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The Attributes of Ocean Energy

OREG 2009 Fall Symposium
Ocean Energy in Ottawa

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Outline

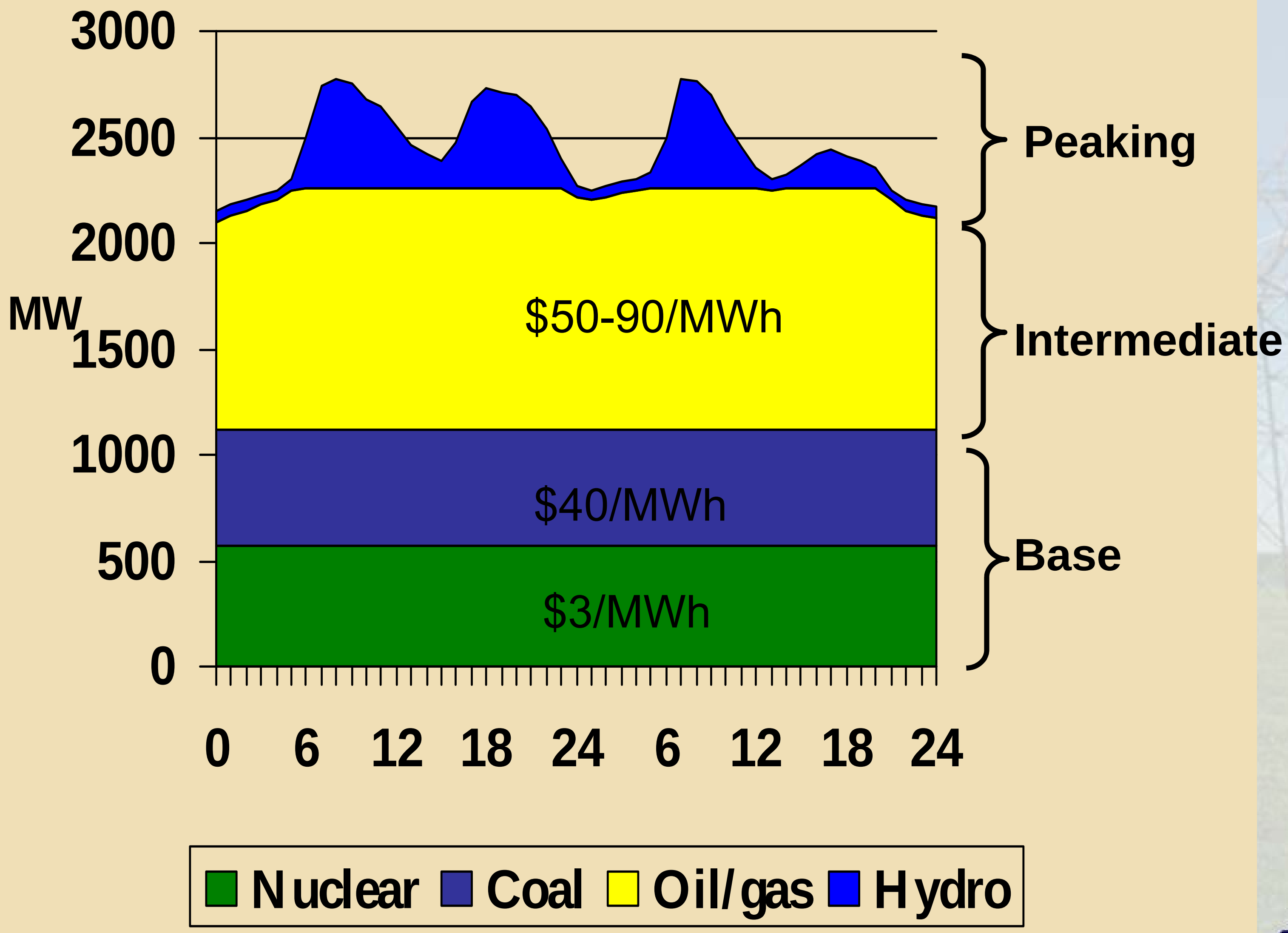
- Description of the power system (i.e. the grid)
- Attributes of ocean renewable energy sources
  - Offshore wind
  - In-stream tidal
  - Wave
  - Barrage tidal
- Integration of ocean renewables into the grid

The Grid

Nature of the Grid

- Equipment must not be overloaded
- Local voltage support is required
- Supply must always equal demand (must be balanced because electricity cannot be stored economically)
  - Customers set demand, and the system must respond
  - Extra generation is required in reserve, because demand changes over time, and because supplies are not always all available
  - The consequence of imbalance could be minor frequency or voltage fluctuation, or a major blackout

Economic Dispatch (Pre-Wind)



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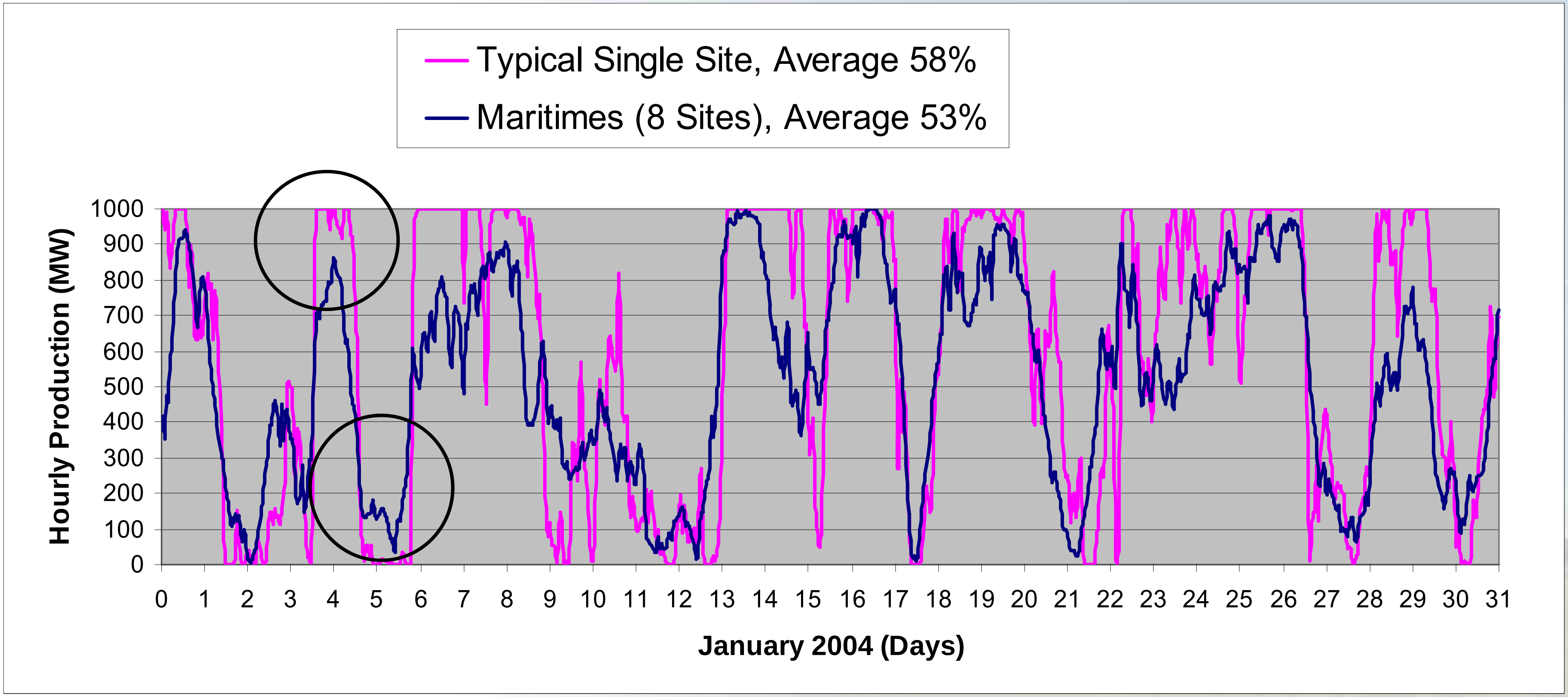
On-Shore Wind Power Production



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Simulated Dispatch (with Wind Power)

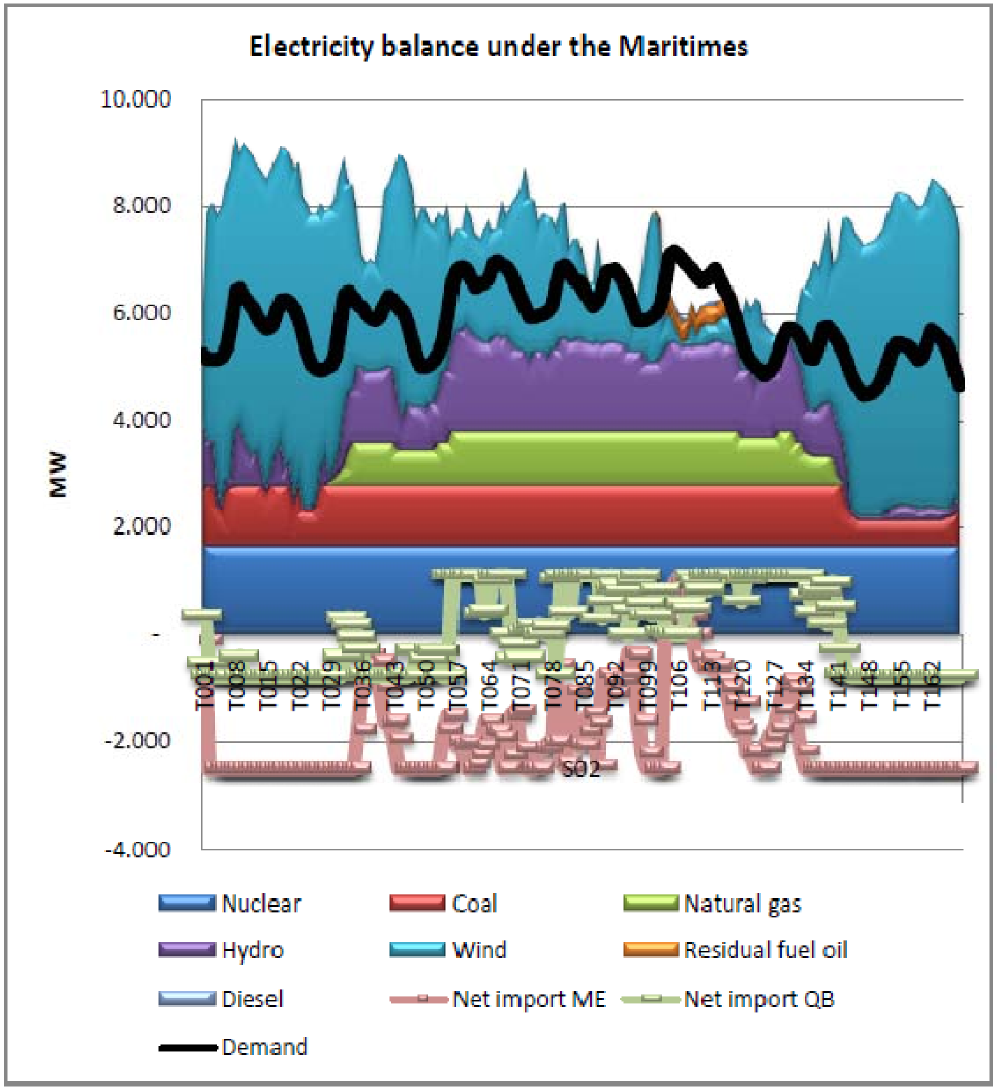

Figure 58: Electricity balance in the Maritimes during peak demand.

- Very large volume of wind power
- Highly variable imports & exports
- "Cycling" of coal, natural gas, and oil-fired generation

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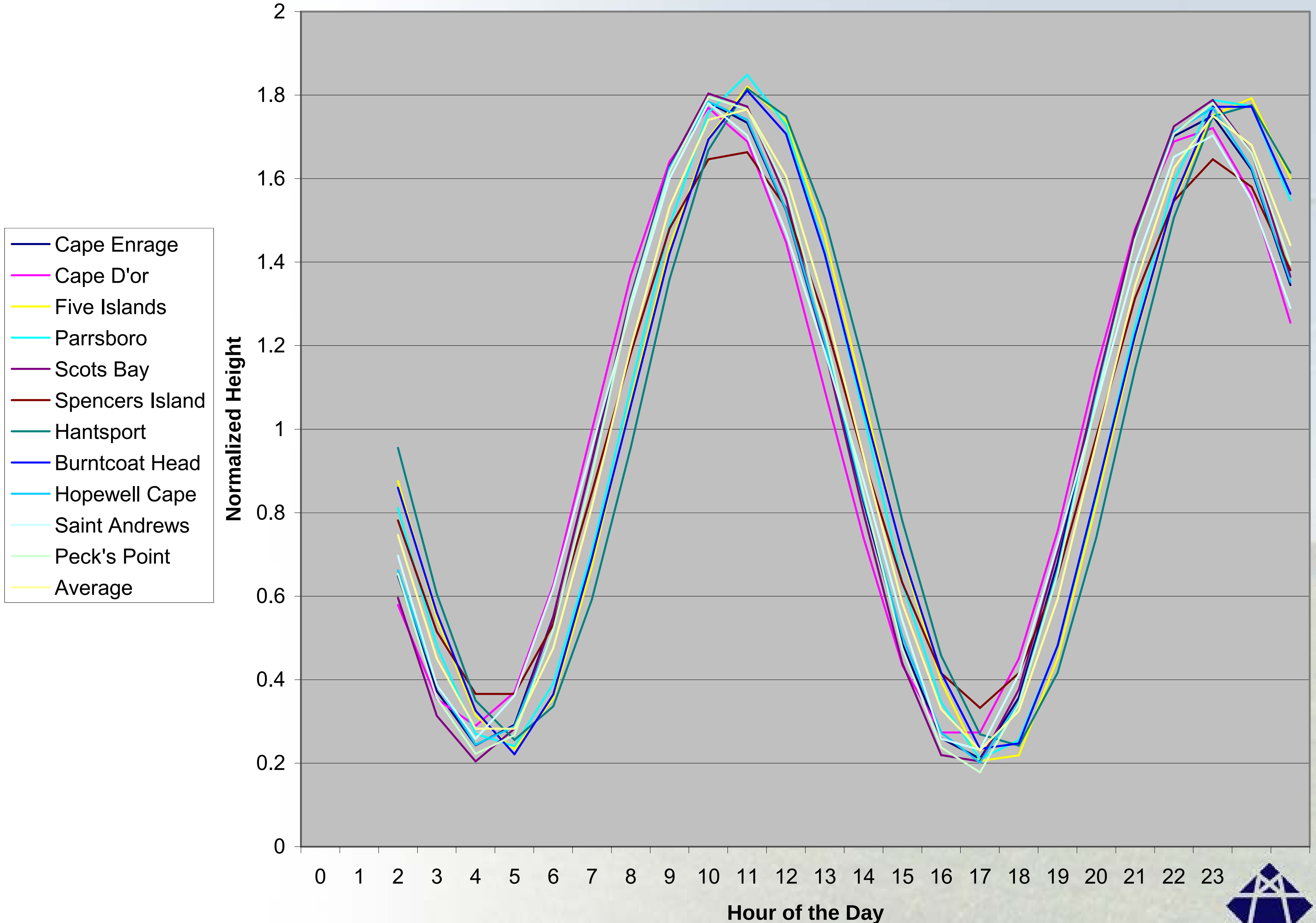
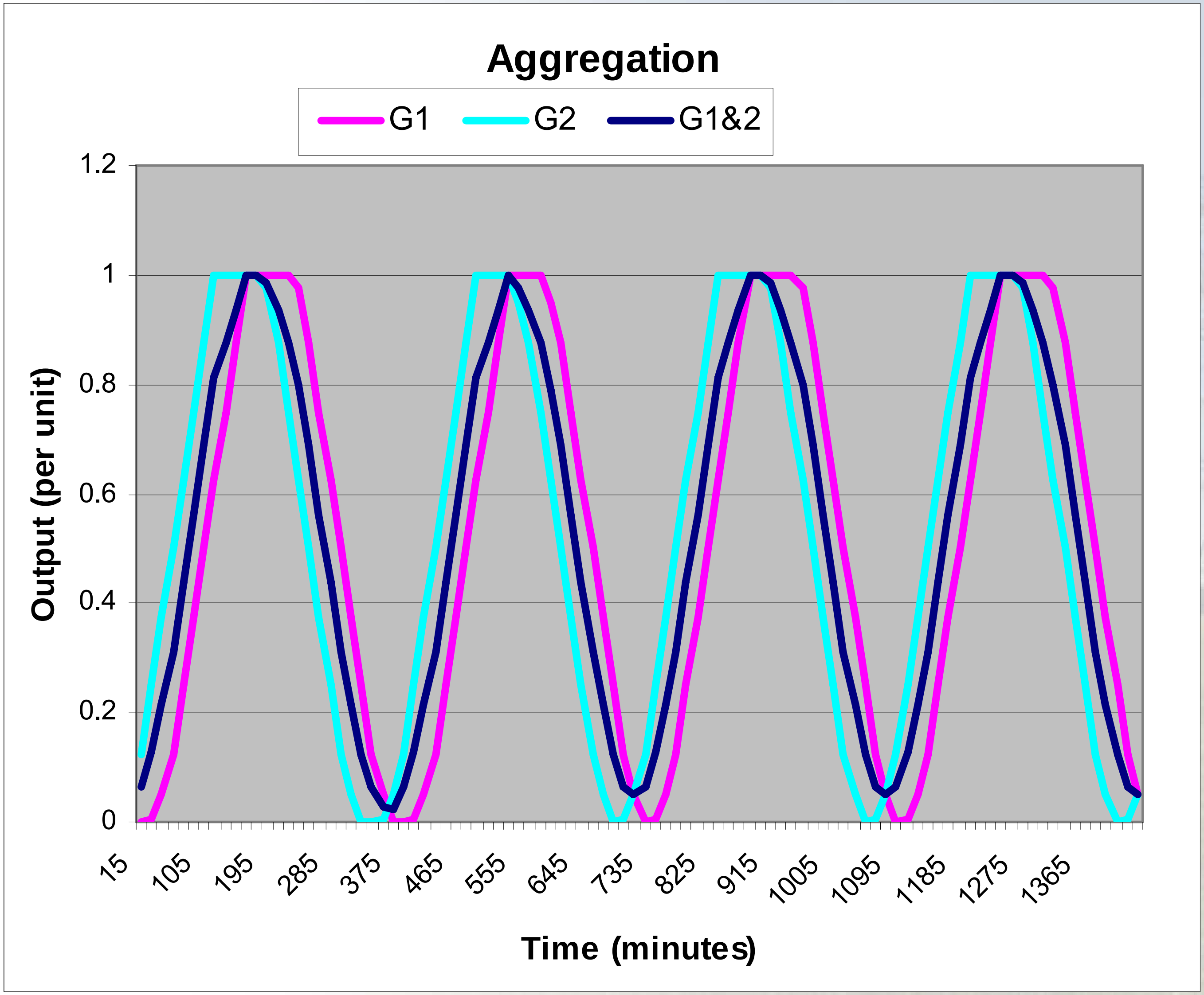
Attributes of Ocean Renewables

Normalized Bay of Fundy Tide Heights



Simulated Bay of Fundy In-Stream Tidal "Saint Andrews" and "Cobequid Bay"



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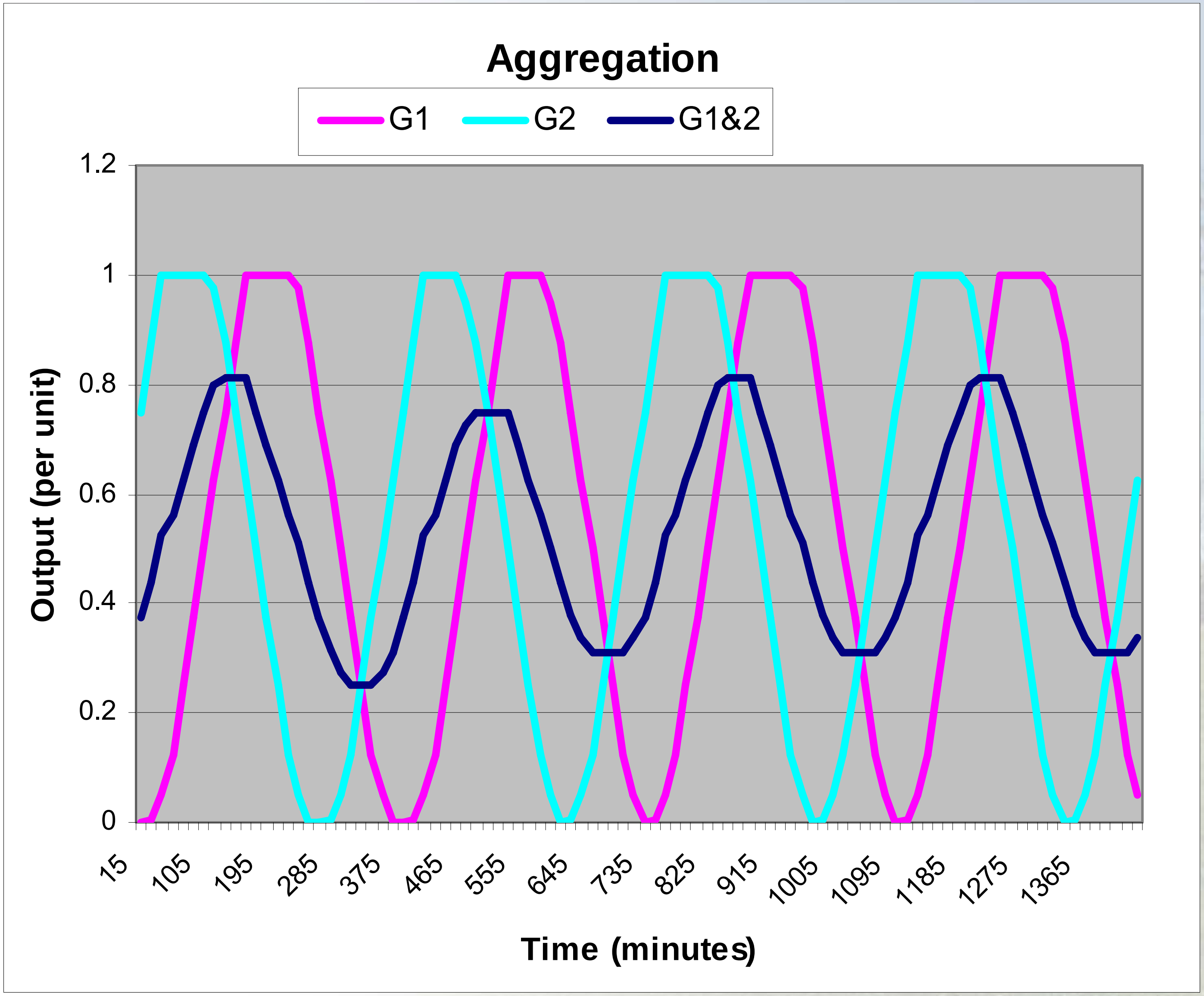
Simulated In-Stream Tidal "Saint Andrews" and "Sydney"



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Wave Power

- What would be the characteristics of wave power production?
  - Predictability?
  - Variability?
  - Correlation between forecasting for various sites?
  - Correlation between productions at various sites?
- Measured data must be accurately time-stamped for proper analysis of short-term diversity!
- Comparison to wind and in-stream tidal?
- Future study work planned by anyone?

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Impact of Ocean Energy on the Grid

Commercial Products & Pricing Tools

Service	Description	Provided by
Capacity	Basic capacity to balance demand and supply	Generator or responsive demand
Energy	Hourly injection or withdrawal arranged with customer	Generator or responsive demand
Market clearing price	Used for market settlement (typically the marginal cost of energy in spot market)	Market operator calculation based marginal supplier bid

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Ancillary Services for Reliability

Service	Description	Provided by
Regulation	Minute-by-minute variations on demand/supply balance	Fast flexible generator (or load) on automatic control
Load Following	Hourly trends in dispatch required	Flexible generator (or load)
Operating Reserves	Fast response capacity for large & sudden supply loss	Dispatchable generator (or load)
Balancing Energy	Hourly under (or over) injection (or withdrawal)	Any of the above

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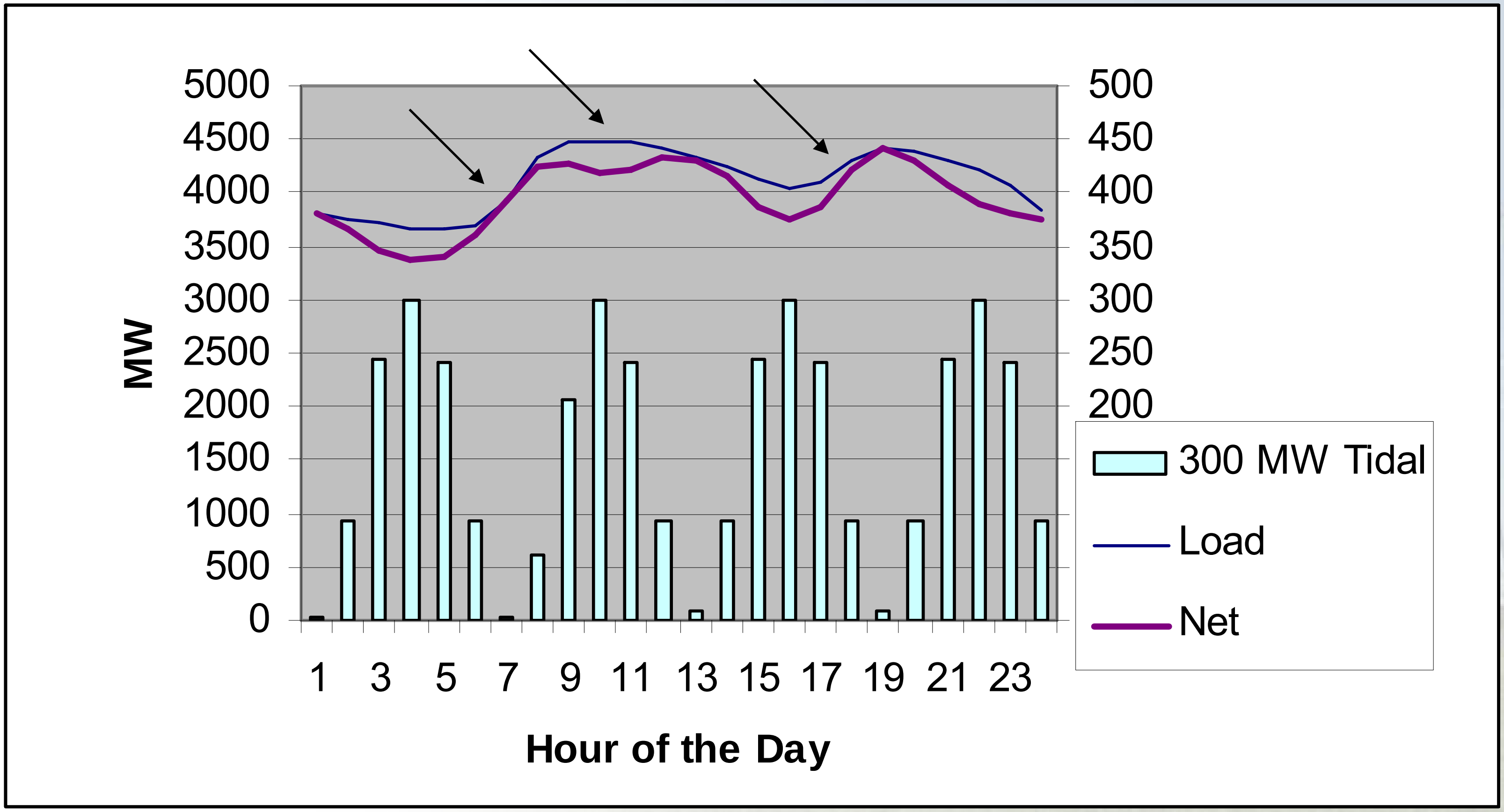
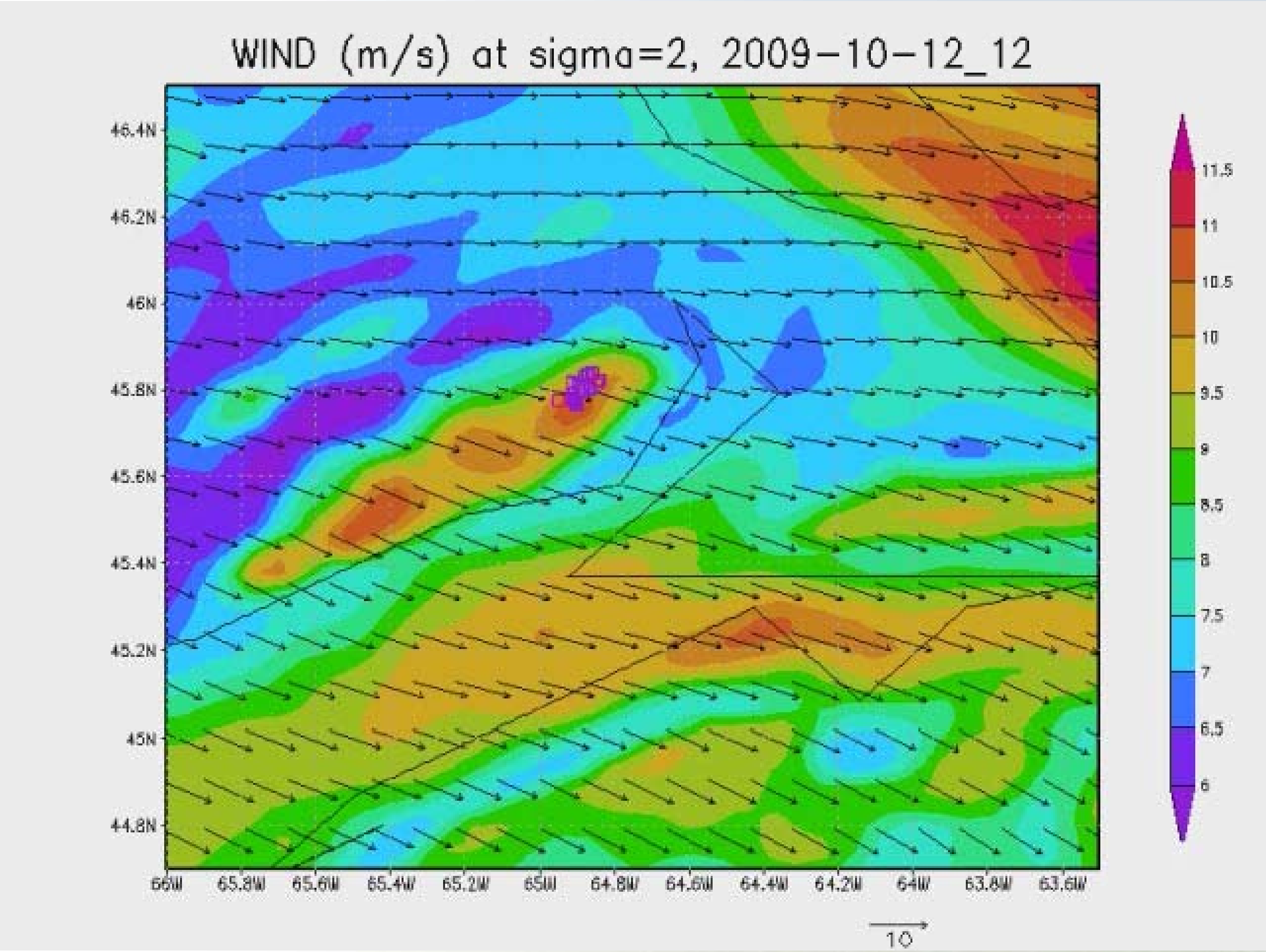
Impacts of Renewables

Service	Wind	Tidal	Wave
Capacity	How much?	How much?	How much?
Energy	Variable, not dispatchable	Variable, not dispatchable	Variable, not dispatchable
Regulation	Increase	Little increase?	Increase
Load Following	Increase	Increase	Increase
Operating Reserves	No increase?	No increase?	No increase?
Energy Imbalance	Actual less Forecast	Actual less Forecast	Actual less Forecast
General	Difficult forecast	Easy forecast	Difficult forecast

Impact of Tidal on Net Load Served



Forecasting Wind Speed and Direction



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Local Opportunities

- Diversity of wind, wave, and tidal
- Accuracy of forecasting
- More flexibility (generation and load)
  - Hydro
  - Combined cycle gas turbine
  - Electric vehicles
  - Stationary demand response
  - Storage technology
- Fair mechanism to curtail surplus
- Dynamic pricing signals

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Regional Opportunities

- More transmission
- New inter-area "balancing" services
  - Sub-hourly schedules (e.g. 30 min)
  - Dispatchable energy on-demand
  - Regulation
  - Load following
  - Dynamic scheduling
- Market integration (larger Balancing Area, single dispatch)

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Smart Grid Characteristics

1. Enable participation √
2. Accommodate various resources √
3. Enable new products, services, and markets √
4. Provide power quality
5. Optimize assets and operate efficiently √
6. Anticipate and respond to system disturbances
7. Operate resiliently against attack and natural disasters

√ = marine friendly

Key Smart Grid Technology Areas

1. Integrated communications √
2. Sensing and measurement support faster and more accurate response √
3. Advanced components (e.g. superconductor, storage, etc) √
4. Advanced control for monitoring, diagnosing and addressing any event √
5. Improved interfaces and decision support enhance human decision-making √

√ = marine friendly

Response to Redpoint's Report

- The approach as described is sound
- The study's results make sense directionally
- The apparent savings are substantial
- The analysis which was performed is very much dependent on the context (e.g. power system)
- What about in North America?
- If scientifically studied and clearly explained, the results make a case for paying <u>some</u> premium for marine renewables, but how much?

Redpoint Report for BWEA

Apparent Marine Premium in U.K.
(at various % of 120 TWH of variable renewables)

		0%	25%	40%	60%
A	Cost savings (£mn/year) from Table 2 of Redpoint	-	£717	£901	£841
B	Cost if wind (£mn/year) based on wind @ £70/MWh	n/a	£2,100	£3,360	£5,040
A/B	Apparent "marine premium value" versus wind	n/a	34%	27%	17%

Currently the cost premium for marine versus wind exceeds 100%, but how quickly will this drop?

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Summary

- Grid operation requires continuous balancing
- Changes to the grid and its operation can make the integration of all variable renewables more efficient
- Diverse sites and diverse technologies can reduce variability and forecast error
- Adequate assessments and clear explanations of costs and benefits are important