



# Yap State States of Micronesia

- RE Integration
- Challenges & Lessons Learned

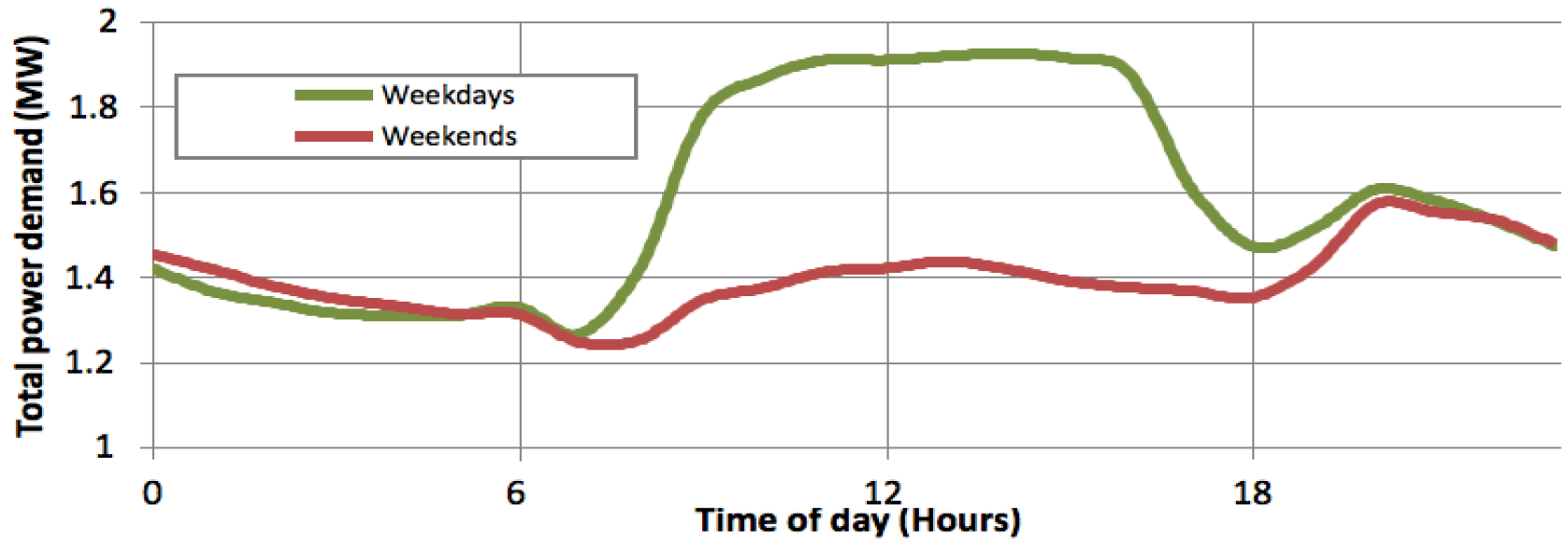
**REMOTE SMALL ISLAND GRID**

# Load Profile

- <2,000 ratepayers
- <7,000 consumers
  
- Annual Energy Consumption - 13 GWh
- Base Load – 1.2 MW
- Peak Load – 2.4 MW

# Consumption Fairly Constant Yearly (13 GWh)

- Weekdays (1.2 MW to 2.4 MW)
- Weekends (1.4 MW)



# Current Generation System

- Dominantly Diesel Generation
  - 200 kW grid-tied PV (under installation)
  - 72 kW customer PV net-metering
- Diesel Installed Capacity – (6.9 MW)
  - 2 Duetz (3.2 MW each)
  - 1 White Superior (de-rated to 500 kW)

# **Current System Constraints & Inefficiency**

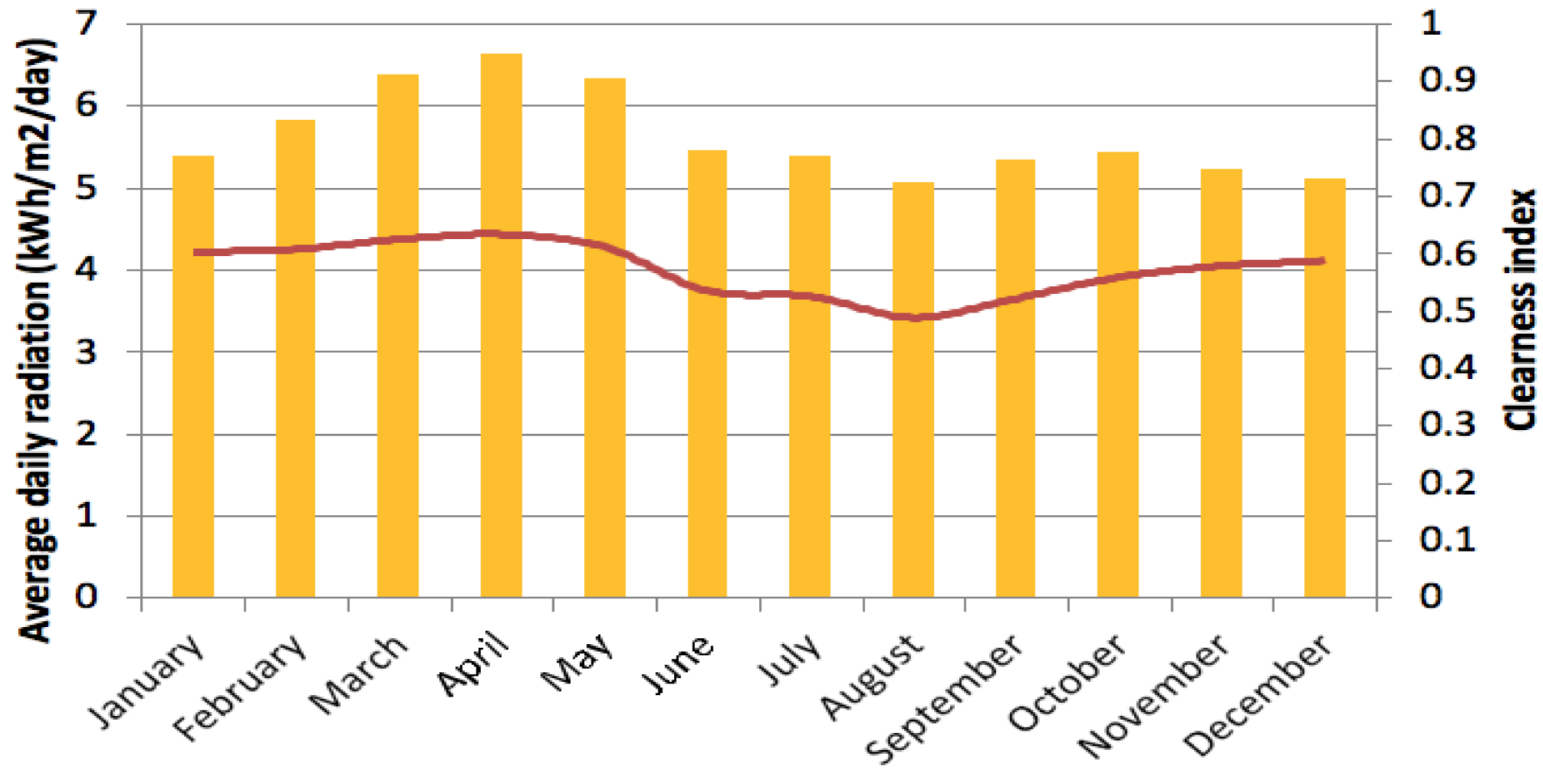
- **Low Fuel Efficiency of 3.2 MW Duetz**
  - Rating oversized for load (esp. off-peak hours)
- **Dependency on Fossil Fuel**
  - High Fuel Cost (remoteness & diseconomy of scale)
  - High Tariff
  - System & Customers Vulnerable to Volatility of Fuel Cost

# Solution – Integrated Mix

- **New Diesel**
  - Efficient and more appropriately rated for Load
  - Allowance for High RE Penetration
- **High RE Integration into Mix**
  - Lessen Dependence on Fossil Fuel
  - Stabilize Tariff During Spikes in Fossil Fuel Cost
- **Available RE Resources**
  - Wind
  - Solar

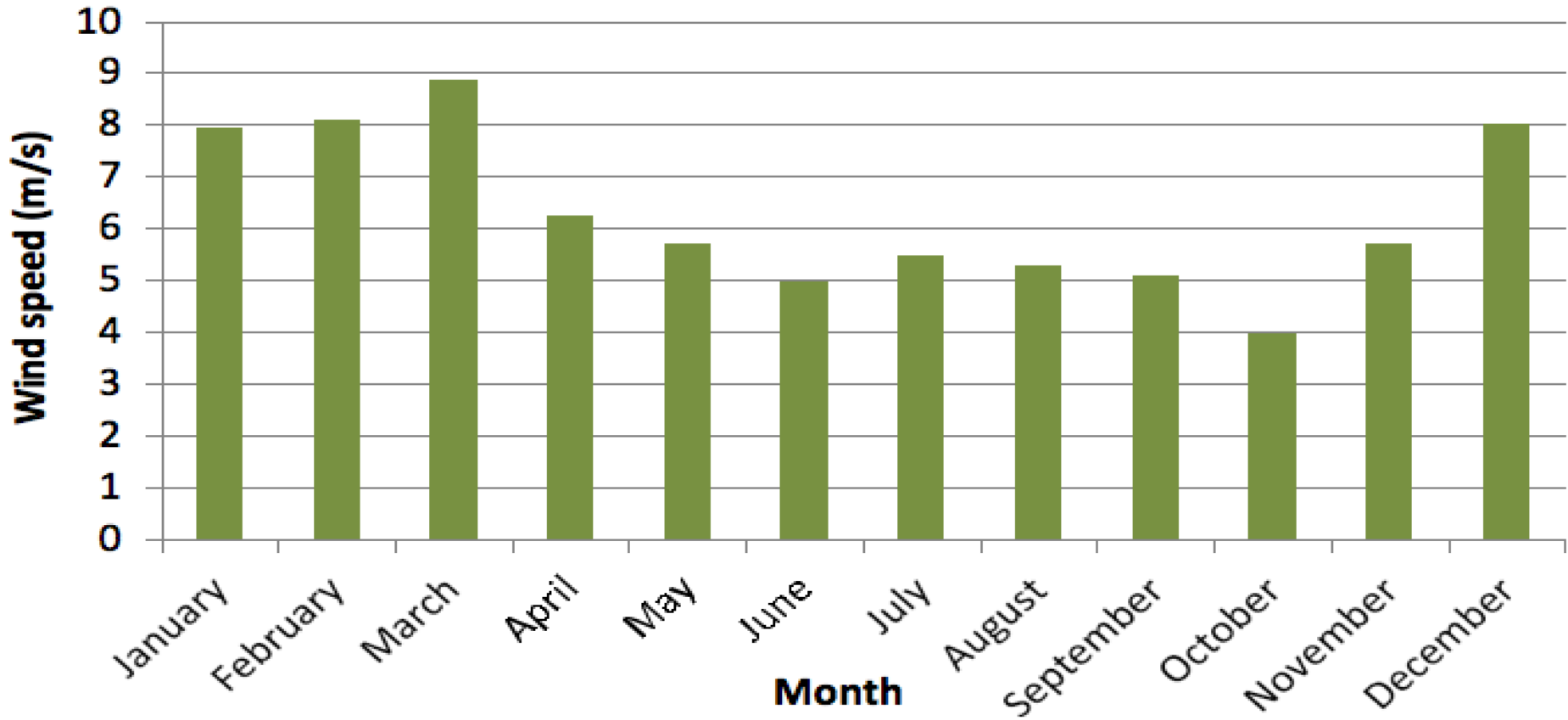
# Solar Assessment

Radiation Average (5.63 kWh/m<sup>2</sup>/day)



# Wind Assessment

- 6.4 m/s (annual average)
- Dec – March (Speed Consistently Higher)





# Renewable Energy Estimate

- **Wind - Based on 3 WTG (825 kW)**
  - P50 energy output of 1.4 GWh/yr
  - P75 energy output of 1.3 GWh/yr
  - P90 energy output of 1.2 GWh/yr
- **Solar – Based on 500 kW**
  - 830 MWh/yr

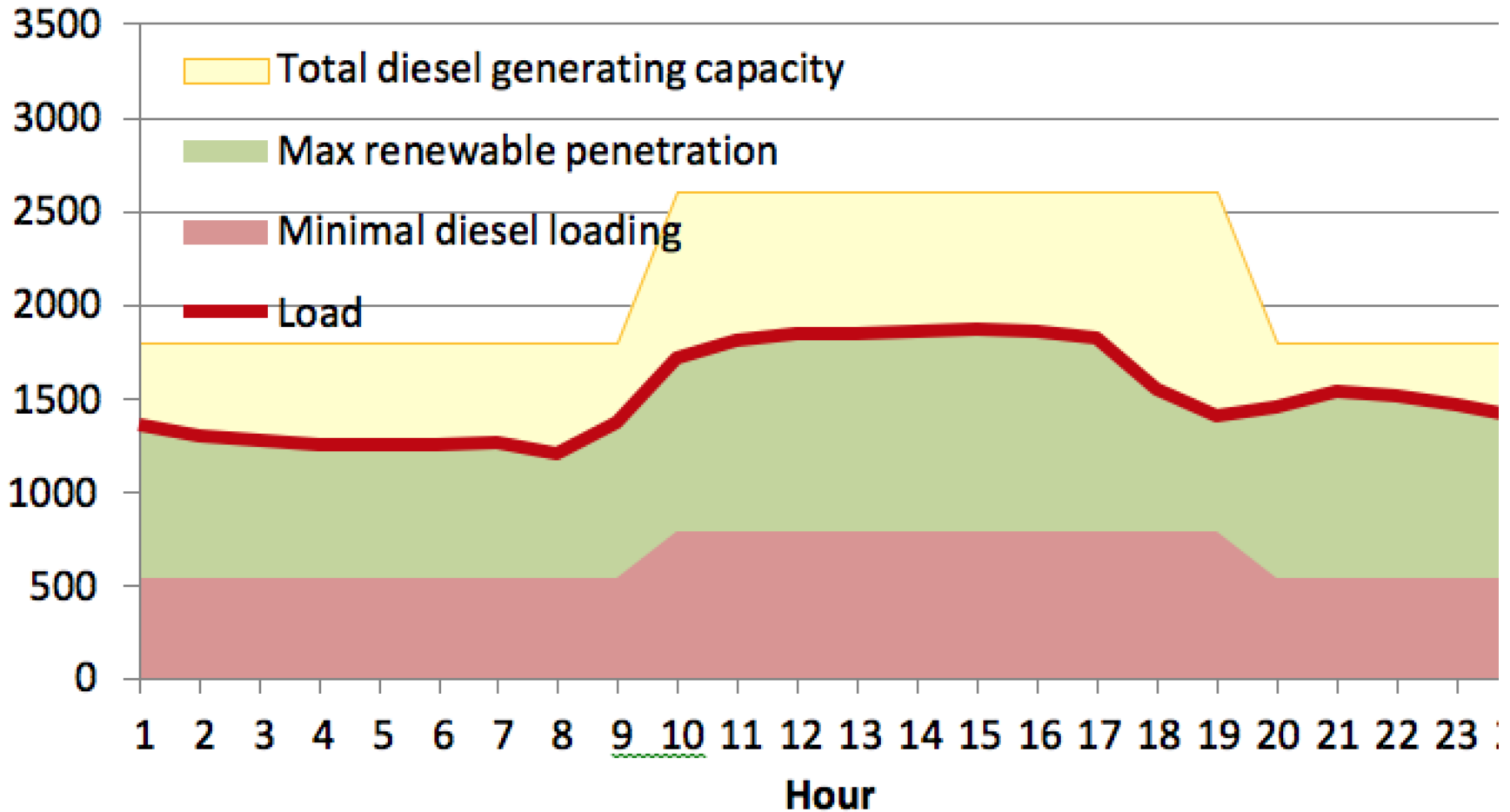
# Modeling Integrated System

Solar size (kW)	WTG (#)	Diesel size (kW)	Small diesel (kW)	Initial capital (\$M)	Total operating cost (\$M)	COE (\$/kWh)	RE Pen (%)	Diesel fuel cons. per year (gal x10 <sup>3</sup> )	Average fuel eff. (kWh/gal)	Renew. <u>energy</u> spill (GWh/yr)
500	3	1600	800	8.895	5.33	0.439	17	778	13.73	0.02
500	3	1800	800	8.945	5.35	0.438	17	782	13.69	0.04
500	5	1600	800	10.76	5.15	0.428	22	772	13.61	0.26
500	5	1800	800	10.81	5.15	0.430	22	738	13.59	0.32

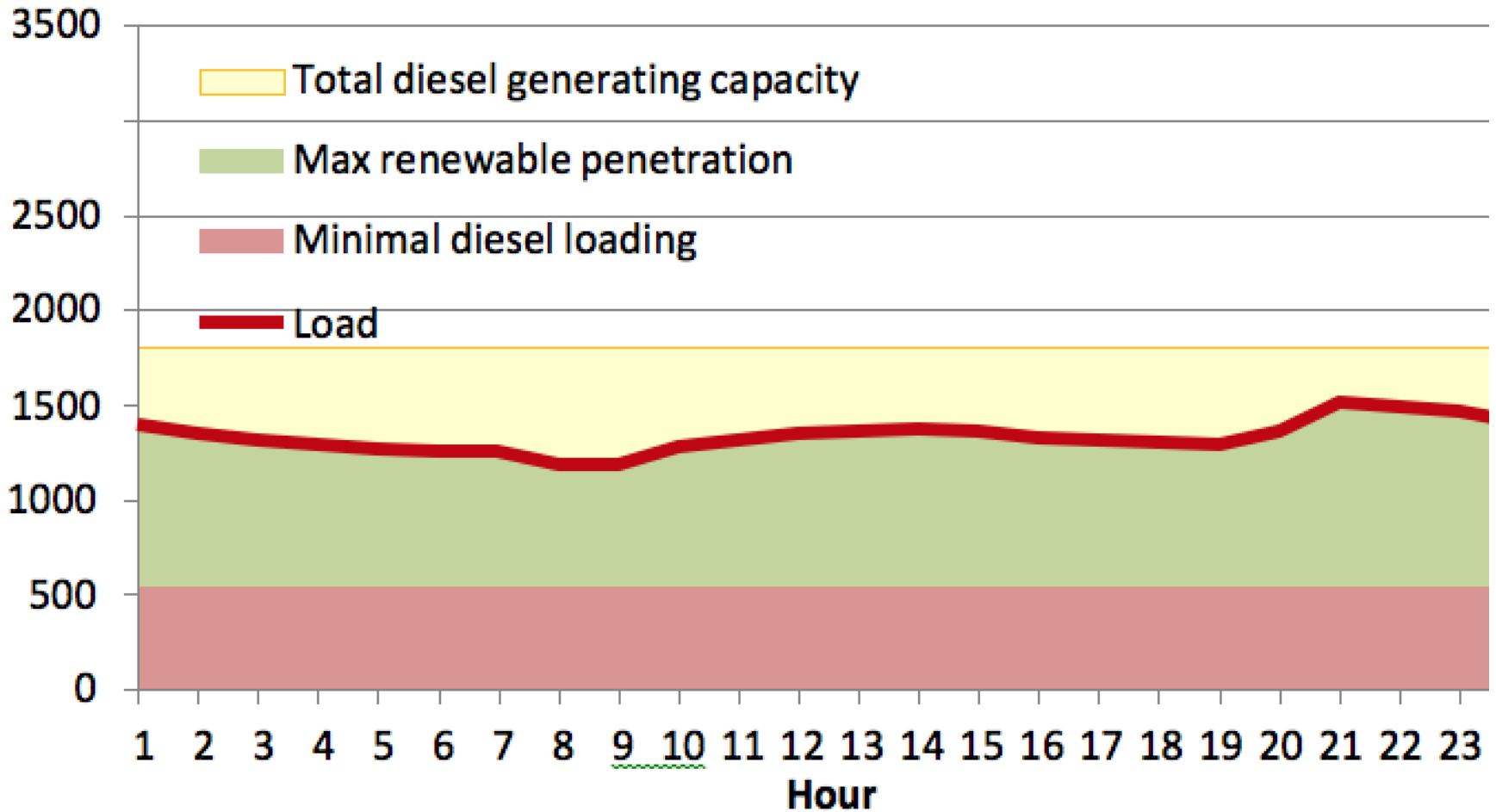
# Models Under Tender

Solar size (kW)	WTG (#)	Diesel size (kW)	Small diesel (kW)	Initial capital (\$M)	Total operating cost (\$M)	COE (\$/kWh)	RE Pen (%)	Diesel fuel cons. per year (gal x10 <sup>3</sup> )	Average fuel eff. (kWh/gal)	Renew. <u>energy</u> spill ( <u>GWh/yr</u> )
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# Operation Strategy - Weekdays



# Operation Strategy - Weekends



# Implementation Challenges

- **Constraints on Options for Turbine Types**
  - Typhoon Prone Environment
  - Limited Local Lifting/Transport Equipment
  - Terrain Accessibility and Spacing Limitation
- **Wind Measurement**
  - Lead Time for Measurement
- **Land Ownership**
  - Unregistration of Land
  - Size of Land Parcels
- **Remoteness & Scale of Project**
  - Investment Disincentive

**THANK YOU**