2026 to 100 000 people. The Government has released 2,000 new land leases on Kiritimati

[2] “World Development Indicators,” World Bank, accessed January 22, 2018.

[3] National Statistics Office, Ministry of Finance, Kiribati, “2015 Population and Housing Census”, 2016.

[4] GoK, “Kiribati Development Plan 2016-19”, 2016.

[5] Central Intelligence Agency, “The World Factbook: Kiribati”, 2017.

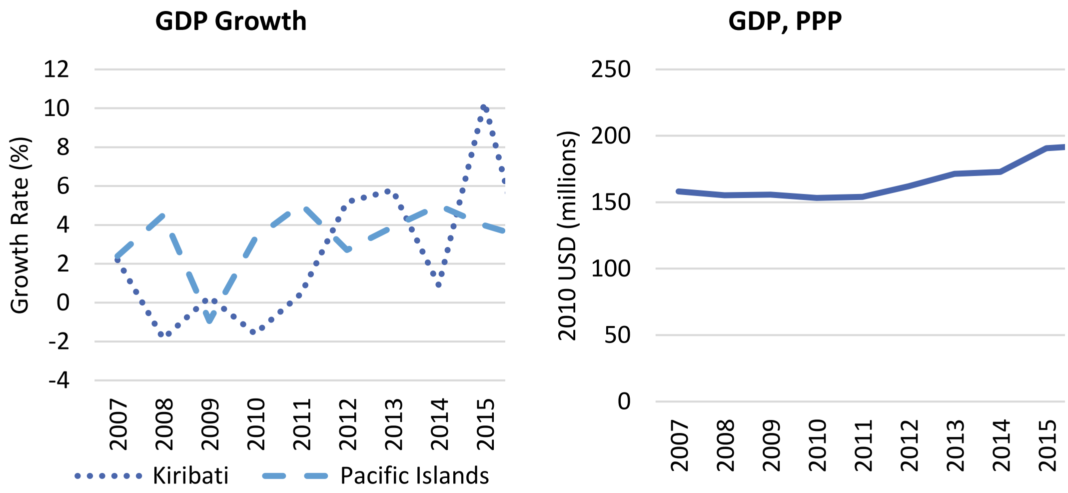
Island with the intent of redirecting the migratory flow from South Tarawa to Kiritimati.[6]

Socioeconomic Challenges and Opportunities

Kiribati's economy is mostly service-driven, representing 66.5 per cent of Gross domestic product (GDP).[7] Some of the largest services in Kiribati are copra production and fisheries. Kiribati's trade deficit is high. In 2013, the country exported USD 6.8 million (12.5 per cent of GDP)[8] coconut and fisheries products and imported USD 103.3 million products (92.78 per cent of GDP),[9] mostly foodstuffs.[10]

GDP per capita was USD 1 838 in 2014, one of the lowest among Pacific countries, as shown in Figure 2.2.[11] Economic growth has been volatile since 2007 but is picking up in the country overall.[12] Real growth in GDP rose by 5.2 per cent in 2012, 5.8 per cent in 2013, and levelled at 2.4 per cent in 2014.[13] Real GDP has gradually increased since 2011 and can be attributed to the sale of fishing licences (90 per cent of overall GDP in 2015), the introduction of a VAT and Excise Tax in 2014, and abolition of Customs Duties (which increased income more than USD 5 million from 2013 to 2015).[14]

Figure 2.2: Economic Growth in Kiribati and the Pacific Islands, 2007 – 2016



Source: World Bank World Development Indicators.

[6] IRENA, "Kiribati Renewables Readiness Assessment 2012", 2013.

[7] World Bank et al., "Regional Partnership Framework", 2017.

[8] "Kiribati Exports of goods and services % of GDP 1988-2013", World Integrated Trade Solution, 2018.

[9] "Kiribati Imports of goods and services % of GDP 1988-2013", World Integrated Trade Solution, 2018.

[10] GoK, "Kiribati Development Plan 2016-19", 2016.

[11] GoK, "Kiribati Development Plan 2016-19", 2016.

[12] World Bank et al., "Regional Partnership Framework", 2017.

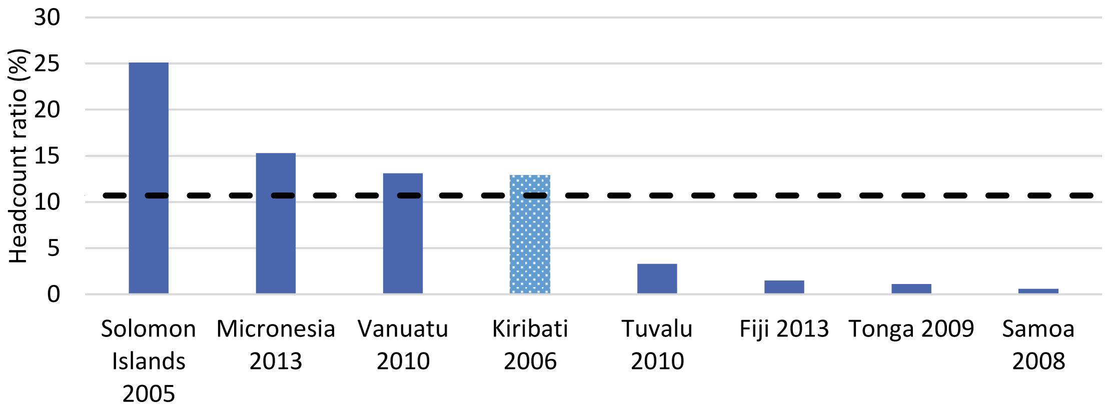
[13] GoK, "Kiribati Development Plan 2016-19", 2016.

[14] World Bank et al., "Regional Partnership Framework", 2017.

In 2010, about 31 per cent of the population was unemployed.[15] Unemployment is higher among people aged between 15 and 24, who compose 57 per cent of the population. The high rate of unemployment in Kiribati means that 30 per cent of the population support the remaining 70 per cent.[16] Formal private sector employment is rare; the public sector provides 60 per cent of the country's formal jobs.

Kiribati's poverty rate was 22 per cent in 2006, among the highest in the Pacific. The Southern Gilbert islands (29 per cent of households) and South Tarawa (17 per cent of households) have the highest rates, and South Tarawa is home to the greatest number of poor people.[17] People rarely find work as they migrate from outer islands to South Tarawa, yet they choose to stay because of the high-cost of returning home and the challenges of a subsistence lifestyle on outer islands, such as the lack of access to basic services. Figure 2.3 compares the poverty headcount ratio at USD 1.90 a day among Pacific Island countries.

Figure 2.3: Poverty Headcount Ratio at USD 1.90 a Day in Pacific Island Countries



Source: World Bank World Development Indicators. Countries limited to those reporting after 2005, and excluding Marshall Islands, Nauru, and Palau.

Note: Poverty headcount ratio is based on 2011 PPP USD

Kiribati does not currently face the nutrition challenges often associated with high-levels of poverty. In 2014-2016, only 3.3 per cent of the population was undernourished compared to 28.6 per cent among low-income countries and 17.7 per cent among small island developing states.[18] Kiribati imports foodstuffs, but has a large supply of fish, breadfruit, and coconuts to sustain itself. Kiribati is vulnerable, however, to food insecurity as climatic variability can impact fisheries and subsistence agriculture.[19]

[15] GoK, "Kiribati Development Plan 2016-19", 2016.

[16] Australia DFAT, "Kiribati Program Poverty Assessment", 2013.

[17] Australia DFAT, "Kiribati Program Poverty Assessment", 2013.

[18] Food and Agriculture Organization of the United Nations, "Food Security Indicators", 2017.

[19] Food and Agriculture Organization of the United Nations, "Climate Change and Food Security in the Pacific", 2009.

The GoK prioritised both human resource development and economic growth and poverty reduction in its 2016 to 2019 Kiribati Development Plan. In the medium-term, possible areas for job growth include development in domestic tuna fisheries, an interisland seafaring market, tourism, and seasonal employment in other countries, such as New Zealand and Australia.

Gender Equality Progress and Opportunities

Gender mainstreaming[20] in Kiribati, which has historically focused on reducing domestic violence has been expanded to include in sectors outside the home. Women and men are now equally represented in senior government positions and in the rate of primary and secondary school enrolment.[21] The GoK has articulated its commitment to provide equal opportunity and outcomes for all I-Kiribati's by incorporating a policy of gender mainstreaming in its Economic Development Plan for 2016-2019 and the draft Kiribati 2020 Vision Strategy.

Gender mainstreaming is, however, still relatively new and not uniformly implemented. Gender equality is a guiding principle in the GoK's Energy Policy (2009) but has not been explicitly incorporated in other energy sector strategies except for the 2014 Cook for Life Strategy and the 2014 Kiribati Joint Implementation Plan for Climate Change and Disaster Risk Management (KJIP).[22] There is also limited baseline data disaggregated by gender that would allow for monitoring and evaluation of gendered outcomes in the energy sector.

Gender inequalities are still observed in the public and private sectors, and within the home. The unemployment rate among women (58 per cent) is substantially higher than men (41 per cent).[23] Women do not have the same access to labour markets or opportunities for employment and entrepreneurship.[24] Finding higher paid work abroad is rare; hiring for short-term agricultural work in New Zealand and Australia and work as seafaring favours men. Land erosion and water salinisation caused by climate change especially harm women, who are predominantly responsible for water

[20] Gender mainstreaming is "the process of assessing the implications for women and men of any planned actions, including legislation, policies or programs, in all areas and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programs in all political, economic and societal spheres, so that women and men benefit equally and inequality is not perpetuated." Secretariat of the Pacific Community, "Stocktake of the gender mainstreaming capacity of Pacific Island governments Kiribati", 2015.

[21] NAP Global Network, "Strengthening Gender Considerations in Kiribati's National Adaptation Plan (NAP) Process", 2017.

[22] The GoK's Cook for Life Strategy recognizes the benefits that improved cookstoves provide for women. Cooking time and exposure to pollutants is reduced. Time savings can allow women to become more involved in the community, contribute to decision making, and participate in income-generating activities. All strategies and actions in the KJIP are inclusive of women and other vulnerable groups and incorporates a gender sensitivity indicator.

[23] Kiribati National Statistics Office, "2015 Population and Housing Census", 2016.

[24] Government of Kiribati, "Kiribati 20-Year Vision 2016-2036 (KV20) Draft", 2018.

and food security. Female representation in Parliament and island councils remains below six per cent.[25] Domestic violence is still a serious social problem in Kiribati.

Climate Change Adaptation and Mitigation Challenges

Kiribati's demographic and socioeconomic challenges exacerbate the country's climate vulnerabilities, which are attributed to its low-lying atolls. Most of Kiribati's islands are only two metres above sea level, making them particularly vulnerable to rising sea levels and extreme weather (drought and storms). The sea level is projected to rise 5–15 cm by 2030 and 20–60 cm by 2090, with seasonal and regional variability. This increase, along with natural changes in climate each year, will worsen the impact of storm surges and coastal flooding. Storm surges increase coastal erosion, resulting in loss of land and coastal biodiversity, reduced access to safe drinking water and food resources, damaged homes and infrastructure, and added conflict over land rights, forcing further interisland migration as people are displaced. By 2050, up to 80 per cent of the land in Bairiki, North Tarawa and 50 per cent in Bikenibeu, South Tarawa may become inundated.[26]

Rainfall is expected to increase more than five per cent by 2030 and 15 per cent by 2090, reducing the likelihood of droughts in Kiribati. By 2090, the likelihood of droughts is expected to decrease from two or three occurrences every 20 years to one or two occurrences. Nevertheless, when droughts occur it is particularly bad for Kiribati because groundwater turns brackish and copra production declines as foliage turns yellow, depressing outer island economies.[27]

The GoK recognises the need to undertake adaptation and mitigation measures to minimise the impact of climate change on Kiribati's development. The Government recently developed the Intended NDC and Joint Implementation Plan for Climate Change and Disaster Risk Management 2014-2023 (KJIP), which propose measures to cope with the impacts of climate change and associated risks. The KJIP identifies two specific goals for 2023. First, the GoK will promote the use of sustainable, renewable sources of energy and energy efficiency, as further detailed in Section 3.1.2.[28] Second, the GoK will strengthen Kiribati's capacity to access finance, monitor expenditures, and maintain strong partnerships.[29] Specifically, the GoK plans to strengthen coordination and approval mechanisms related to reviewing proposals for climate change mitigation and disaster risk reduction projects, and leverage national and external finance to support such initiatives.

[25] NAP Global Network, "Strengthening Gender Considerations in Kiribati's National Adaptation Plan (NAP) Process", 2017.

[26] GoK, "Intended Nationally Determined Contribution", 2015.

[27] GoK, "Intended Nationally Determined Contribution", 2015.

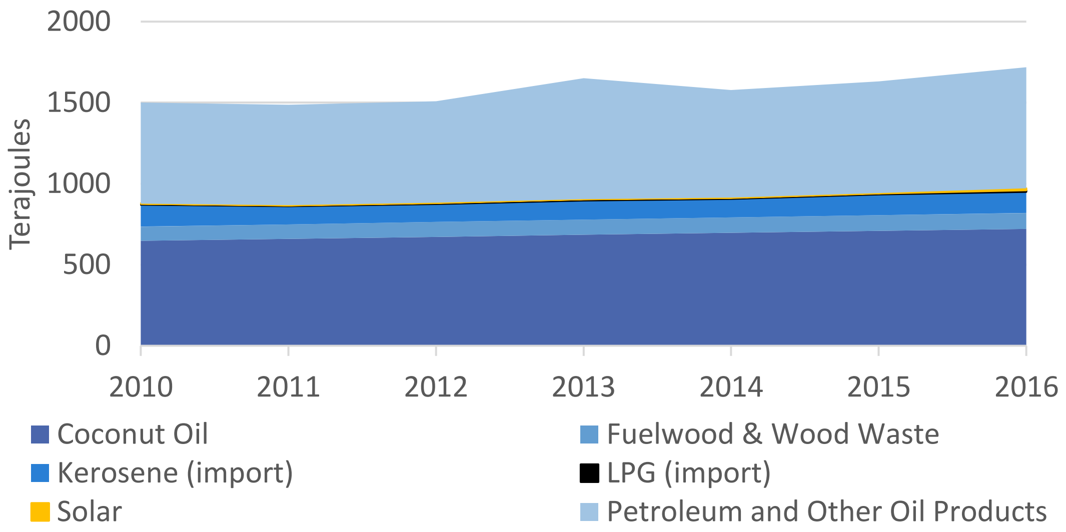
[28] GoK, "Kiribati Joint Implementation Plan for Climate Change and Disaster Risk Management 2014-2023", 2014.

[29] GoK, "Kiribati Joint Implementation Plan for Climate Change and Disaster Risk Management 2014-2023", 2014.

3 Energy Sector Context

Kiribati's energy mix, which is dominated by imported fossil fuel (52 per cent) and coconut oil (42 per cent) has been steadily increasing over the last few years.[30] The country relies on imports because of its remoteness and lack of indigenous fossil fuel resources. The share of fossil fuel imports has been constant in recent years – making up 49 to 52 per cent of the country's total primary energy supply between 2010 to 2016 – despite additions of new solar installations for power generation. Figure 3.1 shows the composition of Kiribati's primary energy supply since 2010.

Figure 3.1: Primary Energy Supply (2010-2016)



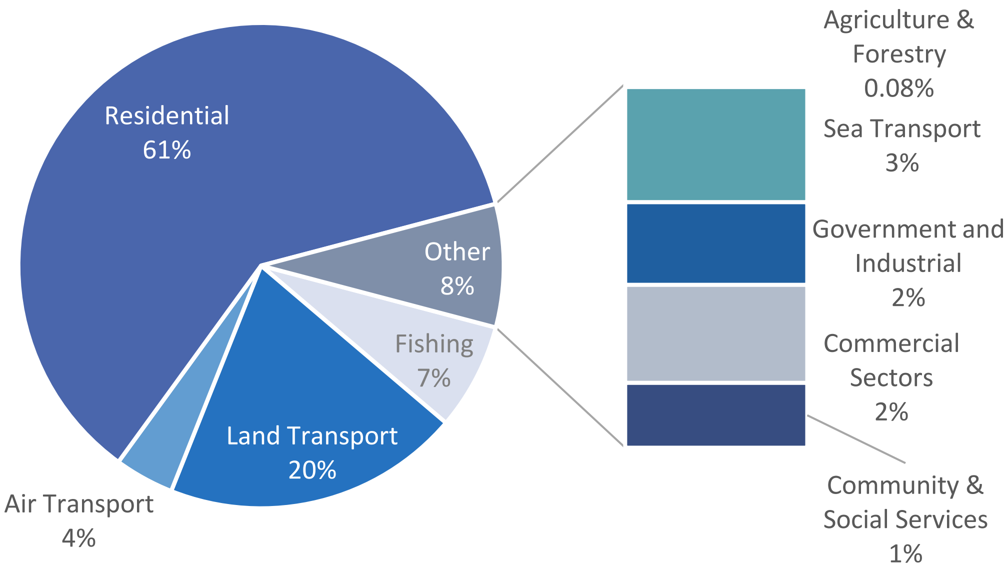
Note: Energy balance data is currently only available for the Gilbert Island Group.

Source: MISE

Figure 3.2 shows Kiribati's final energy consumption by sector. The residential sector is the largest consumer of energy followed by land transport. As of 2016, electricity makes up only 3 per cent of household's energy consumption. More than 95 per cent of households' energy consumption comes from biomass in the form of coconut oil and palm oil residue (77 per cent) and fuel wood and wood waste (10 per cent), and petroleum products in the from kerosene (5 per cent) and petroleum (5 per cent).

[30] IRENA, "Kiribati integrated Energy Roadmap: 2016–2025," (August 2016).

Figure 3.2: Final Energy Consumption by Sector



Source: MISE

I-Kiribati primarily use wood and kerosene for cooking. Liquefied petroleum gas use is limited because of its high costs, especially in comparison with kerosene.[31] The Government subsidises kerosene directly (through price controls) and indirectly (through VAT and excise duty exemptions), which has led to kerosene prices being constant since 2009 despite large volatility in world prices. One study estimates that the total subsidy on kerosene could be up to AUD 0.60 a litre.[32] The average household in South Tarawa and Kiritimati Island uses both bioenergy and kerosene.[33] Bioenergy is commonly used for open fire cooking, particularly in lower income households and for prolonged cooking (e.g., boiling water and pigs' food).[34] As of 2009, 98 per cent of households cooked using an open fire or stove with no chimney or hood.[35] According to the 2016 Urban Household Energy Survey Report, 80 per cent of households in South Tarawa and Kiritimati Island have a kerosene cooking unit. Figure 3.3 shows the cooking fuels used by households in South Tarawa and Kiritimati Island in 2016.

[31] IRENA, "Kiribati integrated Energy Roadmap: 2016–2025," (August 2016).

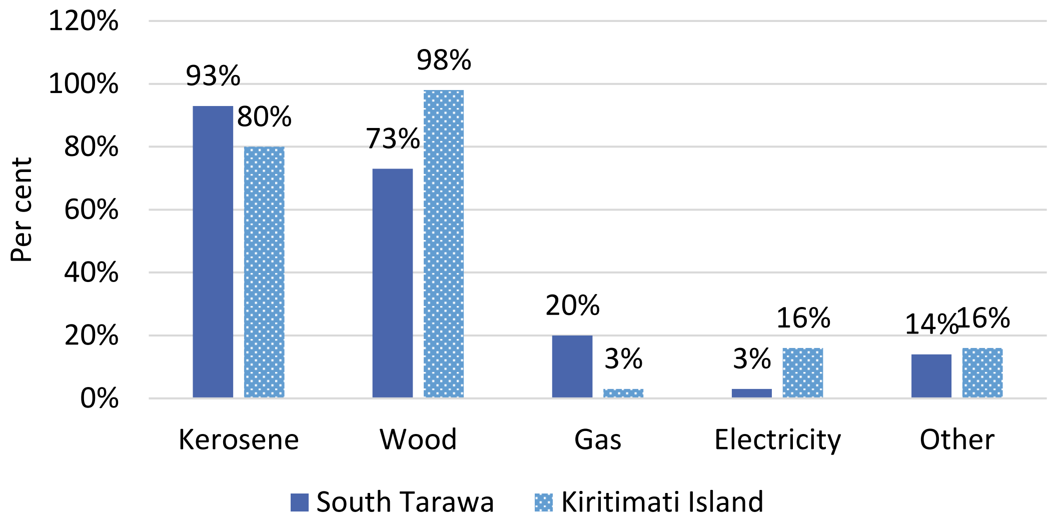
[32] Pacific Community, "Review of fuel subsidies in Kiribati", 2017.

[33] Jensen, Thomas Lynge, "Kiribati 2016 Urban Household Electrical Appliances, Lights, and End-use Survey Process and Findings," UNDP (March 2017).

[34] IRENA, "Kiribati integrated Energy Roadmap: 2016–2025," (August 2016).

[35] Kiribati National Statistics Office, "Kiribati Demographic and Health Survey 2009," Tarawa, Kiribati, (2010).

Figure 3.3: Cooking Fuels used in Households (2016)



Source: Jensen, Thomas Lynge, "Kiribati 2016 Urban Household Electrical Appliances, Lights, and End-use Survey Process and Findings," UNDP (March 2017).

Most households on South Tarawa (71 per cent) and Kiritimati Island (85 per cent) have access to electric lighting, but that lighting is often minimal, inefficient, and expensive.[36] South Tarawa households use an average of 0.5 kWh per day for lighting, of which 64.2 per cent of this energy use is attributed to inefficient T12/T8 standard fluorescent tubes with iron ballasts. The average South Tarawa household has three light bulbs or tubes, used for 6.1 hours per day. Kiritimati Island households use an average of 0.7 kWh per day for lighting, with 82.6 per cent of this energy use attributed to inefficient T12/T8 standard fluorescent tubes with iron ballasts. The average Kiritimati household has four light bulbs or tubes, used for 5.5 hours per day.

The following subsections provide more details about the energy sector in Kiribati. Section 3.1 describes the institutional, legal, and regulatory framework in the energy sector; Section 3.2 and 3.3 provides an overview of the electricity sector; and Section 3.4 summarizes the key energy sector challenges Kiribati faces.

3.1 Institutional, Legal, and Regulatory Framework

Section 3.1.1 provides information on important institutions in the energy sector, including those responsible for policy, regulation, generation, transmission, distribution, and electrification. Section 3.1.2 summarizes key energy sector policies, legislation, and regulations in the energy sector of Kiribati.

3.1.1 Institutional framework in the energy sector

The government institutions that carryout sector policy and administration include:

- **Ministry of Infrastructure and Sustainable Energy (MISE)** is responsible for planning, managing, and coordinating activities in the energy sector. The

[36] Jensen, Thomas Lynge, "Kiribati 2016 Urban Household Electrical Appliances, Lights, and End-use Survey Process and Findings," UNDP (March 2017).

Energy Planning Unit (EPU), under MISE administers the Petroleum Ordinance.[37] There is currently no legal document formally establishing the EPU's legal roles and functions in electricity regulation.

- **Ministry of Finance and Economic Development** is responsible for budgeting, managing fiscal expenditure, and donor outlays for energy sector projects.
- **Climate Finance Division (CFD),** under MFED focuses on facilitating access to multilateral climate funds and is the focal point for Government to the Climate Investment Fund, Green Climate Fund and Adaptation Fund. The Division oversees all SREP activities including Investment Plan and proposal development.
- **Kiribati Oil Company** (KOIL) is a majority state-owned enterprise that serves as the main fuel importer and distributor in Kiribati. It operates the main fuel terminal on South Tarawa and a smaller bulk fuel terminal on Kiritimati.
- **Kiribati Solar Energy Company** (KSEC) is a state-owned enterprise that sells and leases micro solar technologies such as SHS, solar street lights, and other components. Its mandate is to facilitate the uptake of RE in Kiribati by distributing solar technologies.
- **Public Utilities Board** (PUB) is a vertically integrated—responsible for generation, transmission, distribution—public utility that provides electricity and water and waste water supply services on South Tarawa and some villages of North Tarawa. By May 2018, PUB will assume responsibility for electricity and water services on Kiritimati Island.
- **Ministry of Line and Phoenix Islands Development** (MLPID) is responsible for all public services on Kiritimati Island, and other populated islands in the Line and Phoenix group. It has a project management unit that is responsible for coordinating energy sector projects on the Kiritimati Island. Until May 2018, MLPID is responsible for managing electricity supply services on Kiritimati Island.

3.1.2 Key energy sector policies, laws, and regulations

The **Kiribati 20-Year Vision for 2016 – 2036 (KV20),** an overarching framework for all national policies and plans, is a long term development blueprint for Kiribati that aims to transform Kiribati to a healthier, wealthier and peaceful nation by maximising the development benefits from fisheries and tourism as key productive sectors. KV20 is anchored on four pillars: Wealth; Peace and Security; Infrastructure; and Governance. The Infrastructure pillar aims at improving connectivity and accessibility in relation to economic and social infrastructure including energy, which is a foundation and enabler for achievement of the Vision.

The **Kiribati Development Plan for 2016-2019**, which identifies six priority areas for development in Kiribati for the next three years also includes provisions for the

[37] The Petroleum Ordinance is described in Table 3.1.

scaling-up of renewable energy in all sectors of the economy as part of its goal to increase I-Kiribati's access to high-quality and climate-resilient infrastructure.

The **Climate Change Policy (2018)** strategically guides and supports decision-making processes and sets the direction for enhanced coordination and scaled-up implementation of climate change adaptation, mitigation and disaster risk reduction interventions. Energy Security is among the ten priorities laid out in the policy, which includes the following three related objectives:

- Objective 1: Promote and enhance the transition towards renewable energy sources.
- Objective 2: Strengthen the technical and institutional capacities of the energy sector using the most innovative technologies available.
- Objective 3: Increase energy conservation and energy efficiency on both the supply and demand sides.

The **Energy Policy of 2009** is the major policy document that guides the development of the sector. The policy was adopted in alignment with the Kiribati Development Plan 2008-2011, which focuses on economic growth and improvement of livelihoods through the availability/accessibility of reliable, affordable, clean, and sustainable energy. The policy addresses major challenges in the sector, including human and institutional resource development, energy security, economic growth and improvement of livelihoods and access. It also defines guiding principles for the sector, including sustainability, gender equity, environment compatibility, stakeholder participation, good governance, and cultural and traditional compatibility. Policies specific to expanding renewable energy in Kiribati include the following[38]:

- Promote sustainable renewable energy development
- Ensure that the limited biomass (inclusive of biofuels) resources are used in an economic, environmental, and culturally sustainable manner
- Strengthen collaboration with development partners for the advancement of renewable energy programs
- Promote and encourage the use of appropriate renewable energy technologies
- Expedite the replication of successful solar programs
- Introduce appropriate incentive packages including taxes, duties and tariffs to encourage use of renewable energy technologies.

The **KIER** is a medium-term strategy document prepared with assistance from the International Renewable Energy Agency (IRENA) to guide the energy sector from 2016 to 2025. It provides a detailed overview of Kiribati's energy sector, the key challenges it faces, sets targets for renewable and energy efficiency to reduce fossil fuel consumption, and identifies specific activities and investments that are necessary to

[38] Government of the Republic of Kiribati, "Kiribati National Energy Policy," (April 2009).

achieve these targets. By 2025, the GoK plans to reduce fossil fuel consumption by 23 per cent in South Tarawa, 40 per cent on Kiritimati Island, and 40 per cent in the outer islands by deploying more renewable energy generation. Additionally, the GoK plans to reduce fossil fuel usage (by 22 per cent on South Tarawa, 20 per cent on Kiritimati Island, and 20 per cent the outer islands) through the uptake of energy efficiency measures.

The NDC is a document that describes Kiribati's commitment to sustainable development and combating climate change as a signatory of the 2015 Paris Agreement. It outlines climate change adaptation and mitigation measures the GoK's intends to undertake to reduce GHG emissions by 2030. There are several discrete targets in the NDC that demonstrate the level of GHG reductions the GoK believes it can achieve with and without international assistance. By 2025, the GoK has committed to reducing GHG emissions by 13.7 per cent (without international assistance), and 48.8 per cent if international assistance is provided. By 2030, the GoK has committed to a reduction in GHG emissions of 49 per cent.[39].

As evident by this extensive policy framework, the GoK has made renewable energy a priority within both national and energy sector strategies. Each subsequent policy has aimed to build on or elaborate the goals set out in the previous policy. Appendix C provides a summary of how these policies are connected. The projects the GoK has implemented with its donor partners have also contributed to the objectives laid out in these policies. Related accomplishments include:

- Investment of 1.6MW of solar PV on the grid with the support of the World Bank, the Pacific Environment Community Fund, and the United Arab Emirates
- Installation of supervisory control and data acquisition (SCADA) and Energy Management System to optimise input of renewable energy in the grids
- Hybridisation of the Kiritimati Island grid (solar/diesel) with the support of the European Union and New Zealand
- Maintenance and purchase of high efficiency generators by PUB to improve generation performance and loss reduction on the distribution system
- PUB reform to improve institutional, operation and financial performance of the organisation, thereby reduce tariffs and connection costs.

The investments that are proposed in this SREP IP specifically aim to contribute to the targets set out in the KIER and NDC. Box 3.1 shows the level of renewable energy generation required to meet targets in the KIER and NDC.

[39] The GoK believes that it can achieve more than 60 per cent in GHG emission reductions based on 2014 levels with international donor assistance.

Box 3.1: Renewable Energy Generation Required to Meet KIER and NDC Targets

Policy document	Target	Target reduction amount	Target MWh equivalent	Level of RE penetration (%)
KIER	23 per cent reduction of fossil fuel consumption*	4 638 798 litres	17 164	36
NDC	48.8 reduction in GHG emissions	30 744 tons of CO_2	29 514	61

Note: Calculations are based on 2014 energy balance and CO_2 inventory data. Fossil fuel reduction calculated based on a heating value of 39MJ/l. Target MWh equivalents and level of RE penetration is based on estimated load in 2025. *Calculation for South Tarawa only because procedures for accurate data collection for load and supply data for Kiritimati Island recently begun and new generation capacity was recently commissioned.

Table 3.1 lists the energy sector's principal laws, regulations, and guidelines.

Table 3.1: Key Legislation, Guidelines, and Regulations

Legislation	Overview
The Public Utilities Ordinance (CAP 83 of 1977 revised 1998 and 2010)	The ordinance allows for the formation of the PUB and for MISE to define supply areas as exclusive to the PUB. It describes the right to supply electricity and water within an area and to permit others to generate, distribute, supply, and sell water or electricity, or to fine those without permission. The ordinance further outlines the powers of the Board; financial provisions, revenue, tariffs, and taxes; offences and injurious acts; and the power of and regulations by the Minister.
Prices Ordinance (Cap 1975 and revised in 1981)	The ordinance sets price controls for petrol and kerosene.
The State-Owned-Enterprise (SOE) Act 2012 (revised May 2013)	The Act defines the structure, reporting requirements and principles for governing and managing SOEs to ensure transparent, effective and efficient functioning of such enterprises.
Regulations	**Overview**
Petroleum Ordinance (Cap 69)	The ordinance defines regulations to import, store, hawk, and test petroleum to regulate its safety, storage, rationing, and customs inspections. It sets out regulations for crafts with petroleum on board, petroleum warehouses, modes of testing, and disposal of petroleum.

Environment Act (Act 9 of 1999, amended in 2007)	The Act sets out the functions of the Minister for Environment, Lands and Agriculture Development, who is responsible for the administration and implementation of the Act, and describes performance targets, development control, environmental impact assessment and development, control of pollution, and regulations to ensure the protection, improvement, and conservation of the environment.
Guidelines	**Overview**
SEIAPI Guidelines	Sets guidelines for grid-connected and off-grid Photovoltaic (PV) system design and installation.
AS/NZ 3000 – electrical wiring rules **AS5033 – solar arrays** **AS4777 (2015) – grid-connected inverters** **AS/NZ5139 – battery standard (new)** **IEC62109 – Electrical Safety (Parts 1 and 2)**	A collection of grid electricity standards adopted from Australia/New Zealand (they are informally adopted and as such there is difficulty in enforcing them for all electrical imports).

Kiribati's Electricity Act exists only in draft form.[40] Currently, PUB, KSEC, and KOIL are all essentially self-regulating. PUB tariffs are supposed to be set by their Board of Directors, but board decisions are sometimes overturned by higher levels of government because of affordability concerns.[41]

3.2 Electricity Supply

There are three systems that provide power for Kiribati, each using a combination of diesel and solar PV generation. They are, in order of size: South Tarawa, Kiritimati, and outer islands. Each system comprises several isolated grids owing to the dispersed nature of villages and islands. Solar PV is the main source of electricity generation in the outer islands. Generation assets range from pico-solar devices such as solar lights, SHS and maneaba (meeting house) systems, solar pumps, and school mini-grids.

The electricity system on South Tarawa has a total installed capacity of 7.01MW, most of which is diesel generation. Since 2014, 1 556 kW of solar PV has been added to the grid. As of March 2018, 22 per cent of total installed capacity on South Tarawa is ground and roof mounted solar PV. A 64 kilometre, 11-kV distribution network serves the current load. PUB has rehabilitated parts of the distribution network and is currently replacing transformers on the network and installing a SCADA system that will monitor selected transformers and PV systems on the grid. Technical losses have fallen dramatically, from 22.61 per cent in 2015 to 13.49 per cent in 2016 since distribution upgrades were made. PUB also recently purchased three new high-speed diesel generators, which is expected to be installed within 2018. These high-speed units will allow PUB to better manage the grid as intermittent generation from solar

[40] IRENA, "Kiribati Integrated Energy Roadmap: 2016–2025," (August 2016).

[41] IRENA, "Kiribati Renewables readiness Assessment 2012," (2013).

PV increases, as well as carry out planned maintenance of generation assets (insufficient redundancy has meant that when generators fail, PUB has had to carry out load shedding). Table 3.2 shows the generation assets in South Tarawa.

Table 3.2 Generation Assets on South Tarawa

Power Plant	Technology	Capacity
Bikenibeu Powerplant	Diesel	1 400 kW x3 (de-rated to 1 200 kW x3) New: 780 kVa and 1 200 kVa
Betio Powerplant	Diesel	1 250 kW (de-rated to 1 100 kW) New: 700KVa
Bikenibeu (PEC funded)	Grid-connected PV	400 kWp; 100 kW (unit capacity)
Bonriki (UAE)		500 kWp; 25 kW
Betio Sports		546 kWp; 20 kW combined
Betio KIT		
Bikenibeu Hospital		
Bikenibeu King George V High School		
Betio KSEC		10 kWp; 12 kW
Taeoraereke USP		9.6 kWp; 12 kW
Mormon system		100 kWp; 25 kW
	Total capacity	**7.01MW (excluding new gensets)**

Source: IRENA, "Kiribati Integrated Energy Roadmap: 2016–2025," (August 2016); PUB; Trama TecnoAmbiental, "Technical Support Consultancy for the Kiribati Grid-Connected Solar PV Power Station Project, Addendum 2 – Feasibility study on upscaling solar PV," (September 2016).

Note: PEC refers to Pacific Energy Community

The electricity system on Kiritimati Island is owned and operated by MLPID.[42] There are three zones in the system. Zone 1 consists of London, Tennessee and Tabwakea; Zone 2 consists of Banana, New Banana, and Kiritimati Island Airport; and Zone 3 is an isolated grid serving Poland village. The system was recently overhauled under the KIESP, funded by the European Union and New Zealand. The project included investments in new generation assets for all zones and a high voltage transmission network (11 kV) to interconnect Zones 1 and 2. Works in Zones 1 and 2 have been completed and construction is ongoing for Zone 3 (isolated grid). Once new generation assets in Zone 3 are commissioned, the system will have a total installed capacity of

[42] Although MLPID currently owns and operates the Kiritimati Island grid, the PUB will soon take over both the electricity system and the water system on Kiritimati island.

1.46 MW (1273 kW of diesel generation, and 186.5 kW of solar PV capacity). Table 3.3 shows the generation assets on Kiritimati Island, including Zone 3 investments that are currently ongoing.

Table 3.3 Generation Assets on Kiritimati Island

Location	Technology	Capacity
Zone 1 (now interconnected with Zone 2)	Solar PV	150 kWp
	Diesel generator	945 kW (315 kW x3)
Zone 2	Diesel generator	280 kW (200 kVA and 80 kVa)
Zone 3 (under construction; isolated grid)	Solar PV and battery storage	36.5 kWp (battery capacity: 346 kWh)
	Diesel generator	48 kW
	Total	**1.76 MW**

Source: IT Power, "KIESP: Introduction and Project Information;" 2017. IT Power, "Poland Hybrid Power System: Commissioning MSQA," 2018.

There is currently enough installed capacity on South Tarawa and Kiritimati Island to meet peak demand, but grid reliability will increasingly be put at risk as additional intermittent generation is added to the grid. As noted above, the electricity system on South Tarawa currently does not have enough redundancy; to meet peak demand all generators must be operational. In the past, the failure of one generator has resulted in load shedding.

3.2.1 Electricity costs and tariffs on South Tarawa

There is no formal regulatory framework for setting electricity tariffs on South Tarawa.[43] Tariffs are proposed by PUB and approved by the Cabinet. Tariff reforms were considered under a World Bank funded study in 2016. The GoK has implemented a lifeline tariff in line with recommendations from the study. Table 3.4 shows the electricity tariffs on South Tarawa.

[43] VINSTAR Consulting, "Performance Improvement Plan and Preliminary Reform Options Report," May 2, 2016.

Table 3.4 Electricity Tariffs on South Tarawa

	Tariffs (AUD per kWh)
	Current (2016)
Domestic	0.10 (lifeline for first 100 kWh) 0.40 (101-300 kWh) 0.55 (>300 kWh)
Commercial	0.55
Industrial/Government	0.70
Water and sewerage pumping	0.60
Weighted average tariff	0.51

Source: VINSTAR Consulting, "Performance Improvement Plan and Preliminary Reform Options Report," May 2, 2016.

As shown in Table 3.4, domestic consumers have a lifeline tariff of AUD 0.10 (USD 0.08) for consumption under 100 kWh per month, a tariff of AUD 0.40 (USD 0.31) for consumption 101-300 kWh, and AUD 0.55 (USD 0.43) for consumption over 300 kWh. The lifeline is funded under a Community Service Obligation (CSO) agreement. The Government subsidy/CSO to PUB totalled AUD 1 135 000 (USD 821 059) in 2017.[44]

Electricity tariffs for household consumers do not currently recover the costs of generation.[45] Below cost-recovery tariffs are one of several reasons for PUB's poor financial performance, as is evident through operating losses in every year 2008-2017, except for 2016 (for electricity and water operations combined). Other contributing factors include high fuel costs charged by the Government and low collections: electricity debtors owed PUB AUD 7.524 million (USD 6.114 million) as of June 2015.[46]

3.2.2 Electricity cost and tariffs on Kiritimati Island

As in South Tarawa, there is no regulatory mechanism for setting tariffs on Kiritimati Island. Existing tariffs, which are below cost recovery, are set by MLPID. Residential customers pay a tariff of AUD 0.30/kWh (USD 0.24/kWh) and other customer classes pay AUD 0.33/kWh (USD 0.26/kWh). Unmetered customers are charged a normative tariff of AUD five (USD 3.92) each month.[47]

Electricity tariffs do not recover the costs of generation. In 2015, MLPID collected AUD 325 586 (USD 264 604) in revenue, representing 35 per cent of fuel costs for

[44] PUB, "Financial Performance for the Year Ended 31 December 2017".

[45] VINSTAR Consulting, "Performance Improvement Plan and Preliminary Reform Options Report," May 2, 2016.

[46] VINSTAR Consulting, "Performance Improvement Plan and Preliminary Reform Options Report," May 2, 2016.

[47] IT Power, "Expansion of Kiritimati Electricity System: Technical Design Document", May 2015.

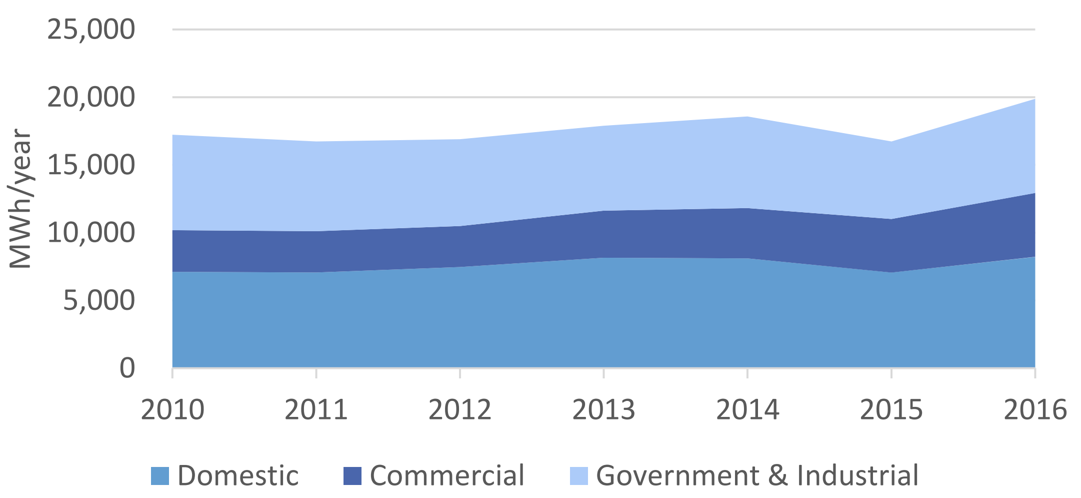
generation (AUD 922 981; USD 750 107).[48] A Government subsidy of AUD 884 404 (USD 718 755) to MLPID was provided to cover the revenue deficit. The EU and New Zealand Ministry of Foreign Affairs and Trade (MFAT), through the Kiribati Island Energy Sector Plan/Strategic Energy Plan (KIESP or KISEP) is currently developing a plan to address the problem of unmetered customers (mostly government buildings), introduce regular meter reading and billing procedures, and formally introduce a connection fee for new customers. These operational changes, combined with investments in upgrades to Kiritimati's electricity system, are expected to ensure that the operational and financial performance of the sector improves in the medium-term.

3.3 Electricity Demand

South Tarawa

In South Tarawa, demand increase only 15 per cent between 2010 and 2016, despite a 40 per cent increase in the customer base. This result is likely because new customers—who would be mostly from the outer islands or North Tarawa—consume, on average, less electricity than existing customers. Domestic use accounts for the most electricity consumption at 41 per cent, while government and industrial use accounts for 35 per cent and commercial use 24 per cent. Figure 3.4 shows electricity demand on South Tarawa from 2010 to 2016.

Figure 3.4: Yearly Electricity Consumption by Customer Class on South Tarawa (2010-2016)



Source: Data provided by MISE

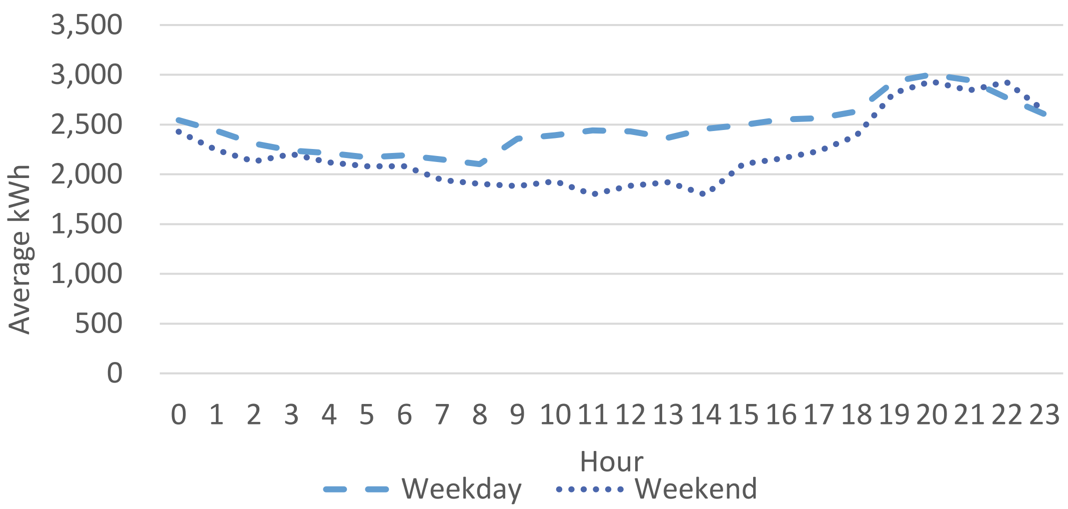
South Tarawa has two load peaks during the work week, including a smaller daytime peak caused by air conditioning in government offices, and the higher evening peak around 2,000 hours caused by residential lighting.[49] Weekends only have the evening peak. Figure 3.5 shows average hourly demand for each hour of the average weekday

[48] IT Power, "Expansion of Kiritimati Electricity System: Technical Design Document", May 2015.

[49] IRENA, "Pacific Lighthouses, Renewable energy opportunities and challenges in the Pacific Islands region: Kiribati," (2013). http://prdrse4all.spc.int/system/files/kiribati_0.pdf.

and weekend day from January to December 2016. Due to Kiribati's proximity to the equator and the relatively constant weather there is no significant seasonal variation in these daily demand patterns.

Figure 3.5: Average Hourly Demand for Weekdays and Weekends (Jan-Dec 2016)

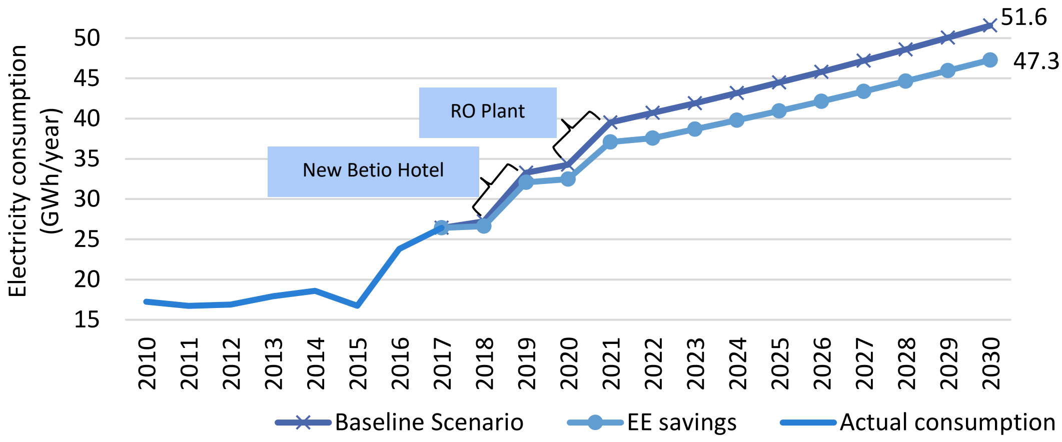


Source: Hourly data provided by the PUB

Demand growth on South Tarawa in the short-term will likely be driven by new developments such as the planned shopping centre on Bairiki and new hotel in Betio, which will open in 2019 and add 600 kW demand to the grid. In 2021, four reverse osmosis (RO) units will add 480 kW to the grid. Population growth will drive electricity demand over time because of the high fertility rate (4.1 children per woman) instead of new customers, because new connections will be formalising customers who are currently sharing a meter. Figure 3.6 shows two demand projection scenarios for South Tarawa. The baseline scenario assumes that demand grows by three per cent each year to consider population growth. The energy efficiency scenario assumes that demand-side energy efficiency measures proposed in the KIER are implemented over five years. The energy efficiency measures include replacement of inefficient lighting, air conditioning units, freezers and refrigerators; building retrofits; and improving PUB's water pump efficiency.

Under the baseline scenario, by 2030 South Tarawa's electricity demand will reach 51.6 GWh; peak demand will increase from 5.21 MW in 2018 to 9.87 MW in 2030. In the energy efficiency scenario, electricity demand will reach 47.3 GWh by 2030 (or peak demand of 8.89 MW).

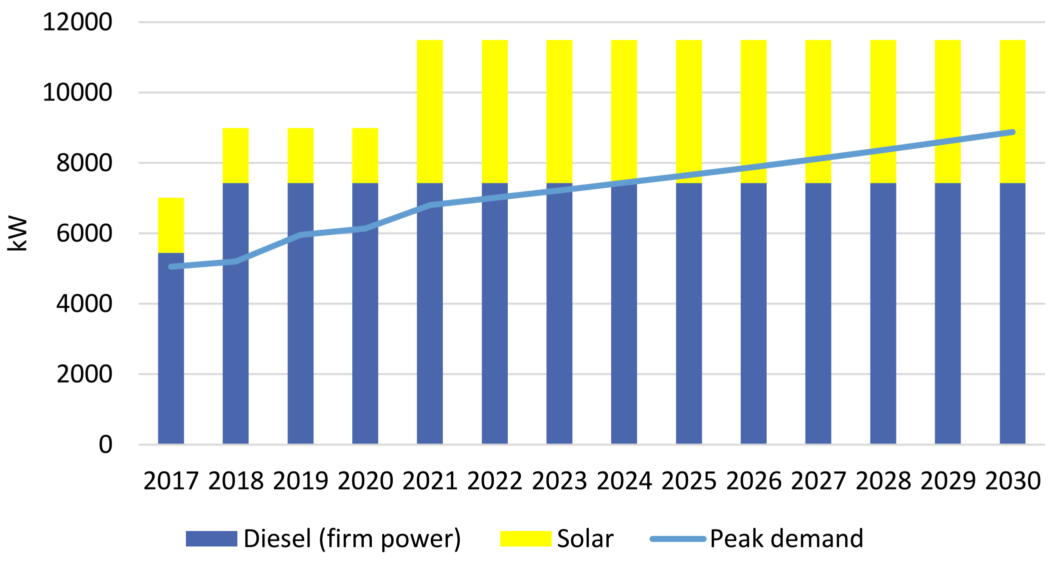
Figure 3.6: Electricity Demand Forecast Scenarios for South Tarawa



Source: PUB and Consultant's estimates

Existing capacity (about 7 MW) and planned additions to the network (one 780 kVa unit at Betio power station, and one 1200 kVa unit at the Bikenibeu power station), will mean that PUB will have about 9 MW of dispatchable generation at its disposal by late 2018. Figure 3.7 compares the electricity supply to peak demand in South Tarawa. Dispatchable generation capacity will be enough to meet demand growth under the baseline scenario up to 2023 but will still be insufficient meet power system redundancy requirements and ensure network stability as more intermittent RE generation is added to the grid.

Figure 3.7: Electricity Supply Versus Peak Demand Forecast for South Tarawa



Source: PUB and Consultant's estimates

Kiritimati

An assessment of historical trends of electricity demand in Kiritimati is not possible because data collection procedures have been only recently adopted as part of the EU and MFAT reform project. The Consultant team conducting this work has estimated a typical daily load for Zones 1 and 2 in Kiritimati that, as evident in Figure 3.8, shows a daily pattern like the one experienced in South Tarawa.

Figure 3.8: Kiritimati Zone 1 + 2 Daily Load (estimate)

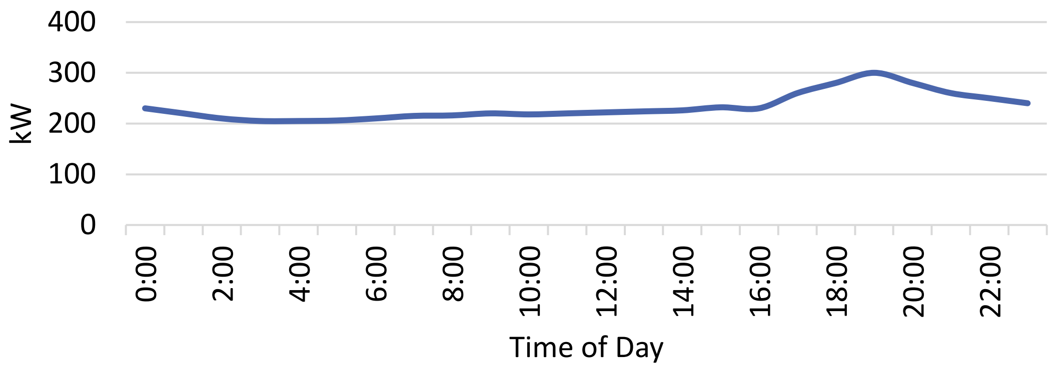


Figure based on IT Power (ITP) Power estimates for 2017.

These daily demand estimates as well as other estimates from recent projects in Kiritimati can provide an adequate picture of current demand (see Table 3.5).

Table 3.5: Estimated Kiritimati Demand

Indicator	Zone 1 +2	Zone 3	Total
Annual Consumption (MWh)	2 200	10	2210
Peak Demand (kW)	300	1.15	--

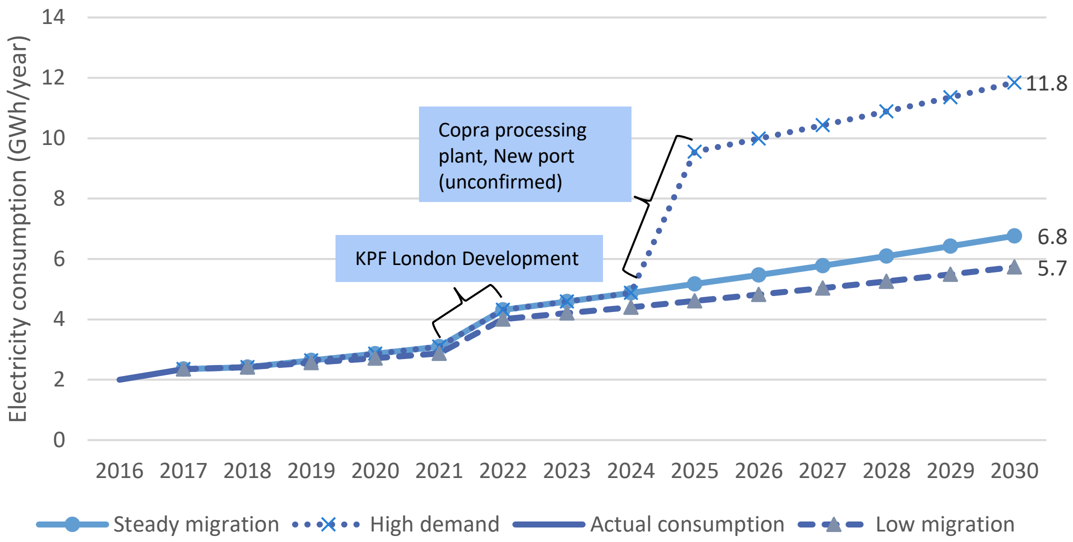
There is much more uncertainty about the demand drivers on Kiritimati Island. About 2,000 new lease settlements have been released and can triple the number of residential leases on the island, but the lack of job opportunities and industries on Kiritimati may limit interisland migration. There are several confirmed projects on Kiritimati Island including a new terminal at the Cassidy airport (under construction) and the Kiribati Provident Fund development on London that is expected to add about 112kWp of load.[50] There are two other potential projects including a port at Poland and a copra processing plant, but they are still at the proposal stage. Three demand scenarios were developed for Kiritimati Island:

- Steady migration scenario. This scenario assumes a steady migration of 2,000 I-Kiribati households (167 per year) from other islands to Kiritimati from 2019 to 2030 and confirmed developments coming online in 2022.
- Low migration scenario. This scenario assumes a lower rate of migration of I-Kiribati households (83 households per year) from other islands to Kiritimati between 2019 and 2030 such that only 1000 leases area taken up and confirmed developments coming online in 2022.
- High demand scenario. This scenario adds onto the steady migration scenario a new copra processing plant and port in Poland (assumed as 500 kW of new load) in 2025.

As shown in Figure 3.9, demand is expected to grow from 2.4 GWh in 2018 to 5.7 GWh (or 918 kW of peak demand) in 2030 if migration rates are low and only 1000 leases are taken up by 2030. If there is steady migration to Kiritimati and all 2000 leases are taken up by 2030, demand will grow from 2.4 GWh in 2018 to 6.8 GWh by 2030 (or peak demand of 1 073 kW). The high demand scenario results in substantially higher demand of 12.2 GWh by 2030 (or peak demand of 2 493 kW).

[50] Load from the London development is only indicative.

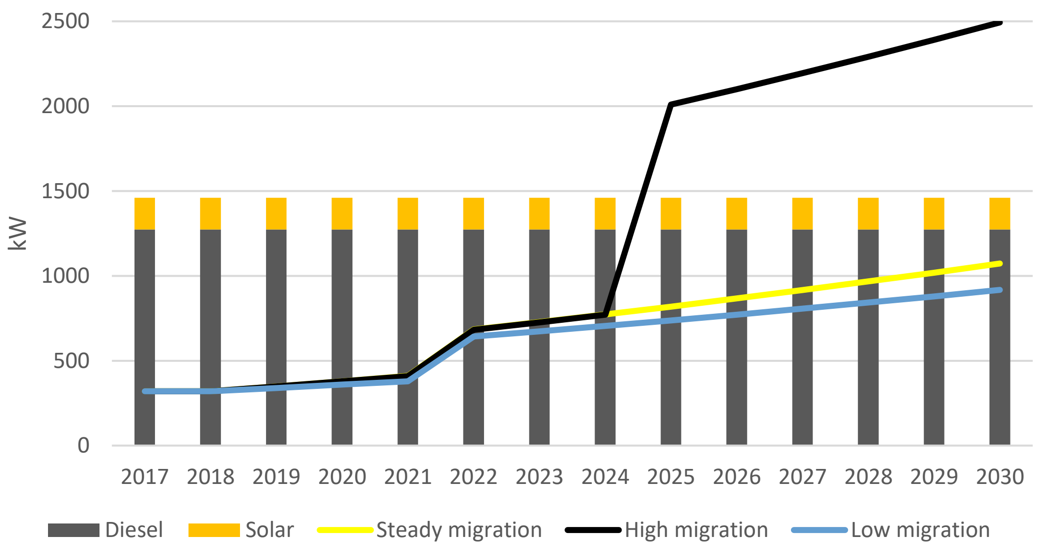
Figure 3.9: Electricity Demand Forecast Scenarios for Kiritimati Island



Source: IT Power

Kiritimati Island currently has 1 238 kW of diesel generation capacity and 186.5kW of ground-mounted solar PV to meet approximately 320 kW of peak demand. As shown in Figure 3.10, Kiritimati's electricity system will be able to meet demand until 2030 under the low and steady migration scenario, though investments in distribution extensions and energy storage will be required if more people move to the island. Under the high demand scenario, investments in additional capacity and energy storage will be required to come online by 2024, to meet additional load from the proposed port and copra processing plant.

Figure 3.10: Generation Capacity Versus Peak Demand Forecast for Kiritimati Island



3.4 Key Challenges

The most important challenges facing Kiribati's energy sector are an overdependence on expensive fossil fuel imports, insufficient reserve generation and energy storage to meet increasing intermittent demand.

3.4.1 Overdependence on expensive fossil fuel imports

More than half (52 per cent) of Kiribati's primary energy consumption is made up of fossil fuel imports, of which 55 per cent was diesel. Almost half (49 per cent) of imported diesel is reserved for the power sector.

Reliance on imported diesel for power generation translates into high costs of electricity and is a burden on government expenditures because of subsidies to the sector. In 2017, 57 per cent of PUB's expenditures (AUD 8.4 million; USD 6.1 million) was spent on diesel and lubricant. MLPID spent AUD 922 981 (USD 667 684) on fuel to generate electricity on Kiritimati Island, 76 per cent of total sector costs. Because electricity tariffs are set below cost-recovery levels to account for affordability concerns, Government subsidises the sector. In 2015, a subsidy of AUD 884 404 (USD 718 755) was required to cover the revenue gap in the Kiritimati Island electricity sector. In 2017, Government provided a subsidy of AUD 1.1 million (USD 0.8 million) to PUB to cover losses in the South Tarawa electricity sector.

The GoK wants to reduce its reliance on fossil fuel imports by scaling-up renewable energy and energy efficiency. On South Tarawa, the GoK hopes to reduce fossil fuel use by 23 per cent through renewable energy investments and 22 per cent from energy efficiency improvements by 2025. On Kiritimati Island, Government's targets are to reduce fossil fuel use by 40 per cent from renewable energy investments and 20 per cent from energy efficiency improvements by 2025.

3.4.2 Insufficient reserve generation and energy storage capacity to cope with increasing intermittent generation

As described in Section 3.2, there is sufficient generation capacity installed on South Tarawa and Kiritimati Island to meet current demand, but grid reliability is a serious concern as the percentage of intermittent generation increases in line with government's goals to reduce its reliance on fossil fuel generation. In addition, because of Kiribati's remoteness and reliance on development partner funding for the electricity sector and lack of backup generation assets, substantial repairs, large capital replacements (such as generation assets), or fuel shipments take a long time to procure. As a result, PUB conducts load shedding to cope when catastrophic events, such as generator failures occur. The GoK hopes that continued investments in renewable energy, energy storage, and distributed technologies that shift load can improve the country's energy security by increasing the reliability of the grid and reducing contingent liabilities from the overreliance on diesel generation.

4 Overview of the Renewable Energy Sector

The GoK is committed to addressing Kiribati's energy sector challenges and mitigating the effects of climate change. As described in Section 3, Kiribati relies heavily on expensive diesel imports to meet its electricity demand. The GoK's goal to reduce its dependence on imported fuels will require additional investments in renewable energy generation capacity, energy storage, and enhancements to the grid to absorb increases in intermittent generation. Investments in renewable energy can help the GoK reduce fuel imports and address grid stability issues.

A variety of options are available to Kiribati. On-grid technologies such as utility-scale solar and wind with battery storage can improve grid reliability and increase available capacity. Distributed generation technologies such as solar street lights and microgrids can support load shifting.

An assessment of the technical potential of various technologies was carried out to support the preparation of this SREP Investment Plan. The results of the resource assessment are shown in Table 4.1.

Table 4.1: Summary of Renewable Energy Technical Potential

Technology	Capacity (MW)	Annual Generation (GWh)
South Tarawa Ground Mount PV	69.7	120.3
South Tarawa Rooftop PV	2.36	3.9
Kiritimati Island Ground Mount PV	482	831.3
Kiritimati Island Rooftop PV	0.08	0.1
Kiritimati Island Wind	1.1	1.4
North Tarawa Microgrids	0.323	0.001 (1 010 kWh)
South Tarawa Solar Streetlights	0.073	0.091
Kiritimati Island Solar Streetlights	0.023	0.037
Total	**555.7**	**957.1**

The technical potential for renewable energy in Kiribati is high, but its development and deployment has been limited because of several barriers including: an incomplete enabling environment, concerns about grid stability, limited availability of land, limited financing and delivery options for renewable energy, high-cost of importing these technologies, and limited of knowledge on how to properly operate distributed renewable energy technologies. These barriers are described in more detail in Section 4.3. Renewable energy potential is also limited by the low energy requirements, compared with the generation potential, and the fact that existing demand is already being met. The principal need for renewable energy in Kiribati is to increase energy security and reduce carbon emissions by displacing diesel generation.

The subsections below provide an overview of the renewable energy sector in Kiribati. Section 4.1 describes the current use of and potential of various renewable energy technologies in Kiribati. Section 4.2 describes the availability of financing for renewable energy projects in Kiribati, and Section 4.3 summarizes the barriers to scaling-up renewable energy and proposes measures to overcome them.

4.1 Potential of Renewable Energy Technologies

As described in Section 3.4, Kiribati wants to transition from an electricity generation portfolio that consists of majority diesel generation by scaling-up renewable energy. One of the main challenges to substantially increasing renewable energy generation is the impact that additional intermittent renewable energy generation will have on the stability of the grids in South Tarawa and Kiritimati. This is a concern in South Tarawa where the current levels of solar PV—around 9 per cent of annual load—is thought to be the maximum system operators can currently manage without energy storage investments. With that challenge in mind, the investment in any grid-connected renewable energy technologies will need to be paired with batteries that allow for more reliable, stable generation.

The following subsections provide an overview of renewable energy technologies selected for elaboration in Kiribati's SREP Investment Plan. An initial desk study was conducted to reach a short list of priority technologies for deeper analysis in the Investment Plan. Several technologies were excluded because the GoK wanted to: (1) focus its request for SREP funds on grid-connected investments, (2) technical and commercial viability were limited for several technologies, and (3) funding from other sources had already been secured for some technologies such as clean cookstoves or distributed solar technologies. The short list of technologies described in this section were selected from a longer list based on discussions with stakeholders, existing reports, and data. These technologies were determined to be the most appropriate options to support the GoK's endeavour to move away from diesel generation. An overview of the excluded technologies and rationale for exclusion is provided in Appendix B.

4.1.1 Utility-scale solar photovoltaic

Kiribati has substantial experience with solar PV technology. Utility-scale solar makes up 22 per cent of generation capacity on South Tarawa and 11 per cent on Kiritimati Island. There are plans to further increase solar PV deployment within the next few years, but the GoK is conscious that studies must be conducted to understand and ensure system reliability at high-levels of renewable energy penetration.[51] Table 4.2 provides a summary of existing and proposed grid-connected solar PV deployments on South Tarawa and Kiritimati Island.

[51] The KIER recommends that increases in solar PV for power generation should be discontinued until dynamic electrical studies are conducted to better understand the impact of increasing levels of PV integration into the grid, and the necessary investments to ensure system stability and performance.

Table 4.2: Proposed and Existing Grid-Connected Solar PV in South Tarawa and Kiritimati Island

Island	Status	Location	PV Size (kW)
South Tarawa	Proposed	Betio Sports Complex Field (ground-mounted)	443 kWp
		King George V Secondary School Field (ground-mounted)	689 kWp
		Temaiku Primary School (ground-mounted)	176 kWp
		Bikenibeu Power Station	98 kWp
		TAMOA Place	81 kWp
	Existing	Bikenibeu (PEC funded)	400 kWp
		Bonriki (UAE)	500 kWp
		Betio Sports	550 kWp; 560 kW
		Betio KIT	
		Bikenibeu Hospital	
		Bikenibeu King George V high school	
		Betio KSEC	10 kWp; 12 kW
		Taeoraereke USP	9.6 kWp; 12 kW
		Mormon system	100 kWp; 20-25 kW
Kiritimati Island	Existing	Zone 1	150 kWp
	Under construction	Zone 3	36.5 kWp (battery capacity: 346 kWh)

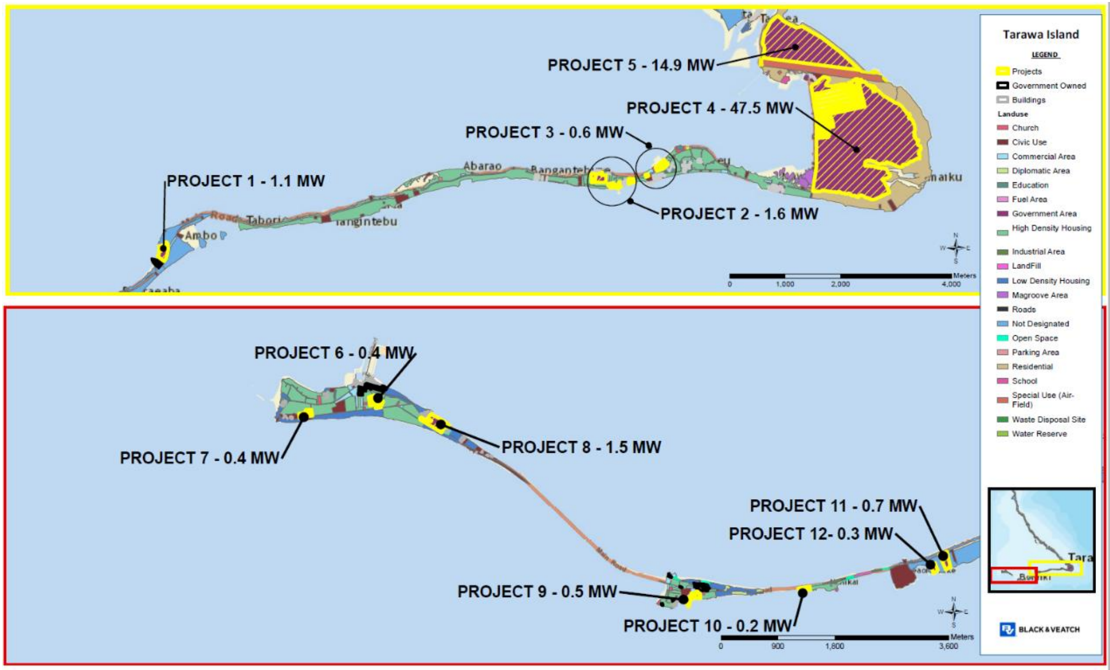
Source: IRENA, "KIER: 2016–2025," (August 2016); PUB; Trama TecnoAmbiental, "Technical Support Consultancy for the Kiribati Grid-Connected Solar PV Power Station Project, Addendum 2 – Feasibility study on upscaling solar PV," (September 2016). IT Power, "KIESP: Introduction and Project Information;" 2017. IT Power, "Poland Hybrid Power System: Commissioning MSQA," 2018.

The potential for solar energy depends on the intensity and duration of exposure to sunlight at a given location. These factors are most notably tied to the proximity and angle of solar photovoltaic panels relative to the sun. Local placement of solar PV is also dictated by shading from vegetation and buildings. The technical potential for ground-mounted solar PV and roof mounted solar PV is described below.

Ground-mounted Solar PV

The technical potential for ground-mounted solar PV was determined by applying exclusions to geographic information system (GIS) land use data provided by the Ministry of Environment, Lands, and Agricultural Development to determine practical areas for ground-mounted solar PV.[52] Areas that were excluded on South Tarawa include areas with existing usage designated for housing, church, civic, commercial, diplomatic, educational, school, fuel, industrial, landfill, residential, school and airfield, parking, and waste disposal uses.[53] Once the land usage exclusions were applied the remaining land area was further discounted to take into account for possible unidentified obstructions or potential that some of the identified terrain may not be suitable for development. An estimate for buildable capacity was calculated assuming a land use requirement of 7 acres per megawatt. Generation capacity was determined by estimating capacity factors from the operational performance of existing PV plants on South Tarawa (19.7 per cent). Figure 4.1 shows potential sites for ground-mounted solar PV in South Tarawa. Table 4.3 shows the potential buildable capacity and generation at each identified site.

Figure 4.1: Technical Potential for Ground-mounted Solar PV on South Tarawa



[52] Land usage categories follow those used by the Ministry of Environment, Lands, and Agricultural Development.

Table 4.3: Potential Ground-mounted Solar PV Projects in South Tarawa

Project number	Project name	Capacity (MW)	Annual generation (GWh)
1	Ambo Solar Field	1.1	1.9
2	Eita Solar Field	1.6	2.8
3	Bikenibeu Solar Field	0.6	1.0
4	Temaiku Solar Field	47.5	82.0
5	Bonriki Solar Field	14.9	25.7
6	Betio Solar Field #1	0.4	0.7
7	Betio Solar Field #2	0.4	0.7
8	Betio Solar Field #3	1.5	2.6
9	Bairiki Solar Field	0.5	0.9
10	Nanikaai Solar Field	0.2	0.3
11	Teaoraereke Solar Field #1	0.7	1.2
12	Teaoraereke Solar Field #2	0.3	0.5
	Total	**69.7**	**120.3**

On Kiritimati Island, land with existing usage such as commercial and residential, governmental and environmental, environmental protection, water reserve, wildlife conservation, and wildlife sanctuary areas were excluded. Land reserved for government uses was selected for the development of solar PV, to take into consideration land rights concerns. The remaining land area (government reserve area), was further constrained by excluding land that was already built and then discounted yet again by 75 per cent to exclude coastal areas. Buildable capacity was then determined based on estimated capacity factors from the operational performance of existing PV plants (19.7 per cent). Figure 4.2 shows potential site for ground-mounted solar PV on Kiritimati Island. Table 4.4 shows the potential buildable capacity and generation at each identified site.

Figure 4.2: Technical Potential for Ground-mounted Solar PV on Kiritimati Island

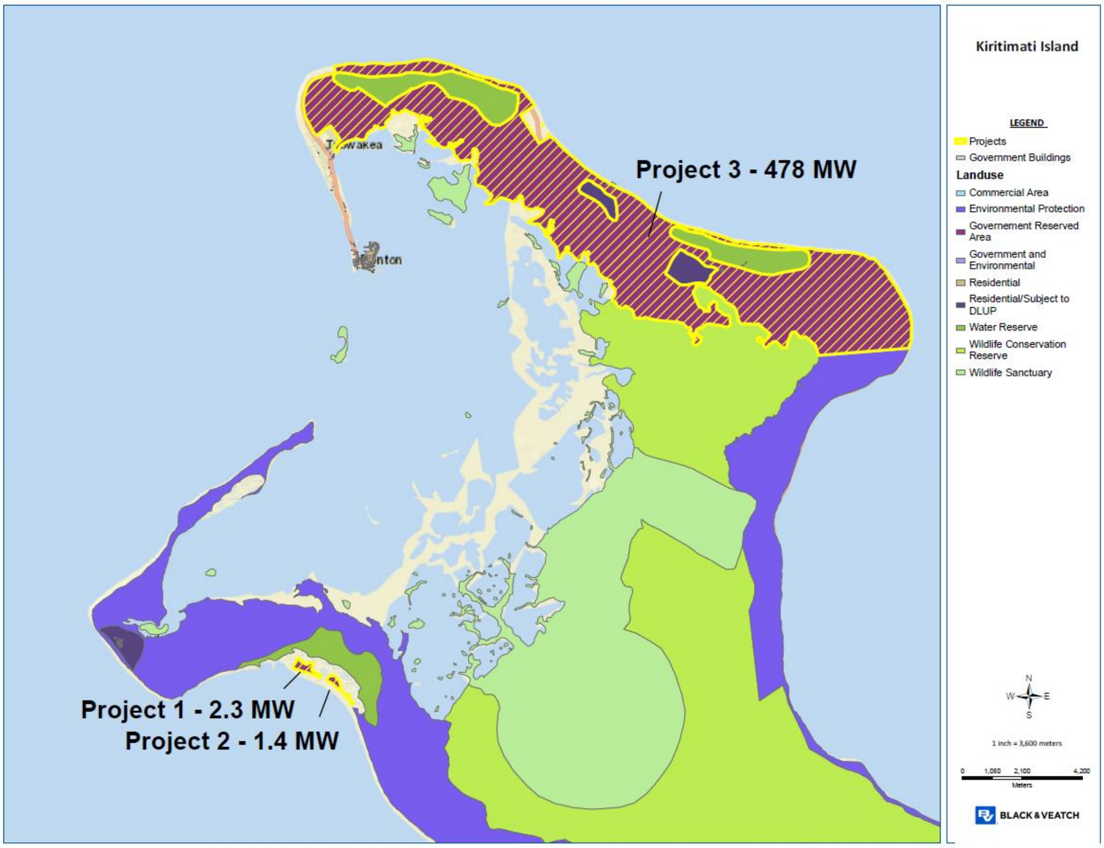


Table 4.4: Potential Ground-mounted Solar PV Projects Kiritimati Island

Project number	Project name	Capacity (MW)	Annual generation (GWh)
1	Poland Solar Field #1	2.3	4
2	Poland Solar Field #2	1.4	2.4
3	North Kiritimati Solar Field	478	824.9
	Total	**482**	**831.3**

4.1.2 Rooftop solar PV

Roof mounted solar also has potential and, in South Tarawa in particular, addresses concerns about land use. The technical potential for rooftop solar deployment was estimated only for the existing public building stock because of challenges associated with land/rooftop use rights for residential or commercial buildings. Estimates for the technical potential of rooftop solar PV were derived using GIS files obtained from the Lands Division at the Ministry of Environment, Lands and Agricultural Development. Only buildings with at least 1 000 m^2 of roof area were included in the estimate of total available roof area, excluding smaller buildings where it is unlikely that rooftop PV would be feasible. The theoretical potential for solar deployment was then estimated at 2.5 acres/MW_{dc}, based on typical rooftop design practices (module angle, row spacing, space for maintenance access, distance from edge of roof to meet safety requirements). Only 15 per cent of total theoretical potential was included, to provide a conservative estimate by excluding buildings that are not structurally suitable for rooftop mounted PV.[54] Table 4.5 shows the estimated technical potential for rooftop solar PV on public buildings on South Tarawa and Kiritimati Island.

Table 4.5: Technical Potential for Rooftop Solar PV on Public Buildings on South Tarawa and Kiritimati Island

		South Tarawa	Kiritimati Island
Technical potential	Total Roof area (m^2)	159 060.0	5 547.0
	Total Roof Area (Acres)	39.30	1.37
	Theoretical Potential (MW)	15.72	0.55
	Total Developable potential (MW_{dc})	**2.36**	**0.08**
	Total generation (MWh)	**3 863.13**	**134.72**
	Undeveloped Technical Potential accounting for previously Identified Projects (MW)[1]	1.84	0.08
Accounting for project identified in RO Study and the Coconut Development Company	**Total New Technical Potential (not previously identified MW)**	**1.21**	**0.08**
	Total Generation (MWh)	**1,980.93**	**134.72**

Note: [1] Undeveloped technical potential refers to previously identified locations that are suitable for rooftop solar PV development but have not yet been developed. They include the Coconut Development Company (133 kW) and sites identified (total: 500 kW) but not selected for the ADB/World Bank RE RO project, which required a location that could support 2500 kW.

4.1.3 Utility-scale wind

There are currently no wind farms in Kiribati. A few wind speed studies have been conducted for Kiritimati Island and South Tarawa, but to date, no detailed feasibility studies have been conducted.[55] Based on wind speed data collected at 34 metres, the average wind speed in London (Kiritimati Island) is 6.7 m/s, and 6.6 m/s in Banana (Kiritimati Island). The average wind speed at 34 metres on South Tarawa is 5.7 m/s.

[54] Structural suitability accounts for age of roof, impacts from shape and size of roof and existing rooftop equipment. Performance includes shading from plants and structures.

[55] Sugimoto, Shin, "Mid Term Report – Wind Resource Assessment on Kiritimati Island", 2009. Hassan, Garrad, "Wind Energy Feasibility Study for Kiritimati Island", 2012.

These measurements indicate that, with existing wind turbine technology, grid-connected wind power is only technically feasible for Kiritimati Island. The KIER includes up to two 275 kW wind turbines (with a capacity factor of 36 per cent) in the proposed renewable energy generation mix for Zone 1 on Kiritimati Island. Sites in Zones 2 and 3 will need to be considered to account for the potential wind regime to Kiritimati Island to address the future development plans in these zones.

A secondary resource assessment was conducted for Kiritimati Island taking into consideration the earlier wind studies and using data on wind speeds from the Technical University of Denmark (DTU) Global Wind Atlas, which provides average wind speeds at heights of 50, 100, and 200 metres. Speeds reported in the previous wind study on Kiritimati Island were substantially higher than the DTU study and could not be validated using DTU modelling wind speed estimates for Kiritimati Island and the region. To present a conservative estimate, the DTU average wind speeds were selected to be the basis of the assessment of potential sites for wind development on Kiritimati Island. Geographical exclusions were applied to identify the most practical areas for wind development on Kiritimati Island. The geographical exclusions include treed areas, areas prone to flooding, residential and commercial areas, areas identified for environmental protection, and areas within one mile of populated areas. Based on these exclusions, four sites were identified as potential wind farm sites. The sites are shown in Table 4.6. The technical potential for wind assumes the same 275 kW turbine capacity from the KIER could be installed at each location, though a feasibility study would need to be conducted to determine the exact buildable capacity for each site.

Figure 4.3: Potential Wind Farm Sites on Kiritimati Island

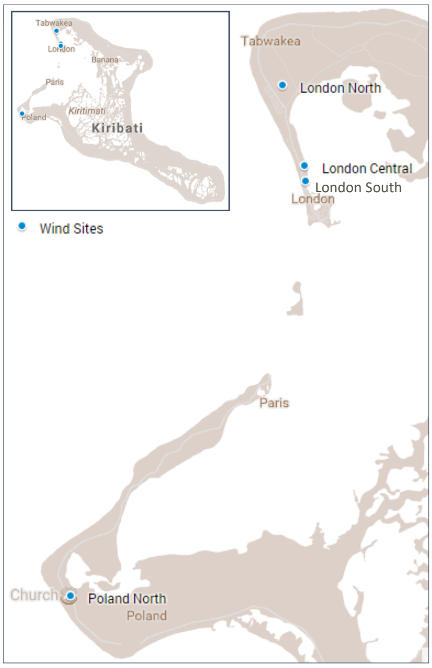


Table 4.6: Potential Wind Farm Sites on Kiritimati Island and Capacity Factors

Location of wind farm	Net capacity factor
London North (Zone 1)	16%
London Central (Zone 1)	15%
London South (Zone 1)	14%
Poland North (Zone 3)	15%

Note: Net capacity factors were calculated using mean wind speeds from the DTU Global Wind Atlas and from power curves from a representative wind turbine. The wind turbine design selected was a guyed tilt-up tilt down turbine, which can be lowered and tied down when there are above cut-out winds. A 15 per cent reduction from gross production was assumed to consider losses from turbine availability, utility downtime, electrical efficiency, blade degradation, high temperatures, extreme weather, and power curve performance.

4.1.4 Solar Microgrids

There is potential for solar microgrids on North Tarawa (northern part of Tarawa) outside of PUB's service area. PUB currently serves 48 per cent of the population—in the Nabeina, Tabiteuea, Abatao, and Buota villages—that live in the settlement.[56] Two options have been considered to bring electrification to these villages: grid extension and microgrids within each village. There is little scope of additional PV microgrids on Kiritimati Island. There is currently one PV microgrid on Kiritimati Island: a 150 kW PV diesel hybrid system in Poland (Zone 3).[57] The use of PV microgrids may be phased out because there are plans to integrate the microgrids on Kiritimati Island to improve supply reliability on the island; in 2017 the EU and MFAT integrated Zones 1 and 2 on Kiritimati Island. Figure 4.4 shows the potential microgrid sites on North Tarawa and Table 4.7 shows the technical potential for solar PV microgrids by village.

[56] National Statistics Office, Ministry of Finance, "2015 Population and Housing Census: Volume 1: Management Report and Basic Tables", 2016.

[57] Government of Kiribati, "Kiribati Integrated Energy Roadmap", 2016.

Figure 4.4: Potential Sites of Microgrids on North Tarawa

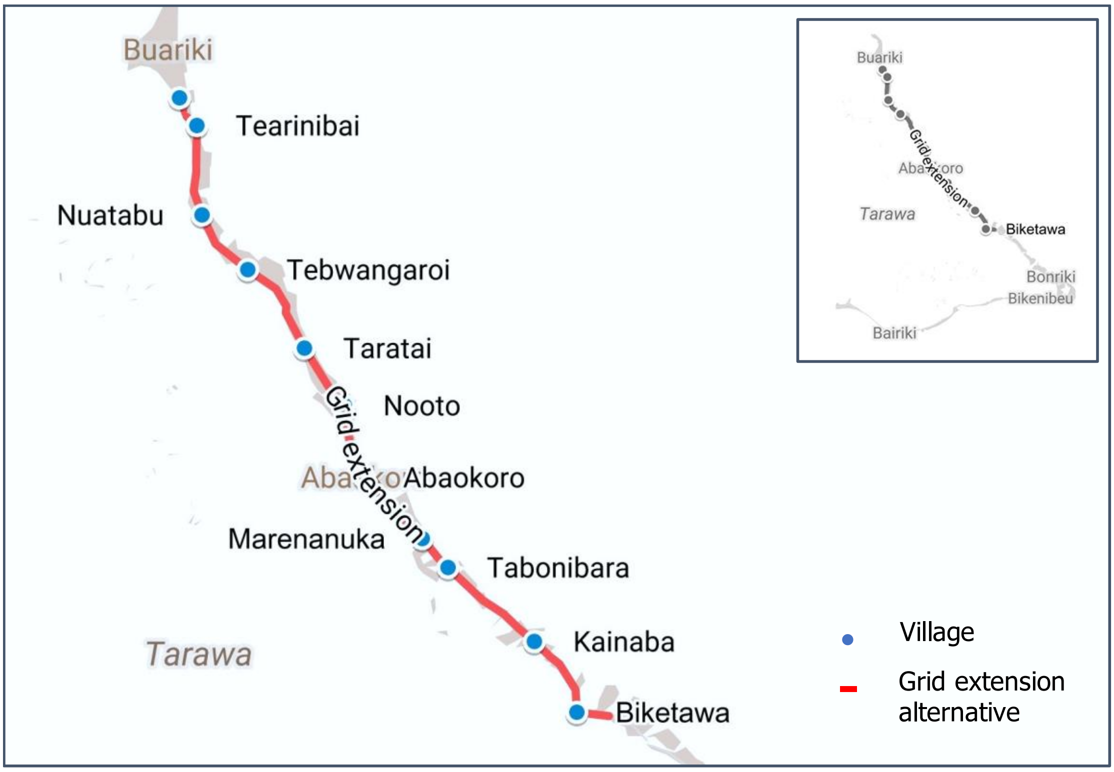


Table 4.7: Technical Potential for Microgrids on North Tarawa

Village	Population (hhs)	Number of microgrids	PV capacity (kW)	Battery capacity (kWh)
Bairiki	152	10	81	2027
Tearinibai	53	4	28	707
Nuatabu	46	3	25	613
Tebwangaroi	4	2	20	493
Taratai	33			
Nooto	108	7	58	1440
Marenanuka	29	2	15	387
Abaokoro	48	3	26	640
Tabonibara	65	4	35	867
Kainaba	68	5	36	907
Total	**606**	**40**	**323**	**8080**

Note: Microgrids are sized to serve 60 persons, with an annual load of 14MWh. A PV size of 8 kW and battery size of 25 kWh is assumed. The daily load per household is assumed to be 2.5 kWh/day. Note that larger microgrid installations may be possible but onsite inspection would be needed for an accurate assessment.

4.1.5 Solar street lighting

Solar street lighting uses a solar PV module to accumulate power in a digitally controlled battery. The power is discharged at night to power efficient light-emitting diode (LED) light sources. Such systems can also be used as public charging stations for small electronic devices. Solar LED street lights can last up to 15 years (about 65 000 working hours), ten times longer than conventional lighting technologies.[58] Solar street lights are available from 10 W to 100 W in different capacities.

Solar street lights can support the GoK's load shifting strategy by replacing existing grid-connected sodium lamps. Street lighting also provides additional public safety benefits for drivers and pedestrians. Current street lighting installations only cover a small portion of both islands, leaving many roads and residential areas without public lighting. Uptake of solar street lights is also currently limited. There are currently 147 solar street lights (80Wp solar panel with sealed underground battery) on South Tarawa and 60 solar street lights on Kiritimati Island. Figure 4.5 shows the potential for solar street lights on South Tarawa and Kiritimati, assuming a 20W lamp with 70W solar panels and a 750Wh lithium ion battery pack and 12 hours of light.

Figure 4.5: Technical Potential for Solar Street Lights on South Tarawa and Kiritimati Island

Location		Length of road (m)	Number of street lights	Technical potential (MWh/year)
South Tarawa	Betio	5800	116	10.2
	Betio feeder	6133	123	10.8
	Nippon Causeway	3500	70	6.1
	Bairiki	3300	66	5.8
	Bairiki Causeway	600	12	1.1
	Nanikai	600	12	1.1
	Anderson Causeway	700	14	1.2
	Teaoraereke – Ambo	5600	112	9.8
	St Louis feeder	416	8	0.7
	Abaunamou feeder	200	4	0.4
	JSS 2 feeder	250	5	0.4
	Tebwanimwaneka feeder	200	4	0.4
	Stewart Causeway	500	10	0.9
	Taborio – Ananau Causeway	10 900	218	19.1
	Bikenibeu feeder	3724	74	6.5
	Temaiku Coastal	6107	122	10.7
	Ananau Causeway – Bonriki Airport	2100	42	3.7

[58] The solar PV panel life span is 25 years.

	Bonriki Airport – Anraei	1649	33	2.9
	Anraei – Kawaiaeboou	2670	53	4.7
	Anraei – Bouta North	2512	50	4.4
Kiritimati Island	Main road from London to Cassidy airport	24 000	480	42.1
	Ronton feeder	4600	92	8.06
	Tabwakea feeder	15 000	300	26.3
	Main Camp feeder	791	16	1.4
	Banana feeder	2978	60	5.2
	Poland feeder	2208	44	3.9
Existing solar street lights				
South Tarawa			147	12.9
Kiritimati Island			60	5.3
Total generation potential (excluding existing solar street light installments)				**172.8**

Note: The assumed interval between street lights is 50 metres, following current practice on South Tarawa.

4.2 Availability of Financing for Renewable Energy Technologies and Projects in Kiribati

Existing renewable energy projects are almost exclusively funded by development partners. There is currently no private sector participation or commercial financing available in Kiribati, except for some retailers and KSEC, a state-owned enterprise that offers solar products.

There are several bilateral and two multilateral development partners that are currently providing technical assistance and financing for renewable energy projects in Kiribati.[59] In the past, Japan and the United Arab Emirates have also grant funded solar PV installations on South Tarawa. The technologies supported include solar PV and battery storage, solar desalination and ocean thermal conversion technology for electricity generation. Table 4.8 summarizes ongoing and planned (secured financing) development partner projects.

[59] These partners include the Asian Development Bank, World Bank, European Commission, Australia, New Zealand, Korea, Taiwan, India, Italy, and Japan.

Table 4.8: Ongoing and Planned Renewable Energy Projects on South Tarawa and Kiritimati Island

Donor	Project title	Project description	Location	Technology	Time frame	Cost (USD)
EU/NZ	KIESP	The objective of this project is to improve electricity access on Kiritimati Island. The project includes several components: ▪ *Upgrade of Hybrid Solar PV Grid at Poland (Zone 3).* The project included 36.5 kWp of ground-mounted solar arrays; 346 kWh of lead-acid battery capacity and a 48-kW diesel generator. ▪ *Supply contract for Design, Supply, Installation, and Commissioning of High voltage network, power stations, 150 kWp PV system and associated works in Banana and Ronton (Zones 1 and 2).* The project included a 11-kV interconnection between Zones 1 and 2, installation of street lighting and meters, 150 kWp of solar PV in Zone 2, and two new power stations. ▪ *Technical assistance and capacity building.* Overall project management, institutional review, asset management plan, management training, technical training, and efficiency/safety awareness raising.	Kiritimati	Solar PV	2014-2019	8.87 million
NZ	Kiribati Electricity Sector Least Cost Study	The least cost plan will review existing and planned electricity sector assets and identify specific supply and demand-side measures to meet GoK fossil fuel reduction targets in the KIER. The least cost options identified will consider replacing diesel generation to include more flexible baseload generation assets that can support higher levels of intermittent RE generation, grid reliability management, necessary network investments, and the impact of such investments on the levelised cost of generation.	Kiritimati, South Tarawa	Solar PV, battery storage, Wind	2017-2018	--

ADB, WB	South Tarawa Water Supply Project	The project will construct solar PV desalination plants on South Tarawa to address the GoK's dual goals of water and energy security.	South Tarawa	Solar PV, RE Reverse osmosis	2016-2020	USD 9 million for the solar PV component alone
Korea	South Tarawa Ocean Thermal Energy Conversion Project	The Ministry of Oceans and Fisheries of the Republic of Korea plans to construct and commission a 1MW ocean thermal energy conversion plant in South Tarawa.	South Tarawa	Ocean	2020 (planned year of commissioning)	28 million
EU	EDF 11	The GoK has requested that the EU contribute to the sustainable socioeconomic development of Kiritimati Island to ensure the implementation of the Line and Phoenix Island Integrated Development Strategy (2016-2036). To this end, the GoK has requested that the EU prioritise investments in the energy and water sectors. Project identification is ongoing.	Kiritimati Island	Undecided	2014-2020	12.2 million (of 24.4 million earmarked for the energy sector)

4.3 Key Barriers to Scaling-up Renewable Energy

Investments in renewable energy can be a solution to Kiribati's energy sector challenges—high dependence on expensive fossil fuel imports and insufficient generation capacity to meet future demand—and contribute towards mitigating the effects of climate change. As described in Section 4.2 above, several development partner projects are proceeding, but more needs to be done if Kiribati is to achieve its renewable energy objectives. There are regulatory and institutional, technical and capacity, environmental, social and financial barriers that must be addressed to unlock financing and potential private sector participation in the renewable energy sector in Kiribati. Table 4.9 summarizes the key barriers to scaling-up renewable energy and proposes some mitigating measures.

Table 4.9: Summary of Key Barriers to Scaling-Up Renewable Energy in Kiribati

Category	Specific barrier	Potential mitigation measure
Regulatory and institutional	**Incomplete legal and regulatory framework** ▪ Electricity Act only exists in draft form and there is no formal regulatory framework for setting electricity tariffs, creating an uncertain investment climate for potential private sector led RE investment. ▪ Absence of an Energy Act to regulate and incentivise the scaling-up of renewable energy and energy efficiency in all sectors	▪ Enact the draft Electricity Act ▪ Draft and enact an Energy Act ▪ Develop regulations for private sector participation in the RE market ▪ Develop regulatory framework for setting electricity tariffs
	Lack of formal adoption of technical standards Limited control over the quality of imported distributed RE technologies	Formally adopt Australian and New Zealand technical standards that are used by GoK and development partners in procuring and installing RE technologies
Technical/ capacity	**Insufficient local technical capacity to maintain RE technologies such as microgrids, roof mounted solar PV, and solar street lights** ▪ Limited group of individuals with experience necessary to maintain distributed RE technologies limits the useful life of RE installations and products and increases the need to replace them.	▪ Technical assistance and training for PUB, KSEC, and private sector in microgrid maintenance ▪ Develop training curriculum and program for I-Kiribati, especially women interested in working in the RE sector ▪ Training for GoK to enforce Electricity and Energy Acts once they are drafted and enacted Use business models that promote private sector operation

	▪ Limited public administration capacity to regulate and oversee development of RE technologies	
	Concern about grid stability and addition of more intermittent resources PUB believes the current installed RE capacity is the maximum amount of intermittent resources it can manage without jeopardising grid stability	▪ Conduct RE integration study and provide training to PUB on how to manage intermittent resources ▪ Include batteries in any new grid-connected RE project
	Lack of experience conducting competitive tenders for RE development Limited experience in conducting competitive tenders for RE development may result in unfavourable terms for Government, delays in procurement, and private sector may game the process	Provide capacity building to public servants to manage and conduct RE procurement, including technical assistance to prepare templates of model request for proposal, power purchase agreement, and related procedural documents for RE procurement
Environmental	**Limited availability of land for RE development** On South Tarawa, land use for RE development completes with domestic and commercial land use. Protected areas also limit space for RE development	Integrate RE technology with existing structures, such as on the rooftops of public and residential buildings (when feasible)
Financial	**Financing for RE is limited to Government or development partner funding** Lack of precedent of private sector led RE development signals to potential investors that the investment climate is risky	▪ Include risk guarantees in initial RE projects led by private sector ▪ Provide transaction advisory services to improve proposal and tender document quality and thereby attract private investors
	Limited income generation opportunities among population reduces ability to afford RE technologies Low-income households are unlikely to be able to afford the upfront costs of RE technologies	▪ Introduce and enforce payment installments that allow households to break up high upfront cost of RE technologies ▪ Investigate the potential for lease options, or pay-as-you-go business models to finance and deliver RE technologies
	High-cost of importing RE technologies Remoteness of Kiribati and need to import all RE components and building materials increases the cost of RE technologies	▪ Develop local capacity to maintain RE technologies to maximise the useful life of products

		▪ Remove any import tariffs on construction materials for RE instalments or components
Social	**Lack of knowledge on how to properly operate distributed solar technologies** Lack of awareness about the proper use of distributed solar technologies decreases their useful life	Ensure that initiatives and projects that introduce distributed RE technologies include an awareness raising, education component for households to maximise the useful life of products

5 Financial and Economic Viability of Renewable Energy Technologies

This section assesses the financial and economic viability of renewable energy technologies that were determined, in Section 4 to be technically viable in Kiribati. The financial and economic analyses use the levelised cost of energy (LCOE) of each renewable energy technology, which is the present value of the cost to build and operate a power producing plant over its lifetime to evaluate the relative cost competitiveness of each renewable energy technology to the cost of existing fossil fuel production.

Section 5.1 summarizes the cost assumptions used in the LCOE calculations. Section 5.2 presents the economic viability assessment and Section 5.3 presents the financial viability assessment. respectively. Finally, Section 5.4 discusses the costs and affordability for the distributed technologies where LCOE calculations were not appropriate.

5.1 Renewable Energy Technology Cost Assumptions

The cost assumptions for calculating the LCOEs of each renewable energy technology are based on a combination of costs identified in project documents and where information was either not available or determined to be inconsistent with current market prices we used regional costs adjusted for the country context. The costs of grid-connected renewable energy options are "all-in" costs meaning that they are inclusive of all project costs including grid-connection.[60] Cost assumptions are presented in Table 5.1.

[60] In addition to technology components the all-in costs include: land, civil engineering, DC cables, SCADA system, data system, transmission line, and installation and design. The inclusion of these costs might make the capital costs used in the IP appear to be relatively high compared to other CAPEX estimates that only include the technology-specific components.

Table 5.1: Cost Assumptions for RE Technologies

Technology	Capital cost (US$/kW)		Fixed O&M cost (US$/kWy)		Variable O&M cost (US$/kWh)		Capacity factor (%)		Asset life (years)
	South Tarawa	Kiritimati	South Tarawa	Kiritimati	South Tarawa	Kiritimati	South Tarawa	Kiritimati	South Tarawa/ Kiritimati
Solar PV[1] + Battery [a]**	3 155		80		0		19.29		20
Solar rooftop PV[2] + Battery [b]**	7,215-8,195*	N/A	80	N/A	0		17.77	N/A	20
Wind[3] + Battery [c]	N/A	6 175	N/A	130	0		N/A	14.00-16.00*	20

Sources: IRENA, "Renewable Power Generation Costs in 2017," 2017. ADB, "RO Plant Options Study," 2017. Lazard, "Levelised Cost of Storage Analysis – version 3.0," 2017. Wind Power in Fiji: A preliminary analysis of the Butoni wind farm.

Note: [1]Solar PV capital expenditure (CAPEX) (USD 2,750/kW) includes: Land, civil engineering, solar PV modules, mounting structure, inverter, DC cables, SCADA system, energy management system, data system, transmission line, and installation and design. [a] Battery (lithium ion) for ground-mounted solar (sized as 80 per cent of solar PV installation, following a similar approach to the ADB/WB RO project) is USD1,739/kW. [2] Rooftop solar PV CAPEX (USD 5,370/kW) based on historical project costs (WB solar project). [b] Battery for rooftop solar assumes use of Tesla Power Pak at USD 700 000 (up to 140 kW per installation). Cost includes: Equipment, design, delivery of equipment, integration with PV system installation, testing and commissioning. ** Solar PV and battery costs in the table reflect expected real decreases in the prices of PV (-6% per year) panels and lithium ion batteries (-10% per year) to show the likely cost of the technology in 2023 when the SREP program will likely be implemented. [3] Wind costs based on wind installation on Fiji, adjusted to expected local prices USD 4000 per kW and O&M cost of USD 75 per kW per year. [C] Battery costs for wind based on Lazard's levelised cost of storage analysis version 3.0 (2017), lithium ion battery at USD 2,266/kW.

*Varies by location

5.2 Economic Viability Analysis

The economic viability analysis compares the LCOE of each renewable energy technology (identified in Section 4), to the opportunity cost of diesel generation (fuel cost plus O&M costs) valued at AUD 0.38/kWh (USD 0.30/kWh) in Kiribati plus the real social cost of CO_2 (USD 0.02/kWh) emissions per kWh produced.[61] The technology costs – not including financing costs – are discounted over the lifetime of each option at the social cost of capital (six per cent).[62] The economic analysis is meant to demonstrate how competitive each renewable energy option would be in Kiribati regardless of financing costs and taking into account negative externalities such as pollution emissions.

Supply curves represent the results of the LCOE calculations under the economic viability scenario. A supply curve[63] (positive and upward slope) represents the cumulative generation of technically feasible renewable energy options; technologies are ranked from lowest to highest cost, where technologies with the lowest LCOE are shown on the left and technologies with the highest LCOE are shown on the right. A dashed line shows the opportunity cost of generation. Technologies with LCOEs that are above the dashed line are higher cost relative to the opportunity cost of generation and therefore not economically viable. Technologies with LCOEs that are below the dashed line have a lower cost relative to the opportunity cost of generation and are economically viable. The economic viability scenario supply curves for South Tarawa and Kiritimati are shown in Figure 5.1 and Figure 5.2.

[61] The emissions factor assumed is 550g/kWh.

[62] Because different technologies have different asset lives, a discount rate is used to bring all costs to a net present value so that there is a common point of comparison across technologies. Historically the social opportunity cost or economic cost of capital has been set at standard 10-12 per cent by most MDBs when evaluating projects in developing countries. In recent years, notes at the World Bank ("Discounting Costs and Benefits in Economic Analysis of World Bank Projects" Guidance note, 2016.) and United States Federal Reserve (Warusawitharana, Missaka. "The Social Discount Rate in Developing Countries." FEDs Notes. 9 October 2014) have questioned whether this standard should be continued. The Guidance Note recommends that a base of six per cent be used going forward and that a sensitivity analysis be done to see the effects of increasing/decreasing the rate to ensure that projects are not being eliminated/selected based on some arbitrary cut-off.

[63] The supply curves and LCOEs presented in this IP are meant to be indicative of technology costs and not the actual costs of project sites. Additional resource assessments and specific site surveys are needed to get precise estimates for specific projects.

Figure 5.1: Economic Viability of Renewable Energy Options, South Tarawa

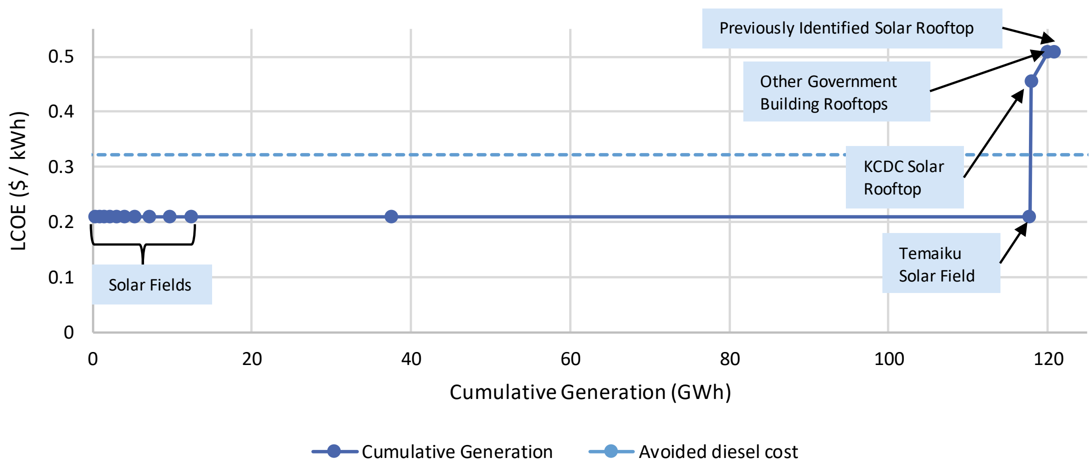
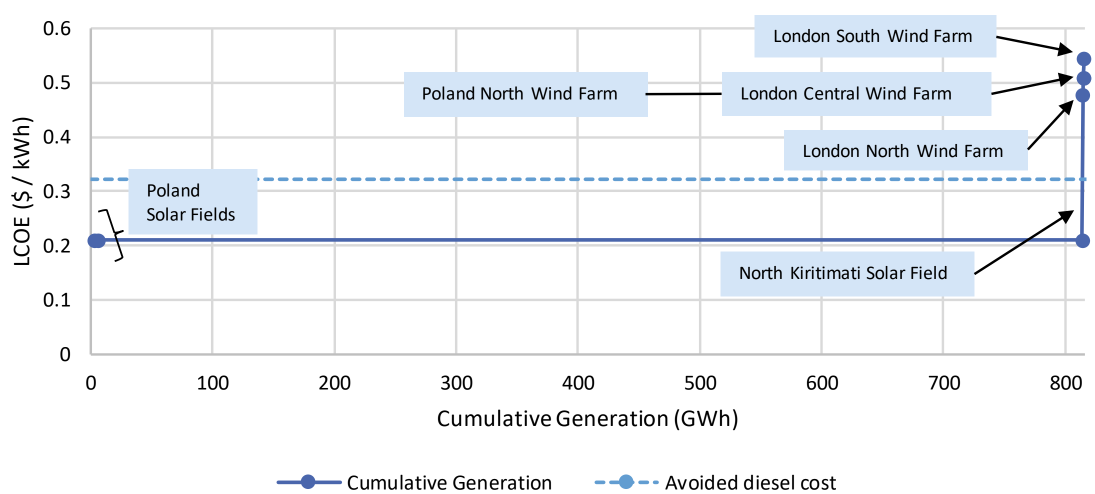


Figure 5.2: Economic Viability of Renewable Energy Options, Kiritimati Island



In both South Tarawa and Kiritimati, solar fields are economically viable. Solar fields are the cheapest option, followed by wind, then rooftop mounted solar PV. None of the wind farm or solar rooftop projects identified are economically viable options, when compared with the cost of diesel generation (plus external cost of pollution).

5.3 Financial Viability Analysis

The financial viability analysis includes the cost of financing in estimating the LCOE of renewable energy technologies identified for Kiribati. The financial viability of each technology was assessed under commercial financing arrangements. Technologies that are viable under commercial financing terms are more likely to attract private sector investment. Table 5.2 shows the commercial financing terms assumed for the analysis.

Table 5.2: Financing Terms of Financial Viability Scenarios

	Commercial
Debt/equity split (%)	70/30
Debt rate (%)	8
Equity return (%)	12
Debt term (years)	15

The results of the financial viability analysis using commercial financing terms are shown in Figure 5.3 (South Tarawa) and Figure 5.4 (Kiritimati). Any investment at or below the viability threshold (represented by a dotted line) is considered financially viable. Here, "viability" means that the cost of energy being produced is equal to or cheaper than the cost of energy being replaced (i.e. the cost of diesel generation).

Figure 5.3: Financial Viability (Commercial Financing), South Tarawa

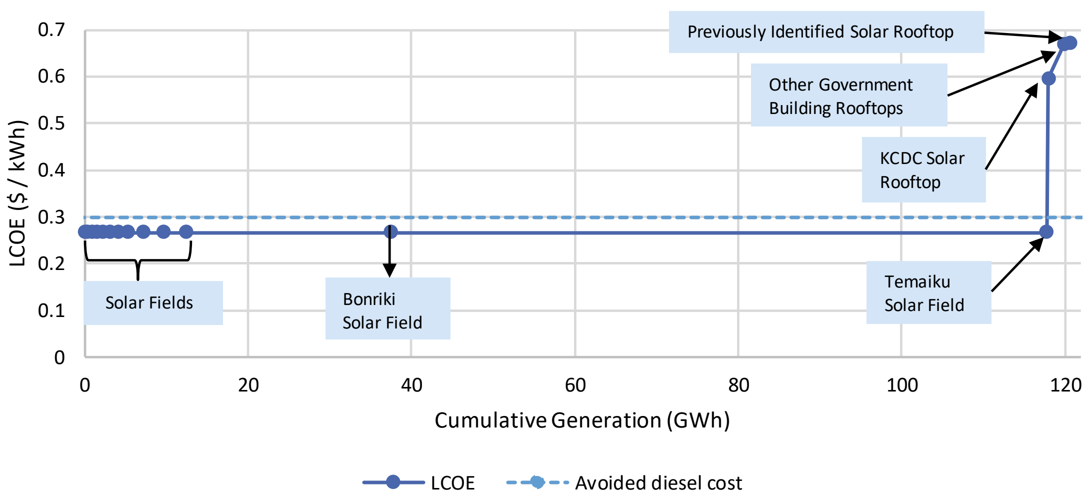
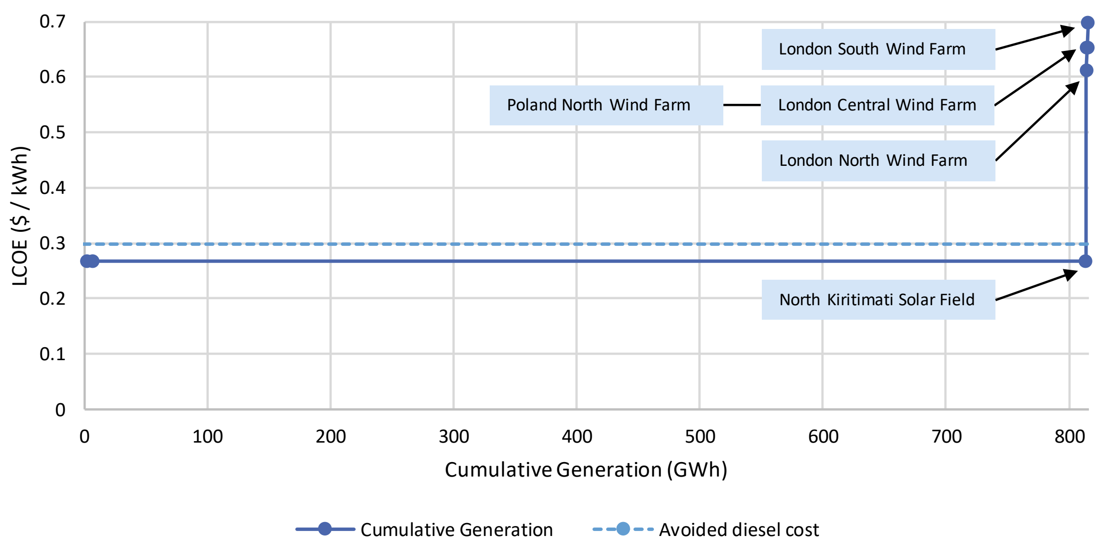


Figure 5.4: Financial Viability (Commercial Financing), Kiritimati



In both South Tarawa and Kiritimati, ground-mounted solar PV projects with energy storage are financially viable using commercial financing. It is possible that there is no private sector participation in the electricity sector because it is still an unproven market. The private sector may view Kiribati as a high-risk investment due to its remoteness, incomplete renewable energy framework (does not have provisions for private sector participation), and Government's cautious approach towards private sector entry.[64]

SREP funds can play a key role in improving the financial viability of solar PV and energy storage in Kiribati. SREP funds are often used to support projects that will create an enabling environment for private sector participation and help to bring down the technology and financing costs for subsequent projects. In Kiribati, SREP and MDB funds can be used to grant fund a centralised energy storage component that can eventually encourage private sector participation in solar PV. Figure 5.5 and Figure 5.6 show that the financial viability of solar PV investments increases substantially when energy storage is grant funded.

[6464] See section 4.3 for a description of barriers to renewable energy in Kiribati.

Figure 5.5: Financial Viability (Grant Financed Energy Storage), South Tarawa

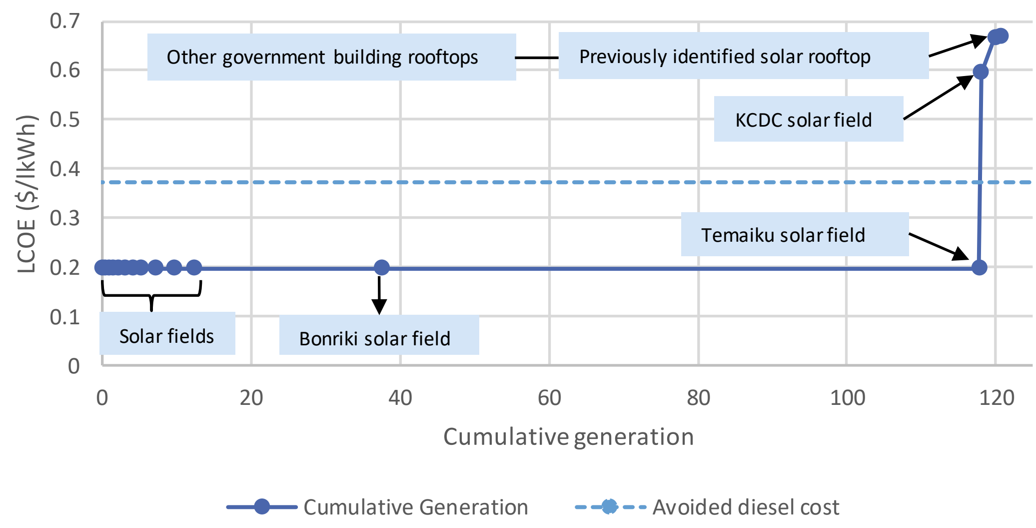
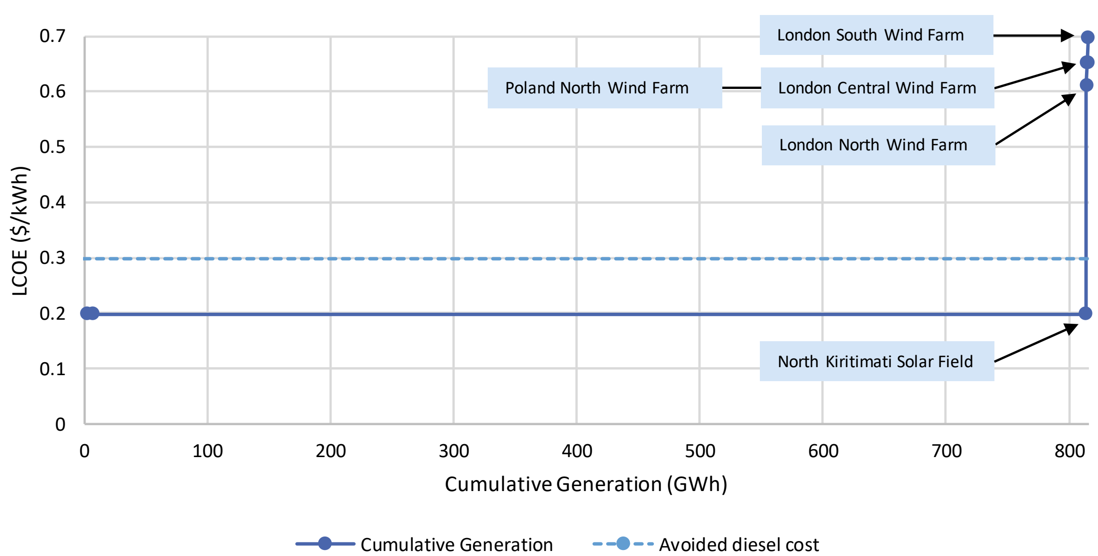


Figure 5.6: Financial Viability (Grant Financed Energy Storage), Kiritimati



Since the levelised cost of solar PV generation (USD 0.20/kWh) is 10 cents lower than the avoided fuel and O&M cost associated with running a diesel generation plant (USD 0.30/kWh), that GoK stands to reap fiscal savings of up to USD 17 million per year on South Tarawa alone if solar PV can be scaled up to meet KIER 2025 targets (reduction of 23 per cent of fossil fuel use). Fiscal savings will be even higher at USD 30million per year if solar PV investments can be increased to meet NDC targets (48.8 per cent reduction in GHG emissions by 2025).

5.4 Cost of Other RE Technologies

The subsections below assess the cost of solar street lighting and solar microgrid technologies.

Cost of Solar Street Lighting

There are currently 147 solar streetlights in South Tarawa and 60 in Kiritimati. An additional 1,972 solar streetlights could be added, assuming an interval of 50 metres between each streetlight. The cost of additional solar streetlights with a built-in battery was compared to the cost of erecting conventional streetlights with LED lamps with centralised battery storage using the life cycle cost analysis method. The life cycle cost analysis (LCCA) estimates the present value of the cost of each initial investment, annual O&M costs, cost of component replacements, and residual costs at the end of the project life cycle (25 years). Based on the LCCA, the life cycle cost of solar street lights (with built-in battery) is USD 8.01 million and the cost of conventional streetlights with LED lamps and centralised battery storage is USD 9.14 million. The costs are indicative and particularly sensitive to changes in O&M costs actual life spans of battery storage. A feasibility study should be conducted to determine which technology is most cost effective. Table 5.3 shows the LCCA results.

Table 5.3: Life Cycle Cost Analysis Comparison of Stand Alone Solar Streetlights and Conventional Streetlights with LED Lamps and Centralised Battery Storage

	Solar streetlights	Conventional Streetlights with LED lamps and centralised battery storage
	USD	
Initial investment cost[1]	5 746 861.56	6 531 111.36
Replacement cost[2]	1 800 617.30	728 587.19
Annual cost[3]	630 283.38	2 056 886.13
Residual cost	(163 308.12)	(173 841.73)
Total life cycle cost	**8 014 454.11**	**9 142 742.95**

Note: The discount rate assumed is six per cent and only feeder roads are assumed to require new poles and cabling for the centralised battery storage option. [1]Initial investment cost: Solar streetlights include cost of pole and installation (USD2,914 per pole); LED lamp + battery include cost of lamps (USD300 per lamp), poles (USD707 per pole), cabling (USD17,000 per km), and central battery (USD 4.9 million for seven 140 kW/210 kWh units).[2] Replacement cost includes replacements for lamp (life span(LS): 11 years), battery (LS: 7 years), centralised battery (LS: 15 years). [3]Annual costs refers to annual O&M for solar street lights (USD 25 per pole) and LED lamps with central storage (USD 2 438 per km). A charging cost is included for LED lamps with central storage.

Cost of Solar Microgrids

As described in Section 4.1.4, microgrids are a potential option to increase electricity access to 52 per cent of the North Tarawa population (606 households) where the PUB grid does not reach. The alternative to microgrids is grid extension. The investment cost of solar microgrids with battery storage was compared to the cost of grid extension using the LCCA method. LCCA estimates the present value of the cost of a project's total life cycle costs including: (1) initial investment costs, (2) annual O&M costs, (3) replacement costs, and (4) residual costs. Assuming a microgrid sized to serve 15 households with an annual load of 14MWh (2.5 kWh/day) and replacing battery storage in year 10 and 20 of operations, the life cycle cost of 40 microgrids is USD 2.82 million. The grid extension alternative, which assumes 23.68 kilometres of high voltage line will be required to connect households up to the northern most village of Bairiki costs USD 5.31 million. Table 5.4 compares the lifecycle cost of solar microgrids and grid extension in North Tarawa.

Table 5.4: LCCA Comparison of Solar Microgrids with Battery Storage and Grid Extension in North Tarawa

	Solar Microgrid	Grid extension
	USD	
Initial investment cost	1 547 320	2 800 000.00
Replacement cost	1 375 797	
Annual cost[1]	82 631.61[a]	2 633 575.90[b]
Residual cost	(188 262.89)	(122 609.06)
Total life cycle cost	**2 817 486.07**	**5 310 966.85**

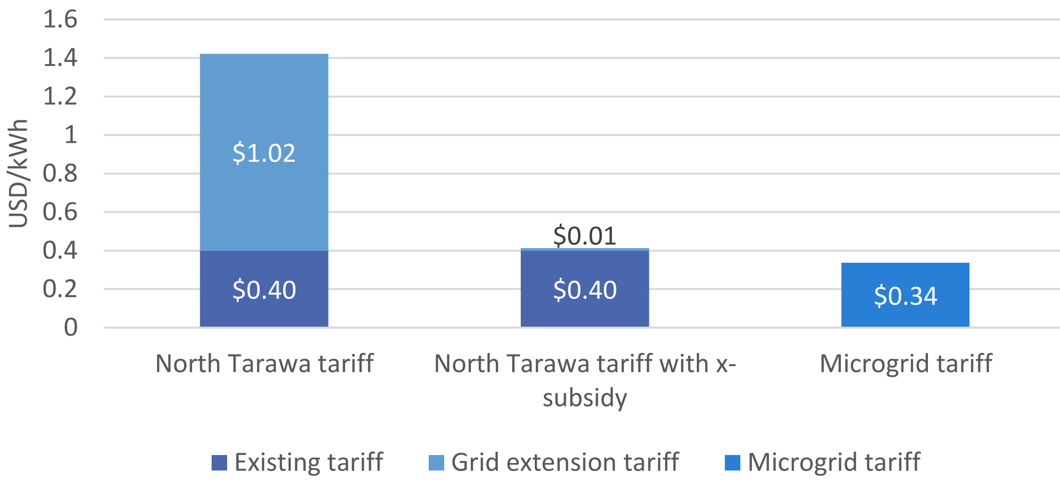
Note: The discount rate assumed is six per cent. [1]Annual cost refers to plant O&M costs.

Sources: [a]Anderson, Katherine H., Nicholas A. Diorio, Dylan S. Cutler, Robert S. Butt, and Allison Richards. "Increasing Resiliency Through Renewable Energy Microgrids." Journal of Energy Management 2, no. NREL/JA-7A40-69034 (2017). [b]Pacific Power Association, "Pacific Power Utilities Benchmarking Summary Report for the 2016 Fiscal Year," (2016).

The LCOE of solar microgrids under commercial financing arrangements was compared to estimated transmission tariffs under the grid extension alternative to assess the average breakeven price North Tarawa households would be required to pay for electricity access. The costs of grid extension can be borne fully by North Tarawa households or shared among all of PUB's customers. As shown in Figure 5.7, the PUB tariff for grid extension alone is USD 1.02/kWh if all costs are borne by North Tarawa households only, and USD 0.01/kWh if the grid extension costs are shared among all PUB customers (shared with South Tarawa households).

If existing PUB tariffs that include grid extension costs are borne by North Tarawa households, the total tariff is USD 1.42/kWh. If the cost of grid extension is shared among all PUB customers (South Tarawa and North Tarawa), the total tariff is USD 0.41/kWh. Microgrid unit costs are more affordable at USD 0.34/kWh compared to grid extension tariffs. Figure 5.7 compares the average unit cost required to break even on microgrid investments to cost-recovery PUB tariffs (including the costs of grid extension).

Figure 5.7: Comparison of Average Unit Cost of Microgrids to Grid Extension Tariffs



6 Prioritisation of Renewable Energy Technologies

This section prioritises technologies based on SREP and Government criteria.[65] Government criteria were identified during the Kick-off Mission through consultations with the National Task Force.[66]

Each technology (described in Section 4 and 5) is scored against SREP and Government criteria. A scoring scale of one to five is used, with one being the lowest score and five being the highest score. The technology that receives the highest total score (scores added up for each technology) will be prioritised over technologies with lower scores. Because Government's top five priorities— (1) increased capacity and generation from RE sources, (2) increased access to energy, (3) economic and financial viability, (4) affordability of electricity, and (5) increased energy security—overlap with some SREP criteria, scores for these criteria are weighed two times more than other criteria. For example, if a technology receives a score of "4" for the criteria "increased installed capacity for RE resources," which is both an SREP and Government criterion, it will receive a score of "8".

Table 6.1 defines the SREP and GoK selection criteria and describes how the technologies were evaluated against them.

Table 6.1: Criteria for Technology Prioritisation

Criteria	Description	SREP	GoK
Increased installed capacity from RE sources*	Technologies that increase installed generation (MW) of renewable energy sources are ranked higher. Technologies were ranked based on the technical potential results presented in Section 4.1.	✓	✓
Increased access to energy through RE	Technologies that directly increase the number of I-Kiribati with access to modern energy services are ranked higher. Technologies with an indirect impact on access to modern energy sources are ranked lower.	✓	✓
Low emissions development	Technologies that have the lowest carbon emissions when operating were ranked higher.	✓	
Increased affordability and competitiveness of RE sources*	Technologies that increase the affordability and competitiveness of renewable energy markets in Kiribati are ranked higher.	✓	✓
Increase in the productive use of energy	Technologies that contribute to increasing income levels and productivity of the I-Kiribati are ranked higher.	✓	

[65] Climate Investment Funds, "SREP Programming Modalities and Operational Guidelines", 2010.

[66] Appendix E describes the missions undertaken as part of preparation of this SREP IP.

Economic, social, and environmental development impact	Technologies that result in positive economic, social, and environmental development impact are ranked higher. Technologies that result that collectively increase economic and social benefits, and environmental abatement are ranked higher.	✓	
Level of economic and financial viability*	Technologies that have a higher level of economic and financial viability (lower LCOE) are ranked higher. Technologies that are financially viable are ranked higher. Technologies that require subsidies or highly concessional financing are ranked lower.	✓	✓
Leverage	Technologies that trigger additional projects, result in investments from other donors or private sector, and catalyse energy sector reforms are ranked higher. Technologies with proven private sector and donor interest, and a high number of potential investment opportunities were ranked higher.	✓	
Gender	Technologies that directly promote gender inclusiveness, increase opportunities for women, and decrease the domestic burden on women are ranked higher.	✓	
Co-benefits of RE scale up	Technologies that result in additional benefits in other sectors are ranked higher; for example, improved solid waste management, or reduced cost of desalination etc.	✓	
Increases energy security	Technologies that increase Kiribati's energy security (reduces imports, increases reliability of energy supplies) are ranked higher.		✓

Table 6.2 shows the ranking of each technology by each criterion and provides brief explanations for the ranking.

Table 6.2: Evaluation of RE Technologies against SREP and Government Criteria

Criteria	Solar PV	Wind	Microgrids	Solar Street Lights
SREP Criteria				
Increased installed capacity from RE	**10**	**6**	**2**	**2**
	Highest buildable capacity (554MW)	Second highest buildable capacity (1.1MW)	Does not directly increase energy capacity	Does not directly increase energy capacity
Increased access to energy through RE	**4**	**4**	**10**	**2**
	Improves reliability therefore quality of access to electricity	Improves reliability therefore quality of access to electricity	Directly supports electrification and load shifting	Supports load shifting
Low emissions development	**5**	**5**	**5**	**5**
	Zero GHG emissions	Zero GHG emissions	Zero GHG emissions	Zero GHG emissions
RE affordability & competitiveness	**10**	**6**	**4**	**2**
	Most competitive resource under economic and concessional finance scenarios	Second most competitive resource under economic and concessional finance scenarios	Lower investment cost than grid extension, but affordability is a concern for customers on North Tarawa	Lower investment cost than LED retrofits with centralised storage, but still requires high upfront investment
Productive use of energy	**4**	**3**	**5**	**2**
	Resource availability aligns with afternoon peak demand	Resource may be available at peak but not reliable enough for firm power	Provides reliable and firm power for productive uses	Indirectly supports economic activity by increasing public and transport safety
Economic, social, & environmental development impact	**3**	**3**	**4**	**5**
	(+) Offsets diesel generation (-) limits land for other uses (for ground-mounted PV) (-) need to safely dispose of battery	(+) Offsets diesel generation (-) bird/wildlife concerns (-) need to safely dispose of battery	(+) off-grid economic activity (+) in-home lighting (-) need to properly dispose of battery	(+) local jobs (+) improved public safety (+) supported load shifting
	6	**6**	**4**	**4**

Economic and financial viability	Economically viable and financially viable with subsidies	Economically viable and financially viable with subsidies	Concessional financing required	Concessional financing required
Leverage	**5**	**2**	**3**	**3**
	Donors and GoK has experience funding similar projects	Limited investment opportunities	Donors have experience funding similar projects on other islands, but limited investment opportunity	Donors and GoK has experience funding similar projects, but limited investment opportunity
Gender	**3**	**3**	**4**	**4**
	Potential job creation and/or increased productive uses of electricity can improve women's lives	Potential job creation and/or increased productive uses of electricity can improve women's lives	Allows children/girls to study in the evenings	Increased public safety greatly benefits women who are prime targets of harassment
Co-Benefits	**3**	**3**	**4**	**4**
	Higher resource potential may result in more long-term jobs	Higher resource potential may result in more long-term jobs	Allows children to study in the evenings	Improved public and road safety
Additional National Criteria				
Ensures energy security	**5**	**5**	**5**	**5**
	Reduces reliance on imported fossil fuels for power generation	Reduces reliance on imported fossil fuels for power generation	Reduces reliance on imported fossil fuels for power generation	Reduces reliance on imported fossil fuels for power generation

Table 6.3 summarizes the prioritisation results. Solar PV + battery storage is the highest ranked technology followed by solar microgrids + battery storage, wind + battery storage, and solar street lighting technologies.

Table 6.3: Prioritisation Results

	Solar PV + battery	Wind + battery	Microgrids	Solar street lights
Score	58	46	50	38
Rank	1	3	2	4

7 Program Description

The prioritisation exercise in Section 6 identified solar PV with battery storage as best suited for scaling-up renewable energy investments in Kiribati, and for achieving the GoK's 2025 KIER and NDC targets.[67] This combination of technologies has the most potential to contribute to the challenges facing Kiribati's energy sector, namely, an overdependence on expensive fuel imports and a lack of reserves to backstop intermittent renewable energy generation.

The proposed investment program consists of two projects—the South Tarawa Renewable Energy Project and the Kiritimati Electricity Access Project. The projects include a combination of investment and technical assistance. The SREP investment program is the first of two phases of renewable energy investment the GoK has planned to achieve its KIER and NDC targets. Box 7.1 summarizes GoK's renewable energy plan and the targets it plans to achieve.

Box 7.1: Summary of GoK's Two Phase Renewable Energy Investment Plan to Achieve KIER and NDC Targets

The GoK has developed a two phased approach to reach its ambitious targets in the KIER and NDC. The SREP program represents phase I of the GoK's two phase program. Phase I investments will enable the GoK to achieve 69 per cent of its 2025 KIER target for South Tarawa (a reduction of 23 per cent of fossil fuel usage) and universal electricity access on Kiritimati Island. Phase II investments will enable the GoK to achieve its 2025 KIER and NDC target to reduce 48.8 per cent of GHG emissions compared to 2014 levels. The table below summarises the investments required to meet the KIER and NDC targets.

Phase I (SREP)

Investments on South Tarawa

- Investment in 4.1MW of solar PV and 1.9 MW (2.6 MWh) of energy storage (USD 10.7 million)

Investments on Kiritimati include:

- Investment in distribution network rehabilitation and expansion on Kiritimati Island (USD 3.4 million)
- Technical assistance for an electricity demand study, and institutional support and capacity building to improve the operational and financial sustainability of the power sector (USD 1.3 million)

Phase I investments amount to **USD 15.4million** and will help the GoK expand electricity access on Kiritimati Island and achieve 26 per cent RE penetration, which achieves 69 per cent of its 2025 KIER target to reduce fossil fuel consumption by 23 per cent on South Tarawa, and 40 per cent of its NDC GHG reduction targets.

Phase II

Investments on South Tarawa include:

- Investment in 23.2MW of solar PV and 4.8MW (54.4MWh) of energy storage (USD 50 million in PV and USD 4.7 million in energy storage)
- Technical assistance for feasibility studies or transaction advisory (USD 0.5 million)

Investments on Kiritimati Island include:

[67] As noted in Section 3.1.2, the 2025 KIER target is to reduce fossil fuel consumption by 23 per cent on South Tarawa and the 2025 NDC target is to reduce GHG emissions by 48.8 per cent based on 2014 levels.

- Investments in RE generation, contingent on results of the demand study in phase I (USD 5.3 million)
- Technical assistance for feasibility studies or transaction advisory (USD 0.5 million)

Phase II investments amount to **USD 61.0 million** and will help the GoK attain 61 per cent RE penetration, which is equivalent to 1.6 times its 2025 KIER target to reduce fossil fuel consumption by 23 per cent on South Tarawa and meets 2025 NDC targets to reduce GHG emissions by 48.8 per cent from 2014 levels.

MISE will provide overall guidance to the implementation of the proposed SREP Investment Plan. As the institution responsible for policy setting and sector coordination, the MISE has the functional authority needed to coordinate the activities of the SREP projects. Preliminary implementation arrangements and MDB co-sponsors for each individual component are described in the sections below.

Section 7.1 and 7.2 describe each project and the component activities that will be supported with SREP and MDB co-sponsor funds as well as the complementary activities to be carried out by other donor partners. Section 7.4 describes the expected co-benefits and environmental and social risks associated with the proposed project.

7.1 Project 1: South Tarawa Renewable Energy Project

The objective of the South Tarawa Renewable Energy Project is to provide investments that displace expensive diesel imports and support higher levels of intermittent generation in the South Tarawa grid. The project includes renewable energy investments which will put Kiribati on the path towards achieving its KIER and NDC targets. The program will enable Kiribati to achieve 69 per cent of its 2025 fossil fuel reduction target (23 per cent) for South Tarawa and 40 per cent its NDC goal of reducing GHG emissions by 48.8 per cent. Preliminary implementation arrangements and MDB co-sponsors for each individual component are described in the subsections below. The sub-sections below describe the investment component of the project, related project preparation activities, and other complementary activities underway by other development bank partners.

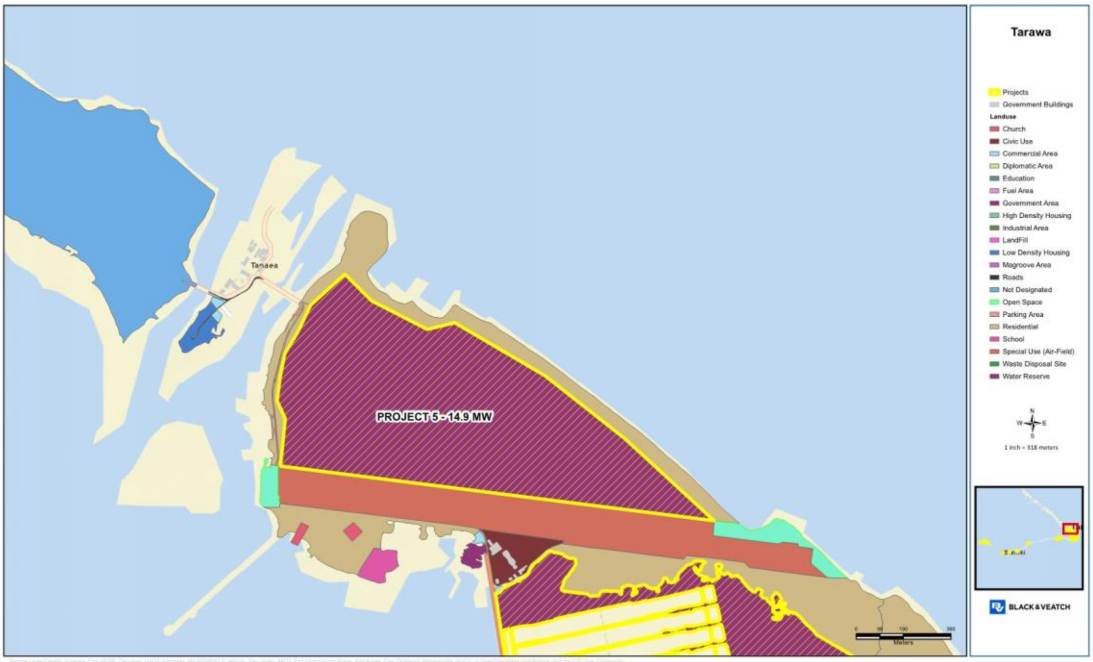
7.1.1 Investment in Utility-scale Solar PV and battery storage investment

Solar PV and battery storage have been identified in this IP as the renewable energy technology with the best potential to enable the transition away from diesel power. This component aims to add 4.1MW in ground-mounted solar PV and 1.9MW (2.6MWh) of battery storage over the next three years. Investments in battery storage are initially required to provide grid stability during periods of cloud cover. As additional PV capacity is added to the grid, battery storage will be used as a dispatchable generation resource and will reduce diesel generation required to meet peak demand.

The investment will enable Kiribati to meet 26 per cent of electricity demand from renewable energy, which is equivalent to 3 million litres in diesel savings (69 per cent of the total diesel equivalent in fossil reduction required to meet KIER targets). The installation will be made on publicly-leased land at the water lens on Bonriki. The water lens was chosen because of the available land in the area and publicly-leased land was chosen because of the relatively short time required to procure land rights.

The project will also include follow-on activities in establishing enabling regulatory frameworks for private sector participation and in institutional capacity building for energy sector agencies. Figure 7.1 shows the location for the envisioned solar PV project.

Figure 7.1: Location of Utility-Scale Solar PV Envisioned in Kiribati's SREP Program



Note: MW shown on the map shows the likely technical potential for solar PV on the water lens. A more accurate estimate technical potential must be derived from a feasibility study.

The investment in PV and storage, proposed to be funded by grants from ADB and SREP, will be publicly owned and operated by PUB. The GoK has opted to pursue a "public first, private later" approach. There are several reasons for this, including very limited existing private sector investment in the country and PUB's limited experience managing a grid with high-levels of renewable energy integration. The GoK is also aware that some Pacific Island countries such as Samoa have experienced grid management problems when private sector investments in solar PV scale up too quickly. The GoK plans to adopt a prudent and pragmatic approach to introducing private sector investments by learning from the experiences of its regional counterparts. This means that the GoK will first develop a supportive regulatory environment and build up local capacity in and monitor how countries such as Samoa deal with the financing and grid management challenges associated with private sector investment in grid-connected renewable energy. Plans for private sector investment in renewable energy are described in section 8 as part of phase II of Government's long-term plan (the SREP program represents phase I of Government's plans) to secure renewable energy investments to meet its ambitious KIER and NDC targets.

7.1.2 Project Preparation and Technical Advice Activities:

The project preparation components will enable PUB to address the challenges of adding solar PV and battery to the South Tarawa grid and additional technical support will establish the framework needed to enable future private transactions.

Technical Study under the Technical Assistance grant (Project Preparation and Renewable Energy Integration Study)

Feasibility study and all required due diligence will be conducted to prepare the investment project for SREP and ADB financing approval. In addition, a renewable energy integration study will be needed to evaluate the impact of the additional solar PV and inverter capacity on system stability. The results of this study would be used to prepare the technical requirements for the solar PV and storage, and to identify any additional steps PUB would need to make to be able to manage these new assets and any future planned renewable energy projects such as the WB/ADB project described below.

Renewable Energy Enabling Framework under the Technical Assistance grant

Private sector financing will not initially be sought for the realisation of Kiribati's SREP program, but the GoK recognises the importance of creating an enabling regulatory framework to attract private sector renewable energy investments in the future. Specific barriers preventing the future development of a private renewable energy market are the lack of technical standards needed to facilitate such transactions, and the lack of local capacity to manage renewable energy projects if Kiribati is to attract private sector investment in the sector. SREP funds would be used to implement a legal and regulatory strengthening and capacity building program.

The technical assistance envisioned in the SREP funded program will support the GoK in closing these remaining gaps in the renewable energy framework. The technical assistance will specifically support the GoK in:

- Drafting and enacting an Energy Act to regulate and incentivise the scaling-up of renewable energy and energy efficiency in all sectors
- Formalising technical standards on electrical equipment, which follow New Zealand and Australian standards so that such standards can be enforced
- Drafting and updating grid codes to support the safe operation of the grid at high-levels ofrenewable energypenetration
- Preparing the request for proposal, power purchase agreement (PPA), and other procurement documents that will support the introduction of IPPs in Kiribati in the future.

A multiyear capacity building program will be developed and carried out concurrent to the regulatory technical assistance. The program will provide on-the-job training to relevant staff at PUB, MISE, and Ministry of Finance & Economic Development (MFED) and support the development of internal management and operations procedures to support the realisation of the SREP Renewable Energy Project and future (private sector led) investments in the power sector. The capacity development program will also apply a policy of gender mainstreaming by introducing a quota system or preference for women in the training program selection process, since women's participation in Kiribati's energy sector is low, despite equal levels of school enrolment. The program will also include gender disaggregated targets and indicators to establish a baseline and monitor and evaluate gender outcomes of the capacity development program.

7.1.3 Complementary activities:

The SREP funded activities will complement other ongoing donor programs:

The World Bank and ADB Solar PV Reverse Osmosis (RO) Project

The World Bank and ADB are currently implementing the South Tarawa Water Supply Project that will construct solar PV desalination plants. The project touches on the nexus between energy and water and addresses the GoK's dual goals of water security and reducing fossil fuel use by scaling-up renewable energy. The RO project will add 480 kW of RO load to the Kiribati grid, and install 2.5 MW of solar PV with a 2 MW smoothing energy storage system to offset part of the increased load and ensure system stability. The SREP Investment Plan for Kiribati considers additional load to PUB's network in the demand forecast used to size solar PV and energy storage investments (components 1 and 2) described above.

The MFAT Funded Kiribati Electricity Sector Least Cost Plan Project

A comprehensive electricity generation least cost plan was developed for South Tarawa, Kiritimati Island, and the outer islands concurrent to the development of the SREP IP. The least cost plan reviewed existing electricity sector arrangements and plans and then identified specific supply and demand-side measures to meet fossil fuel reduction goals set forth in the KIER. A least cost pathway was developed for Kiribati with the objective to replace diesel generation and support higher levels of renewable energy generation (more than 80 per cent by 2038). The least cost plan identified specific generation, and network investments include that will support higher levels of intermittent generation and improve grid reliability and security.

7.2 Project 2: Kiritimati Island Electricity Access Project

The objective of the Kiritimati Island Electricity Access Project is to increase electricity access to the existing population on the island, improve the operational and financial sustainability of the sector, and better understand the island's electricity supply needs for the future. The project will include investments in the low voltage distribution network with the aim of evacuating excess solar PV capacity and thereby increase access and reliability of electricity supply services to the existing population. The project will also include two technical assistance components that will strengthen local capacity to operate and maintain recent investments as well as put in place reforms to improve the financial viability of the sector. Finally, the project will include a demand study to assess the amount of investments required under different migration and development scenarios to meet the population's energy needs in the future. Preliminary implementation arrangements and MDB co-sponsors for each individual component are described in the subsections below.

7.2.1 Component 1: Electricity demand study

As described in section 3.3, there is still much uncertainty surrounding demand growth on Kiritimati Island. KIESP, which was funded by the EU and New Zealand's MFAT recently installed enough generation capacity on Kiritimati Island to meet existing demand. As of 2017, there is 1 459.5kW of generation capacity on the island to meet about 320kW of demand. About 2,000 land leases were recently released by the government, but migration has thus far been limited and land plots are being used to formalise leasing arrangements of the existing population. In addition, procedures to ensure accurate load and power generation data collection and new generation capacity were only recently put in place. It is expected to take several years to obtain a clearer picture of the demand and supply needs in Kiritimati Island. The GoK is preparing a request to the EU for funding of a detailed demand study to identify how much renewable energy investments will be needed in the medium to long-term on Kiritimati Island. Findings of the demand study will be used to inform any generation investments in phase II of GoK's renewable energy investment plans (described in section 8).

7.2.2 Component 2: Institutional support and capacity building program

The KISEP project identified several institutional and capacity gaps that should be addressed to ensure the operational and financial sustainability of Kiritimati's electricity sector. As described in section 3.2.2, there is currently no regulatory mechanism in place for setting tariffs or connection fees, a problem of unmetered customers, and no regular meeting and billing procedures in place to allow MLPID to recover the costs of generation. There is also limited local capacity to operate and maintain the network and an asset maintenance and replacement plan has yet to be put in place. As part of KISEP, a ten-year asset management and replacement plan was developed, and training provided to MLPID staff to maintain and operate new network investments. Continued on-the-job training and support is needed to ensure the adoption and implementation of the asset management plan, accurate collection of key data (load and generation) and improve bill collections. The EU and GoK are in preliminary discussions around a budgetary support package of up to USD 8 million that would partially include funding for these reform programs.

7.2.3 Component 3: Investment in low voltage distribution network rehabilitation and expansion

The high voltage distribution network on Kiritimati Island was recently replaced, but the low voltage network still needs to be rehabilitated and expanded. The existing low voltage network consists of wires that are of different standards and sizes. There are also parts of the network that is exposed and incorrectly terminated at distribution pillars. Where cables used in the distribution network are undersized, customers have reported voltage fluctuations and damage to their appliances. There are also about 350 households in in Tabwakea, Main Camp, and Poland that have not been connected to the grid. This component of the project will provide investments to replace parts of the low voltage distribution network that are not compatible with the newly installed high voltage distribution network and will expand the network to connect households who do not yet have a connection to the grid.

7.2.4 Complementary activities:

None. This project will be a continuation of EU's multiyear budgetary and technical assistance support for the GoK.

7.3 Environmental and Social Co-Benefits

The technologies included in Kiribati's SREP Investment Plan have environmental and social co-benefits. Many of these benefits are the same across the RE technologies, but each technology also has its own unique benefits to be considered. Section 7.3.1 to 7.3.5 describes some of the benefits related to these technologies.

7.3.1 Employment benefits

- Investments in utility-scale technologies can increase access and reliability of electricity supply in South Tarawa and Kiritimati Island. Improvements in electricity supply will directly support productive uses of energy, resulting in job creation that can address the high unemployment and underemployment rates in Kiribati, especially among youth and women population segments.
- The additional power available from utility-scale generation and storage can expand the tourism economy and develop increased tourism-related employment for residents especially on Kiritimati Island.
- Kiribati can diversify its economy by developing previously non-existent wind energy industry in the form of construction, operations, and maintenance jobs.

7.3.2 Social services and infrastructure benefits

- Investments in on-grid renewable energy technologies can improve access and reliability of electricity, improving service delivery at schools, hospitals and clinics, and potential new businesses. In South Tarawa, reliable electricity will allow the hospital to begin using equipment it previously was unable to run because of insufficient energy supply. A reliable power supply can promote service expansion, improved lifestyles, and better health outcomes.
- Additional power from utility-scale and energy storage technologies can support the improvement and expansion of water supply and waste management infrastructure in South Tarawa and Kiritimati Island.

7.3.3 Natural resource management and land use benefits

- Utility-scale solar and wind technologies require minimal water for construction and operation, which contributes to addressing the problem of water scarcity in Kiribati.
- Utility-scale solar deployment at the water lens at Bonriki provides shading that will contribute, albeit marginally to fresh water conservation.
- Investments in roof mounted solar PV on existing buildings minimise land use impacts to keep the land open for alternative uses, provide power sources in densely populated areas without displacing current residents or other existing critical land use, and generates and stores power close to existing grids and users.
- Wind with storage uses less land area per kW generated than solar requires.

7.3.4 Climate change effects and local air pollution benefits

Kiribati is especially vulnerable to climate change, which could increase the risk of flooding, storm surges, land degradation, and loss of biodiversity. Adopting renewable energy technologies results in lower GHG compared to fossil fuel-based electricity generation on which the country relies.

7.3.5 Financial and timesaving benefits

- Recent technological progress has made solar PV and wind turbines more efficient and cheaper to construct and operate.
- Investments in renewable energy technology may benefit the Kiribati economy and public by reducing the its dependence on expensive fossil fuel imports for power generation.

7.4 Environmental and Social Risks

The technologies included in this IP all have environmental and social risks. Many of these risks are the same across the renewable energy technologies, but each technology also has its own unique risks to be considered. Sections 7.4.1 to 7.4.3 describe some of the risks related to these technologies.

7.4.1 Pollution risks

- Installation of generation and storage equipment requires safe removal and disposal of broken solar panels, end-of-life batteries, and any chemical waste materials associated with equipment use and maintenance that could endanger the local area if exposed.
- Construction of renewable energy technologies may result in short-term pollution at project sites.

7.4.2 Biodiversity, conservation, and land use risks

- Renewable energy site construction may compete for limited land use, displace important land use, and result in the loss of agricultural land, especially in the densely populated South Tarawa region.
- There are informal settlements at the Bonriki water lens, which is government leased land reserved for PV construction and water abstraction. New PV developments in this area will likely involve resettlement that must adhere to MDB social safeguards.
- Solar PV project locations may suffer from spatial environmental constraints, such as the need to minimise impacts to protected areas (including wildlife sanctuary reserves on Kiritimati Island), minimise resettlement of residents, and avoid areas prone to flooding and sea surges (particularly on South Tarawa where land is much more limited).
- Wind development may need an expanded transmission system to connect wind system to the grid, which could impact land use with new transmission corridors.
- Direct and indirect impacts of renewable energy technology, particularly wind, may harm sensitive resident and migratory bird species on Kiritimati Island, including Bokikokiko, Phoenix petrel, Polynesian storm petrel, and

Rimatara Lorikeet, all endangered species according to the International Union for Conservation of Nature. The project impacts may pose risks to bird sanctuary programs and tourism development related to maintaining bird populations.

7.4.3 Noise pollution and other disturbance risks

- Solar PV and wind technology with proximity to airports and flight paths can cause glint or glare for airplanes or interfere with flight-related radar and communications.
- Both roof-top solar PVs and wind technology may pose a visual disturbance to nearby residents, and wind technology can create noise and vibration disturbances.

8 Financing Plan

Table 8.1 presents the planned financing amount, sources, and instruments for Kiribati's SREP Investment Plan. A mix of MDB and other donor funds will be used to finance 4.1MW of utility-scale solar PV and 2.6MWh of battery storage on South Tarawa and provide necessary technical assistance and capability building to facilitate said investments. The SREP components in South Tarawa will help Kiribati reduce its dependence on imported diesel for electricity generation and investments in solar PV accompanied by energy storage investments will improve grid stability at higher levels of renewable energy penetration. These investments will enable the GoK to achieve 26 per cent renewable energy penetration and 69 percent of its KIER fossil fuel reduction targets for South Tarawa, and 40 per cent of its NDC GHG targets by 2025. On Kiritimati Island, investments in the low voltage distribution network will evacuate excess solar PV capacity to a segment of the population that does not have electricity access and improve the quality of supply for existing customers. The demand study will help the GoK obtain a clearer picture of future demand needs and identify investments to meet them. These investments will help the GoK achieve universal electricity access on Kiritimati Island.

Financing arrangements for each component of the SREP program for Kiribati will be determined at the project appraisal stage, but it is expected that USD 3.7 million in SREP funding will be used to leverage USD 7 million in funding from ADB and bilateral donors to construct 4.1MW of solar PV and 2.6MWh of battery storage on South Tarawa. A USD 1 million in SREP Project Preparation Grant will be used to strengthen Kiribati's legal and regulatory framework for renewable energy, provide capacity building to key energy sector stakeholders (PUB, MISE, and MFED), and provide project preparation support in the form of feasibility and grid integration studies for solar PV and storage investments. The objective of the technical assistance will be to ensure that Kiribati's enabling environment is conducive for future private sector participation in the renewable energy sector. Investments and technical assistance will be provided to Kiritimati Island using EU budgetary support, to conduct a detailed demand study, rehabilitate and expand the existing low voltage distribution network, and establish an institutional reform and capacity building program to improve the operational and financial sustainability of the electricity sector.

Table 8.1: Kiribati SREP Indicative Financing Plan

Phase I	Total	SREP***	ADB**	Other donors	Private sector	GoK*
South Tarawa Renewable Energy Project	**USD million**					
Investment in PV and energy storage	10.7	3.7	5	2		
Subtotal	10.7	3.7	5	2	0	0
SREP Leverage	1:1.9					
Kiritimati Island Electricity Access Project	**USD million**					
Electricity demand study	0.3					0.3*
Investment in distribution network rehabilitation and expansion	3.4					3.4*
Ffeasibility studies, institutional support and capacity building program	1					1*
Subtotal	4.7	0	0	0	0	4.7
Total	15.4	3.7	5	2	0	4.7
Total SREP Leverage	**1:3.2**					

Note: *The EU is currently in discussions with the GoK on the exact scale and scope of the support that will be offered to Kiritimati Island for sustainable development under the EDF 11 envelope. Funds may be put towards general budgetary support, technical assistance, and/or infrastructure investment. Note that because the discussions are still ongoing the funding amounts provided here are meant to be indicative.

**The ADB is in discussion with the GOK on potential additional funding for SREP (Phase I), and possibly for Phase II. The Phase I funding amount and size of the infrastructure project are therefore indicative and will likely increase upon confirmation of funding increase by Q1 2019 and start of project preparation.

*** Excludes Investment Plan Preparation Grant (IPPG) of USD 0.3 million and Project Preparation Grant (PPG) of USD 1 million

Investments described in Kiribati's SREP program (section 7) represent phase I of the GoK's renewable energy investment plans. Phase II of the Government's Investment Plan builds on phase I by using improvements in the renewable energy legal and regulatory framework, local capacity, and understanding of future demand needs (especially on Kiritimati Island) to substantially scale up private sector led renewable energy investments to surpass the KIER targets for South Tarawa and meet 2025 NDC targets to reduce GHG emissions by 48.8 per cent.

Phase II of the GoK's investment plans will include: The South Tarawa Renewable Energy Project II and the Kiritimati Island Grid-Connected Renewable Energy Project.

The South Tarawa Renewable Energy Project will include the following components:

- **Investments in grid-connected solar.** After Phase 1 another 23.2MW of solar PV will be required for GoK to meet a 48.8 per cent reduction in GHG emissions by 2025 and surpass its 23 per cent fossil fuel reduction targets in the KIER by 58 per cent.[68] The GoK recognises that private sector financing must be mobilised to achieve the scale of investments required to reach this target.
- **Investments in battery storage.** In addition to investments in solar PV, up to 4.8MW (54.4MWh) of battery storage investments will be required to meet NDC GHG emissions reduction targets. Attracting investors for solar PV will already represent a significant step in private sector participation in Kiribati. Requiring private investors to enter a new market and take on the higher cost of battery integration may represent one barrier too many. For this reason, the GoK plans to submit a request to the Green Climate Fund (GCF) to fund a centralised storage facility. The centralised storage may prove to be transformative to Kiribati's energy sector; it may catalyse private sector solar PV investments.
- **Supporting feasibility studies and transaction advisory.** The GoK will request funding for technical assistance in the form of feasibility studies or transaction advisory assistance or to support the procurement of private sector investment in renewable energy.

The Kiritimati Island Grid-Connected Renewable Energy Project will include the following components:

- **Investments in renewable energy generation.** The GoK plans to use the results of the demand study conducted in phase I to identify the buildable capacity required to meet Kiritimati's demand needs in the medium-term. Another component of the EU support program under discussion with the GoK is an agreement to The EU has agreed to provide technical assistance in the form of feasibility studies or transaction advisory assistance or both to the GoK and PUB to support the procurement of private sector investment in renewable energy.
- **Supporting feasibility studies and transaction advisory.** Another component of the EU support program under discussion with the GoK is an

[68] The base year for GHG and diesel usage reductions is 2014.

agreement to The EU has agreed to provide technical assistance in the form of feasibility studies or transaction advisory assistance or both to the GoK and PUB to support the procurement of private sector investment in renewable energy.

The GoK plans to seek financing support for projects in phase II from MDBs, the EU, bilateral donors, and the GCF. Table 8.2 shows how the GoK envisions financing for phase II projects. The funding amounts for the South Tarawa project are indicative, while the amounts for Kiritimati Island have been committed by the EU (exact financing amounts and allocations will be finalised when Phase I is completed).

Table 8.2: Financing Plan for Phase II of GoK's Renewable Energy Investment Plans

Phase II	Total	SREP	ADB	GCF and other donors	Private sector
South Tarawa Renewable Energy Project II	**USD million**				
Investment in PV	50				50
Investment in energy storage	4.7			4.7	
Feasibility studies/transaction advisory support)	0.5			0.5	
Subtotal	**55.2**	**0**	**0**	**5.5**	**50**
Kiritimati Island Grid-Connected Renewable Energy Project	**USD million**				
Investment in renewable energy generation*	5.3			5.3**	
Feasibility studies/transaction advisory support	0.5			0.5**	
Subtotal	**5.8**	**0**	**0**	**5.8**	**0**
Total	**61.0**	**0**	**0**	**11.3**	**51**

Note: *Contingent on results of the demand study in phase I ** Please note these amounts for EU funding are indicative. Discussion between the GoK and EU on the exact scale and scope of the EDF 11 envelope are still ongoing.

9 Responsiveness to SREP Criteria

Kiribati's proposed SREP program, which conforms to SREP criteria, is summarised in Table 9.1.

Table 9.1: Summary of Proposed Project's Responsiveness to SREP Criteria

Criteria	South Tarawa Renewable Energy Project
Increased installed capacity from renewable energy	SREP resources will be used to finance the development of 4.1MW of utility-scale solar PV and 2.6MWh of battery storage
Increased access to energy through renewable energy	▪ Investments in solar PV and battery storage will increase the reliability and quality of energy access on South Tarawa ▪ On Kiritimati Island, investments in the low voltage distribution network will increase electricity access to 350 households
Lower emissions	Solar PV and battery technologies do not produce GHG emissions
Affordability & competitiveness	▪ Solar PV is the most competitive resource under economic and concessional financing scenarios ▪ MDB and donor support to bring battery storage capacity online will make solar PV investments in Kiribati more attractive to the private sector
Productive use of energy	▪ Solar resource availability coincides with afternoon peak demand that serves businesses and government offices ▪ Improved reliability and quality of electricity supply directly supports productive uses of energy that can result in job creation or increase the attractiveness of Kiribati for industries such as tourism or light manufacturing
Economic, environmental, and social impact	(+) Solar PV will offset expensive diesel imports for power generation. (+) Solar PV requires minimal water for construction and operation and thus will not contribute to water scarcity problems in Kiribati. (+) Shading from solar PV panels on the Bonriki water lens may contribute to water conservation (reducing rate of evaporation) and reduction of settlements and human activities will help reduce adverse environmental impacts on the water lens. (-) Batteries need to be disposed of properly. (-) Land used for solar competes with other productive uses of land, which is scarce on South Tarawa. There are informal settlements at the Bonriki water lens, which will likely require resettlement
Economic and financial viability	Economically and financially viable with subsidies (support from MDB and SREP)
Leverage	Investments from MDBs and Government are expected to leverage 3.2 times the amount contributed by SREP.
Gender	The program adopts a policy of gender mainstreaming and will require gender elements and considerations in the design, implementation, and evaluation of projects/activities

Criteria	South Tarawa Renewable Energy Project
Co-benefits	Increased reliability and quality of electricity supply, which increases the potential for more productive/efficient uses of energy (through job creation, cost and time savings in doing business) can result in improvements (increased stability, income generation potential) to Kiribati's economy
Ensures energy security	▪ 11 766 MWh generated from solar PV investments will reduce the need for 3 million litres of imported diesel by 2025 ▪ Investments in battery storage will improve grid reliability at higher levels of renewable energy penetration.

10 Implementation Potential with Risk Assessment

The implementation risk of Kiribati's SREP Investment Plan is moderate. Table 10.1 summarizes key risks that can impact the implementation of Kiribati's SREP Investment Plan.

Table 10.1: Risk Assessment of the SREP Investment Plan for Kiribati

Risk category	Description	Mitigation measure	Residual risk
Market	Uncertainty about future electricity demand growth on Kiritimati Island can result in a supply glut	▪ Establish and implement data collection on generation and load through a capacity building program ▪ Regularly monitor migration to Kiritimati Island for the next three to five years ▪ Conduct a detailed demand study to understand medium to long-term demand trends	Low
Legal and regulatory	Incomplete (not adopted) legal and regulatory framework for RE creates an uncertain investment climate for potential project sponsors	▪ Adopt draft Electricity and Energy Acts ▪ Complete renewable energy regulatory framework	Low
Institutional and capacity	Limited capacity for operating and maintaining the electricity system on Kiritimati Island	SREP program will include on-the-job training to utility staff to operate and maintain network investments and improve data collection practices	Low
Technology specific	Technical specifications of proposed projects are not optimised	MDBs will support the preparation of project feasibility studies to ensure that they meet the highest technical specifications	Low
	Distributed technologies are poorly installed and maintained	▪ Provide training to local technicians to ensure equipment is installed and maintained to highest standards ▪ Provide training to target users on proper use and maintenance of technology	Moderate

Financial	Access to commercial financing for project sponsors is limited	▪ Grant finance solar PV and battery storage to improve the financial viability of Projects	Moderate
	Customers unable and or unwilling to pay for electricity	Conduct willingness to pay and affordability studies to inform the development of subsidies and targeted social protection schemes for low-income customers	
Environmental	RE projects may negatively impact surrounding areas during construction or operations (noise pollution, land use changes, chemical and other pollutant discharge)	Each RE project will undergo MDB approved environmental assessments and due diligence processes to ensure environmental risks are addressed	Moderate
Social	RE projects may have unintended social impacts during construction or operations that adversely impact power dynamics among local population or require resettlement	Each RE project will undergo MDB approved social assessments and due diligence processes to ensure social risks are addressed	Moderate
	RE projects may adversely impact women or fail to include gender elements	Each RE project will undergo MDB approved gender assessments, include requirements for gendered targets and indicators to monitor and evaluate project outcomes from a gendered lens	Low

11 Monitoring and Evaluation

The investments proposed in this Investment Plan on utility-scale solar and battery storage can help Kiribati diversify and increase its generation capacity to meet future demand and reduce its dependence on expensive fossil fuel imports.

A monitoring and evaluation (M&E) system will be established by the Government, in cooperation with MDBs and other donor partners to track and report the program's progress towards achieving its objectives. The M&E framework will be coordinated by MISE. MDBs and other development partners such as the EU, New Zealand and Australia's High Commissions have pledged to provide MISE with support and training to facilitate data collection, analysis, and reporting for SREP Investment Plan M&E framework. Table 11.1 describes the proposed M&E framework for the Kiribati SREP Investment Plan.

Table 11.1: Kiribati SREP Investment Plan Results Framework

Result	Indicators	Baseline (2017)	Targets (2023)	Means of Verification
SREP Transformative impact indicators				
Support low-carbon development pathways by reducing energy poverty and/or increasing energy security	Annual electricity output from RE as a percentage of total load served on South Tarawa[69]	9%	26% [70]	MISE/PUB from hourly generation data
	Percentage of off-grid households with access to electricity on Kiritimati Island	84%[71]	100%	MISE M&E system
	Avoided CO_2 emissions	0	7 200 tons of CO_2 per year[72]	MISE/SREP project M&E system
SREP outcomes				
Increased supply, reliability and quality of power through renewable energy and battery storage systems	Annual electricity output (GWh) and share of RE generation on South Tarawa	2.37 GWh/year (9% of supply mix)	16.25 GWh/year by 2025 (36% of generation mix)	MISE/PUB from hourly generation data by generation unit

[69] Assumes that all domestic electricity production is renewable, and all imports are non-renewable.

[70] Target assumes the baseline South Tarawa forecast not including EE (see Figure 3.6).

[71] From EU Commission estimates.

[72] Calculated based on 793.7 tons CO2eq per GWh, based on the proxy-based method established by the SREP sub-committee.

Increased access to modern energy services	Number of women and men, businesses and community services benefiting from improved access to electricity on Kiritimati[73]	0	1050 men 1050 women 0 businesses & Community services	Project M&E
Increased economic participation of women in the energy sector	Women as per cent of all persons employed in the energy sector	28.3% (2015[74])	50% (2025)	MFED
RE investment after SREP Program	Million US$	$0 (2023)	$50 million (2030)	MISE
New and additional resources for RE projects	Leverage ratio: US$ SREP funding compared to financing from other sources compared	0	1:3.2	MFED/SREP Project M&E system
Adoption of RE enabling framework	Adoption of an Electricity Act	Not Adopted	Adopted	MISE
	Adoption of RE Technical Standards	Not Adopted	Adopted	MISE
	Adoption of a Grid Code	Not Adopted	Adopted	MISE
	Adoption of a Model PPA	Not Adopted	Adopted	MISE

[73] Target based on household demographic data from the 2015 census.

[74] GoK, "2015 Population and Housing Census", 2015.

Appendix A: Project Concept Briefs

A.1 South Tarawa Renewable Energy Project

Problem Statement

1. Kiribati is one of the countries that is most vulnerable to the effects of climate change. With the release of the Intergovernmental Panel on Climate Change's (IPCC) report on the potential impact of a 1.5 centigrade temperature rise showing that these impacts could arrive sooner than initially expected, the decarbonisation of our energy systems is clearly now more imperative than ever. The GoK recognises the need for a profound transformation and has set policy goals through its NDC commitments and KIER to ensure the I-Kiribati will do their part in the global effort to mitigate the effects of climate change.
2. Kiribati currently relies predominately on diesel fuel to generate 91 per cent (2017) of electricity supplied on South Tarawa where 50 per cent—and growing—of the i-Kiribati reside. The reliance on diesel fuel for electricity is not only expensive, it is one of the country's main contributor to greenhouse gas (GHG) emissions. In the KIER, a medium-term energy strategy document, the GoK set targets to reduce diesel consumption by 23 per cent and increase the penetration of RE in its electricity mix to 23 per cent by 2025. These goals are part of Kiribati's NDC commitment to reduce overall GHG emission by 48.8 per cent by 2030.
3. Solar PV is viewed as the best domestic resource option for Kiribati to transition to as it moves away from diesel power. Donor and non-governmental organisations (NGO) funding has already brought 1.6 MW of rooftop and small-scale ground-mounted solar PV systems onto the South Tarawa grid. These installations accounted for 2.3 GWh or nine per cent of South Tarawa's 26.4 GWh demand in 2017. With the technical potential to produce upwards of another 120 GWh per year there is more than enough solar PV resources on South Tarawa to meet both short-term and long-term demand.
4. To achieve both the NDC emission reduction and KIER fuel consumption goals there will need to be at least 27MW of solar PV installed over the next decade. Technical and financial challenges remain preventing Kiribati from progressing much beyond the current generation mix. PUB has found that the current solar PV capacity is the maximum it can handle and still maintain grid stability without the installation of batteries to help modulate frequency during cloud cover periods. An estimated 57 to 66 MWh in energy storage will be needed to compliment the 27 MW in solar PV capacity required to achieve the policy goals. Together the solar PV and energy storage capacity will cost somewhere in the range of $65-70 million.
5. While there continues to be donor interest in supporting Kiribati's transition away from diesel, the magnitude of the investments needed is beyond what will be available from multilateral and bilateral donors. Private investment is inevitably going to be required to meet this goal. There is, however, no example of how battery storage and solar PV will work on South Tarawa nor a regulatory environment to support private transactions.

Project Objective

6. The objective of the South Tarawa Renewable Energy Project is to set the stage for development of a private investment market in Kiribati by demonstrating the technical and financial viability of a utility-scale solar PV and battery energy storage system (BESS) on the South Tarawa grid. SREP investment grant funds will be used to leverage additional grants from ADB and another bilateral donor (to be determined) to finance the construction of 4.1MW of solar PV and 2.6MWh of battery storage on South Tarawa.

Proposed Contribution to Initiating Transformation

7. The investments in solar PV and battery will enable Kiribati to exceed 26 per cent of electricity demand from renewable energy, which is equivalent to 3 million litres in diesel savings (69 per cent of the total diesel equivalent in fossil reduction required to meet KIER targets).

Implementation Readiness

8. Both the solar PV and battery installations will be installed at the public-owned water lens area in Bonriki where the GoK has already allotted a part of the area for renewable energy development.

Environmental and Social Impact Mitigation Plan

9. The main environmental concern will be pollution at the beginning of the project during construction and the end of life when solar PV and battery components need to be disposed. Construction phase impacts will be mitigated by procuring experienced contractors with a proven track record of safely installing solar PV and battery systems in similar conditions. The contractor(s) will be required to implement the environmental management plan developed during the initial environmental examination and due diligence at project preparation stage to mitigate any potential environmental impacts. Solar PV and battery recycling operations are already available in the Pacific region and their ability to repurpose/recycle these components should only improve over the next 20 years.

10. There will be no social displacement resulting from the project because it is inhabitable land.

Rationale for SREP Financing

11. Private sector financing is going to be needed to achieve national targets for solar PV and battery storage capacity installations. SREP grant support is needed to help Kiribati demonstrate the technical and financial viability of utility-scale solar PV and battery on South Tarawa to help achieve national targets in renewable energy generation and emissions reductions.

Results Indicators and Development Co-benefits

12. The core indicators of the project include:

- Installation of 4.1 MW solar PV and 2.6 MWh battery storage
- Generation of an additional 9 GWh/year from renewable energy

- 5 000 estimated number of households or 35 000 individuals (approximately 50% female) will benefit from improved access to electricity[75]

13. Development co-benefit indicators include:

- Increased institutional capacity in developing, installing and operating PV and BESS
- Gender elements / Gender Action Plan
- Up to 7 200 tons of GHG emissions avoided per year.[76]

[75] To be confirmed during due diligence and project preparation

[76] Assumes current emission from diesel generation are 793.7 tons CO_2eq per GWh

Financing Plan (Million US$)

Component	SREP	ADB	Other donor (TBD)	Total
1: Solar PV + Battery	3.7	5.0	2.0	10.7
Total	**3.7**	**5.0**	**2.0**	**10.7**

Lead Implementing Agencies

14. ADB will administer the technical assistance and project grants and will work with the PUB and the MISE..

Project Preparation Timeline

15. A tentative schedule for project preparation is presented below.

Project Preparation Step	Timeline and milestones
ADB approval of solar PV + battery storage project concept	Q4 2018
ADB consultant recruitment and project preparation	Q1-Q4 2019
Approval of RE enabling framework recommendations and RE technical study	Q4 2019
SREP IP Endorsement	Q1 2019
SREP Funding approval	Q4 2019
ADB Board/Management approval	Q1 2020

Project Preparation Grant

16. The Government of Kiribati is requesting a project preparation grant of $US 1.0 million to prepare the renewable energy enabling framework and technical integration study.

Appendix B: Renewable Energy Technologies Not Prioritised for Inclusion in the Kiribati SREP Investment Plan

During the Kick-off Mission in February, the National Task Force and MDBs agreed to exclude several technologies from Kiribati's SREP program. The following subsections provide an overview of technologies not included in the investment plan.

B.1 Solar PV Powered Reverse Osmosis (RO) Plants

RO is particularly important to ensuring sustainable potable water supply in South Tarawa. An options study conducted as part of the KIER identified solar PV as the most appropriate RE desalination technology for South Tarawa because it is a mature technology, the scale of typical units fit the island's demand profile, and components for the plant are widely available in the region. The roadmap recommends installing five PV RO plants with a production capacity of 528 000 litres per day to meet water demand in South Tarawa by 2025. The analysis assumes that water demand per person per day is 50 litres, and that measures are taken to increase rainwater collection and reduce water distribution network losses. Appendix Table B.1 shows the number of RO plants required to meet water demand on South Tarawa by 2025.

Appendix Table B.1: Number of Solar Powered Reverse Osmosis Plants Required to Meet Water Demand in South Tarawa by 2025 (Based on KIER Estimates)

		2015: current losses	2015: improved distribution and rain collection	2025: improved distribution and rain collection
Water Demand	Population	60 936		89 131
	Estimated water demand per capita (litres/day)	50		
	Total net water demand (litres/day)	3 046 800		4 456 550
	Water distribution losses (%)	60%	20%	15%
	Water distribution losses (litres/day)	1 828 080	609 360	668 483
	Total gross water demand (litres/day)	4 874 880	3 656 160	5 125 033
Fresh Water Supply	Sustainable yield from ground water (litres/day)	2 510 000		2 177 000
	Households with rain water tanks (%)	10%	25%	65%
	Rain water supply per household (litres/day)	5		
	Total rain water supply (litres/day)	30 468	76 170	289 676
	Gross fresh water supply gap (litres/day)	2 316 131	1 054 756	2 614 905
Desalination supply	Gross RO system production (litres/day/system)	528 000		
	Number of systems to fully cover supply gap	4.39	2.00	4.95
	Number of systems recommended	4	2	5
Total gross water supply gap or surplus (litres/day)		-204,131	+1 244	+25 095
Total net water supply gap or surplus (litres/day)		**-81,652**	**+995**	**+21 330**

Source: GoK, "KIER," 2016.

The ADB and World Bank are currently implementing the South Tarawa Water Supply Project, which will identify specific PV power supply options for a proposed desalination plant. The RO plant that will be commissioned under this project will have a capacity of 4 000 m^3 per day to meet the expected water supply gap by 2025 and there is a provision for a 6 000 m^3 per day capacity update. The PV options study conducted for the project recommends a 2500 kW fixed mounted PV array with 2000 kW of solar smoothing energy storage near the Bonriki pumping station.

Supplementing fresh water supply with desalination may not be necessary on Kiritimati Island if measures are taken to increase rainwater collection and reduce water distribution network losses. Appendix Table B.2 shows the number of solar powered RO plants required to meet water demand on Kiritimati by 2025.

Appendix Table B.2: Number of Solar Powered Reverse Osmosis Plants Required to Meet Water Demand on Kiritimati Island by 2025

		2015	2025
Water demand	Population	5 500	27 500
	Estimated water demand per capita (litres/day)	50	
	Total net water demand (litres/day)	275 000	1 375 000
	Water distribution losses (%)	30%	15%
	Total gross water demand (litres/day)	357 500	1 581 250
Fresh water supply	Sustainable yield from ground water (litres/day)	1 810 000	1 569 869
	Households with rain water tanks (%)	1.3%	10%
	Rain water supply per household (litres/day)	5	
	Total rain water supply (litres/day)	358	13 750
	Gross fresh water supply gap or *surplus* (litres/day)	+1 452 947	+5 806

Source: GoK, "KIER," 2016.

Because donor funding has been secured for PV RO projects on South Tarawa and RO plants are not needed on Kiritimati Island, the National Task Force and MDBs agreed to exclude this technology from Kiribati's SREP program.

B.2 Biofuel for Power Generation

Coconut palms, from which crude coconut oil (CNO) is made, are abundant in Kiribati. About 70 to 80 per cent of the country's land area is covered by coconut palms, 190 km^2 on the Gilbert Islands, and 330 km^2 on the Line and Phoenix Islands (especially on Kiritimati Island).[77]

Kiribati has been producing CNO since 2001, but production is limited to about 20 per cent of total copra production due to processing capacity constraints. The Kiribati Copra Mill Company produces 15 to 20 tonnes of CNO per day and 10 tonnes of dry copra cake. The technical potential for CNO production is much higher; considering the historic variations in annual copra production, Kiribati has the potential to produce between 3 to 7 million litres of CNO, which can offset up between 40-90 per cent of diesel consumption for power generation in South Tarawa and 50-126 per cent on

[77] International Renewable Energy Agency, "Kiribati Renewables Readiness Assessment 2012", 2013

Kiritimati Island. Appendix Table B.3 compares the historic production of copra production on South Tarawa and Kiritimati and the potential for CNO production.

Appendix Table B.3: Potential of CNO Production

Location	Historic copra production 2003-2012 (tons / year)		CNO potential (litres of diesel equivalent / year)	Reduction of annual diesel usage for electricity generation
South Tarawa	min.	5 000	2 500 000	40%
	max	11 500	5 750 000	91%
Kiritimati	min.	1 000	500 000	50%
	max	2 500	1 250 000	126%

Source: GoK, "KIER," 2016.

However, before scaling-up CNO production an in-depth study of the impacts on traditional uses of coconut palm products (for cooking, food, building materials, and export), establishing a CNO-based production supply chain, and additional tests on fuel blending need to be conducted. In addition, the economic and financial viability of CNO production will be contingent on cost reflective prices of raw copra. Currently, raw copra is highly subsidised by the GoK, which guarantees a minimum price for raw copra from the outer islands. For these reasons, the National Task Force and MDBs did not put forward refined CNO for power generation for consideration in the SREP program.

B.3 Solar PV for Marine Transportation

There is some potential for solar powered electric drives for small scale marine transportation, such as interisland transport in Kiribati. According to the KIER, the GoK plans to conduct a pilot study to test the use of RE powered catamarans for interisland transportation and deploy the technology if a successful design configuration is found. Funding has not yet been secured for such a project. The use of solar PV for interisland transportation can have positive socioeconomic impacts beyond the populations living on South Tarawa and Kiritimati Island, including but not limited to increased access to markets for the population living on the outer islands and changes to internal migration patterns. Appendix Table B.4 shows a potential configuration for interisland catamarans using solar PV and battery.

Appendix Table B.4: Potential for Solar PV and Battery Powered Interisland Marine Transportation

Motor options	Dual, industrial-grade
Max power input (kW)	2 x 25
Equivalent gasoline outboard propulsion power (HP)	2 x 40
Battery options	2 x 345 V 12.8 kWh (long life Li-Ion)
Usable battery capacity (kWh)	25.6
Range (nm) @ 5 knots	40
Range (nm) @ 20 knots	18
Ideal PV size for 5h/day daytime cruising at five knots (kWp)	6

Note: Nautical miles (nm)
Source: GoK, "KIER," 2016.

Solar PV for marine transportation does not meet the GoK's priority criteria for RE technology selection such as increased power capacity and generation and access to energy, despite promising socioeconomic and environmental co-benefits and was therefore excluded from the SREP program.

B.4 Ocean Energy

Ocean energy, in the form of thermal and mechanical energy can be harnessed for electricity generation. Ocean thermal energy comes from the sun's heat. Ocean mechanical energy comes from the gravitational pull of the Moon or from waves, which are created by wind. tidal and wave technologies are more intermittent than ocean thermal technologies. There are currently no resource potential estimates of ocean thermal or mechanical energy for Kiribati. Ocean energy technologies are highly location specific and have not yet been deployed on a large scale. Ocean energy technologies, except for tidal energy, are rarely cost competitive compared to other RE technologies, are still new, and face technical implementation challenges. According to KIER, there are plans to deploy a 1MW (gross capacity) offshore power plant that uses ocean thermal energy conversion off the coast of South Tarawa. The plant will be located six kilometres offshore from South Tarawa and use deep and cold ocean water to drive a fluid cycle that powers an electric generator. The plant will be able to provide base load generation of400 kW, transmitted through an undersea cable. The project is funded by the Ministry of Oceans and Fisheries of the Republic Korea and will come online in 2020. Appendix Table B.5 shows the RE potential of the proposed ocean thermal energy conversion plant.

Appendix Table B.5: Capacity and Generation Potential of the Ocean Thermal Energy Conversion Plant

Gross capacity (MW)	Generation capacity (MW)	Capacity factor	Annual Operation (hours)	Annual generation (MWh)
1	0.6	80%	7 008	4 205

Source: GoK, "KIER," 2016.

Since the proposed project has already secured funding, and other ocean technologies unlikely to be cost competitive relative to other RE technologies, we recommend excluding ocean technology from the Investment Plan.

B.5 Micro Solar Technologies

The following micro solar technologies are excluded from the Kiribati SREP program:

- **Solar home systems (SHS).** A SHS is a combined solar panel and battery unit that provides a small amount of electricity for daily lighting and cooking needs. They are ideal for residences that do not have accessibility to a gridded electrical system. Power is generally available through this system for a few hours per day. A successful SHS will include a well-positioned solar panel and will be used with high efficiency appliances.

  There has been support from several donors such as the Japanese International Cooperation Agency and the European Union, to introduce SHS to communities in Kiribati. The deployment of SHS has almost exclusively been in rural communities in the outer islands since populations on South Tarawa and Kiritimati have access to grid electricity or microgrids. For this reason, and because SHS is typically not cost competitive relative to other RE technologies, it is excluded from the SREP program.

- **Solar water heating.** Kiribati has limited experience with solar water heating because demand for heated water is low. In addition, it is difficult to maintain solar water heaters that use solar collector tubes due to the hardness of atoll water, which results in the accumulation of mineral deposits. Alternative technologies that use vacuum tubes may be more appropriate for Kiribati's environment. Because demand for heated water is low and maintenance is challenging due to accumulated mineral deposits, solar water heaters are excluded from the SREP program.

- **Solar water pumping.** The GoK has some experience with solar water pumping systems. In the past, the United Nations Development Program installed several pumps in villages in schools. There has however, been challenges associated with the long-term maintenance of solar water pumps. Solar water pumps from early projects have stopped working due to the accumulation of coral dust lack of maintenance and are only in recent years being rehabilitated by the Public Works Department. Since water lens are high on the atolls, scaling-up solar water pumping is limited. Therefore, this technology from the Investment Plan.

Appendix C: Status of Kiribati's RE Policy Framework

Appendix Table C.1: RE Policy Framework Status

Policy Document	Year Adopted	Status/Steps taken by GoK
Kiribati National Energy Policy (KNEP)	2009	▪ The KNEP 2009 calls for access to sustainable, reliable and affordable energy services ▪ The KNEP key policy areas are the guiding principles to the formulation of the KIER 2017 – 2025
Renewables Readiness Assessment (RRA)	2012	▪ The RRA set out RE and energy efficiency (EE) targets through the reduction uses of fossil fuels ▪ The targets were declared by the GoK during the 44^{th} Pacific Forum Leader's meeting in Majuro 2013 ▪ The targets are set and adopted goals of the KIER
Kiribati Development Plan 2016-2019	2016	▪ Infrastructure is key priority area number six, and energy is one of the components in this priority area ▪ The Ministry Operation Plan (MOP) aligned to the KDP 2016-2019 goal: 'T*o improve access to quality climate change resilient infrastructure in urban and rural areas'*
Kiribati Integrated Energy Roadmap (KIER) 2017 – 2025	2017	▪ The KIER is used as an implementation plan to the Kiribati National Energy Policy completed in 2009 ▪ The KIER presents a package plan of institutional, policy, regulatory, technical, financial and capacity building actions that will enable the GoK to achieve its energy objectives, in line with the Kiribati Development Plan 2016-2019 ▪ This SREP IP aims to implement projects that will contribute significantly to RE penetration and fuel reduction targets set out in the KIER
Nationally Determined Contributions (NDC)	2015	▪ The reduction in carbon emission targets set out in the NDC aligned to Kiribati energy targets and goals. ▪ The KIER is also used as an implantation plan to achieve NDC goals

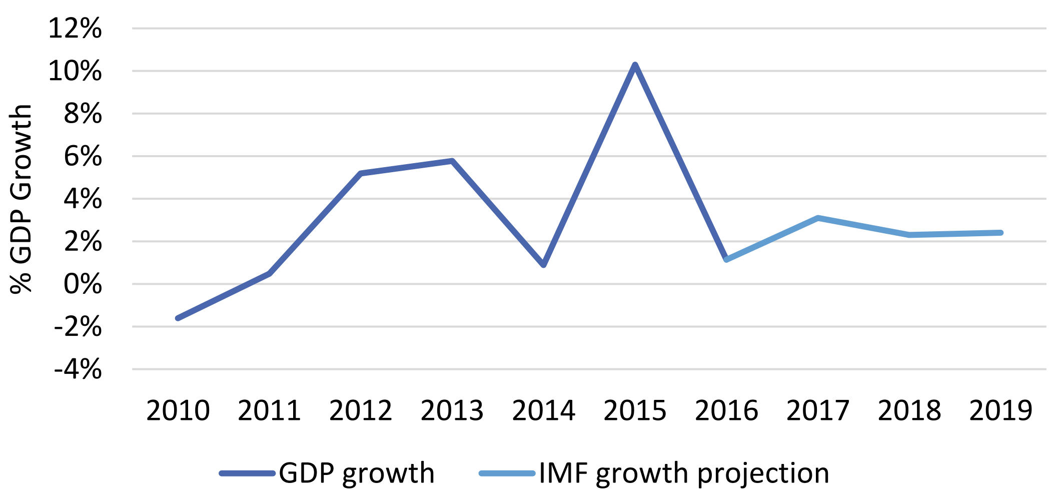
Appendix D: Assessment of Kiribati's Absorptive Capacity

This appendix contains an assessment of Kiribati's ability to absorb the financing envisioned as part of the IP. It describes the macroeconomic, debt sustainability, and institutional dimensions of the country's absorptive capacity.

D.1 Macroeconomic Outlook

In 2015, Kiribati's GDP growth spiked to 10.3 per cent, but then declined to just 1.1 per cent in 2016 due to the completion of a major road project in Tarawa and a decline in fishing revenue.[78] The International Monetary Fund (IMF) projected increased growth of about 3 per cent in 2017, driven by construction and wholesale retail trade. Fishing revenues, which represented 80 per cent of GDP in 2014-2016, are expected to remain robust in the medium-term. In addition, there are several donor-financed infrastructure projects in the pipeline, which can bolster medium-term growth. Long-term growth could potentially be sustained by upcoming investments in telecommunication, transportation, and outer island development. Appendix Figure D.1 shows Kiribati's GDP growth since 2010 and IMF projections to 2019.

Appendix Figure D.1: GDP Growth and IMF Projections, 2010-2019



Sources: World Bank Development Indicators; IMF, "Kiribati 2017 Article IV Consultation-Press Release; and Staff Report," Report No. 17/386, December 2017.

Kiribati faces several economic challenges and risks.[79] About a fifth of the population lives below the basic needs poverty line. Job opportunities are limited by the narrow business climate (dominated almost entirely by fisheries and copra production) and weak financial intermediation. Dependence on fishing licences as a major component of GDP is also a risk for economic stability, given fishing volume variability with weather conditions. A change in the current favourable climate could create large

[78] IMF, "Kiribati 2017 Article IV Consultation-Press Release; and Staff Report," Report No. 17/386, December 2017.

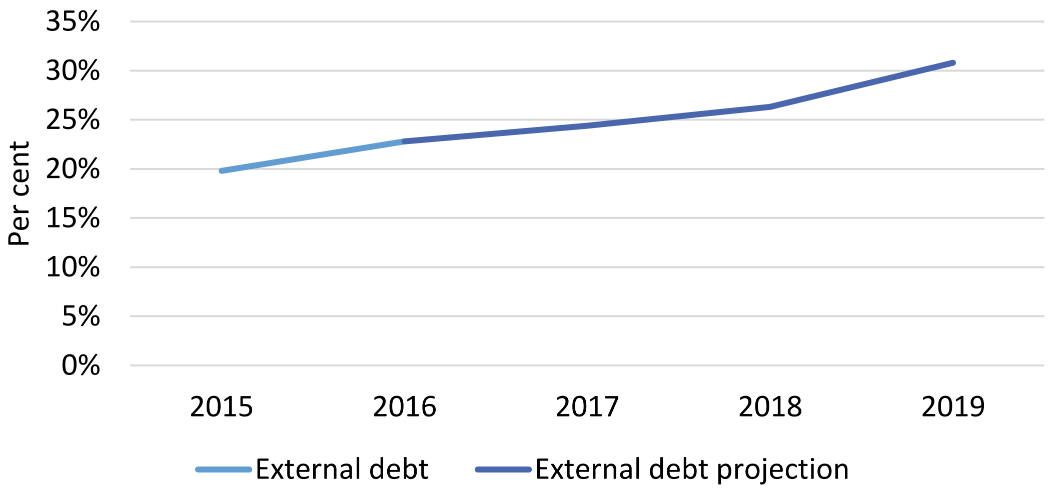
[79] IMF, "Kiribati 2017 Article IV Consultation-Press Release; and Staff Report," Report No. 17/386, December 2017.

revenue uncertainties. Commodity price shocks and exchange rate volatility are also risks, given that Kiribati relies heavily on imports.

D.2 Debt Sustainability

The IMF projects Kiribati's debt-to-GDP ratio to steadily increase from 22.8 per cent in 2016 to 30.8 per cent in 2019, as shown in Appendix Figure D.2.

Appendix Figure D.2: Kiribati's Debt-to-GDP Ratio and IMF Projections, 2015-2019



Source: IMF, "Kiribati 2017 Article IV Consultation-Press Release; and Staff Report," Report No. 17/386, December 2017.

Kiribati has a high-risk of debt distress, with limited scope for external borrowing.[80] Fiscal surpluses have historically been attributed to robust fishing licence fees, but the possible reduction of this revenue stream presents a major risk, necessitating strong fiscal commitment. Kiribati faces many serious threats resulting from climate change, and necessary capital projects to mitigate these effects require the fiscal support of development partners. Continued support from development partners will also be needed to finance development investments, which are important to closing the large infrastructure gap and reducing reliance on imports in the long-term.

[80] IMF, "Kiribati 2017 Article IV Consultation-Press Release; and Staff Report," Report No. 17/386, December 2017.

Appendix E: Stakeholder Consultations

The Kiribati SREP IP is the result of a consultative process, led by the GoK and represented by MISE and MFED to identify priority RE technologies for development in Kiribati. The consultations included government agencies, representatives from civil society, and international development partners (EU, the Australian High Commission, and the New Zealand High Commission). There were two consultations over the course of the IP's preparation. A Kick-off Mission, conducted in February was used to discuss the overall strategic approach of the IP with Government and energy sector stakeholders, commence data collection, understand Government's strategic priorities and challenges facing the energy sector, and identify a short list of RE technologies to be considered in the Investment Plan. An Options Study (OS) presentation was prepared and presented to the National Task Force, MFAT, the Australian High Commission, and World Bank during the mission's wrap up meeting and circulated to other MDBs (EU and ADB) for review because of the compressed timeline for preparing the Investment Plan.[81] The OS laid out the energy sector background, the assessment of the potential of various RE technologies in Kiribati as well as the main barriers to their development. Based on comments received on the OS, a draft IP was developed and distributed in March 2018 for comments and discussion with the main stakeholders. In June 2018, a Joint Mission was conducted to verify the correctness of the overall approach, identify priority projects and to gather additional materials needed for updating and finalising the draft IP. During the Joint Mission, discussions were conducted with MISE, PUB, and international development partners (EU, the Australian High Commission, and the New Zealand High Commission) to ensure that the technology and models proposed in the draft IP were coherent and complementary with ongoing activities in Kiribati in terms of RE development. The subsections below briefly describe the key findings and discussions from each consultation.

E.1 Kick-off Mission

The Consultant and World Bank teams participated in the Kick-off Mission from February 18 to February 26, 2018 to start the preparation of the SREP. The overall goal the Kick-off Mission was to gather the necessary information and feedback from GoK to prepare a draft Investment Plan. The specific objectives and outcomes of the Kick-off Mission are summarised in Appendix Table E.1.

Appendix Table E.1: Summary of Key Objectives and Outcomes of the Kick-off Mission

Objective	Outcome
Present to GoK initial list of technically feasible RE options for consideration in the SREP Investment Plan	The National Task Force (NTF) asked the Consultant to focus solely on-grid connected investments (solar PV and wind with battery storage) except for microgrids for North Tarawa, and solar street lights as potential load shifting options.

[81] The National Task Force members include: MFED, MISE, Kiribati Solar Energy Company, PUB, and the Ministry of Line and Phoenix.

Provide overview of SREP program, technology selection criteria, and identify other national criteria that should be considered in prioritising technologies for inclusion in Kiribati's SREP program	The Consultant conducted two consultation sessions with the NTF and met individually with key energy stakeholders during the Kick-off Mission to provide an overview of the SREP program, explain selection criteria SREP uses to prioritise investments, and identify national criteria for inclusion in the technology prioritisation exercise for Kiribati's SREP Investment Plan. The NTF reiterated the importance of reducing Kiribati's reliance on imported diesel for power generation to improve the country's energy security. Energy security is included as a national criterion for the preparation of Kiribati's SREP Investment Plan.
Obtain a comprehensive understanding of ongoing and proposed RE projects including financing status and gaps	The Consultant met with MISE, MFED, New Zealand's MFAT, PUB, KSEC, and World Bank and ADB representatives during the Kick-off Mission to understand ongoing and proposed RE projects in Kiribati. The Consultant corresponded by email since they were not in-country at the time to obtain an understanding of the EUs portfolio and planned interventions for the future. The Consultant also conducted desk reviews of key energy sector publications to understand the broader context of Kiribati's needs in the energy sector.
Identify potential areas for technical assistance (legal, regulatory, technical, and capacity building) that is necessary to facilitate RE investment/uptake in Kiribati	Key energy stakeholders and NTF members identified key areas for technical assistance and capacity building for the energy sector. They include technical assistance to complete the RE regulatory framework, support the development of PPA contracts and procurement templates, and support enacting the draft electricity act and technical standards. The NTF also requested that capacity building is provided for MISE, PUB, and KSEC staff to procure, manage, and maintain solar PV investments.
Establish roles and responsibilities of the Consultant Team, MDBs, and Government counterpart (NTF) to ensure the delivery of a final Investment Plan to the SREP Subcommittee in time	The Consultant team, NTF members, and MFED agreed on a timeline and established responsibilities of each party to ensure that the Investment Plan prepared for Kiribati is of high-quality on completed on time for SREP Subcommittee meetings. MISE and PUB identified key representatives that would keep in contact with the Consultants throughout the preparation of the Investment Plan. MFED agreed to take

	responsibility for identifying the timeline and approval process required to obtain GoK consent of the SREP Investment Plan.

Appendix Table E.2 shows the Kick-off Mission's record of attendance.

Appendix Table E.2: Stakeholders met during the Kick-off Mission

Date	Name	Designation	Organisation
Introductory Meetings with MFED			
19 Feb	Ms. Saitofi Mika	Secretary	MFED
	Mr James Webb	Director	National Economic Planning Office (NEPO), MFED
	Mr Jonathan Mitchell	Director	Climate Finance, MFED
	Ms. Tebantaake Keariki	Deputy Secretary	MFED
	Ms. Ioanna Mokeaki	Senior Economist	NEPO, MFED
Introductory Meetings with MISE			
19 Feb	Mr Tioti Taaitee	Deputy Secretary	MISE
	Mr Kireua B. Kaiea	Energy Planner	MISE
	Mr Miriam Tikana	Energy Economist	MISE
	Mr Mwaati Oten	Conventional Energy Planner	MISE
Introductory Meeting with Taskforce			
20 Feb	Mr Jonathan Mitchell	Director	Climate Finance Division, MFED
	Mr James Webb	Director	NEPO, MFED
	Mr Kireua B. Kaiea	Energy Planner	MISE
	Mr Tiaon Aukitino	Solar Project Manager	PUB
	Mr Tavita Airam	CEO	KSEC
	Mr Rooti Terubea	Communications Officer	Climate Finance Division, MFED
	Ms. Taati Mamara	Finance Officer	Climate Finance Division, MFED
	Ms. Ueaniti Kiritimati	Assistant Energy Economist	MISE
Meeting with PUB			
20 Feb	Mr Wayne Brearley	CEO	PUB
	Mr Tiaon Aukitino	Solar Project Manager	PUB

Meeting with Kiribati Solar Energy Company (KSEC)			
20 Feb	Mr Tavita Airam	CEO	KSEC
Meeting with Ministry of Health & Medical Services			
21 Feb	Ms. Tiene Tooki	Secretary	MHMS
Meeting with Ministry of Environment, Lands & Agriculture Development			
21 Feb	Ms. Marii Marae	Senior Biodiversity Environment Officer	Environment & Conservation Division, MELAD
	Ms. Eritina Benete	Climate Change Planning Officer	Environment & Conservation Division, MELAD
Meeting with Board of Kiribati Association of Nongovernmental Organisations (KANGO)			
21 Feb	Mr Martin Tofinga	Vice-President	KANGO
	Mr Mataiti Bwebwe	Treasurer	KANGO
	Ms. Bairenga Kirabuke	Board Member	KANGO
	Mr Tanua Pine	Board Member	KANGO
Meeting with MLPID			
21 Feb	Ms. Teeao Timeon	Assistant Secretary	MLPID
Meeting with New Zealand High Commission			
22 Feb	Ms. Meria Russell	Senior Program Officer	NZHC
Taskforce Workshop			
22 Feb	Mr Kireua B. Kaiea	Energy Planner	MISE
	Mr Tavita Airam	CEO	KSEC
	Mr Tiaon Aukitino	Solar Project Manager	PUB
	Mr Rooti Terubea	Communications Officer	Climate Finance Division, MFED
	Ms. Ueaniti Kiritimati	Assistant Energy Economist	MISE
	Ms. Taati Mamara	Finance Officer	Climate Finance Division, MFED
	Ms. Teeao Timeon	Assistant Secretary	MLPID
Meeting with Kiribati Coconut Development Ltd			
22 Feb	Mr Paul Tekanene	CEO	KCDL
	Mr Enari Arioka	Operations Manager	KCDL
Wrap Up Meeting (Presentation of RE OS)			
23 Feb	Mr Jonathan Mitchell	Director	Climate Finance Division, MFED

	Mr Kireua B. Kaiea	Energy Planner	MISE
	Mr Tavita Airam	CEO	KSEC
	Mr Tiaon Aukitino	Solar Project Mgr	PUB
	Mr Rooti Terubea	Communications Officer	Climate Finance Division, MFED
	Ms. Ueaniti Kiritimati	Assistant Energy Economist	MISE
	Ms. Taati Mamara	Finance Officer	Climate Finance Division, MFED
	Ms. Meria Russell	Senior Program Officer	New Zealand High Commission
	Ms. Nuntaake Tokamauea	Program Officer	Australian High Commission

E.2 Joint Mission

The Consultant, World Bank and ADB teams participated in the Joint Mission from June 18 to June 21, 2018 to obtain feedback and discuss next steps to finalise the SREP Investment Plan. The specific objectives and outcomes identified during the Joint Mission are summarised in Appendix Table E.3 below.

Appendix Table E.3: Summary of Key Objectives and Outcomes of the Joint Mission

Objective	Outcome
Update NTF and other stakeholders on changes to the IP since the previous mission	The NTF requested a formal update from the Consultant team and MDBs on updates to the OS that were reflected in the draft SREP IP – specifically the exclusion of Kiritimati Island from the SREP program proposed. The Consultant presented results of the draft IP and explained that Kiritimati Island was excluded because there is currently excess diesel and solar PV capacity and that future growth in demand is uncertain. Nevertheless, the NTF expressed that the socioeconomic development of Kiritimati Island is a current policy priority to the GoK. The Consultants and NTF agreed to include distribution investments and a demand study in the Final SREP IP.
Identify and obtain commitment from GoK, MDBs, and other donors on an SREP investment program for Kiribati	ADB stepped forward as the lead MDB sponsor for Kiribati's SREP Investment Plan. ADB has an indicative envelope of USD 5 million in grant financing. The EU recently received an allocation of EUR 20 million to support Kiritimati's water and energy sector at part of EDF 11. The EU will be able to

	contribute EUR 9 million to the energy sector in general budgetary support, technical assistance, and RE investments.
Review and agree on timeline for finalisation of SREP IP	The Consultants, NTF, and MDBs agreed that the draft SREP IP will be finalised and submitted for public review and submission to the SREP Subcommittee at their November 2018 meeting.

During the mission, it also became apparent that for the GoK to achieve its KIER and NDC targets alternative financing approaches such as potential private sector involvement had to be considered. The NTF an MDBs requested that the Consultant prepare a memo that outlines (1) the amount of investment required to achieve KIER and NDC targets; (2) the amount of solar PV and battery storage capacity that secured through grant funding only; and (3) the key advantages and disadvantages of private sector involvement in the sector. The memo would be used to secure a decision from Cabinet about the business model that should be proposed in Kiribati's SREP program.

Appendix Table E.4 shows the list of stakeholders consulted during the Joint Mission. The Consultant separately contacted EU after the mission to discuss the available financing for Kiritimati Island.

Appendix Table E.4: Stakeholders Consulted During Joint Mission

Name	Designation	Organisation
Mr Jonathan Mitchell	Director	Climate Finance Unit & Focal Point, Ministry of Finance and Economic Development
Mr Rooti Terubea	Communications Officer	Ministry of Finance and Economic Development
Mr Lindsay Davison	Director of Engineering Services	Ministry of Sustainable Energy
Mr Kireua B Kaiea	Energy Planner	Ministry of Sustainable Energy
Ms. Ueaniti Kiritimati	Assistant Energy Economist	Ministry of Sustainable Energy
Mr Wayne Brearley	Chief Executive Officer	PUB
Mr Tiaon Aukitino	Project Manager, WB Solar PV Project	PUB
Mr Tavita Airam	Chief Executive Officer	KSEC
Mr Kianteata Teebo	Representative	European Union
Mr Thomas Roth	Deputy High Commissioner	High Commission of Australia
Ms. Nuntaake Tokamauea	Program Manager, Economic Growth & Infrastructure	High Commission of Australia

Mr Michael Upton	High Commissioner	High Commission of New Zealand
Mr Ross Craven	Urban Development Coordinator	High Commission of New Zealand
Ms. Meria Russell	Senior Development Program Coordinator	High Commission of New Zealand

Appendix F: Co-Benefits

This section focuses specifically on the co-benefits tracked under SREP's Revised Results Framework (as of June 1, 2012). Appendix Table F.1 lists the co-benefits considered under SREP's Revised Results Framework and describes how those co-benefits will be achieved in Kiribati.

Appendix Table F.1: Co-Benefits Associated with SREP Impacts and Outcomes

SREP Transformative Impact		
Results	**Co-benefits**	**Description**
Support low-carbon development pathways by increasing energy security.	Avoided GHG emissions	▪ The technologies supported in Kiribati's SREP Investment Plan will avoid GHG emissions, which is in line with the GoK's and other international efforts to mitigate the effects of climate change ▪ Electricity generated from SREP supported projects will avoid up to 5 500 tons CO2eq per year, based on the proxy-based method established by the SREP Subcommittee[82]
	Employment opportunities	▪ SREP supported programs proposed will have capacity building components that will: provide on-the-job training to: (1.) MISE staff to procure and manage RE projects; (2.) PUB staff to operate and maintain centralised battery storage capacity and the network at higher levels of RE penetration; and (3.) utility staff on Kiritimati Island on data collection, operations, and maintenance of recently commissioned network investments. ▪ A policy of gender mainstreaming will be implemented in the capacity building components of the SREP projects to increase employment opportunities for women in the energy sector.
SREP Outcomes		
Results	**Co-benefits**	**Description**
Increased access to clean energy **Increased supply of RE** **New and additional resources for renewable energy projects/programs**	Increased reliability	▪ The inclusion of battery storage in Kiribati's SREP Investment Plan will result in increased grid reliability as intermittent solar generation capacity is added to the network. ▪ Increasing the use of indigenous energy resources reduces Kiribati's reliance on the fossil fuel import supply chain that can be

[82] SREP, *"Decision on Agenda Item 4, Follow-up to SREP Revised Results Framework"*, 2012.

		disrupted and result in rationing/rolling black outs.
	Reduced costs of RE	▪ The levelised cost of solar PV and battery storage investments are cost competitive with the fuel and O&M cost of running existing diesel generators. ▪ SREP and MDB funding for battery storage makes the cost of scaling-up RE generation more affordable for the GoK and I-Kiribati

Appendix G: Comments from the Independent Technical Reviewer

Comment from Independent Reviewer	Response
1. The IP describes all policy documents adopted earlier by GoK. It would be interesting to learn how effective was the implementation of those documents. If there is successful application of the policy, it would be good to have short description as an annex or supplemental document to confirm the commitment of the GOK for further reforms.	The GoK has put together a table (see Appendix C) that explains how each policy document is related. In many ways, the KIER and NDC targets that the SREP program has been designed around build on the objectives laid out in previous policy documents. We have included some language in the policy section of the IP (see pg. 17) to explain this and provided a list of accomplishments the GoK has achieved through donor projects that have contributed to many of the policy objectives.
2. It is recommended to identify institutional arrangements for projects preparation and implementation. A designated institution should be identified at early stages of preparation of the projects to gain knowledge and experience benefitting from the consultants to be hired. Given the lack of capacity as mentioned in the IP, the MDB administration may be preferable option, nevertheless it is recommended to specify if the MDB will administrate the project and clearly segregate roles and responsibilities of the MDB and the GoK.	ADB will administer the project but will work with both PUB and MISE on implementation. MISE would be the point of contact for the RE framework component while PUB would work with ADB on the RE integration study and investment components.
3. Use of SREP funding for improvement of the legislative framework is welcomed. Although the GoK has adopted strategy-level documents for development of the RE in the country the legal-regulatory framework is not supporting implementation of those higher-level commitments. It is recommended to attach a timeline agreed with the government regarding adoption of the legal-regulatory documents that will enhance enabling environment for RE investments. It is recommended also to include an indicator in the result framework to track the adoption of the documents developed under the SREP. It is important because of the design of the SREP IP activities, i.e. increased generation is not directly linked to the	The SREP funded phase I portion of the GoK's two-phase solar investment plans in South Tarawa is envisioned to be complete by 2023. As part of this phase, the GoK with the support of ADB, would adopt the necessary framework to enable a move to the private sector investment phase-two stage. Thus, in general the goal is to have the legal-regulatory framework in place by 2023. A specific timeline for each of the components that will make up this framework will be developed through the project preparation phase. As requested, we have included in the results framework targets for adoption of: ▪ An Energy Act ▪ RE Technical Standards ▪ Grid code

enabling environment since it is a result of public investments.	▪ Model PPA. We would like to note that one possible reason for the lack of movement to implement a RE regulatory framework is that there has not yet been an established plan for private sector investment. Absent any concrete plans for private sector investment there has not been a major impetus to drive the GoK to implement a regulatory framework. The two-phase program committed to in the IP document is now such an impetus.
4. At the project preparation stage it is recommended to examine the situation with the previous off-grid installations to identify the reasons of failure and minimize the potential risks by planning respective actions and measures.	As part of the project preparation stage there will indeed be consideration of any issues encountered during past donor projects. It is important to note, however, that the off-grid projects that experienced problems in the past were on the outer islands. Much of the issues with these projects can be attributed to the extreme remoteness of the project location. South Tarawa, while still remote, has greater accessibility and more technical capacity available than in the outer islands.
5. The current economic analysis shows LCOE for ground-mounted solar PV as the cheapest option, following with wind and then roof-top solar, however given the cost difference between the ground-mounted and roof-top solar looks significant given that the solar resource is considered as the same. Since the IP does not envisage investments in roof-top solar PV, this observation is not critical, but clarifications will be helpful.	Given that much of the rooftops on the houses in Kiribati would not be able to support a rooftop system the focus of the technical assessment was on potential government and commercial sites. For these sites, it was assumed that should these businesses or agencies wish to self-supply then these would be behind-the-meter (BTM) configuration with multiple hours of battery backup. The additional battery capacity and components needed for BTM used in the rooftop configurations accounts for much of the higher costs. Part of the reason for this assumption was that previous projects have already used many of the best rooftop sites. For this reason, it was decided that there would need to be some strategic goal for rooftop solar other than site resource potential. There are sites, like the copra production facility, that could benefit from the security and reliability of a BTM system with battery.
6. It is recommended to install meters and introduce billing system at least for connections of the new 350 households to ensure adequate collection rate and	Yes. Any additional connections will include metering. The 350 households identified as being targeted for service connections in the IP are in Kiritimati. As part of the KISEP

sustainability of operation. Please clarify if it is envisaged.	project, funded by the EU, prepayment meters have been installed at all existing residential customers on Kiritimati atoll. These same prepayment meters would be used for any new connections.
7. It is recommended also to include as an indicator the total volume of increased investments in RE to track the leverage and transformative impact.	In addition to the financing leveraged through SREP-funded investments we have added a target to achieve $50 million in investment by 2030. The timeline of this target was extended outside the 2025 timing of the other targets in recognition of the reality that building up to this level of investment is a long-term goal and will be achieved well outside the SREP program timeframe.
8. Although the IP does not contain clean cooking component/investments, the extension of more affordable solar PV and increased access to the grid will definitely result in switching to electricity for cooking purposes. It would be interesting to assess transformational impact of the project through introduction of monitoring indicators for cooking. The IP contains sufficient baseline information and analysis of the cooking options in Kiribati.	Thank you for the suggestion, but we have decided to not add an electric cookstove target. We are concerned that including any target for electric cookstoves would be speculative, and most likely unrealistic. The opinion of most stakeholders consulted on the possibility of including electric cookstoves in the IP is that the majority of I-Kiribati would not use an electric stove. Even with near universal electricity access in South Tarawa most families who have moved away from traditional open fire cooking have switched to flame-based LPG over electric. In the 2016 HH survey, only 3 per cent of households surveyed had an electric cooking device and then almost half of these households reported that they seldom use the device.
9. The IP analysis contains scenario with EE measures and without it (for the street lighting installations). It shows significant difference. It is recommended to specify in the result framework the scenario based on which the target indicators are set.	Target indicators in the results framework use the baseline scenario without EE. We have added a footnote to the indicators table to identify that the RE fraction target assumes this demand scenario. The next comment further explains how this target was determined.
10. The IP contains very detailed analysis of expected demographic growth, including migration, fertility, opening of the new business, however it is not clear if the target values are set for baseline or forecasted population size. Please clarify the electricity demand rate used in the result framework.	We assume this comment is in relation to the RE output as a per cent of total load target to achieve 25 per cent by 2025. First, it was not clear in the version that was sent that the baseline and target are specifically for South Tarawa. This has been fixed. To provide a complete response we'll first explain how these baseline and target values were determined.

	The baseline (2017) of nine per cent is based on 26.4 GWh total electricity supplied and 2.38 GWh generated from solar PV. The 25 per cent RE by 2025 target assumes that demand will grow by 68 per cent to 44.6 GWh such that 11.5 GWH in RE will be needed to achieve the target. Th demand projection is the baseline scenario shown in Figure 3.6. This forecast assumes the addition of a new hotel in Betio and the water treatment plant as new load plus an annual growth rate of three per cent to account for higher use per household and migration to South Tarawa. Thus, due to the projected increase in demand, RE generation will need to be almost 5 GWh higher to achieve the target than if demand remained at 2017 levels.
11. These days tenders for utility-scale solar power plant investments are very popular and effective to reach low tariffs. The IP considers support in preparation of transaction documents, capacity building of public employees to conduct such tenders and attract private investors. This approach makes possible to regulate all gaps and issues through the contract with the government. Nevertheless, taking into account the small size of the country and the market, the international tender may not attract foreign investors and will take more time and resources to organize than local tenders with simplified procedures. At the same time it is recommended to consider during the project preparation stage an introduction of the fixed tariff system and other simple and transparent incentives to quick start the private investments and financial market participation in the sector.	Agreed, private sector interest may be a challenge for a country/sector of this size. Given that all Pacific Island countries both share this barrier and have similar resource potential one possibility discussed during this project is to develop a joint initiative or regional facility that would enable the development of regional private operators. The phase II plan for South Tarawa does attempt to address the “interest” barrier by separating investment in solar from the battery capacity needed to integrate higher levels of intermittent power into the grid. The thinking is that given the difference in maturity between solar and battery technologies, a purely solar project will be viewed as being lower risk than a solar and battery project. With all that said, as the RE regulatory framework is prepared there will be careful consideration of what makes the most sense for Kiribati at that time. Should the private solar market expand in the Pacific Island countries over the next 2-3 years then an open tender may in fact be quite realistic.
12. The IP presents the extensive stakeholder consultation and participatory process held for preparation of the SREP IP. It is highly recommended to continue that process, particularly, multi-stakeholder task force participation in project preparation and implementation stages	Agreed, the incorporation of input from multiple stakeholders did indeed benefit the IP. As part of the implementation of RE regulatory framework and solar/battery investment components there would continue to be interaction with these same stakeholder groups. For example, ADB

to foster regulatory improvement and capacity building activities.	anticipates including a communication or public outreach in its terms of reference (ToR) for the consultant it hires to support the RE regulatory framework component.

Appendix H: Preparation Grant and MDB Payment Requests

Appendix Table H.1: SREP Project Preparation Grant Request (On-Grid RE Technologies)

SREP INVESTMENT PROGRAM Project Preparation Grant Request			
1. Country/Region:	Kiribati/Pacific	**2. CIF Project ID#:**	
3. Project Title:	South Tarawa Renewable Energy Project		
4. Tentative SREP Funding Request (in US$ million total) for Project at the time of Investment Plan submission (concept stage):	**Grant:** $3.7 million	**Loan:**	
5. Preparation Grant Request (in US$):	$1.0 million	MDB: ADB	
6. National Project Focal Point:	Jonathan Mitchell, Director, Climate Finance Division, Ministry of Finance and Economic Development		
7. National Implementing Agency (project/program):	▪ MISE (RE Regulatory Framework) ▪ PUB (PV and Storage Project, RE Integration Study)		
8. MDB SREP Focal Point and Project/Program Task Team Leader (TTL):	Focal point: Christian Ellermann (cellermann@adb.org)	TTL: Cindy Tiangco (ctiangco@adb.org)	

Description of activities covered by the preparation grant:

Preparation grant funds will be used to strengthen Kiribati's legal and regulatory framework for RE, provide capacity building to key energy sector stakeholders (PUB, MISE, and MFED), and provide project preparation support in the form of grid integration and feasibility studies for solar PV and storage investments. The objective of the technical assistance will be to prepare for the utility-scale PV and battery system project and to ensure that Kiribati's enabling environment is conducive for future private sector participation in the renewable energy sector. The grant funds will specifically be used for the following two activities:

- **RE Technical Study**. Project preparation grant funds will be used to finance a Technical Study which will include (i) an RE integration study covering the impact of the proposed project, and other planned RE projects, on the combined operation of the existing system with the proposed projects, (ii) a feasibility study for an optimised project scope to ensure reliable and efficient operation of the grid-connected PV and battery combined system, (iii) the conduct of all required due diligence covering technical, financial, economic, social & environmental safeguards, social/gender assessments, and implementation arrangements to prepare the project for SREP and ADB approval, (iii) assistance to pre-implementation works including preparation of bidding documents and assistance in procuring the contractor(s).
- **RE Enabling Framework**. Grant funds will be used to procure legal and regulatory technical services that will support the development and adoption of a multicomponent renewable energy enabling framework to enable private sector transactions. The technical assistance project preparation grant will specifically support the GoK in: (i) drafting an Energy Act to regulate and incentivise the scaling-up of renewable energy and energy efficiency in all sectors; (ii) formulating technical standards on RE related electrical equipment, which follow New Zealand and Australian standards so that such standards can be enforced; (iii) drafting and updating grid codes to support the safe operation of the grid at high-levels of RE penetration; and (iv) preparing the request for proposals, PPA, and other procurement documents that will support the introduction of IPPs in Kiribati in the future.

9. Outputs: Policy Framework

Deliverable	Timeline
RE Enabling Framework (recommendations and draft legal documents)	2019-2020
RE Technical Study	2019-2020

10. Budget (indicative):

Expenditures[b]	**Amount (US$) –**
Consultants/technical assistance	750 000
Equipment (Provisional Sum for Site Investigations)	50,000
Workshops/seminars/trainings	15 000
Travel/transportation	130 000
Others (admin costs/operational costs)	5 000
Contingencies (max. 10%)	50,000
Total cost	$1.0 million
Other contributions:	

11. **Timeframe**: (For the project) SREP Subcommittee approval of PPG: February 2019 SREP Board approval: November 2019 ADB approval: March 2020
12. **Other partners involved in project design and implementation**[d]: To be determined during project preparation stage
13. **If applicable, explanation for why the grant is MDB executed:** The government has little to no experience in implementing utility scale solar and battery systems as well as energy sector regulations and in coordinating private sector transactions, while ADB has extensive experience working with consultants on these issues. Therefore, it is requested that ADB be permitted to administer the grants and implement the project.
14. **Implementation Arrangements** (including procurement of goods and services)**:** The recruitment of consultants will be conducted by ADB following its guidelines and government procurement of contractors will follow ADB Procurement Policy.

a. Including the preparation grant request

b. These expenditure categories may be adjusted during project preparation according to emerging needs

c. In some cases, activities will not require approval of the MDB Board

Other local, national, and international partners expected to be involved in project design and implementation.

Appendix Table H.2: MDB Request for Payment for Project Implementation Services

SCALING-UP RENEWABLE ENERGY PROGRAM IN LOW-INCOME COUNTRIES MDB Request for Payment of Implementation Services Costs			
1. Country/Region:	Kiribati / Pacific	**2. CIF Project ID#:**	(Trustee will assign ID)
3. Project Title:	South Tarawa Renewable Energy Project		
4. Request for project funding (US$ mill.):	*At time of country program submission (tentative):* US$ 3.7 million	*At time of project approval (tentative):* TBD	
5. Estimated costs for MDB project implementation services (US$ mill.):	*Initial estimate - at time of Country program submission:* US$428 000 *Final estimate - at time of project approval:*	*MDB:* ADB *Date:* March 2019	
6. Request for payment of MDB Implementation Services Costs (US$.mill.):	☑ First tranche: US$ US$ US$214 000 ☐ Second tranche:		
7. Project/ program financing category:	a - Investment financing - additional to ongoing MDB project □	☐	
	b- Investment financing - blended with proposed MDB project □	☒	
	c - Investment financing - stand-alone □	☐	
	d - Capacity building - stand-alone □	☐	
8. Expected project duration (no. of years):	3 years – March 2020-February 2023		
9. Explanation of final estimate of MDB costs for implementation services:	If final estimate in 5 above exceeds the relevant benchmark range, explain the exceptional circumstances and reasons: N/A		
10. Justification for proposed stand-alone financing in cases of above 6 c or d: N/A			