Optimizing Wind Energy in Island Networks

Challenges and Opportunities

UVIG Spring Technical Workshop

April 25, 2012

Back in October 2011……

THE CARIBBEAN RENEWABLE ENERGY FORUM CREF 2011

UWIG Utility Wind Integration Group

Increasing Wind Penetration – Challenges & Opportunities

Opportunities

- Electricity price is high due to cost of imported fuel
- Caribbean islands have an attractive wind resource
- Replace the costly gen with wind without negative impacts to the system
- Storage and alternative uses of electricity from wind can increase the wind penetration and provide large benefits:
  - ✓ **The utility** – system stability, increased market size
  - ✓ **Consumers** – lower and more stable prices of electricity

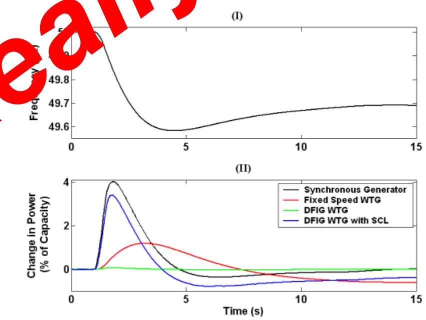
Challenges

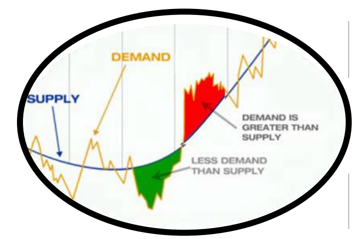
- Variable resources like wind will have a greater impact on smaller networks depending on:
  - Utility operations policies
  - Controls deployed
  - Amount of storage
  - Wind resource diversity
  - Load capacity factor; min load
  - Characteristics of thermal units
- Optimizing wind penetration in these networks will require new approaches

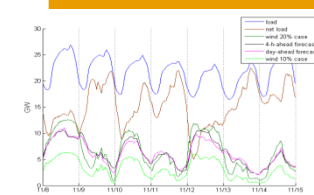
Technical Challenges of Increased Wind Penetration in Islanded Systems

Challenge	Timeframe	Description	
1. Stability/ inertia	milliseconds – seconds	Small system inertia, load shed during unit outages, wind units usually provide no inertia response	
2. Regulation	seconds – minutes	Large net load fluctuations	Low diversity in demand and wind resource
3. Ramps/ load following	minutes – hours	Large ramps	
4. Demand cycles	hours – months	High peaks and low valleys	
5. Resource adequacy	days – years	Significant non-wind backup reserve	
6. Voltage regulation	seconds – hours	Wind units usually provide limited voltage control	

SOME MINOR DETAILS…Really?







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Overcoming Challenges

Wind Plant Controls

- Ramp control, MW control (curtailment)
- Frequency response (mimic inertia)
- Voltage regulation

Demand Controls

- Voltage reduction
- Load shedding (UFLS)
- Controllable demand with storage

System Management

- Advanced forecasts and updated decisions
- Energy and reserve dispatch co-optimization
- Automatic generation control

Storage

- Energy Storage – batteries, flywheels (output smoothing)
- Alternatives – convert to hydrogen for transportation, desalination facilities (high energy volume)

Interconnection

- Diversity
- Inertia

Simulating High Penetration of Wind – Modeling Challenges and Opportunities

Alternative Storage

Desalination

Hydrogen bus

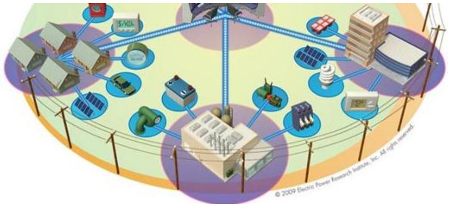
Wind

- Chronological values consistent with load levels
  - Hourly profiles for 1 year
  - Intra-hour variations
- Operational forecast errors
- Turbine controls

Operations

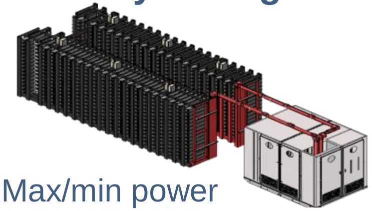
- Operating decision cycles
- Ancillary service requirements
- Ancillary service deployment criteria

Energy Demand



- Chronological load
- Intra-hour operations
- Operational forecast errors
- Demand response
- Load shedding
- Inertia
- Frequency response

Electricity Storage



- Max/min power
- Max/min state of charge
- Response capability
- Efficiency

Thermal Generation

- Heat rates
- Operating constraints
- Ancillary services provision
- Frequency response

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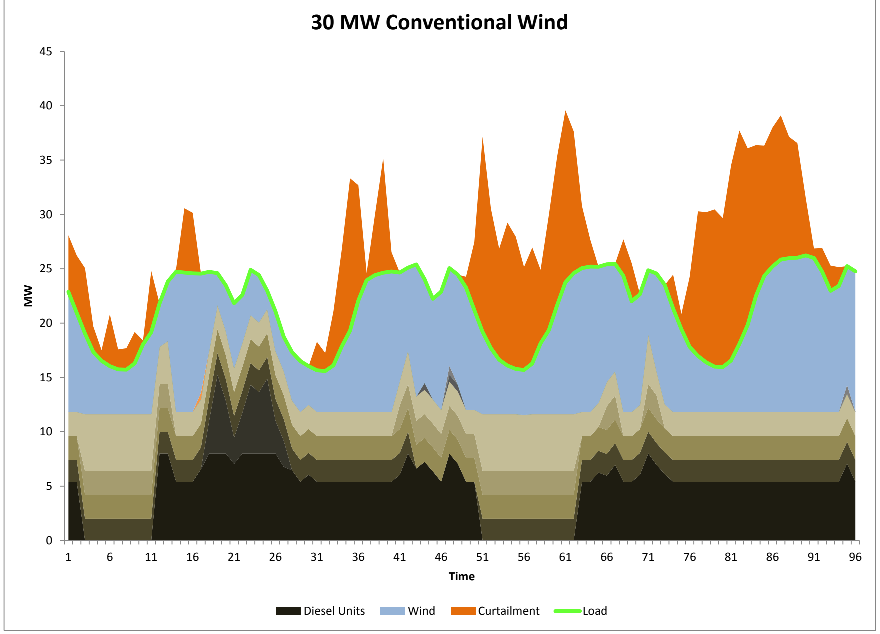
Two Approaches for Wind Integration

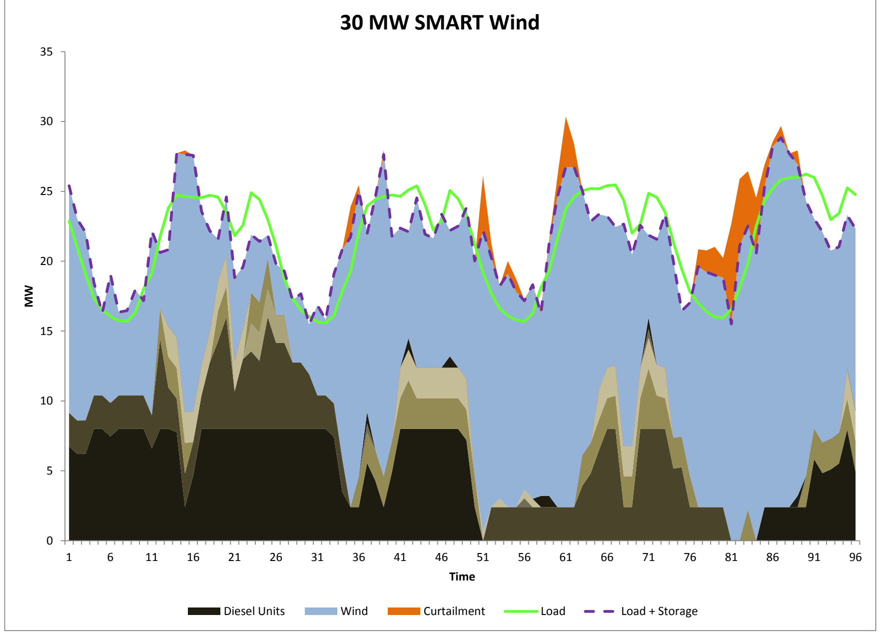
Conventional Wind

- Wind does not provide ancillary services and has limited control capability.
- No storage or demand controls added.
- Thermal units challenged by variability.



Smart Wind

- Use latest technology to allow wind to provide ancillary services if they are valuable.
- Voltage support, storage and demand controls added as penetration increases to extract the most value from wind generation.
- Storage and Demand management.



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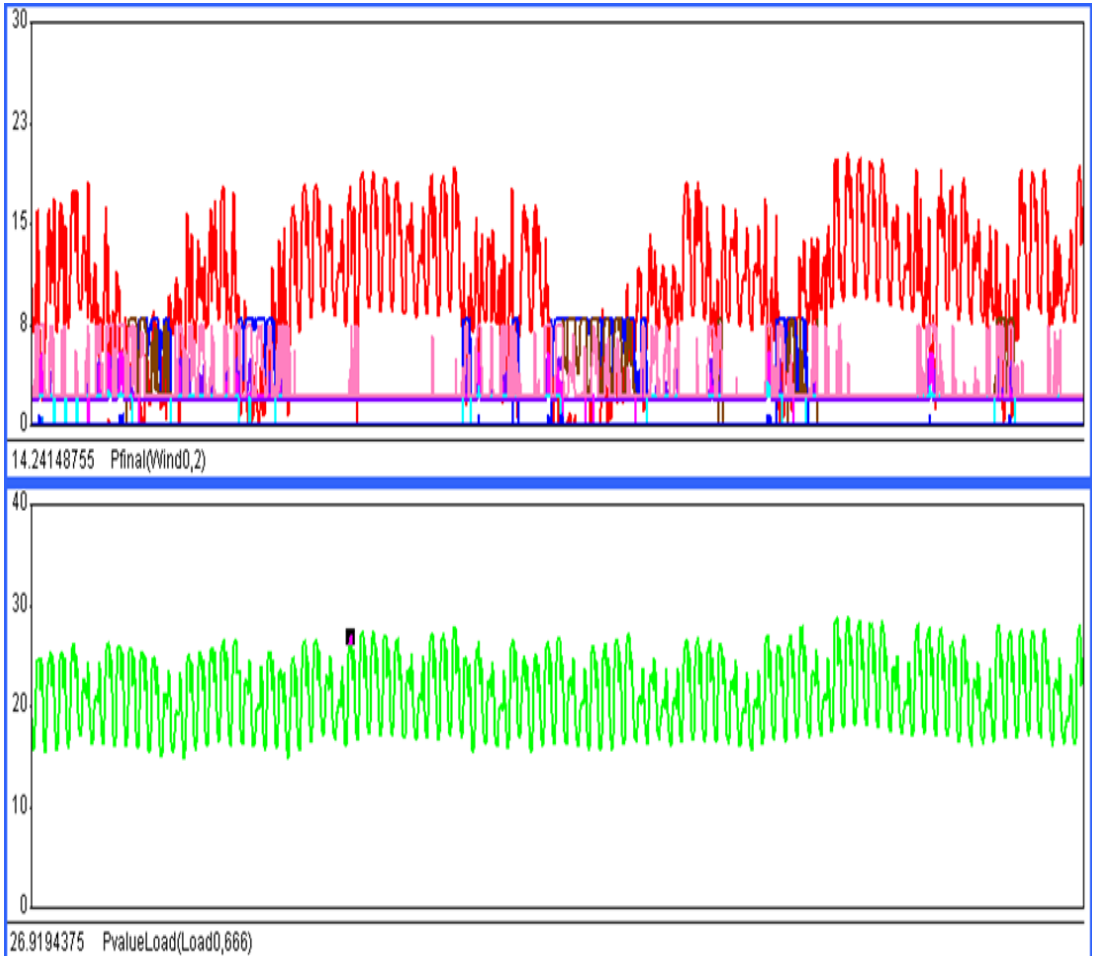
Technical Details for the Engineers ….

PSO Model – Island Operation Simulation Chronological Commitment & Dispatch



Assumptions

Load:
- peak 30MW, mean 22MW, min 14MW
- 15 min load data

Thermal Generation:
- 12 diesel units, 1 – 8MW
- Min gen, start up/shut down, reserves

Fuel Cost: $25/MMBtu

Wind Generation:
- 10 min wind measurements
- Vestas V100 Class II, 2MW turbines
- Turbine controls contribute to A/S

Operations
- Fast start, spin and regulation reserve requirements
- Voltage and stability constraints
- Chronological commitment and dispatch

No T&D Constraints

No Financial Assumptions

Polaris Systems Optimization

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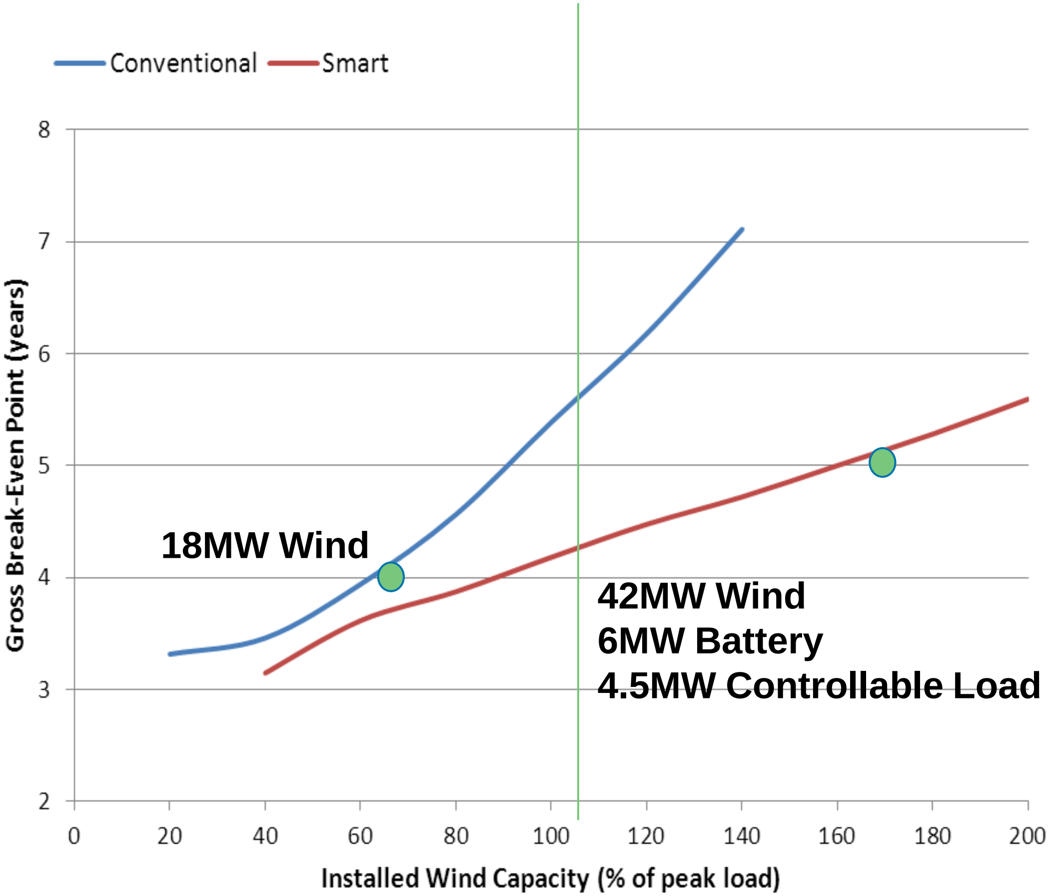
Cost and Benefits:
Conventional Wind with Controls is Good … Smart Wind is Even Better

30 MW Peak Load Island



Cost and Benefits

30% of energy / 60% peak

Simple cost / benefit over 20 years

- Capital = US$ 49 million
- **Fuel saving = US$ 260 million**

73% of energy / 160% peak

Simple cost / benefit over 20 years

- Capital = US$ 154 million
- **Fuel saving = US$ 651 million**

- In high penetration curtailment provides an additional 25% of “free” energy which could be applied to adjacent use such as hydrogen – US$ 3 to 4 million per year fuel savings vs. diesel for buses.

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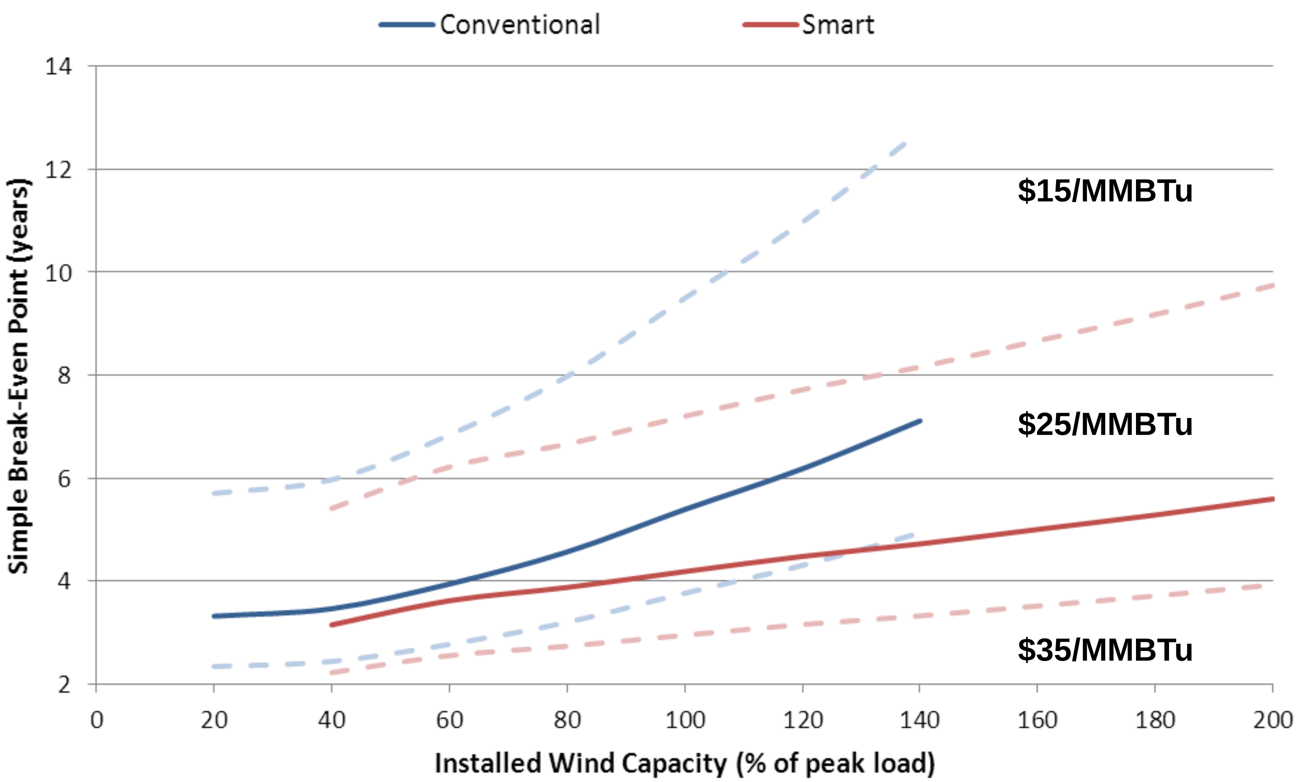
Cost and Benefits:
Sensitivity to Fuel Price



Fuel Savings (nominal US$ over 20 years)

Base Case ($25/MMBtu):	**US$651 million**
High Case ($35/MMBtu):	**US$911 million**
Low Case ($15/MMBtu):	**US$390 million**

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