Ministry of Environment,
Republic of Maldives

Maldives: Storage for a renewable future

THE MALDIVES

- *Republic of Maldives is one of the lowest lying countries in the world making it vulnerable to the adverse impact of climate change.*

- *Further, significant dependence on imported oil for meeting its energy needs also has profound effects on economic development of the country.*

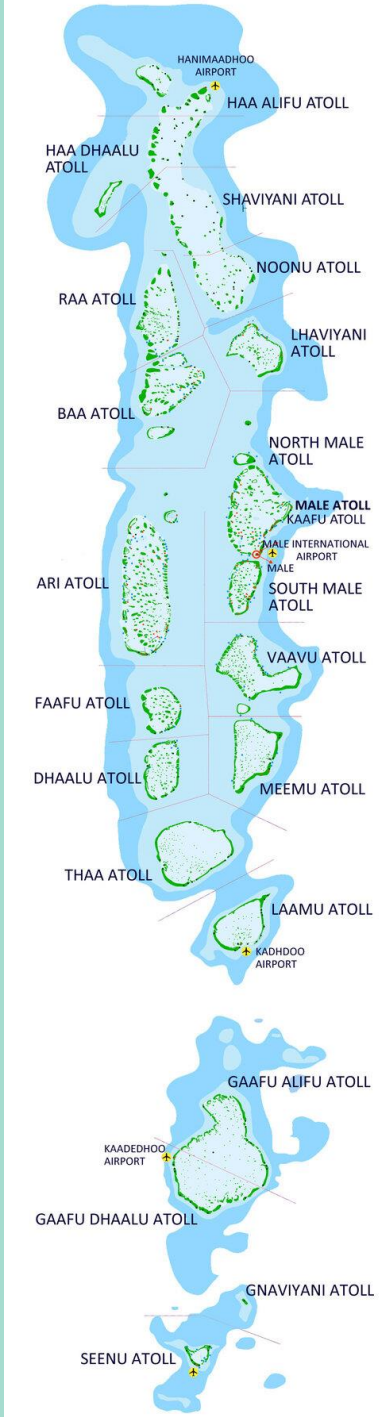
1190
ISLANDS

188
INHABITED ISLANDS

130
TOURIST RESORTS

534 k
POPULATION
(2019 Projected)

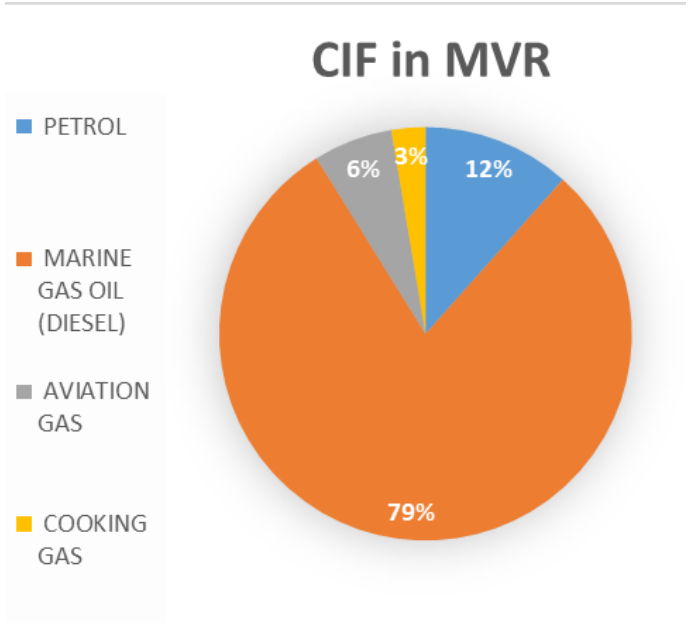
82 B
GDP in MVR
(market price)

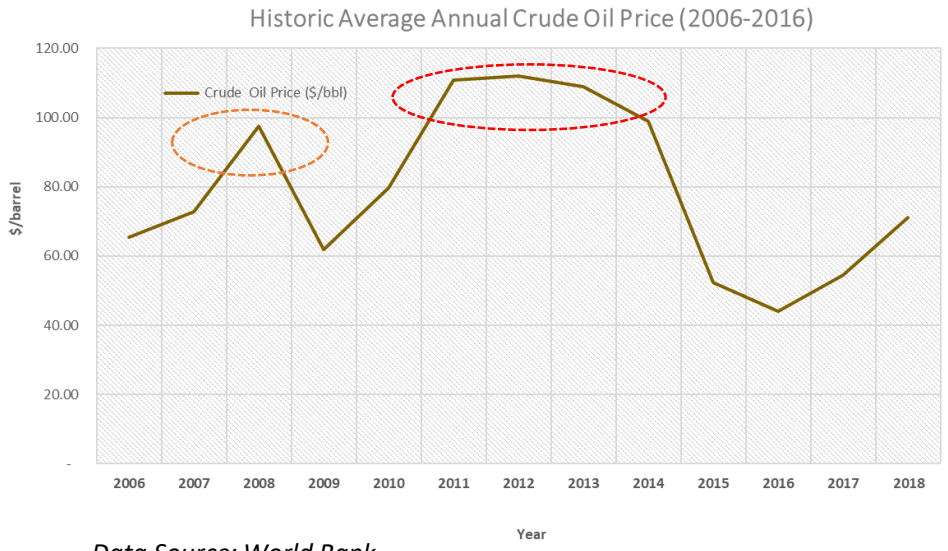


POWER SECTOR

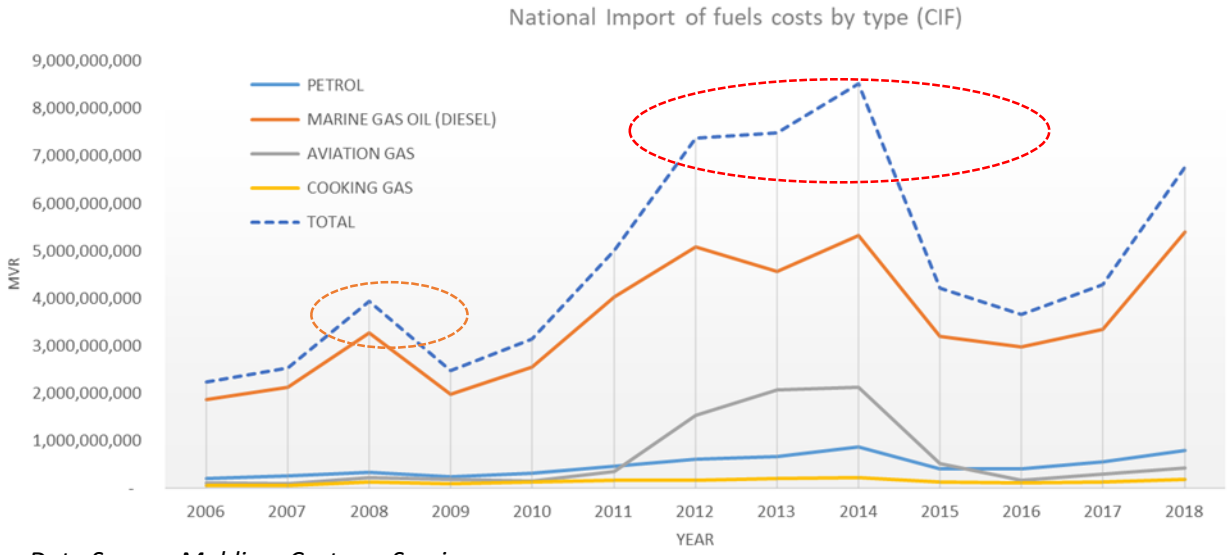
Energy Sector at a glance

- High dependency on fossil fuel.
- Primary uses of energy includes power generation, transportation, cooking
- International fuel price shocks threatens our economy.
- Total fuel expenditure in 2018 ~10% of the GDP





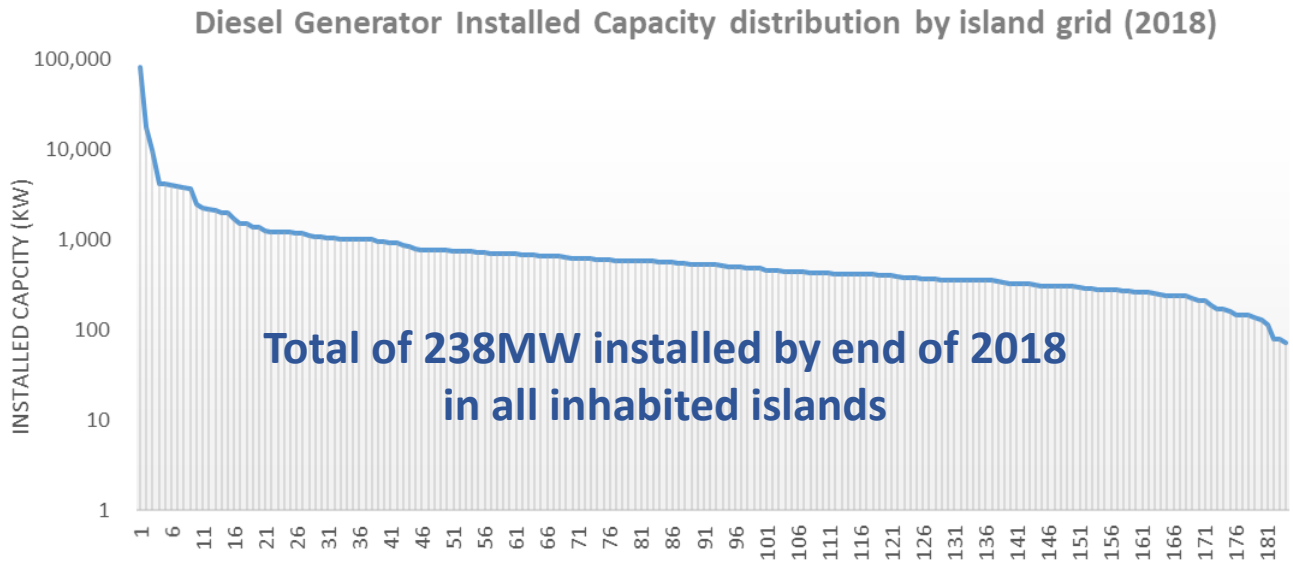
Data Source: World Bank



Data Source: Maldives Customs Services

Electricity Production

- 100% electrification of all inhabited islands achieved in 2008
- Basic infrastructure is a diesel based power house with primarily LV distribution
- Electricity production accounts for 65% of diesel imports
- Demand growth from 8%-11% typical in most islands.



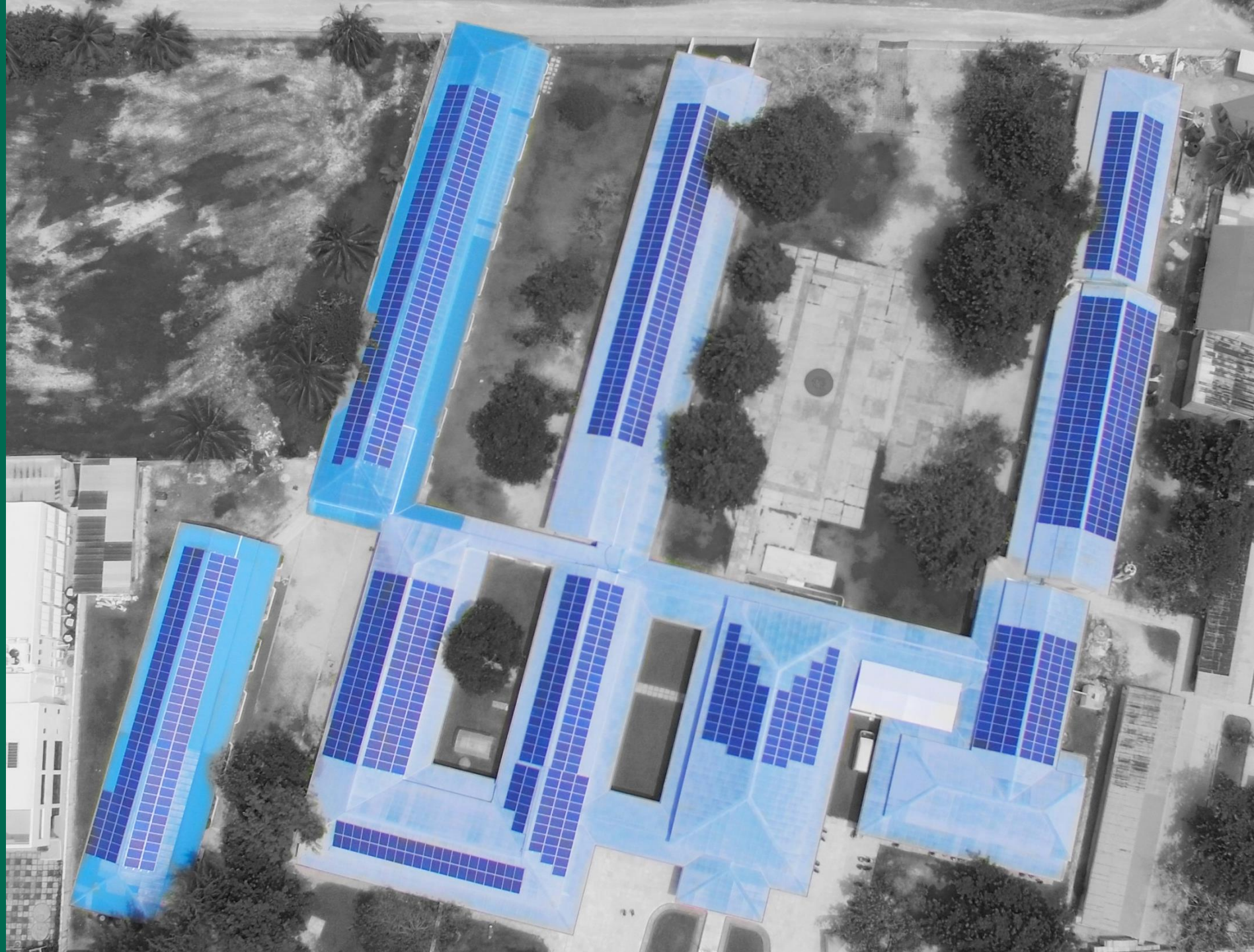
Data Source: Maldives Energy Authority

- Unit Costs of Production from diesel:
  - ❖ Average varies from $0.22/kWh (larger Islands) to $0.31 (smaller outer islands)
- Large subsidy payout to absorb fuel price increases and reduce end user tariff.
- Subsidy payout is unsustainable over the long-term due to high demand growth

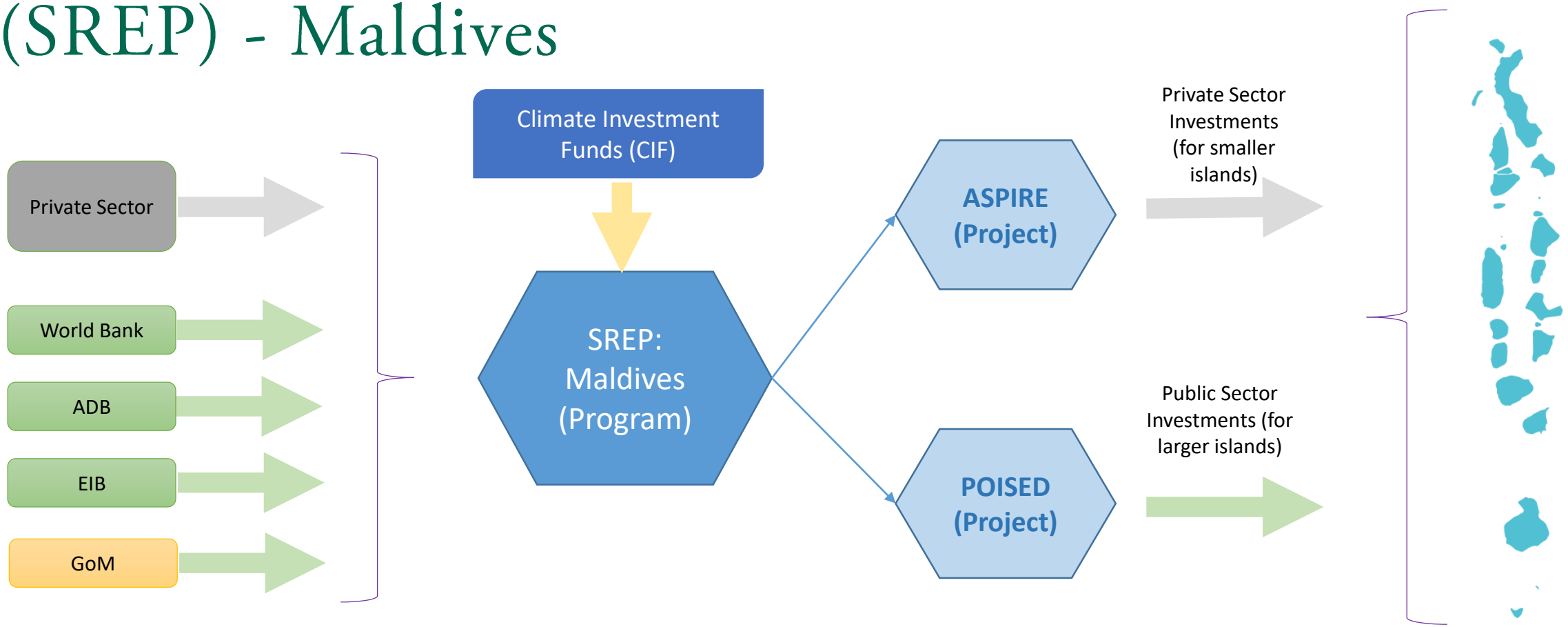
Progress on RE integration:

- ❖ Already 16MW of solar PV installed nationwide (accounts to 6% of total installed capacity of inhabited islands)
- ❖ Targets of up to 21MW of solar PV (over the next 2 years)
- ❖ Most recent target to increase RE in capacity by 70%

Renewable Energy



Scaling-up of Renewable Energy Program (SREP) - Maldives



- Formulated through support mainly from World Bank and ADB.
- One of the key investment programs rolled out by GoM to scale-up renewable Energy
- ASPIRE leverages private sector financing under PPA model, backed by guarantees
- POISED utilize pubic finance to implement PV project in smaller islands.

Taking the next step: Implementation outlook for RE and BESS Scale-up

- New project under formulation with support from World Bank
- A hybrid of Private Sector and Public Sector Investments
- Project to consider innovation, primarily linking storage
  - Mix of public sector and private sector investments
  - Integration and mainstreaming of BESS
  - Power Infrastructure upgrading
  - Floating solar PV (in lagoons)
  - Electrical Vehicles assessments

Existing Challenges for RE Deployment

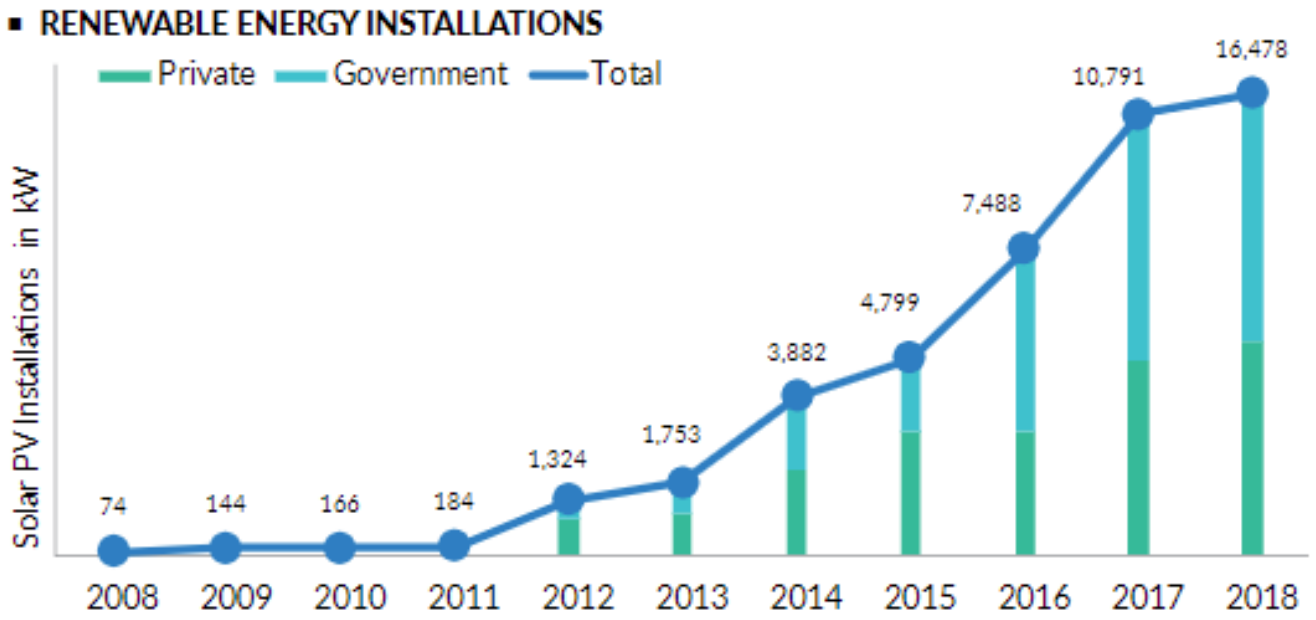
- Limited land space → Limits RE potential such as that for solar PV with existing technologies
- Smaller scale → Higher unit costs
- High capital costs of storage → Without storage, it would be difficult beyond 15% of energy demand by solar PV
- Limited experience in other commercial technologies → No commercial pilots for wind as of date.
- Untapped resources → Maldives with 97% the country being ocean with apparent potential for waves, tidal, ocean currents, OTEC. But limited research and development done to show commercial viability.

Some images……

- Selected sites (among over a 100s of sites in over 45 islands

Progress of RE implementation at national level

- Primarily solar PV use in electricity production
- Other sources such as wind, ocean currents, tidal resource assessment ongoing
- Rapid growth of solar PV installations both from private and public sector

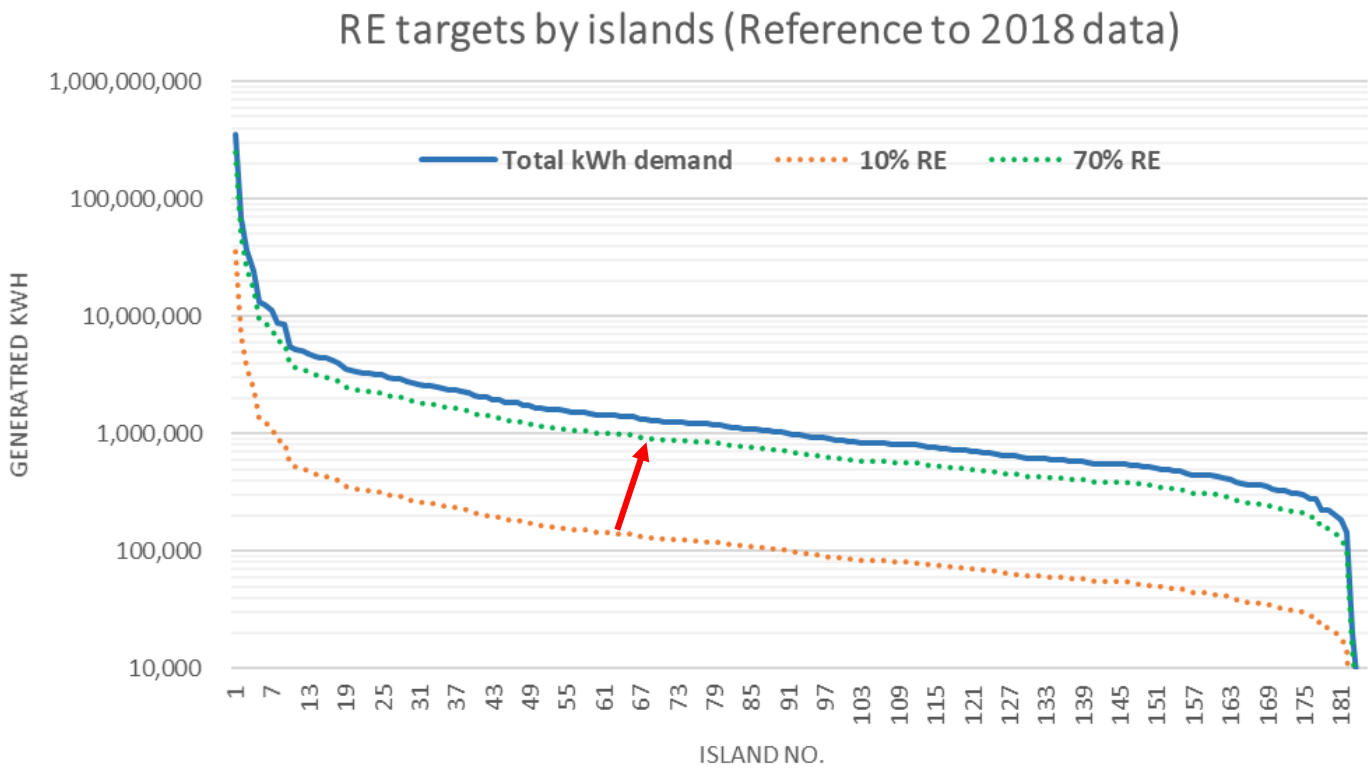


Source: Ministry of Environment

- **Total of 16.5MW of solar PV installed by end of 2018 (Nationwide)**
- **Over 10MW contributed by SPREP (ASPIRE and POISED)**
- **Larger installations in private sector are contributed mainly from resorts.**

Why storage is important

- Findings of Technical Assessments:
  - Without storage only 10-20% RE penetration
  - With storage, up to 100% possible
- Most important is the lower cost of production:
  - Diesel - $0.23-0.31/kWh
  - PV PPA < $0.11/kWh
- High RE fraction needed to reflect the cost of production saving
- Potential to reduce fuel consumption in transport sector



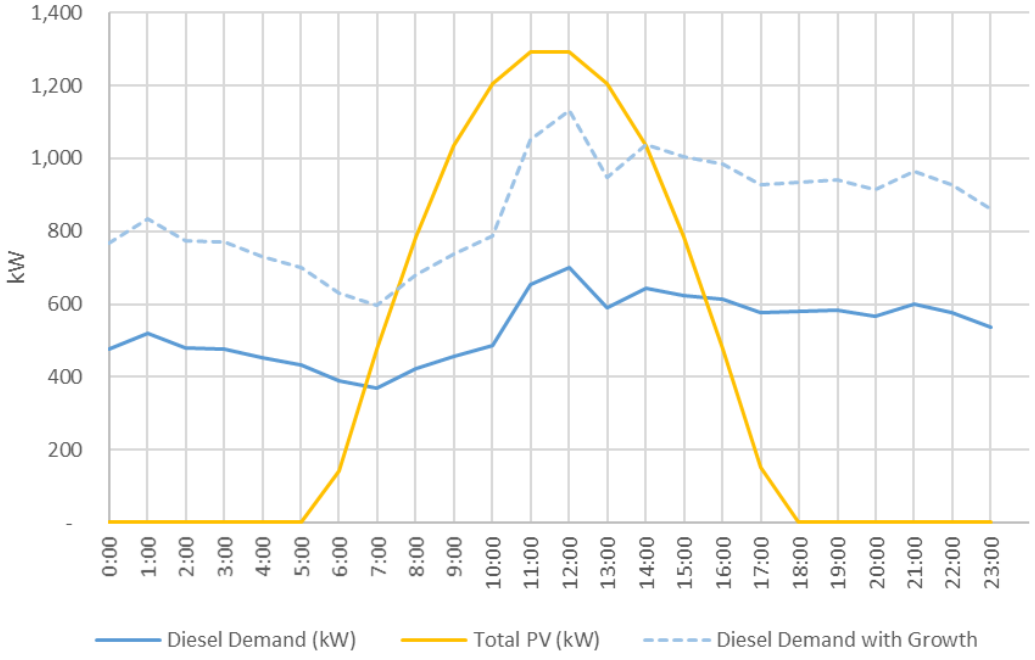
ELECTRICITY STORAGE IN THE MALDIVES

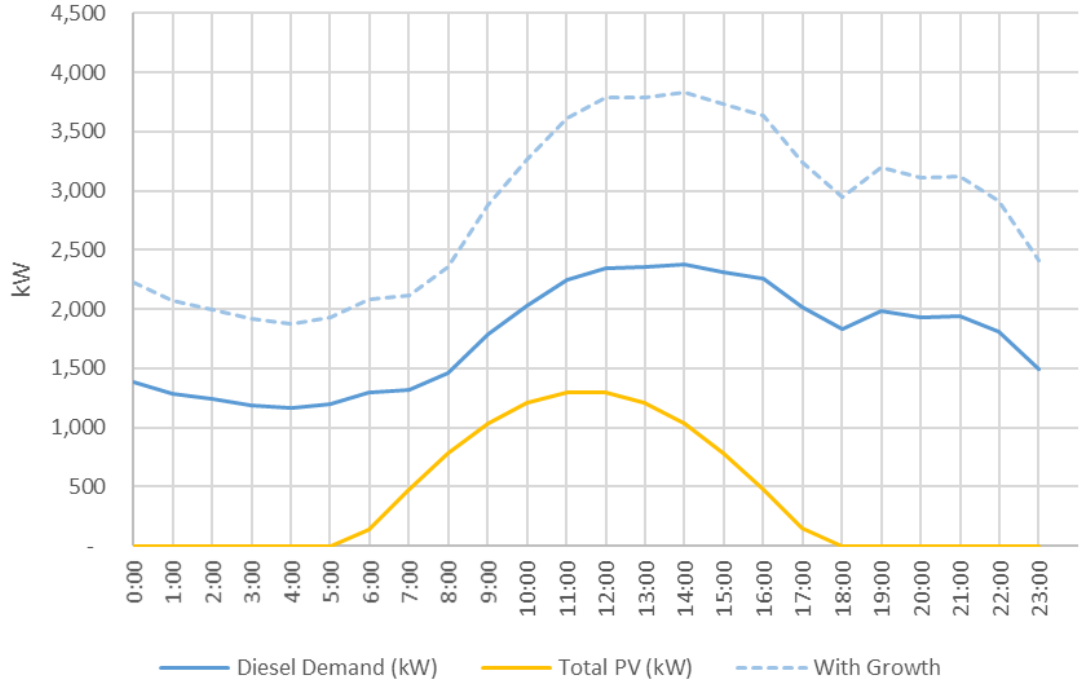
Experience of Storage in Maldives

- Early pilot RE projects used lead-acid batteries, but were not successful due to maintenance issues.
- Small scale storage is already being experienced in smaller islands under POISED Project (Public sector investment), ranging from 50 - 300 kWh, and RE penetration of 15-50%
- A recent assessment titled *Maldives Energy Transition* was carried out with support from WB consultants that looked at cost-benefit of large-scale storage, for 5 islands cases with different electricity demand, PV penetration levels, and resulting overall economic benefit of combined use-cases for storage. PV sizes range from 0-12MW while battery sizes vary from 3MWh to 44MWh depending on PV capacity and demand of island.
- Executive summary of assessment launched during Climate Summit by Minister of Environment.

Experience: Utility application

- Primarily diesel based generation (high vs low RE mix)
- Advantage of day peak demand coinciding with RE production





Experience: Utility application

- PV /BESS/DG Hybrid systems in small islands
- Only solar PV as RE resource
- Mainly distributed generation from RE
- Mini-grids in small islands

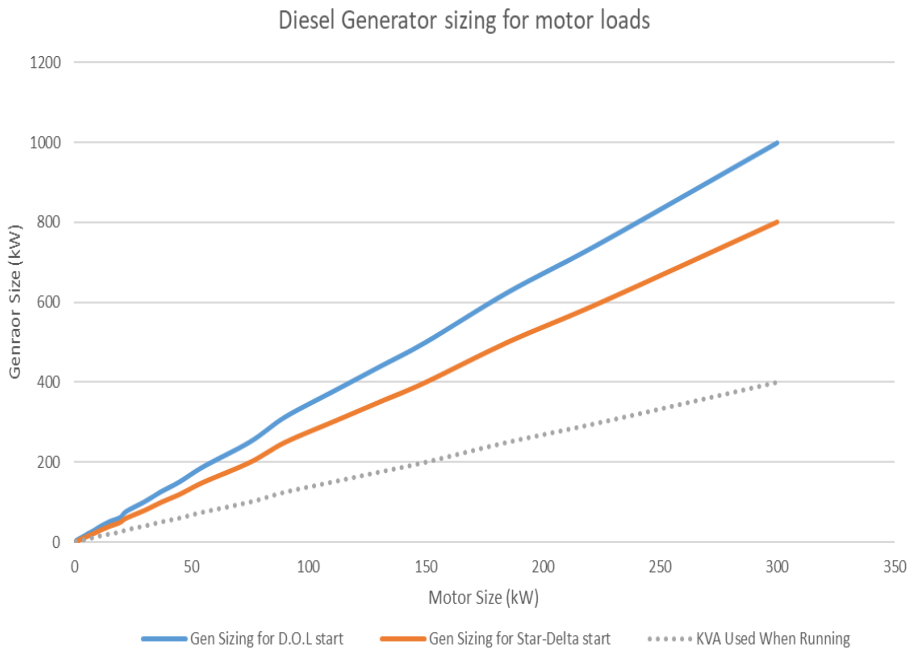
RE Mix Scenario/Type	% of Peak Demand	% of Energy	Battery Used	Level of Autonomy
Low	30%	7%	None	None
Medium	50-70%	7-20%	Li-Ion sized based on PV and load	Potential for few generators to be shut down for short periods
High	70-100% and above	25%-50%	Li-Ion sized based on PV and load	4-6 hours of genset free operation

Experience: Utility application

- General experience is purely with PV hybrid cases
- Overall purpose to maximize RE penetration, thus diesel savings
- Pre-set general configuration :
  - Maximize solar PV use in real-time
  - Minimize diesel generator use
  - Optimal loading of DGs when in use
- General observations:
  - Operationally efficient
  - Very little curtailment needed in general
  - Handful of islands required troubleshooting
- Scenarios may change depending on type and level of RE in the mix

Scope of applications of battery storage for Maldives

- SMALL SCALE APPLICATIONS
  - Replacement of standby/backup generators (for 10s of kW)
  - Stand-alone power sources (eg- Powering Telcom towers)
  - Optimizing gensets sizing, especially for motor based applications



Source: https://www.nationalpump.com.au/

Scope of applications of battery storage for Maldives

- UTILITY SCALE APPLICATIONS
  - Diesel Offset (Primary)
  - Frequency Response
  - Spinning reserve
  - Peak-shifting
  - T&D investment deferral
  - Arbitrage (requires time-of-use tariff structure)

Challenges and barriers for storage deployment

- High costs of storage:
  - Unit cost of storage still high, especially for smaller scale
  - Cost can very significantly based on overall system design, and the features of the energy management system adopted.

- Technology uncertainties:
  - Battery sizing for long-term difficult
  - Reliability benchmarking is a challenge
  - Storage is sensitive to environmental parameters
  - Proprietary hardware/software may limit integration of plants source from different manufacturers
  - Limited experience of local utilities to troubleshoot

- No regulatory interventions:
  - No local regulations on storage technology (to promote storage or ensure safety standards)
  - International experience is limited

- Environmental aspects:
  - No standards for disposing or recycling
  - Will require exporting battery systems to recycling plants at end of life

NEXT STEPS

Key actions needed for storage scale-up

- Incentives for storage projects (such as duty exemption, external & local financing schemes, etc.)
- Capacity building for utilities to operate and manage storage technologies
- Knowledge exchange globally
- Develop and fine-tune business models applicable for the country.
- Development of regulations (Safety, Environmental)
- Explore new storage technologies

A National Commitment:

DR. HUSSAIN RASHEED HASSAN

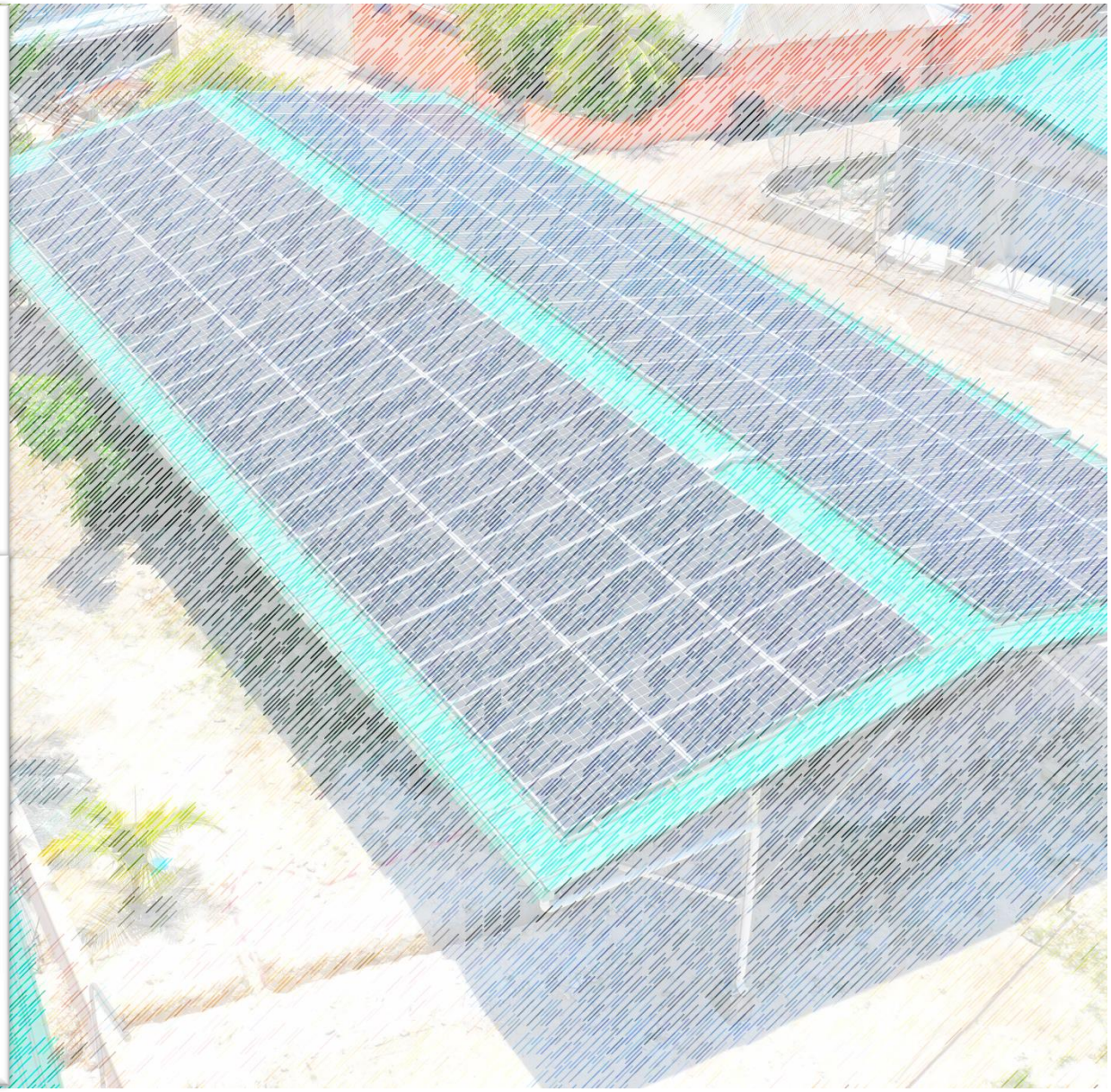
Minister of Environment

ENVIRONMENT / MALDIVES

"We are targeting 70% of clean power production by 2030"

What is your vision for the energy sector regarding renewable power generation capacity?

The Maldives relies heavily on fossil fuels. 10 percent of our GDP is spent on fuel imports. We have very ambitious goals to reduce that dependency. Currently the country has a power generation capacity of 400 MW, however, our total energy demand is approximately 180 MW and only 6 percent (16 MW) of this demand is met with solar power. We are in the process of installing more solar capacity, through STELCO and Fenaka. We have made a Nationally Determined Contribution (NDC) commitment under the Paris Agreement to have 24 percent of our energy produced through renewables by 2030. However, now we are targeting 70 percent of clean power production within that period. I believe that this can be achieved.



Source: *http://www.the-businessreport.com/article/we-are-targeting-70-of-clean-power-production-by-2030/*

Thank You

For Questions
& Comments:

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