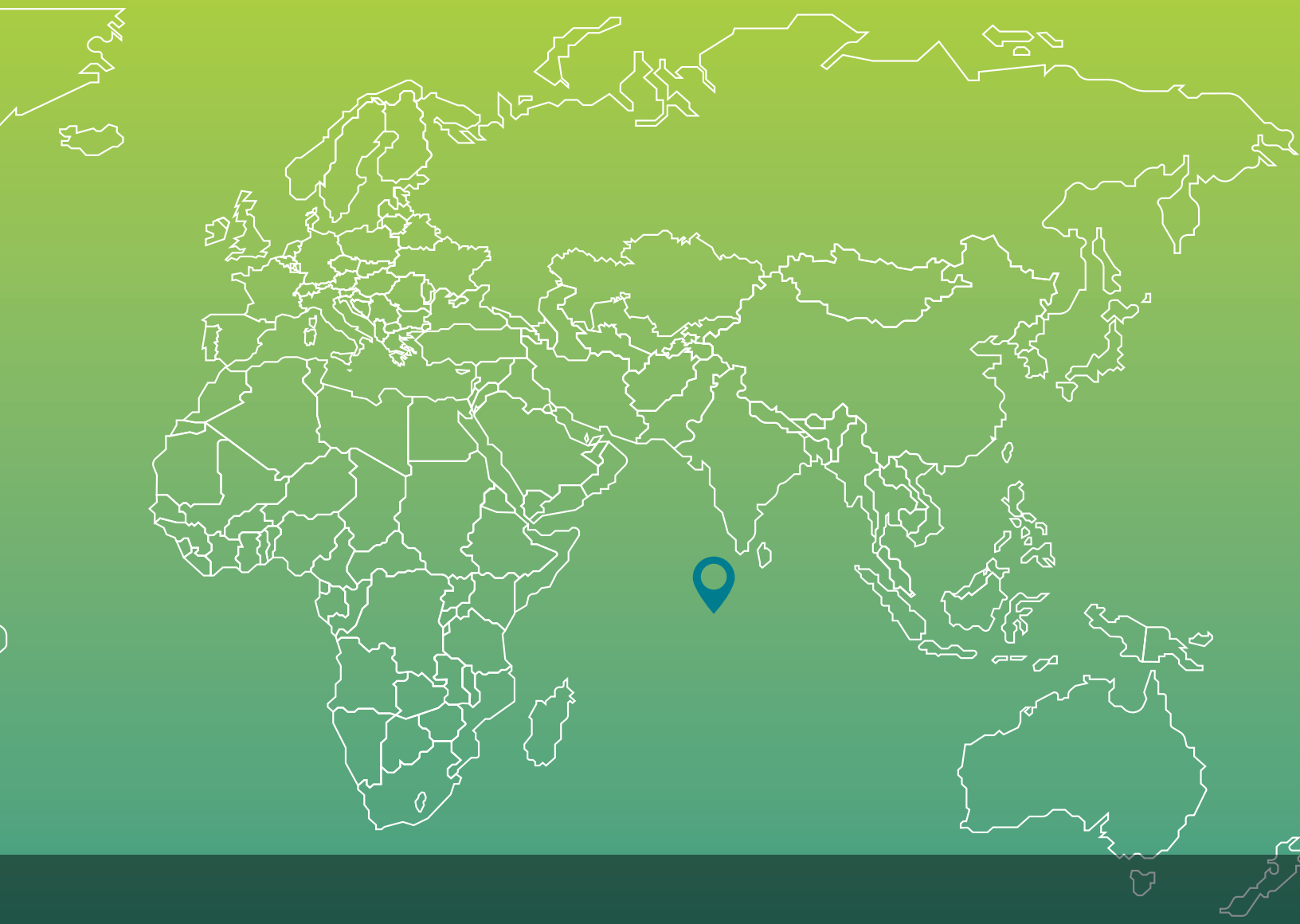
# Preparing Outer Island Sustainable Electricity Development Project (POISED)

CIF-GDI DELIVERY CHALLENGE CASE STUDY - DECEMBER 2019

CLIMATE INVESTMENT FUNDS



# PROJECT DATA

**PARTNER ORGANIZATION**
Ministry of Environment of the Maldives (MoEn)

**ORGANIZATION TYPE**
Government

**DELIVERY CHALLENGES**
- Reticence towards Renewable Energy
- Constraints in finance
- Limited capacity and knowledge

**DEVELOPMENT CHALLENGE**
- Overreliance on fossil fuels for power generation
- High electricity prices

**COUNTRY AND REGION**
Republic of Maldives, Asia

*Cover Photo: MoEn*

**PROJECT TOTAL COST**
$129 million (including $12 million from the Climate Investment Funds (CIF) under its Scaling Up Renewable Energy Program in Low Income Countries SREP)

**PROJECT DURATION**
2015-2020

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# CONTENT



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# EXECUTIVE SUMMARY

*Photo: MoEn*

Maldives is a small island developing state in the Indian Ocean. Its energy sector is heavily dependent on fossil fuel imports, costing the country 20 percent of its GDP in 2016 and making its national economy highly vulnerable to increases in global fuel prices. The cost of electricity is expensive, with rates at US$ 0.30-0.70 per kilowatt hour (kWh)[1], among the highest in South Asia.

This case study examines the Preparing Outer Islands for Sustainable Energy Development Project (POISED) and its pioneering efforts to bring solar photovoltaic (PV)-battery-diesel hybrid energy systems to key outer island locations of Maldives and improve the efficiency of power generation. Supported by the Climate Investment Funds' (CIF) Scaling Up Renewable Energy Program in Low Income Countries (SREP) and the Asian Development Bank (ADB), the POISED project is a successful proof of concept for solar photovoltaics (PV) and battery storage in the country. Through POISED, the solar-PV- battery diesel hybrid energy systems achieved fuel savings of up to 28 percent compared to diesel-only generator sets. It makes the case that investing in renewable energy is financially sound and contributes to de-risking

1 Rates when the POISED project was designed

financial investments in renewable energy in the Maldives.

Nonetheless, the POISED project encountered unexpected delivery challenges during the multiple phases of its implementation process, from which lessons can be drawn. This case study describes the three challenges and how the POISED project overcame them and learned from the experience.

1. **Reticence towards Renewable Energy:** Prior to the POISED project implementation, there had been some previous experiences within the renewable energy sector in the Maldives that raised some reticence towards the implementation of a new renewable energy project. ADB, together with funding from other agencies, such as JICA or World Bank, supported pilot renewable energy projects in the Maldives, which helped show proof of concept, and raised awareness about the benefits of solar-PV-battery diesel hybrid systems.

2. **Constraints in finance:** The typical infrastructure funding for programs in the Maldives tends to be small grants or loans given the country's size, macro-economic conditions and borrowing constraints. The POISED program represented an unprecedented effort to mobilize nearly $129 million (through a concessional combination of grant and loans) to help develop a program that could meaningfully address the issue of fossil fuel imports for electricity generation, while making a financially-sound case for renewable energy. While the project was under implementation, one loan of US$10 million did not materialize, as it was re-allocated for other national priorities, and a US$50 million loan was put on hold for some time. New funding resources were mobilized to cover for these loans, including additional finance from the ADB and a grant from the European Union. The Project Management Unit (PMU) showed flexibility in project design to ensure project implementation is shielded from situations that could compromise effectiveness.

3. **Limited knowledge and capacity:** There was limited local knowledge among foreign contractors hired to install the solar PV-Battery-Diesel hybrid systems and limited technical capacity among local operators hired to maintain them. Foreign contractors won the international competitive bidding, carried out for the project based on technical and financial criteria. Although these contractors partnered with local sub-contractors, there were cases of unfamiliarity with the local context, such as logistics and geographical constraints of bringing all installation materials to the outer islands and language barriers.

Operators hired in the outer islands to maintain the new solar-PV-battery -diesel hybrid systems installed during the first phase of POISED indicated the need for additional hands-on training to operate the grid. Once flagged, the PMU offered more comprehensive training and used the experience to strengthen operator training in subsequent phases of the project.

The POISED project team's success in overcoming these challenges is attributable to the following factors and actions: using a phased and adaptive project management approach; recognizing the need for more tailored, hands-on capacity building; reacting quickly to secure new sources of funding; and acknowledging the local context, in particular, the logistical issues of implementing a project on remote islands.

The POISED project is an example of an unprecedented effort in the Maldives to reduce specific diesel consumption and mobilize financing for renewable energy investments and energy efficiency. It was undertaken in challenging circumstances over 2015-2020 and has demonstrated significant physical progress. This case study demonstrates how the PMU was flexible finding solutions to accommodate changes and keeping the project ongoing even in adverse circumstances. The POISED project and the Maldives' SREP Investment Plan, demonstrate the economic feasibility and growth potential of solar PV systems. These experiences and challenges offer lessons for the installation of solar-PV-battery diesel hybrid systems in other countries, especially for small island countries. This

# INTRODUCTION

*Photo: MoEn*

case study examines the experience of the POISED project in Maldives, funded in part by the CIF's SREP and implemented by the ADB. The study looks at the period from January 2015 (start of implementation) to June 2019 (full disbursement of US$ 12 million SREP grant funding). The original completion date of the project was December 2019, but after some delays, it is expected to reach completion by the end of 2020.

POISED was created to provide a shift towards clean and cost effective energy solutions in the Maldives', and decrease the overreliance on fossil fuels for power generation and high electricity prices. While contributing to the Maldives' carbon neutrality goal by 2020, POISED aims to increase renewable energy capacity and access to sustainable energy in 160 targeted outer islands of the Maldives with the following expected results:

- Reduce dependence on diesel-generated electricity on outer islands, thereby increasing energy security and vulnerability to external shocks

- Increase renewable energy capacity as a share of total production (21 megawatts (MW) of solar PV

installed capacity), thereby increasing access to clean energy

- Reduce greenhouse gas emissions from diesel savings (one million metric tonnes of $CO_2$ equivalent ($tCO_2e$) per year over the project's 25-year lifetime)

- Reduce the cost of electricity through less expensive power generation

- Improve livelihoods, including opportunities from microenterprise development

The project aims to add 21 MW of renewable generation (solar PV) and 7 megawatt hours (MWh) of energy storage, alongside improvements in energy efficiency (20 MW from more efficient diesel generators) and distribution systems[2]. The POISED project is executed by the Government of the Maldives' Ministry of Environment (MoEn), which established a project management unit (PMU) with ministry officials and representatives of FENAKA and STELCO, the two state utility companies responsible for electricity generation and distribution in the Maldives.

This case study focuses on the implementation of the POISED project over several phases and the three main delivery challenges encountered: 1) reticence towards renewable energy, 2) constraints in finance, 3) limited knowledge and capacity. The case study draws on project documents as well as interviews with relevant stakeholders (see Annex 1).

The POISED project has a phased approach, as shown in figure 2:

- Phase 1 included five islands and was completed in 2017.

- Phases 2b and 2c were completed in 2018 and 2017, respectively.

- Phase 3a is still under implementation.

- Phases 3b, 4a, and 4b have not yet started implementation and are on hold. They are being taken forward after loan effectiveness of co-financing sources in November 2019.

While it is still underway, the POISED project has already proven to be a successful pioneer experience in Maldives. Not only has it achieved fuel savings of up to 28 percent (this is from one of the first phase of islands) where new solar-PV-battery diesel hybrid systems have been installed, but also it has generated important lessons on recognizing and overcoming implementation challenges with speed and flexibility.

The POISED project is the first large-scale solar PV initiative—and largest energy sector intervention in the Maldives—in the outer islands, and a proof of concept that investing in renewable energy is financially sound. The project also shows how investing in renewable energy can help Maldives move away from fossil fuels and secure a sustainable future, while helping de-risk renewable energy investments.

2 Asian Development Bank. 2014. *Proposed Grant and Administration of Grant Republic of the Maldives: Preparing Outer Islands for Sustainable Energy Development Project.*

# CONTEXT

*Photo: MoEn*

Located in the Indian Ocean, Maldives is one of the world's most geographically dispersed countries with 1,192 islands of which 187 are inhabited. Nearly half of its 515,700 inhabitants live on the outer islands[3,4]. Maldives achieved universal access to electricity in 2008, but the country's energy sector faces serious challenges. In 2014, it reported that almost all (98 percent) of its 141 MW[5] of installed capacity[6] was fossil fuel based and the government spent US$ 555 million, close to 20 percent of the GDP, to import 667,000 metric tons (t) of diesel fuel[7].

3 World Bank. 2019. https://www.worldbank.org/en/country/maldives/overview

4 SREP. 2014. POISED *Project Approval Request.* Supplementary Document 20 May 2014.

5 Asian Development Bank. 2014. *Proposed Grant and Administration of Grant Republic of the Maldives: Preparing Outer Islands for Sustainable Energy Development Project.*

6 In 2014 there were 141 MW of installed diesel-based generation capacity on the inhabited islands. There were also and another 105 MW on the resort islands.

7 Fathmath Fizna, Yoosuf. 2016. Maldives Energy Authority. *Energy Balance in the Maldives.* https://unstats.un.org/unsd/energy/meetings/2016iwc/25maldives.pdf

## UNSUSTAINABLE ENERGY SECTOR

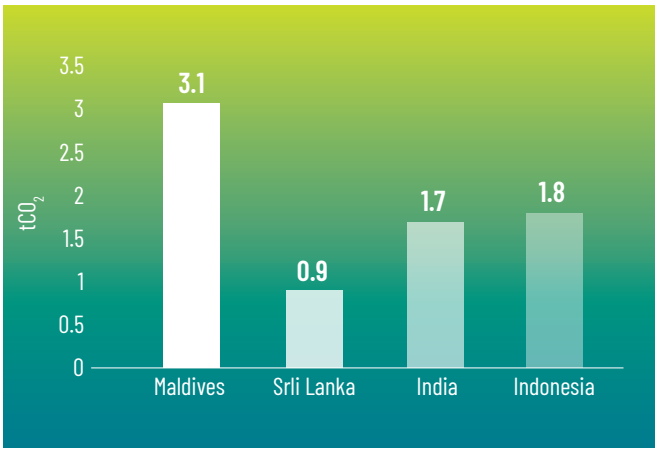
The Government of Maldives (GoM) recognized that such overreliance on fossil fuel imports left the country highly vulnerable to global fuel hikes, with international fuel prices affecting the balance of payments. In addition, transporting imported diesel to many dispersed islands was costly and inefficient.

With a fuel storage capacity of just 28 t, representing 10 days of consumption, the government was importing diesel fuel two or three times per month and distributing it to the outer islands from the capital Male'[8]. Each outer island has a separate power generation and distribution system, or mini grid, and these were often less efficient than on Male' and the larger islands (and hence consumed more diesel per unit generated)[9]. Generator sets in outer islands were usually oversized given demand patterns and operated at low loads, consuming much more fuel than efficiently needed. Costs were further compounded by the need to bring in maintenance crews from Male' or regional offices whenever mini grids needed servicing.

The high dependence on fossil fuels has made Maldives' carbon emissions per unit of electricity[10] and per capita[11] among the highest in the region (see Figure 1). In 2014, imported fossil fuel generated more than 80 percent of the Maldives' emissions[12].

The cost of diesel-based generation is unaffordable at US$ 0.30-0.70 per kilowatt hour (kWh) at the start

Figure 1.
NATIONAL CARBON EMISSIONS PER CAPITA IN 2014 ($TCO_2$)




*Source: The World Bank DataBank. ID:EN.ATM.CO2E.PC.*

of POISED[13] and US$ 0.097-0.45 per kWh in 2019[14]. The country's electricity retail tariffs for businesses are among the highest in South Asia at about $0.40 per kilowatt-hour (kWh)[15]. For certain categories such as domestic consumers, government subsidies for fuel surcharge and usage cover over 50% of the cost of electricity, particularly on the outer islands[16].

For comparison, in 2019 the price for electricity in Maldives was US$ 0.45 per kWh; in Sri Lanka and India was US$ 0.17 per kWh and just US$ 0.11 per kWh in Indonesia[17]. Government subsidies have made electricity more affordable, but consumer costs

8 Government of the Maldives. 2017. *Voluntary National Review for the High Level Political Forum 2017.*

9 World Bank. 2014. *Accelerating Sustainable Private Investments in Renewable Energy (ASPIRE) Project Document.*

10 SREP. 2012. SREP Funding proposal. *POISED Project Approval Request*

11 World Bank. 2014. *Maldives: Country Snapshot.*

12 BeCitizen. 2010. *The Maldives' 2009 Carbon Audit.* http://www.globalislands.net/userfiles/Maldives3.pdf

13 SREP. 2012. SREP Funding proposal. *POISED Project Approval Request.*

14 Data provided by MoEn. Electricity tariffs were reduced in Q42018.

15 The World Bank. 2015-2020. *"Getting electricity: Price of electricity"* (US cents per kWh)(DB 16-19 methodology). DataBank Doing Business.

16 Asian Development Bank. 2014. Preparing Outer Islands for Sustainable Energy Development Project. *Sector Assessment (Summary) Energy.* Project 46122-003

17 This refers to price of electricity for industrial/commercial purposes. The World Bank DataBank Doing Business. "Getting electricity: Price of electricity" (US cents per kWh)(DB 16-19 methodology), 2015-2020.

remain high and vary from island to island[18]. These subsidies are in excess of US$ 40 million a year[19] and remain a large burden on public expenditure.

## TARGETING CARBON NEUTRALITY

As one of the most low-lying countries in the world, Maldives is very vulnerable to the impacts of climate change. Although the contribution of the Maldives to global climate change is negligible, the GoM wanted to demonstrate international leadership to reduce carbon emissions. In 2010, the GoM committed the country to become carbon neutral by 2020[20]. One of the priority areas identified for carbon neutrality is the energy sector, as it imported fossil fuel generates more than 80 percent of the Maldives' emissions[21].

The SREP Investment Plan factored in the country context, spread of islands, electrical grid characteristics, local capacity, constraints on public and private financing for a renewable energy transformation. Given these challenges, the SREP Investment Plan set realistic targets in its contribution to the Maldives' carbon neutrality plan.

The SREP Investment Plan is contributing gradually to the ambitious goal of reduced carbon emissions, while also showing that renewable energy as an economically sound alternative to energy independence.

## PROMOTING RENEWABLE ENERGY

The GoM has acknowledged the challenge of reducing dependency on imported fossil fuels while meeting increasing demand for electricity, and is working to transform its energy sector through renewables.

To drive change, the GoM has set an initial target of using renewable energy sources to generate at least 30 percent of daytime peak load[22] on inhabited islands by 2019[23]. It has also introduced policies for targeted electricity subsidies, import duty exemptions for renewable energy products, and net metering[24]. New regulations have been developed to encourage private sector participation, including a feed-in tariff mechanism, a net metering regulation, and power purchasing arrangements[25].

Special attention is given to energy security as one of the key challenges for an import dependent nation and to the creation on an environment that makes investing in the renewable energy sector in the Maldives as straight forward and risk free as possible. SREP will support the GoM in reaching its target towards transforming the economics of the energy sector and moving renewable energy from niche to mainstream.

The POISED project contributes to Maldives' objectives by increasing the total installed capacity of renewable energy systems. When the project began in 2015, Maldives' installed capacity of renewable energy was 3.9 MW. By 2018, it reached 16.5 MW, with about half coming from the private sector, mostly in resort islands[26]. This figure includes 4.63 MW from installed POISED solar-PV-battery diesel hybrid systems. The

18 This changed in March 2019, when same bands of tariff were exercised for domestic and business category consumers in all islands.

19 Asian Development Bank. 2015. "Maldives: Overcoming the Challenges of a Small Island State: Country Diagnostic Study," ADB Reports. RPT157530-2.

20 Ministry of Housing & Environment. *Towards Carbon Neutrality.* Developing a Renewable Energy Investment Plan for the Maldives. https://www.climateinvestmentfunds.org/sites/cif_enc/files/meeting-documents/3._maldives_salle_south_africa_-_srep_meeting_final_2_0.pdf

21 Ministry of Housing & Environment. *Towards Carbon Neutrality.* Developing a Renewable Energy Investment Plan for the Maldives. https://www.climateinvestmentfunds.org/sites/cif_enc/files/meeting-documents/3._maldives_salle_south_africa_-_srep_meeting_final_2_0.pdf

22 Peak load is the highest amount of energy drawn from the grid in a period of time.

23 IRENA. 2015. *Renewable Energy Roadmap for The Republic of Maldives.*

24 Ministry of Environment and Energy. 2016. *Maldives Energy Policy and Strategy.* Male', Maldives. ISBN 978-99915-59-31-5

25 Ministry of Environment and Energy. 2017. *Solar Resource Overview of Maldives.* Male', Maldives. ISBN 978-99915-59-46-9

26 Ministry of Environment and Energy. 2018. *Island Electricity Data Book 2018.* Male', Maldives. ISBN 978-99915-59-72-8

project reports another 2.9 MW under construction (see Table 1).

Maldives' total installed capacity generated from all sources was 240 MW in 2017 (share of renewable energy was 4.6 percent), of which approximately 135 MW was in the Greater Male' region and 105 MW was in the outer islands. In 2017, outer islands consumed 304 GWh of electricity per year while the Male' region consumed 375.6 GWh per year[27].

## SREP INVESTMENT PLAN

The POISED project is an important component of the investment plan that the Maldives government developed in 2012 through the SREP, a dedicated funding window of the CIF. Maldives' SREP investment plan aligns with its 2010 National Energy Policy and aims to transform its electricity sector and develop renewable energy capacity on a large scale. It specifies how SREP resources, leveraged by co-financiers, can be best used to support the scale-up through two interlinking projects: POISED and ASPIRE (Accelerating Sustainable Private Investments in Renewable Energy). With SREP funding of US$ 12 million for POISED and another US$ 12 million for ASPIRE, the projects seek to add a total of 41 MW[28] of SREP-supported renewable energy capacity to Maldives' clean energy supply and enable more private sector engagement in the country's emerging solar PV sector.

## MALDIVES POWER UTILITIES

The State Electric Company Limited (STELCO) and Fenaka Corporation Ltd (FENAKA) are the two state-owned utilities responsible for generation and distribution of electricity in the country.

Until 2009, STELCO was the integrated utility responsible for electricity generation and supply to about 40 islands around the Male' region, while island cooperatives provided electricity to another 150 other islands. In 2009, the government established six new utilities to supply electricity in different geographic areas not licensed to STELCO. In June 2012, the six utility companies were merged to form FENAKA Corporation Ltd, a fully public company with a mandate to provide island communities outside the greater Male' region with electricity, water, and sewerage.

Today, STELCO provides electricity services to the greater Male' region and nearby atolls, a total of 33 islands, serving about 60 percent of the population of Maldives[29]. FENAKA operates in 150 islands and serves about 40 percent of the population. Most POISED project components are under implementation in islands serviced by FENAKA (see Table 1)[30].

Financial analyses of STELCO and FENAKA reveal both are burdened by the high cost of diesel fuel to generate electricity. Despite an increase in consumer tariffs from November 2009 and the introduction of fuel surcharges, STELCO has experienced dips in profitability, reaching as low as a 1 percent net profit margin in 2012[31] and losses of MVR 72.6 million (US$ 4.7 million) in 2016. FENAKA has a net profit margin of just below 3 percent and requires backstopping and assistance for growth. The POISED project is geared to improve the financial management, asset mapping, Energy Resource Planning (ERP) systems and financial sustainability of these two utility companies.

## POISED PROJECT INTERVENTION

The POISED project was designed to help Maldives shift toward greater energy self-sufficiency and minimize emissions and exposure to global petroleum price volatility. It aims to facilitate the installation of solar-PV-battery diesel hybrid systems, meeting up to 30 percent of the daytime peak load demand

27 Ministry of Environment and Energy. 2018. *Island Electricity Data Book 2018. Male', Maldives.* ISBN 978-99915-59-72-8

28 ASPIRE aims to scale up solar PV up to 20MW and POISED 21 MW.

29 Ibrahim, Ahmed. State Electric Company Limited. *Expanding Renewable Energy Integration to STELCO Grid.* https://www.irena.org/eventdocs/maldives/1expandingrenenintegstelcogrid.pdf

30 Asian Development Bank. 2014. *Preparing Outer Islands for Sustainable Energy Development Project* (Project No. 46122).

31 World Bank. 2014. *Accelerating Sustainable Private Investments in Renewable Energy (ASPIRE) Project Document.*

Table 1
POISED PROJECT IMPLEMENTATION PHASES

| PHASES | ATOLLS | NO OF ISLANDS | ISLANDS | CONTRAC-TOR | FUNDING | CAPACITY INSTALLED (MW) | UTILITY COMPANY |
|---|---|---|---|---|---|---|---|
| **Phase 1** | Pilot islands in Lh, B, T, G, | 5 | 1. Lhaviyani (Atoll) Kurendhoo 2. Baa (Atoll) Goidhoo 3. Thaa (Atoll) Buruni 4. Gaafu Alifu (Atoll) Villingili 5. Seenli/Addu (Atoll) Hithadhoo | CCE OASIS (China) for solar and LTL (Sri Lanka) for grid component | ADB | 2.3 (installed) | FENAKA |
| **Phase 2a** | HDh | 13 | | TrinaSolar | EIB | 2.27 (Planned. EIB loan delayed) | FENAKA |
| **Phase 2b** | HA | 14 | Haa Alif Atoll: Thuraakunu, Uliganmu, Mulhadhoo, Huvarafushi, Ihavandhoo, Kelaa, Vashafaru, Dhidhdhoo, Filladhoo, Maarandhoo, Thakandhoo, Utheemu, Muraidhoo and Baarah | TrinaSolar | ADB | 2.33 (installed) | FENAKA |
| **Phase 2c** | Male | 1 | Male (8MW Efficient Diesel Generator) | Lakdanavi (Sri Lanka) | ADB | 8 (installed) | STELCO |
| **Phase 3a** | Sh & N | 26 | 13 islands in Shaviyani (Sh) and 13 islands in Noonu (N) | Sinomec (China) | ADB | 2.85 (ongoing) | FENAKA |
| **Phase 3b** | K, AA, Adh, V, Hulhum-eedhoo | 24 | Kaafu Atoll (K), Alifu Alifu atolls (AA), Alifu Dhaalu atoll (ADH) S, Vaavu atoll (V) and Hulhumeedhoo islands | TBD Not tendered yet | EIB | 2.92 (Planned. EIB loan delayed) | **STELCO:** K, AA, ADH, V atolls. **FENAKA:** Hulhum-eedhoo islands |
| **Phase 4a** | R&B | 25 | Raa atoll , Baa atoll | TBD Not tendered yet | EIB | 4.48 (Planned. EIB loan delayed) | FENAKA |
| | Addu advanced Battery storage and EMS | 1 | | Nishisawa | JFJCM | | FENAKA |
| **Phase 4b** | M, F, & Dh (Phase 4b) | 19 | Meemu atoll (M), Faafu (F) atoll, Dhaalu (Dh) | TBD not tendered yet | EIB | 2.16 (Planned. EIB loan delayed) | FENAKA |

in about 160 medium and small outer islands with approximately 21 MW in total solar power capacity and an annual electricity output of 27.6 GWh. This includes installing energy management and control systems, increasing energy storage capacity, and improving distribution networks in all project locations. The POISED project includes battery systems and storage to support the solar intermittency.

The MoEn, STELCO, and FENAKA are also gaining experience and capacity in implementing renewable energy mini grids. The project finances the procurement of services to support implementation, including project management, technical support, financial management, safeguards support, and related capacity building training. In addition, the project intends to enable private sector renewable energy generation projects through public sector-led investments to strengthen the electricity grids. The project also supported STELCO and FENAKA on ERP, asset valuation, financial management and balance sheet preparation to ensure the utilities are sustainable after the POISED interventions.

The solar-PV-battery diesel hybrid systems are expected to displace a large portion of diesel used in generator sets. The project is expected to improve the quality of life of island communities with benefits, such as less noise and better air quality through the use of renewable energy and more efficient diesel generator systems, employment opportunities during project construction, microenterprise development opportunities through productive energy use, and the eventual reduction of electricity rates as a result of diesel savings.

*Photo: MoEn*

# TRACING THE IMPLEMENTATION PROCESS

*Photo: MoEn*

The POISED project was declared effective in January 2015 and implementation is ongoing and expected to be completed in December 2020. The project is being implemented over multiple phases, including Phase 1 to roll out the solar PV battery diesel hybrid technology in five outer islands (see Table 1). This phased approached has proven to be effective, as the PMU has been able to draw lessons from the first phase to improve subsequent phases.

Phase 1 started in October 2015 with the awarding of contracts and was completed in 2017 when grid connection was completed[32]. The systems installed not only showed promising results in fuel savings, but new diesel generators and storage systems proved more efficient (see Box 1 and Table 2).

Phase 2 followed, and the contract to replace smaller and inefficient generator sets for the Greater Male' region was awarded in April 2016. The installation of efficient diesel-based generators was completed by

32 By the completion of Phase 1, there were 1.6 MW of solar PV installed in Addu City; 200kW of solar PV and 223 kWh of storage in B. Goidhoo; 100 kW and 110 kWh of storage installed in Lh. Kurendhoo; 100 kW and 111 kWh of storage in Th. Buruni; and 300kW and 223 kWh of storage in GA. Vilingili.

Box 1:

### FUEL SAVINGS OF SOLAR PV BATTERY DIESEL HYBRID SYSTEM VS CONVENTIONAL DIESEL SYSTEM ON KURENDHOO ISLAND

The POISED project installed a 107 kWp solar PV power plant on Kurendhoo island in August 2017. The solar PV battery diesel hybrid system works with three diesel generators (250kW, 150kW, and 104kW), a 42kWh battery storage unit, and an energy management system. Total cost of this system was US$ 253,392 (MVR 3,902,237). The table compares the electricity generation of the diesel-based generator system versus the solar PV battery diesel hybrid system.

| RECORDED PARAMETERS | UNITS | JUNE 2017 | AUGUST 2017 |
|---|---|---|---|
| Electricity generated by diesel | kWh/month | 122,753 | 122,757 |
| Electricity generated by solar PV | kWh/month | 0 | 15,783 |
| Total electricity generated | kWh/month | 122,753 | 138,540 |
| Actual diesel consumption | Liters/month | 43,116 | 38,006 |
| Billed units | kWh/month | 109,062 | 122,465 |
| Sales | MVR/month | 477,912 | 526,600 |
| Diesel consumption without solar | Liters/month | 43,116 | 48,628 |
| Diesel savings with solar | Liters/month | - | 10,622 |
| Avoided cost for diesel savings | MVR/month | - | 84,972 |
| Savings in % of total consumption | % | 0 | 28% |

Once the solar power plant became operational, Kurendhoo Island reported fuel savings of 10,622 L in August 2017, equivalent to 28 percent of total diesel consumption. Considering the cost of diesel is MVR 8 per liter, the avoided cost of diesel was MVR 84,972 (US$ 5,520) that month. Apart from direct savings of diesel, the energy management system improved fuel consumption from 0.351L/kWh to 0.311L/kWh. This means that for every unit of generated electricity 0.041 L diesel is saved, a benefit of 0.328 MVR per kWh of electricity produced.

Table 2

### FUEL SAVINGS IN PHASE 1 OF POISED IMPLEMENTATION

| | TH. BURUNI | | LH. KURENDHOO | |
|---|---|---|---|---|
| | BEFORE POISED | WITH POISED | BEFORE POISED | WITH POISED |
| **Fuel consumption (liters/day)** | 450 | 337 (22% fuel savings) | 1,567 | 1,369 (12% fuel savings) |
| **Efficiency (liters/kWh)** | 0.37 | 0.28 | | |

July 2017. The contracts for the two atolls in the north (Haa Dhaalu (HDh) and Haa Alif (HA)) were awarded in April and May 2017 respectively. The HA solar PV battery diesel hybrid systems, funded through ADB, were installed successfully; however, the HDh systems experienced delays due to the fact that the European Investment Bank (EIB) loan was stalled (see key delivery challenge 2).

Phase 3 aims to install solar-PV-battery diesel hybrid systems in atolls Sh and N started in March 2016 with ADB funding but remains ongoing due to the unavailability of new powerhouses. Phase 3 works in other atolls and Phase 4 has not yet started, due to delays in EIB loan effectiveness. Funds from the Japan Fund for the Joint Crediting Mechanism (JFJCM) were planned to pilot the advanced battery energy storage (3C batteries) in Maldives. JFJCM funds were used to

install advanced energy storage in Addu and to install 1 MW of additional solar PV under net metering.

The installation started in December 2018 and should be completed by the end of 2020. Figure 2 shows the project implementation timeline.

The following three key challenges emerged from the implementation of the POISED project:

## KEY DELIVERY CHALLENGE 1: RETICENCE TOWARDS RENEWABLE ENERGY

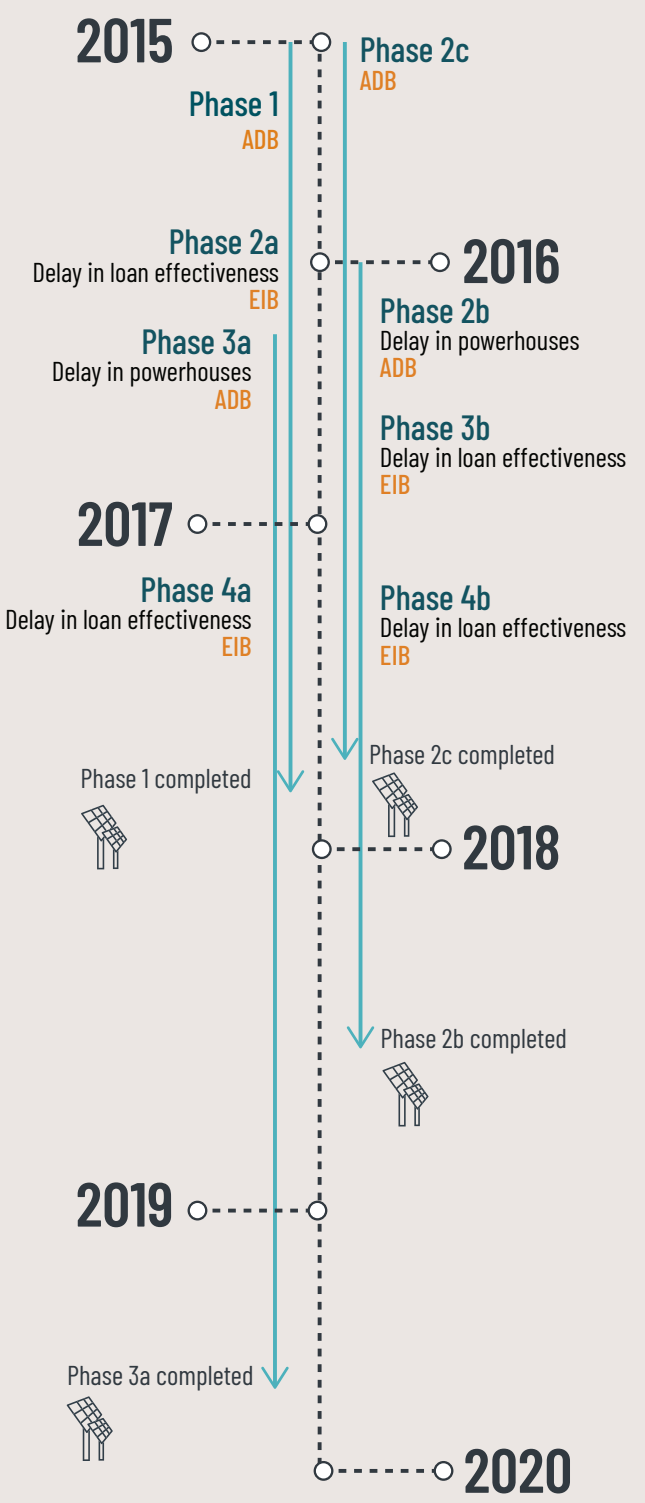
Prior to the POISED project implementation, there had been some previous experience within the renewable energy sector in the Maldives, which left some negative impressions among key policy makers and created a reticence towards the implementation of a new renewable energy project.

The GoM announced in 2009 a 75 MW wind farm project in the North Male' Atoll that was expected to reduce fuel imports by 25 percent and carbon emissions by 40 percent[33]. However, the project did not proceed for various reasons including concerns on pricing.

STELCO also had conveyed their concern that the installation of renewable power projects resulted in burning of more fuel as diesel generator sets operated at the low end of the efficiency curve.

Given this, utilities in Maldives were not too amenable to a large-scale renewable energy roll out and were reticent to private energy generation from renewable energy sources compromising their existing systems in remote areas. In order to overcome this negative perception of renewable energy, it was very important to align motivations between utility management, MoEn, Ministry of Finance and other key stakeholders such as the President's office.

Figure 2.
**POISED PROJECT TIMELINE**




33 Johnstone, Eleanor. Minivan News Archive. December 18, 2011. *Falcon Energy consortium promises legal action against government over Gaafaru wind farm.*

## SOLUTION

Many of the challenges derived from the initial reticence to renewable energy were overcome thanks to the new renewable energy interventions in the country, which proved to be successful. Many of these interventions that were critical for a shift in the perception of renewable energy, were supported by ADB and other development partners, such as Japan International Cooperation Agency (JICA) and the World Bank, and were implemented during POISED design.

ADB supported the implementation of the Dhifusshi pilot project[34], through a grant with Global Sustainable Energy Partnerships, providing 40 kW grid-connected solar PV system on Dhiffushi Island. This project piloted the use of an ice-making machine instead of a conventional battery system for storage of excess solar energy. Local residents use the ice to preserve fish and also sold the ice to neighboring islands, supporting the main economic activity on the island. This project was a successful model for the development of local renewable energy solutions and helped build a narrative on how solar power could support local communities.

Also, ADB was able to prove the benefits of solar energy storage through another solar PV battery hybrid project in the Maldives, the technical assistance (TA) 'Effective Deployment of Distributed Small Wind Power Systems in Asian Rural Areas'[35]. Through this TA, ADB funded the pilot solar PV hybrid power projects in Rakhedhoo and Dhidhoo islands and were able to minimize power from the diesel generators, reduce average costs of electricity generation and mitigate emissions[36]. In these islands, utility staff, local dwellers and government were able to witness for the first time that when diesel generator sets were switched off during the day time, the island's power system was functioning only on solar energy and on the storage. This was a very impactful demonstration of the solar-PV-battery hybrid technology and helped build acceptance on renewable energy and on the lithium ion storage technology.

JICA achieved through the Project for Clean Energy promotion in Male' a total power generation capacity of 120 kWp for grid-tied PV system and 240 kWp for stand-alone PV system with batteries[37]. The World Bank's Clean Energy for Climate Mitigation Project in Thinadhoo, implemented in 2012-2014, supplied 768 MWh of electricity annually from renewable energy displacing fossil fuel[38], and GIZ funded other renewable energy projects (328 kW installed capacity through solar PV) on 2 islands within the same timeframe as POISED in the Maldives.

These activities were very effective demonstrating technical and economic viabilities of renewable energy projects, and raising awareness about renewable energy among local population, utilities and government institutions in the country.

ADB supported trainings and capacity building activities to showcase successful examples of renewable energy projects in the Maldives and in other countries. Another example of a timely intervention was the ADB-supported adoption of energy modeling using the Hybrid Optimization Model for Electric Renewables (HOMER) through the TA[39]. The simulation programme HOMER was used to design the systems and to analyze their technical and economic performances. This model provides hourly-average solar resource data, which helps optimize system design to better match demand, and supply of

34 Global Sustainable Partnership. *The Dhiffushi Solar Ice Project in the Republic of Maldives.* https://www.globalelectricity.org/content/uploads/FINAL-Dhiffushi-interactive-publication.pdf

35 The scope of the Technical Assistance was expanded to cover development of hybrid renewable energy systems, including solar, wind, efficient diesel generator, and energy (battery) storage.

36 Asian Development Bank. 2019. *Effective Deployment of Distributed Small Wind Power Systems in Asian Rural Areas. Completion Report.*

37 Makiko Soma, Global Link Management Inc. 2015. FY2015 Ex-Post Evaluation of Japanese Grant Aid Project "The Project for Clean Energy Promotion in Male". JICA.

38 World Bank. 2015. Implementation Completion and Results Report. *Clean Energy for Climate Mitigation project.*

39 Asian Development Bank. 2017. *Improving Lives of Rural Communities through developing small hybrid renewable energy systems.* 978-92-9257-932-6 (e-ISBN)

power. This is a useful tool because it allows for the calculation of annual cash flows for many different system configurations by simulating their operation hour-by-hour for a year[40].

Raising awareness was crucial to overcome the negative perception towards renewable energy. The POISED project invested on raising awareness about renewable energy, working with local people, school students, and women's groups to explain how renewable energy would benefit them. Also, ADB provided hands-on training to STELCO counterpart staff on installation, testing, and on operation and maintenance of the hybrid renewable energy system.

## KEY DELIVERY CHALLENGE 2: CONSTRAINTS IN FINANCE

Typical infrastructure funding for programs in the Maldives tends to be small grants or loans given the country size, macro-economic situation and borrowing constraints. The POISED program represented an unprecedented effort to mobilize nearly US$129 million (through a concessional combination of grant and loans) (see Figure 3) to help develop a program that could meaningfully address the issue of fossil fuel imports for electricity generation and scale-up the use of renewable energy in the Maldives. However, all this committed funding did not fully materialize as initially planned.

In the last quarter of 2016, the POISED PMU learned that an expected US$10 million loan from the Islamic Development Bank (IsDB) was not going to progress. These funds were intended to finance the expansion of the solar-PV-battery diesel hybrid systems in the atolls of Gaafu Alif (eight islands) and Gaafu Dhal (eight islands). The government decided to re-allocate these funds to other priorities, so they were no longer available for the POISED project.

In March 2016, the government signed an agreement with EIB for a loan of EUR 45 million (US$ 50 million) for the POISED project[41]. Due to various reasons, the process was stalled, and the loan did not become effective. Since 2018, the newly elected administration has addressed this issue with EIB, making the loan effective in November 2019.

The continued delay in the EIB loan has been one of the most significant challenges for the POISED project. It has not been able to pay contracted service providers and, as of this writing, it is not certain about achieving the original goal of reaching 160 islands. The PMU had already programmed the implementation of solar-PV-battery diesel hybrid systems in 133 islands (based on expected funding from ADB, EIB and JFJCM), but work has not started in 78 islands due to the delay in the EIB loan effectiveness. These 'inactive' islands represent 46 percent of total planned installed capacity and correspond to the following atolls and implementation phases (also see Table 1 and Figure 4 for more details):

- Phase 2a: Haa Dhaalu Atoll, HdH
- Phase 3b: Male', K; Alif Alif Atoll, AA; Alif Dhaal Atoll, Adh; Vaavu Atoll,V
- Phase 4a: Raa Atoll, R; Baa Atoll, B; Lhaviyani Atoll, Lh
- Phase 4b: Meemu Atoll, M; Faafu Attoll, F; Dhaalu Atoll, Dh; and Seenu, S

## SOLUTION

The PMU realized that securing funding to cover for the loans that were re-allocated for other purposes and put on hold, was critical to ensuring successful implementation of the project, and worked diligently to do so.

In order to achieve project targets, ADB and PMU followed a sector approach for POISED with preparation of standardized templates for project

40 Asian Development Bank. 2017. *Improving Lives of Rural Communities through developing small hybrid renewable energy systems.* 978-92-9257-932-6 (e-ISBN)

41 Maldives Independent. March 9, 2016. *Europe bank offers Maldives €45 million loan for sustainable energy project.*

design, feasibility studies, due diligence, bid specifications, tendering and implementation.

POISED's project design helped ensure an adaptive management with this key delivery challenge. Procurement and financing of the project was done on an atoll basis, with each atoll being allocated to an agency for all the implementation components (e.g. including solar PV component, diesel generator set, storage), as shown in Table 1. This design allowed that a delay or lack of funding would not result in a complete failure of the program, but that it rather only affected the corresponding atolls covered by that funding.

ADB offered additional finance: a US$ 5 million grant and US$ 5 million in concessional financing expected to be processed in the first half of 2020. In order to expand the POISED project to 16 new islands, the PMU has negotiated a EUR 5 million grant from the European Union (EU)[42]. The signing of the grant agreement is underway. Figure 3 depicts shifts in financing from 2016 to 2018.

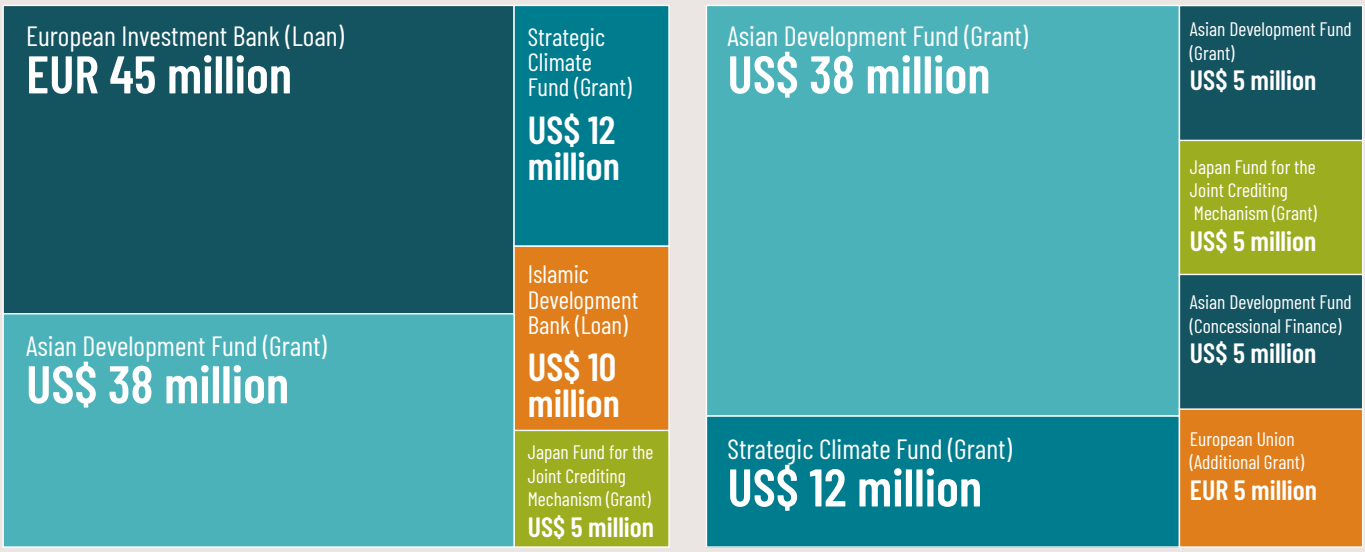
## KEY DELIVERY CHALLENGE 3: LIMITED KNOWLEDGE AND CAPACITY

Soon after implementation started, the PMU realized the project faced two key knowledge gaps. Some of the foreign contractors hired by the project to install the solar PV battery diesel hybrid systems, although they partnered with local sub-contractors, did not understand the local context, and local on-site operators hired to manage and maintain the systems did not have sufficient technical capacity to do their jobs.

### *Limited local knowledge among contractors*

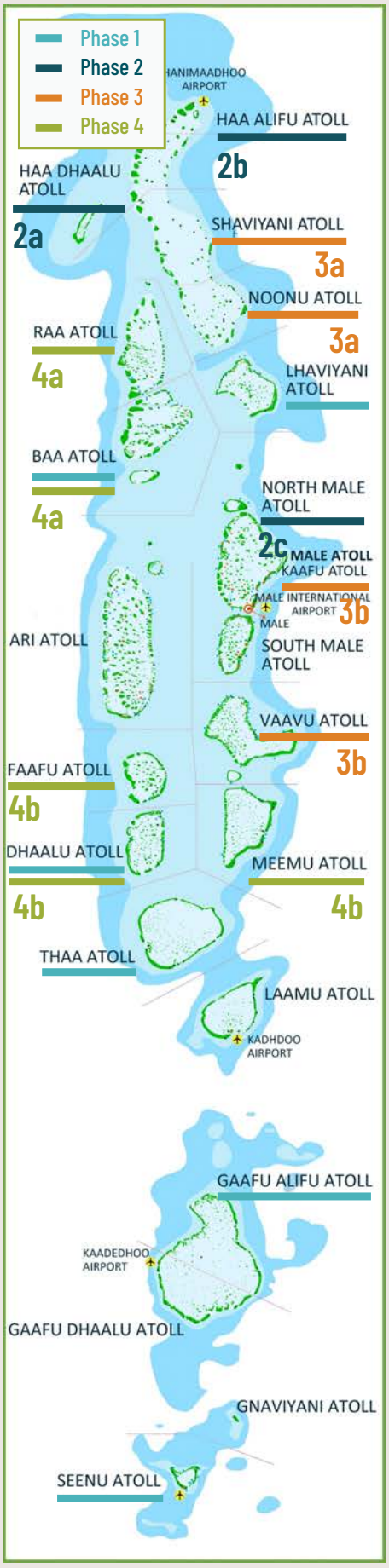
ADB procurement policies required a solid track record of installed capacity in solar PV systems,

Figure 3.
**INITIAL 2016 (LEFT) AND ADJUSTED 2018 (RIGHT) POISED PROJECT FUNDING BY SIZE AND SOURCE (IN MILLION US$)**




42 European Union External Action. June 17, 2019. *EU and Maldives step up cooperation on climate change to implement the Paris Agreement.*

Figure 4.
MALDIVES ATOLLS AND POISED PROJECT PHASES




and the procurement process resulted in selection of technical and financially capable bidders that would compete on least cost. The bidder's past track record was an important element of the evaluation process, given the unprecedentedly large size of the project in the Maldives. Local contractors had limited experience, as prior to the POISED project the country only had 3.9 MW of total installed capacity[43] and therefore participated in the bids as local sub-contractors to international companies.

Contractors from several countries participated in the POISED procurement bid. In Phase 1 foreign companies, although they had partnered with local sub-contractors for the actual implementation of the solar-PV-battery hybrid systems, underestimated the geographical constraints and transportation conditions of bringing all installation materials to the outer islands. Maldives suffers from inadequate maritime infrastructure, which constrains connectivity, limits provision of basic goods and services, and results in high transport and logistics costs over the country's 90,000 square kilometers of dispersed geography. Transporting goods from Male' ports to remote islands of the country requires careful planning that considers appropriate sea transportation options (size of boats, cranes, heavy machinery, route schedules, and other logistic details), sea conditions, and harbor infrastructure required.

Additional challenges were compounded by language barriers. Some of the companies did not have people who could speak English and equipment, namely inverters, energy management systems, whose signals, back-end programs, and instructions were in foreign language. This made it difficult for operators in the outer islands and the PMU to manage the installed equipment. Interfacing between multiple contractors - one for solar PV and batteries and the other for diesel generators and grid upgrades- was a challenge.

43 Ministry of Environment and Energy. 2018. *Island Electricity Data Book 2018.* Male', Maldives. ISBN 978-99915-59-72-8

### *Limited capacities of local operators in the outer islands*

FENAKA, as the utility company responsible for operating the solar-PV-battery diesel hybrid systems, trained and hired local inhabitants of the outer islands to manage these systems. The training program conducted by the contractors did not fully support FENAKA operators to manage the systems. For example, one outer island operator received 20 days of international training, including a week in China. This type of training conducted out of the country was not ideal for on-site problem solving.

Soon after the generator sets were installed and there were interruptions, it became clear that the operators needed more hands on training to fix problems with the solar PV battery diesel hybrid systems. This problem was further compounded by the remoteness of the islands and the challenges for FENAKA staff in Male' or contractors (based outside) to provide quick assistance to the islands.

## SOLUTION

FENAKA and PMU recognized that it would be more useful to provide hands-on training in Dhivehi, the local language, so operators would be better prepared to solve problems on site. A revamped three-day training program was conducted in Dhivehi in March 2018 on the island of Vilingili for all operators in Phase 1. This new training was run by contractors and the PMU, and included mock exercises to solve solar-PV-battery diesel hybrid system breakdowns. The training increased the know-how and enabled operators to fix technical problems.

Experience gained from Phase 1 was important to determine the training and capacity development program to be delivered to operators in the following phases of the project. A more comprehensive training program has been developed and all signals and instructions have been translated into English, ensuring easier management and problem solving. To create a stronger network of PV solar technicians in Maldives, the Energy Department has partnered with the Maldives Polytechnic to develop a syllabus to train new technicians specialized in solar energy systems.

## OTHER ISSUES IMPACTING PHASE 1

The POISED project is a pioneer initiative, and project implementation has come with a steep learning curve, especially during Phase 1. The experience accrued and lessons learned from the implementation in the first five islands has helped to adjust the project's design, management and improve overall implementation. Aside from the three main delivery challenges, there were additional periodic implementation challenges for Phase 1. For example, one international contractor shipped cables with the wrong specifications, which had to be replaced to conform to the requirements. This resulted in the tightening of specifications and more stringent inspections to help address such challenges in future phases. The hands-on effort and problem solving from the PMU ensured the project performed well and progress was good despite various challenges.

# CONCLUSIONS AND LESSONS

*Photo: MoEn*

The POISED project encountered some unexpected delivery challenges during the implementation process, which necessitated certain changes in approach to adapt to a changing environment. The POISED project is a great example of an unprecedented effort to mobilize financing for renewable energy investments, and how the PMU was flexible finding solutions to accommodate changes and keeping the project ongoing in adverse circumstances. Other ADB interventions in the country were crucial to overcome the reticence towards renewable energy.

The POISED project and the Maldives' SREP investment plan demonstrate the economic feasibility and growth potential of solar PV systems. These experiences and challenges offer lessons for the installation of solar-PV-battery diesel hybrid systems in other countries.

**A phased approach improves project performance.** Having a phased approach has allowed the PMU to identify problems, learn from them, and adjust project planning for next phases. Phase1 was implemented in five islands and had a steep learning curve. This is the first time that a large-scale project to install solar-PV-battery diesel hybrid system was implemented in Maldives, and having a phased approach with room

for improving and adjusting has kept the project on track.

**Adaptive project management and a proactive approach to implementation solutions are critical.** The POISED project PMU was proactive in recognizing challenges, finding solutions, and adapting them as needed. The PMU showed leadership being resourceful when faced with unforeseen challenges, such as reticence in the local population and government towards renewable energy, loans not being effective, and limited local knowledge among contractors.

**Tailored, hands-on capacity building is crucial for project success.** Key to project success is ensuring operators on the outer islands have the necessary skillset to manage and maintain a solar-PV-battery diesel hybrid system. An important lesson learned from project implementation is that operator training should be hands-on to foster problem solving and should be conducted on site and in the local language.

As the installed capacity of solar PV grows in Maldives and the renewable energy industry takes root, it is important to develop an in-country network of solar PV experts, including national contractors, to increase country ownership, ease communication, and ensure planning based on local knowledge.

**Securing funding.** The implementation of the POISED project ran into two major challenges in project funding when one US$10 million loan did not materialize and a US$50 million loan was put on hold. The PMU quickly reacted and reviewed project design to ensure that the project would continue and tried to mobilize additional financing. One lesson learned in this project is that it is important to put in place strong loan agreements to ensure that ready projects are not delayed due to lack of available financing.

**Logistics in small island developing states should be thoroughly planned.** Due to Maldives highly dispersed geography, the project has had to transport all materials by boat from the capital to the targeted islands. Maldives' maritime transportation is inadequate and routes between islands are not frequent. For this reason, logistics and overall project implementation arrangements must be thoroughly planned. If a material delivered to the installation site is not fit for use, the overall implementation can be delayed. An important lesson from the project is that foreign contractors should have a good understanding of the local context, and to the extent possible, partner with local companies to provide assistance on logistics.

**Processes should be bundled.** The POISED project implementation showed inefficiencies when different contractors worked on complementary contracts with limited incentive to coordinate. The PMU learned that in order to avoid delays, a turnkey contractor should perform tasks related to solar and energy storage installation as well as grid rehabilitation and connection. This was pursued from Phase 2 onwards.

# INSIGHTS FOR THE SCIENCE OF DELIVERY

*Photo: MoEn*

This case study examined several elements central to the "know-how" delivery approach of the Global Delivery Initiative (GDI). The following case study findings relate to the five key elements of the GDI framework for the science of delivery.

## FOCUS ON THE WELFARE GAINS OF CITIZENS

The project has strong community support in the outer islands. The new powerhouses built under the POISED project are usually located outside of residential areas. The new solar-PV-battery diesel hybrid systems reduce the running time of diesel-powered engines, which reduces air pollution and noise level and improves the quality of life of the residents of the outer islands.

Although there was some initial resistance to installing solar panels on the same roofs where water is collected and stored for drinking, the project was able to prove that this is possible and that one purpose does not interfere with the other. Rooftops of schools, health care centers and local administration building were rapidly mobilized to support the POISED program through coordination by PMU in Male' and discussions with island stakeholders. The POISED project is expected to contribute to a tariff reduction for all power utility users once solar energy has a

higher degree of penetration in the power generation matrix. The POISED project also raised awareness on renewable energy and energy efficiency among the island community by providing sensitization programs covering various groups such as Women Development Councils, island councils, women leaders, government officers, youth and NGOs. The awareness program was already conducted in 88 islands covering over 12,000 participants and 6,800 students. About 150 utility officers were given on the job training during the installation phase.

The project opened up new area of opportunities for local contractors and job opportunities for locals. Women were also employed to supervise the installations by contractors in some islands. The government also distributed over 200,000 LED lamps as part of the energy efficiency awareness program supported under POISED.

## MULTISECTOR AND MULTISTAKEHOLDER APPROACH

The POISED project involves a wide range of stakeholders, including government ministries and agencies, national and international private companies, development finance institutions, and multilateral and bilateral donor organizations. This approach has provided the optimal mix of knowledge, financing and risk mitigation to support the expansion of solar PV systems that one party alone would not be able to provide. There was significant coordination undertaken by the POISED PMU to work with island councils and government ministries in Male' to ensure that project studies and development were streamlined, rooftop locations could be allocated to the project across the 160 islands and support was provided for scaling-up infrastructure development in a rapid manner.

## EVIDENCE TO INFORM LEARNING

The POISED project demonstrates the viability and sustainability of solar-PV-battery diesel hybrid systems in the outer islands of Maldives. The first phase alone proved diesel fuel savings of up to 28 percent per month of solar-PV-battery diesel hybrid systems compared on diesel-only generator sets. As a pioneer experience to introduce solar-PV-battery diesel hybrid systems and improved grid efficiency in Maldives, the POISED project has required a learning-by-doing approach. Learning from the challenges encountered in the initial pilots and then Phase 1 has been critical to the overall success of the project, as it guided the project design and informed the decision-making in subsequent phases.

## ADAPTIVE MANAGEMENT AND CHANGE

The POISED project has been able to offset financial risks and prove the savings potential of more efficient power systems combined with renewable energy generation in the outer islands of Maldives. The project is the first large scale solar PV and battery storage initiative in the Maldives and is a proof of concept that investing in renewable energy is financially sound. The project also shows how investing in renewable energy can help Maldives break from a fossil fuel-dependent economy and secure a sustainable future. The project, together with other government-led measures, is also expected to contribute to reducing power tariffs.

# ANNEX 1: LIST OF INTERVIEWEES

| NAME | POSITION | ORGANIZATION |
|---|---|---|
| Ahmed Shukry Hussain | Social and Gender Specialist | PMU |
| Ahmed Ali | Project Manager | PMU |
| Rifarath Ali Jaleel | Deputy Director | FENAKA |
| Thaalooth Rasheed | local financial expert | PMU |
| Hussain Ageel Naseer | Assistant Engineer | STELCO |
| Fathuhulla Jameel | Consultant | PMU |
| Mizna Mohamed | Environment Specialist | PMU |
| Abdulla Nashith | Director | FENAKA |
| Hassan Yasir | Managing Director | Avi Technologies |
| Abdul Aleam Mohamed | Projects Coordinator | Avi technologies |
| Muawiyath Shareef | Director | Maldives Energy Authority |
| Sugar Gonzales | Project Consultant | ADB |
| Jaimes Kolantharaj | Project Officer | ADB |
| Len George | Energy Specialist | ADB |
| Faathina, Hudha and Abdul Rahman Ali | | REM (subcontractor) |
| Mr. Mohmed | Operator | Island Lh Kurendhoo |
| SINOMEC | Contractor | SINOMEC |

# THE CLIMATE INVESTMENT FUNDS

The Climate Investment Funds (CIF) accelerates climate action by empowering transformations in clean technology, energy access, climate resilience, and sustainable forests in developing and middle-income countries. The CIF's large-scale, low-cost, long-term financing lowers the risk and cost of climate financing. It tests new business models, builds track records in unproven markets, and boosts investor confidence to unlock additional sources of finance.

CIF
CLIMATE INVESTMENT FUNDS

www.climateinvestmentfunds.org

*Photo: MoEn*

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