



Preparing Outer Islands for Sustainable Energy Development (POISED) - Maldives

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Outline

- Overview
- Pilot Islands
- System Design
- Roadmap for expansion
- Final Remarks



Sector Overview

- 1192 islands spread over 750 km by 120km
 - 298 sq km, 1-2 sq km each, 1.5m above msl
 - 194 inhabited islands and about 100 resorts
- Access to electricity 100%
- Installed generation capacity
 - 100% diesel
 - 141 MW in inhabited islands, 105 in resorts
- Electricity costs vary 30-70 cents/kWh
- Annually 120 million liters of diesel for electricity
- subsidies exceeding \$40 million annually



Issues needing attention

- Many independent isolated grids
- Low efficiency in generation
 - Poor accountability in diesel use
- Low availability of generation
- Higher losses in distribution systems
 - Under invested
- Grids not ready for renewable energy absorption
 - Generator controls not good enough

Pilot Islands - Current Status

<i>Island</i>	<i>Population</i>	<i>Daily Peak (kW)</i>	<i>Annual Energy (MWh)</i>
Addu City	25,571	3850	22,161
Villingili	3,460	481	2,684
Kurendhoo	1,945	165	881
Goidhoo	748	69	417
Buruni	579	78	322





Pilot Islands

- Islands operate 1-3 diesel gen sets to meet demand
 - through a small low voltage network
- Peak demand often below 50% of installed capacity
 - substantial additional diesel gen set capacity needed for maintenance
 - poorly designed system with inappropriate generator size



Design Methodology - Objectives

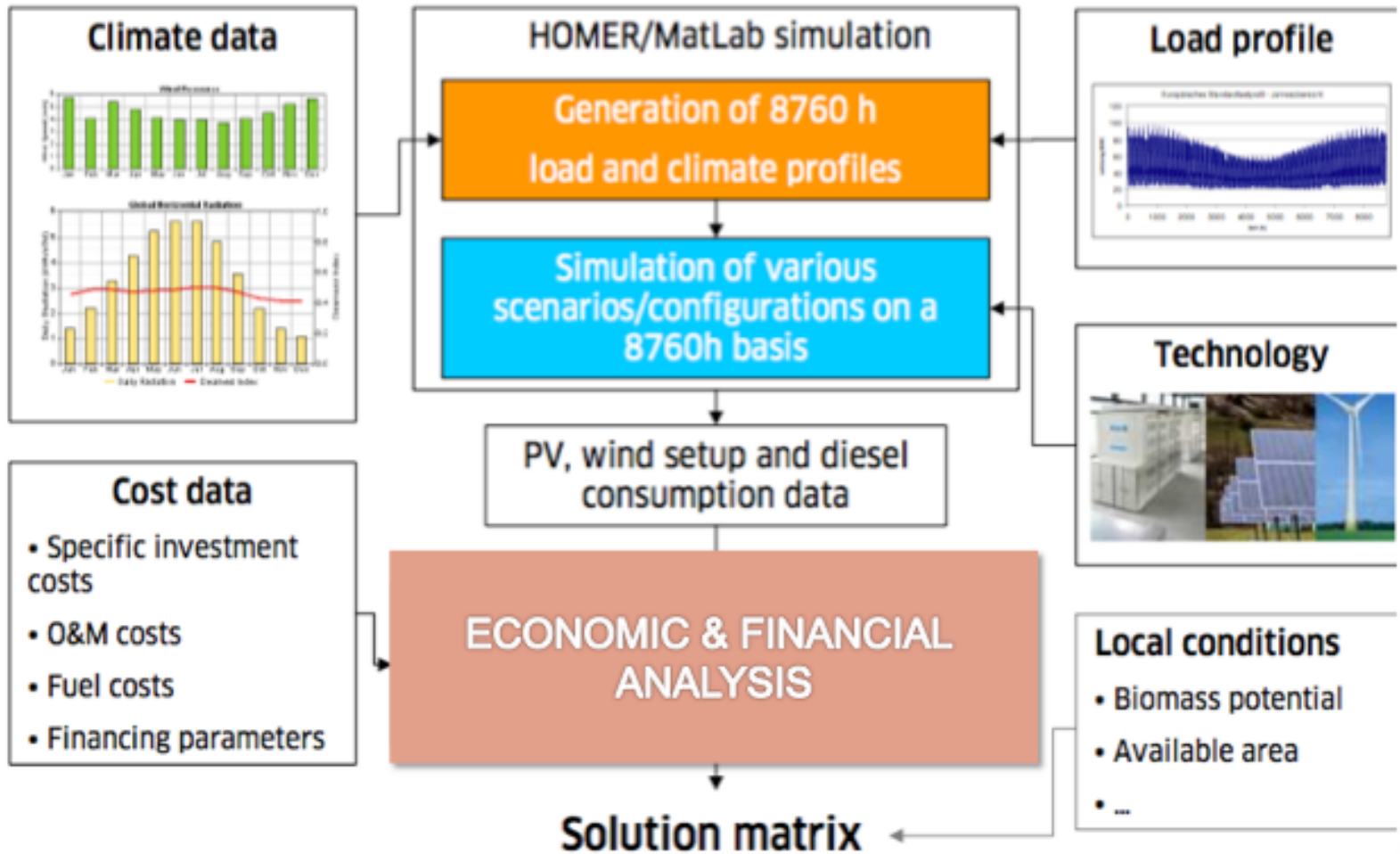
- Minimize fuel consumption
 - Maximize Subsidy Savings
- Optimum level of %RE penetration
 - Minimum operating cost
- Financial and economic viability
- Minimize CO₂ emissions
- Minimize local environmental impact
- Optimize land-use



Design..... - Models

- Type A – Moderate RE penetration
 - Up to 10% of energy or 30%-40% of peak-load
 - No Storage, new generators
- Type B – High RE penetration
 - 10%-80% energy or 90% of peak-load
 - Storage back-up (Security, Grid support)
- Type C – Full RE penetration
 - RE penetration close to 100% (peak <20kW)
 - Storage back-up (security, grid support, load-following)

Design..... -





Output – Generation Mix

Island	PV (kW)	Diesel Generation (kW)	Storage (kWh)	Type
Addu City	1600	6850 (1x1500, 3x1000, 3x750)	None	A
Villingili	300	800 (1x500, 1x300)	223	B
Khurendhoo	300	254 (1x104, 1x150)	223	B
Goidhoo	200	160	223	B
Buruni	100	100	111.5	B

Output – Stability assessment

Island	Conditions	Critical frequency without storage	Critical frequency with storage
Addu City	100% PV power loss	47.93 Hz	-
	Sudden load loss of 40%	51.65 Hz	-
	Load increase and PV power loss with two generators	48.08 Hz	-
Villingilly	100% PV power loss	49.18 Hz	-
	Sudden load loss of 30%	50.8 Hz	-
	50% PV power loss	49.77 Hz	-
	50% PV loss and load increase	47.46 Hz	49.28 Hz
Khurendhoo	100% PV power loss	48.79 Hz	-
	Sudden load loss of 30%	50.56 Hz	-
	50% PV power	49.73 Hz	-
	PV loss and load increase	47.09 Hz	49.38 Hz

Output – Stability assessment

Island	Conditions	Critical frequency without storage	Critical frequency with storage
Buruni	80% PV power loss	49.47	-
	100% PV power loss	48.7	-
	Sudden load loss of 30%	50.49	-
	PV power loss and load increase	47.41	48.49
Goidhoo	80% PV power loss	48.8	-
	100% PV power loss	48.22	-
	Sudden load power loss of 30%	50.60	-
	PV power loss and load increase	47.5	49.27

Economic feasibility

	BAU	No Oil price growth	Capital cost escalation		Solar PV Output Reduced by		Combined effect
			10%	20%	10%	20%	
Addu City	40.96%	38.64%	37.37%	34.37%	39.81%	38.65%	34.12%
Goidhoo	14.30%	12.54%	12.93%	11.76%	14.30%	14.30%	11.20%
Buruni	29.44%	27.08%	26.95%	24.86%	29.44%	29.44%	24.68%
Villingili	19.58%	17.01%	17.80%	16.29%	19.58%	19.58%	15.33%
Khurendhoo	24.32%	22.09%	22.17%	20.36%	24.32%	24.32%	20.01%



Financial feasibility

	Base Case	Increase in Project Cost by 10%	No increase in diesel costs	Reduction in solar intensity by 10%
Addu City	11.7%	10.3%	9.9%	10.7%
Goidhoo	4.9%	3.8%	3.5%	4.2%
Buruni	13.8%	12.4%	12.1%	13.1%
Villingili	5.6%	4.4%	4.0%	4.8%
Khurendhoo	9.1%	7.7%	7.4%	8.0%

- WACC 1.2%



Roadmap for expansion

- Extended to 162 islands
- Solar PV systems
 - On the ground and rooftops
 - Total capacity 25.7MWp
- Diesel generators - 44MW
- Li-Ion batteries – 7.5MWh
- Total cost is in the range of \$140 million



Final Remarks

- Low carbon energy sector development
 - With adequate reliability
- Improved energy security
- RE enabled grids for private sector investment in PV
- Conducive regulatory environment
 - Technical regulations
 - Tariff regulations

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