

Integrating Renewables

***OREG Symposium
Halifax
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and Settlement***

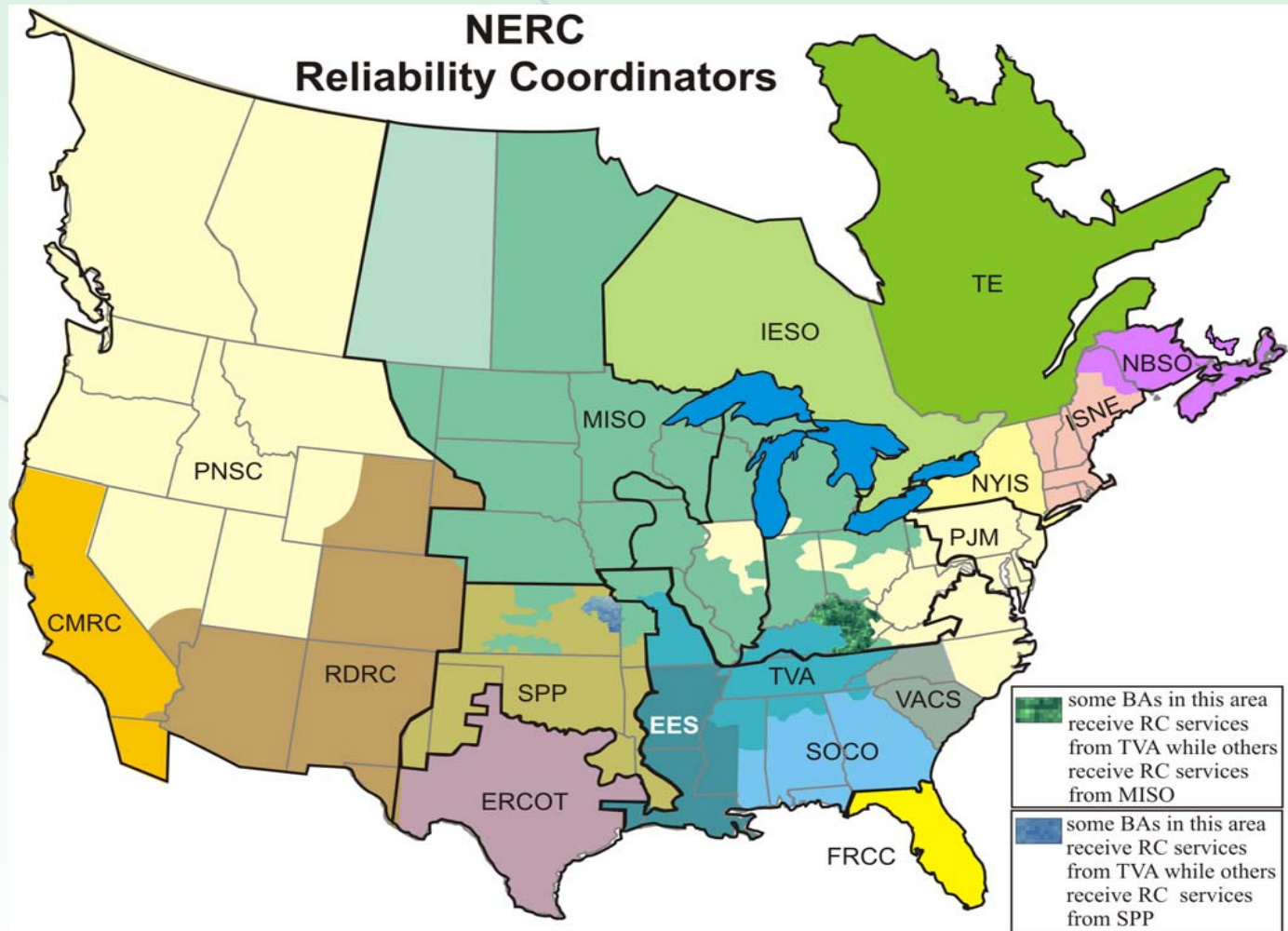


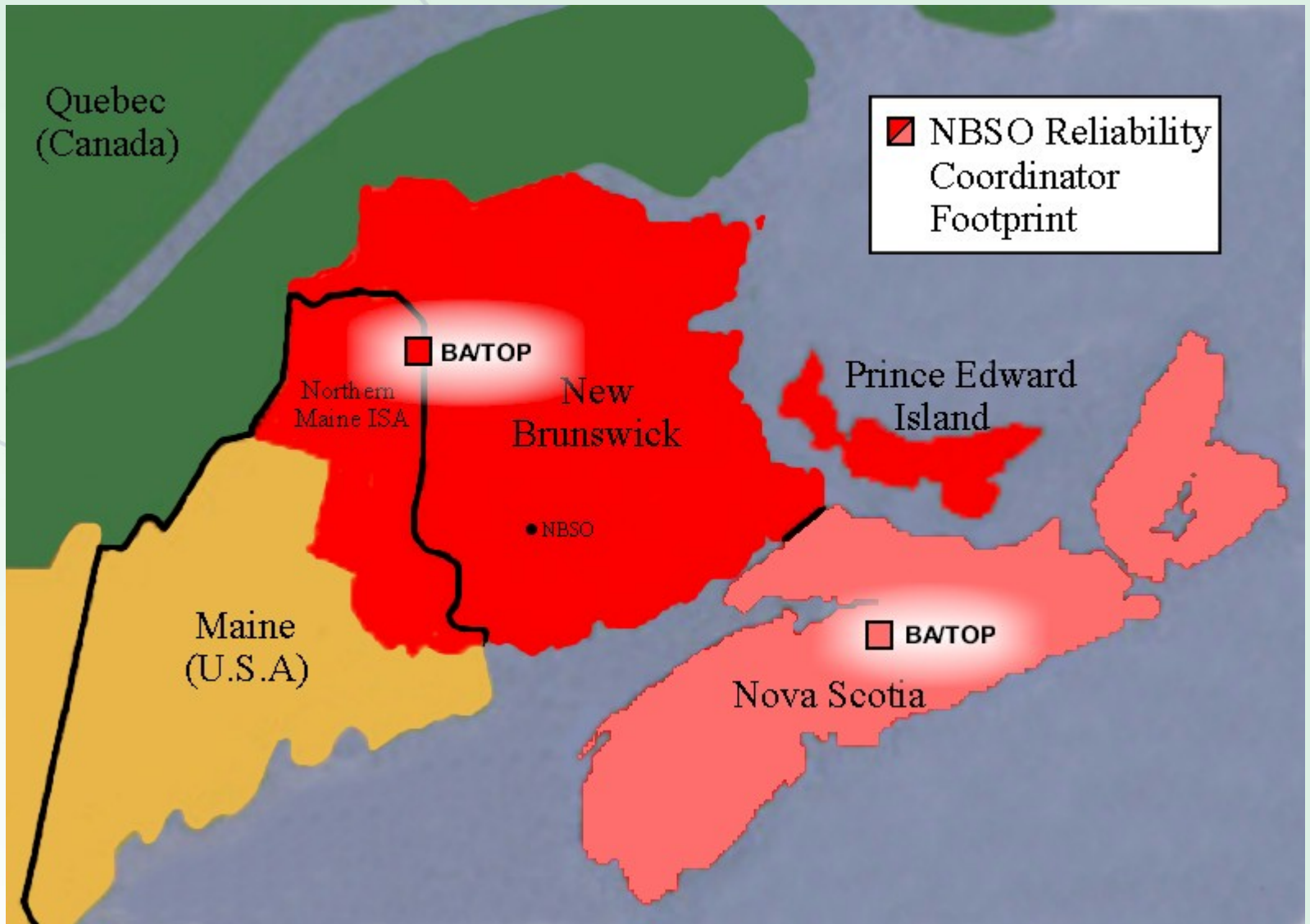
Presentation Summary

1. ***Power System Operations***
2. ***Market Design***
3. ***Integration of Intermittents***

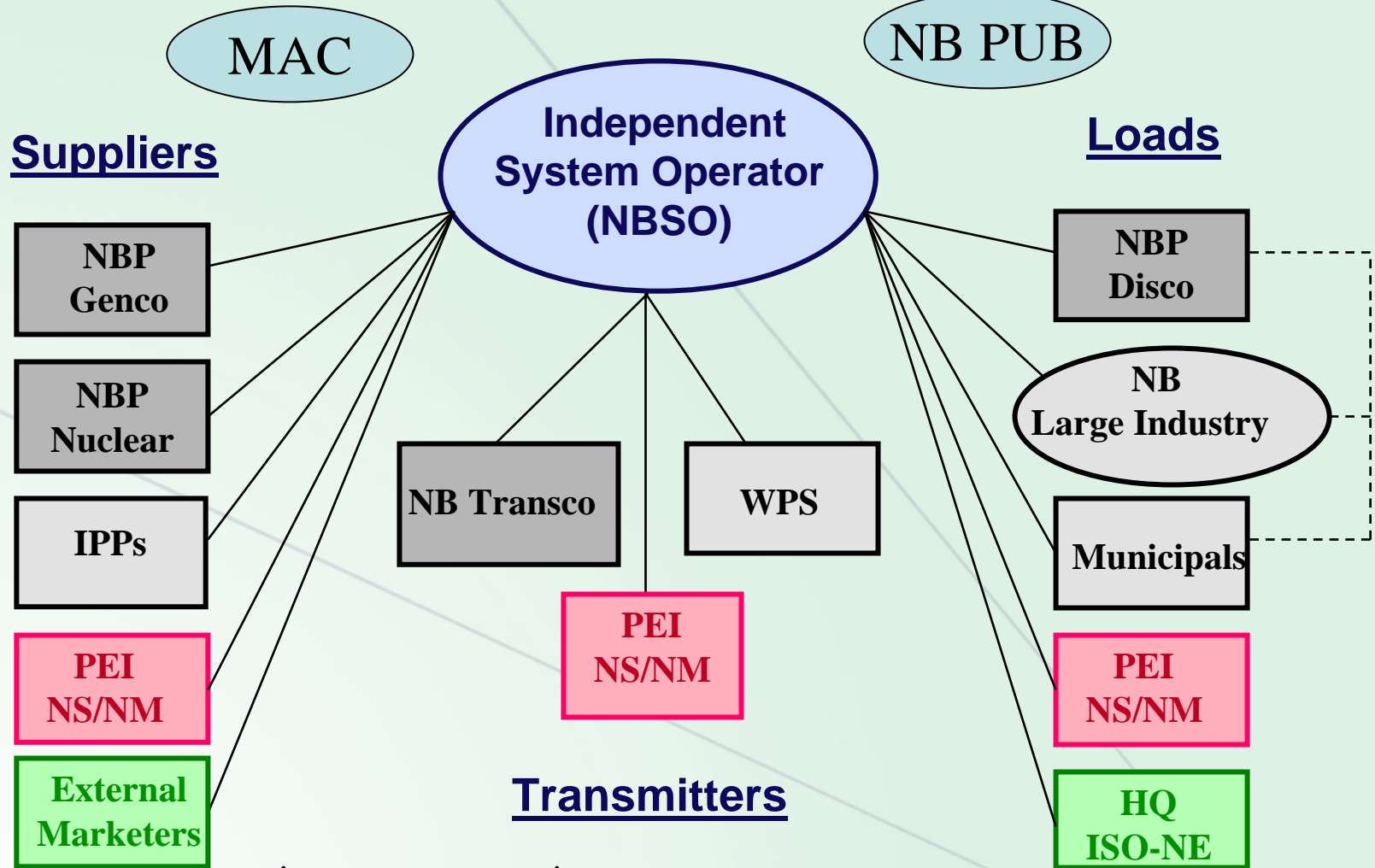


NBSO – One of 17 Reliability Coordinators





Maritimes Area Operation

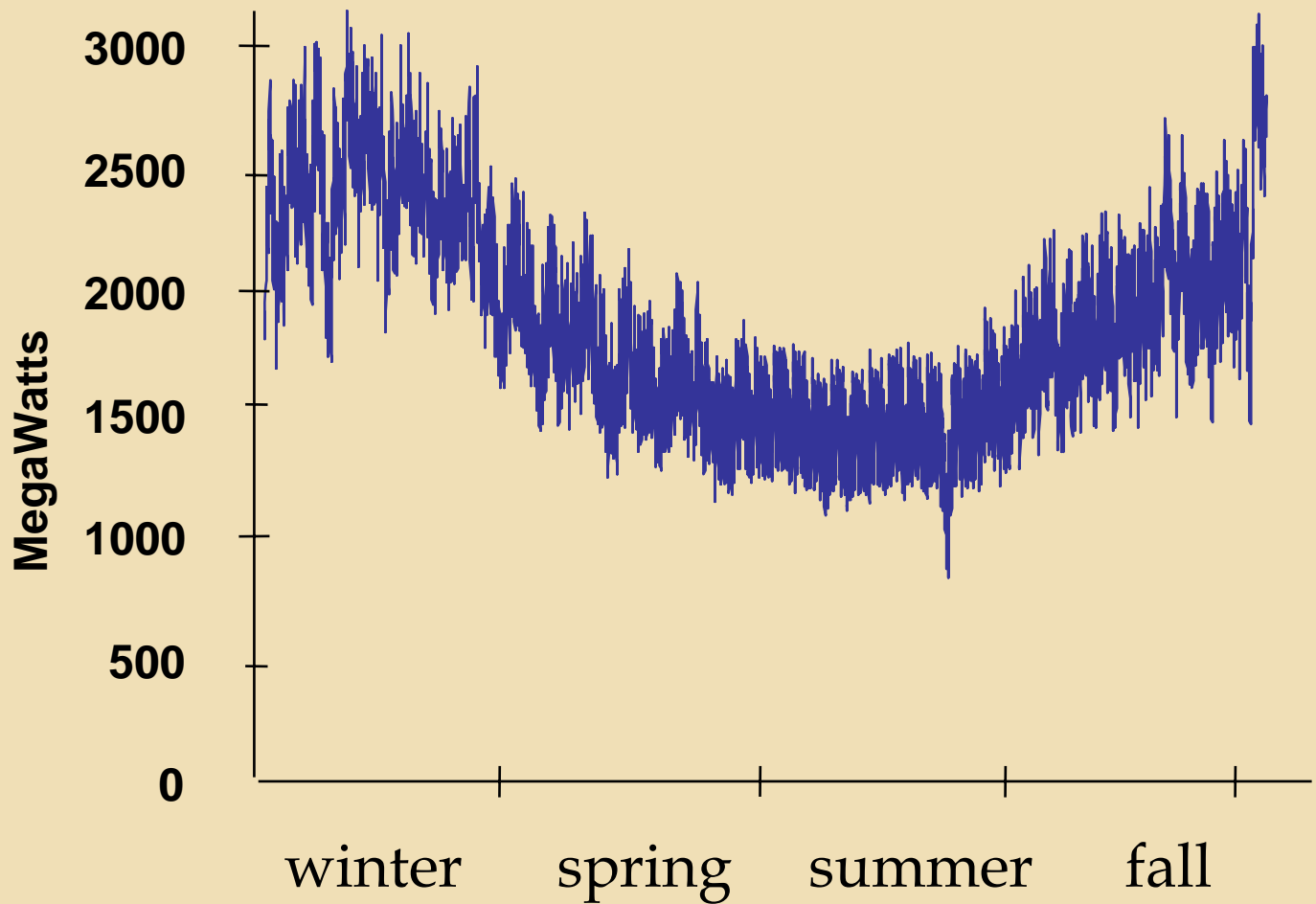


NBSO Responsibilities

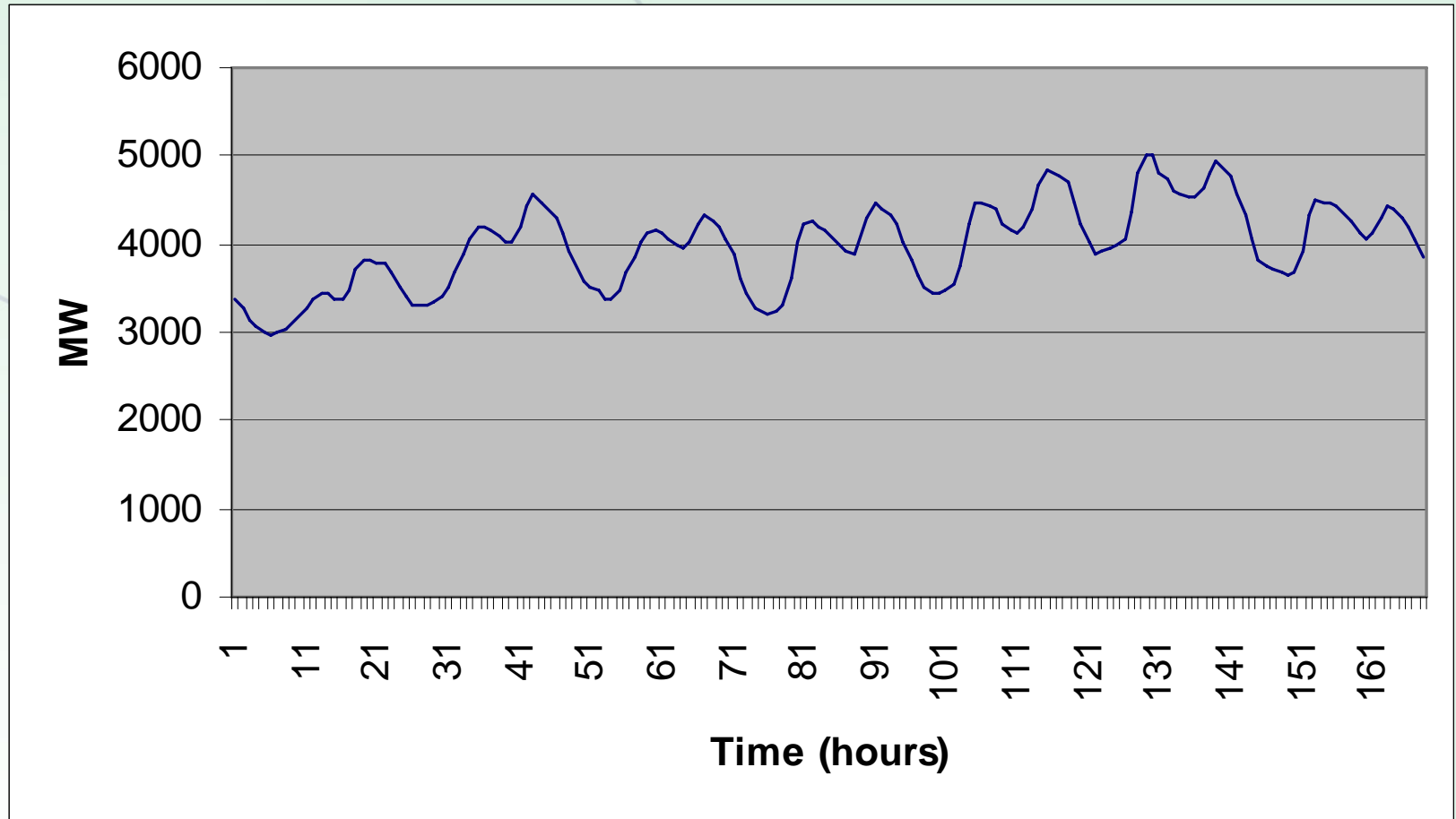
- ***Reliable operation of integrated system within NERC standards and NPCC criteria***
 - As RC, BA and TOP
 - NERC audits completed
- ***Operate NB Electricity market***
 - Design & Administer transmission tariff
 - Maintain & Develop Market Rules
 - Schedule & dispatch generation
 - Perform market settlements
- ***Plan NB grid***
 - Conduct system impact studies
 - Produce long term plan



New Brunswick Load to be Served



Maritime Area Jan 1-7, 2005



Nature of Electricity

- ***Electricity can not be stored***
- ***Supply must equal load demanded at all times***
 - Customers set demand
 - Power system must respond
- ***Reserve generation is required***
 - Meet changing demand
 - Backup sudden unexpected loss of supply
- ***Consequence of imbalance could be***
 - Minor frequency or voltage fluctuation
 - Major blackout
- ***Plus, local voltage support required***



Requirements for Balancing

- ***Planning (say 20%, based on one outage day in 10 years)***
- ***Operational***
 - Peak forecasted hourly load
 - Reserves
 - 100% of largest contingency
 - 50% of second largest contingency
 - Generation (or load reduction) that is controllable and responds adequately (e.g. regulation and load following)



“Balancing” in Diminishing Timeframes

Reliability

- ***Annual 10 Year Outlook***
- ***Quarterly 18 month Assessment***
- ***Day Head Assessment***
- ***Hourly 4 Hour Assessment***
- ***Dispatch for Next Hour***
- ***Intra-hour Dispatch***

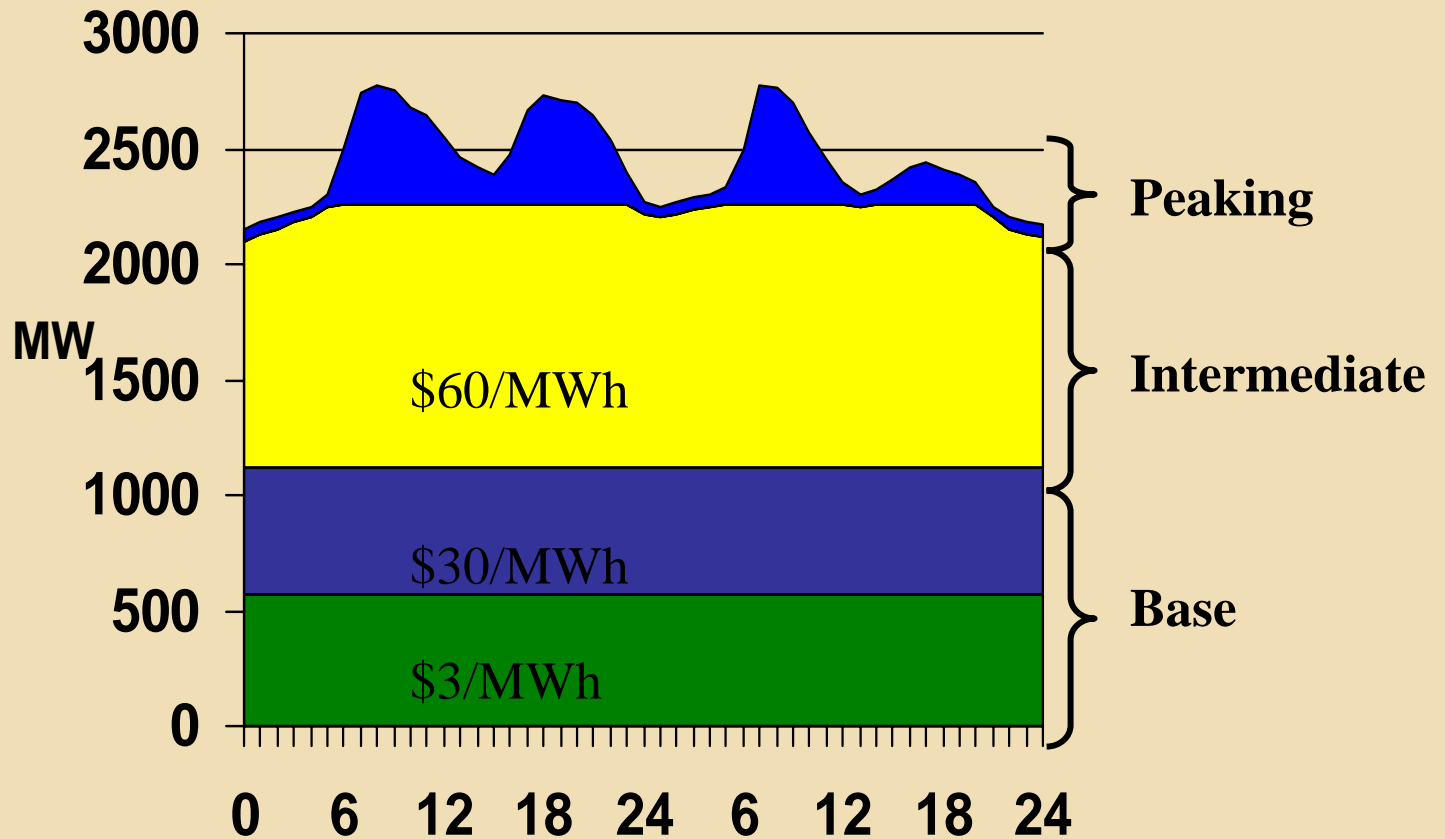
Economic
Dispatch

market transactions

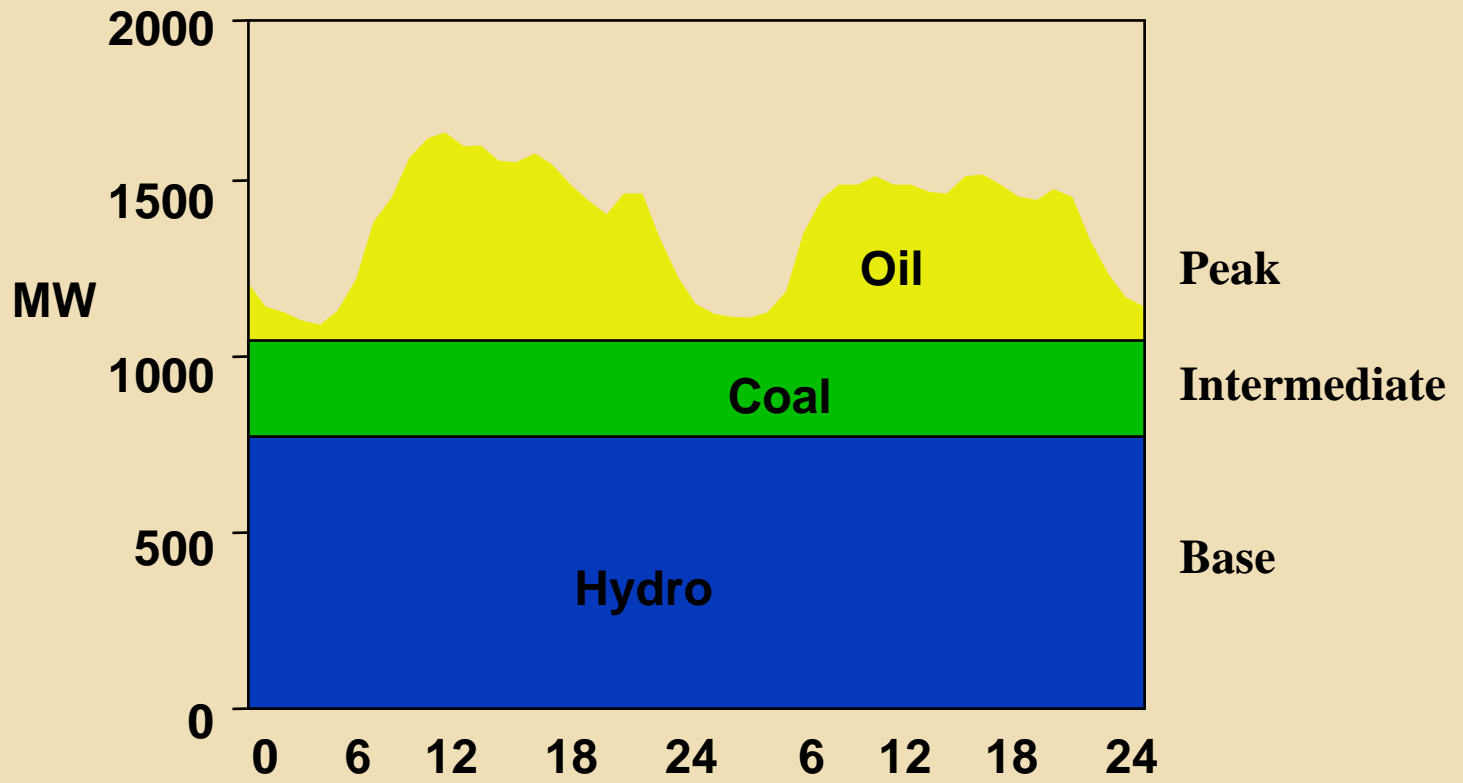
system ops



Generation Dispatch - Normal



Generation Dispatch - Spring Hydro



Maritimes - Diverse Generation Mix

Type	MW	%
Hydro	1340	19
Nuclear	594	8
Coal/Orimulsion	2056	30
Gas CombCycle/Cogen	353	5
Thermal Gas or #6 Oil	1563	23
CT Gas or #2 Oil	823	12
Biomass	135	2
Wind	47	1
Total	6911	100

As filed with NPCC in Dec 04 Triennial Review of Resource Adequacy



Presentation Summary

1. *Power System Operations*
2. *Market Structure*
3. *Integration of Intermittents*



Unbundled Electric Power Supply

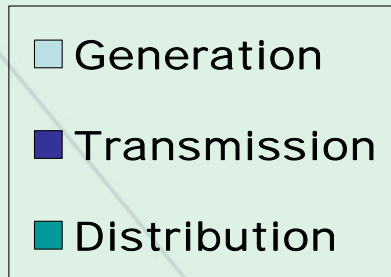
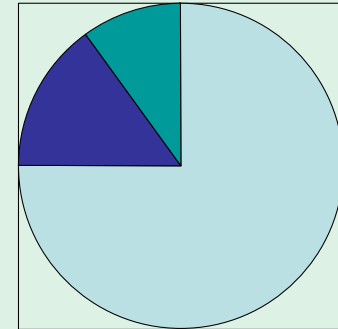
- ***Power***
 - Capacity (reliability)
 - Energy supply (commodity)
 - Energy attributes (“quality”)
 - Renewable
 - Emissions
 - Efficiency
- ***Ancillary Services (reliability)***
- ***Transmission (delivery)***
- ***Distribution (delivery)***



Electricity Cost & Revenue Profile

- **Revenue required to cover costs and return**
 - **65-75% generation - competition**
 - **7-10% transmission - regulated**
 - **15-30% distribution - regulated**

 - **5-10% of the generation is for ancillary services**



Two Fundamental Market Designs

Pool

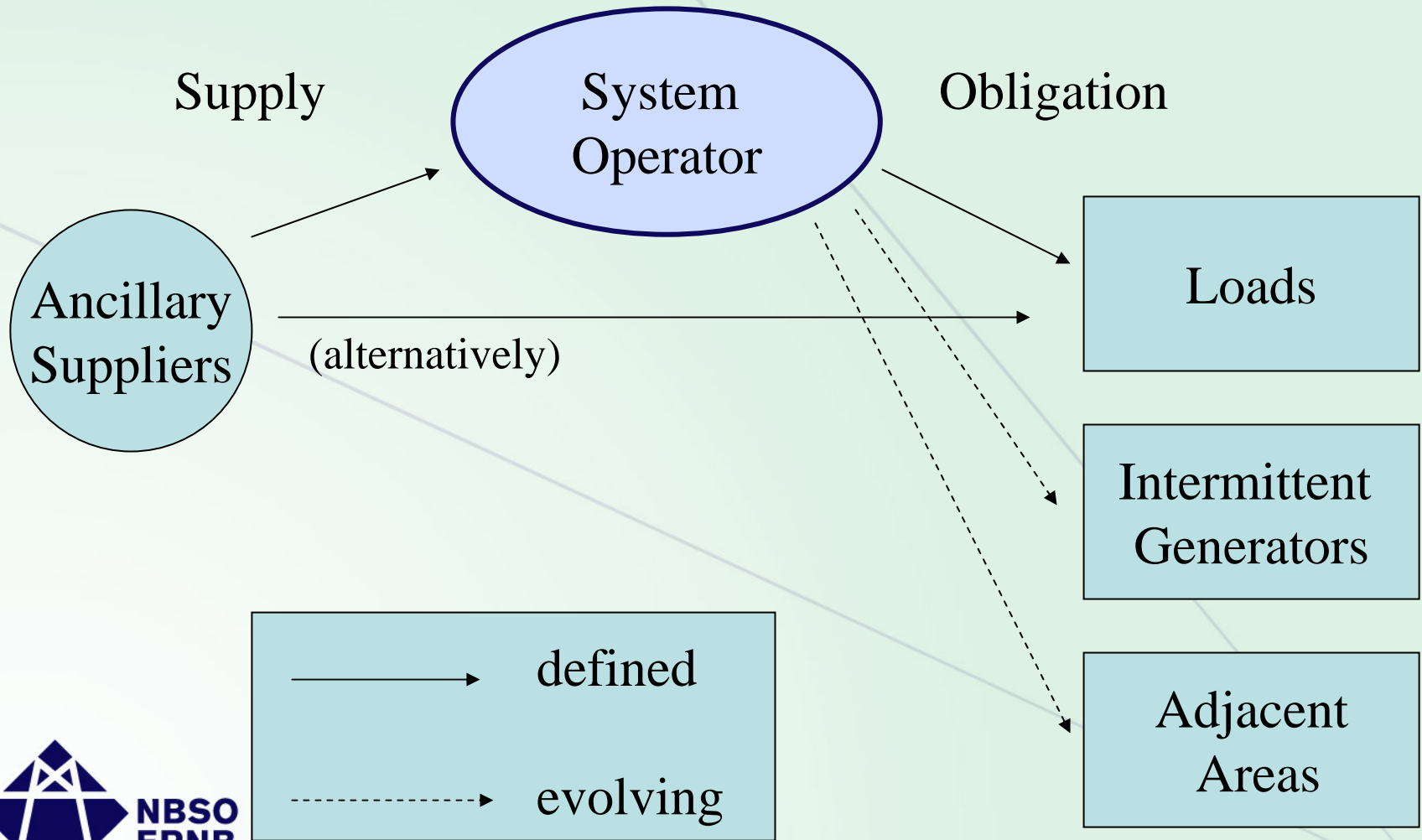
- *Buy energy out of, or sell into centrally administered pool*
- *Generators typically paid at market clearing price*
- *ISO-NE, NY-ISO, Ont, etc*

Physical Bilateral

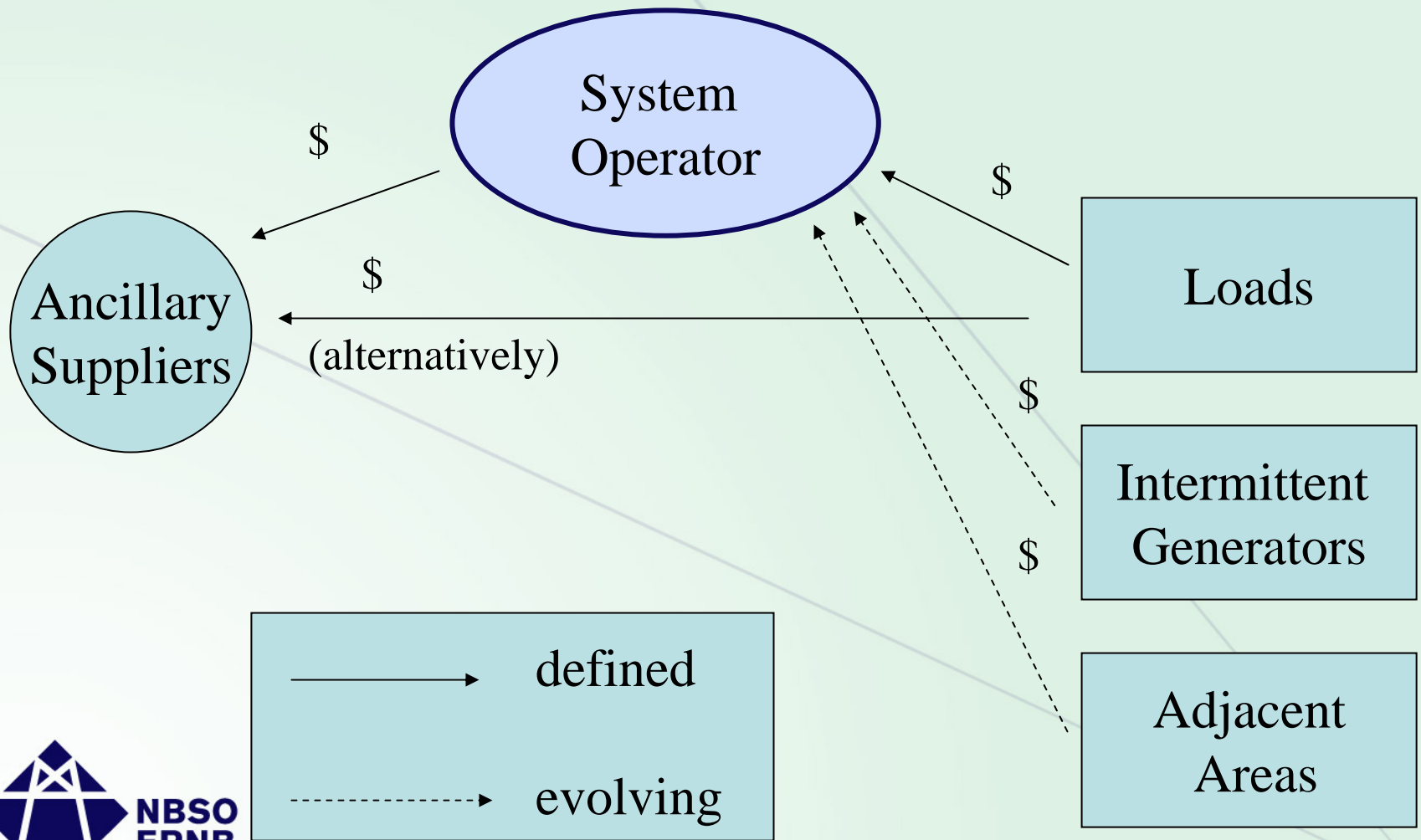
- *Physical balanced schedules*
- *Energy contracts between market participants*
- *NB, NS, Quebec, BC, etc*



Ancillary Services Supply & Obligation



Ancillary Services Payments



Presentation Summary

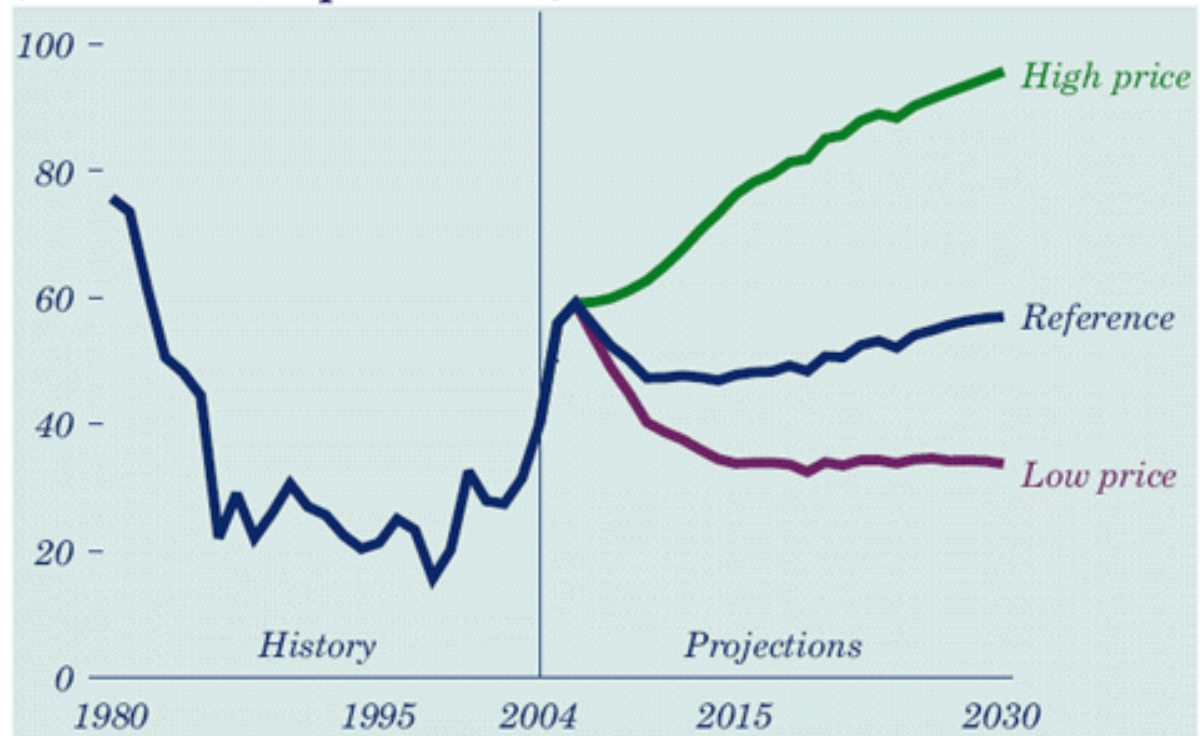
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World Oil Prices

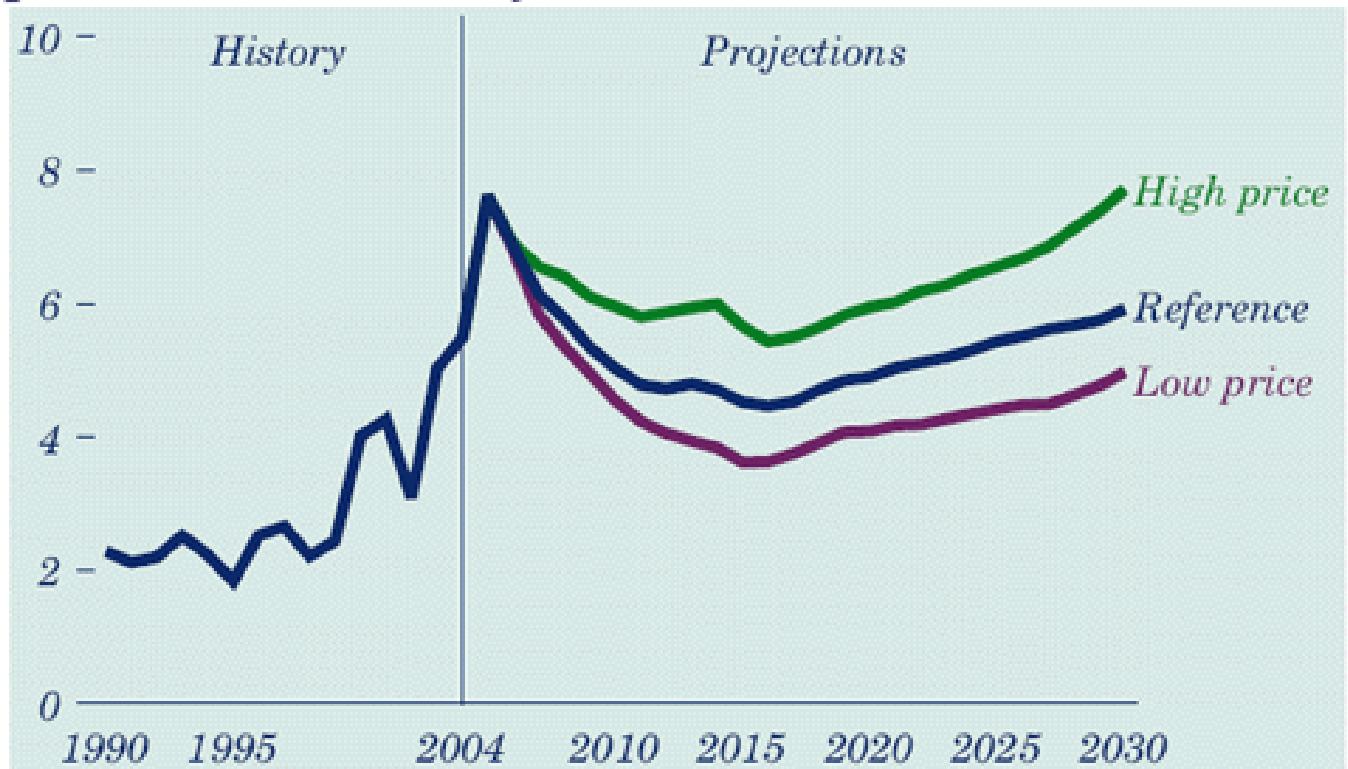
Report #:DOE/EIA-0383(2006)
Release date full report: February 2006
Next release date full report: February 2007

**Figure 29. World oil prices in three cases, 1980-2030
(2004 dollars per barrel)**

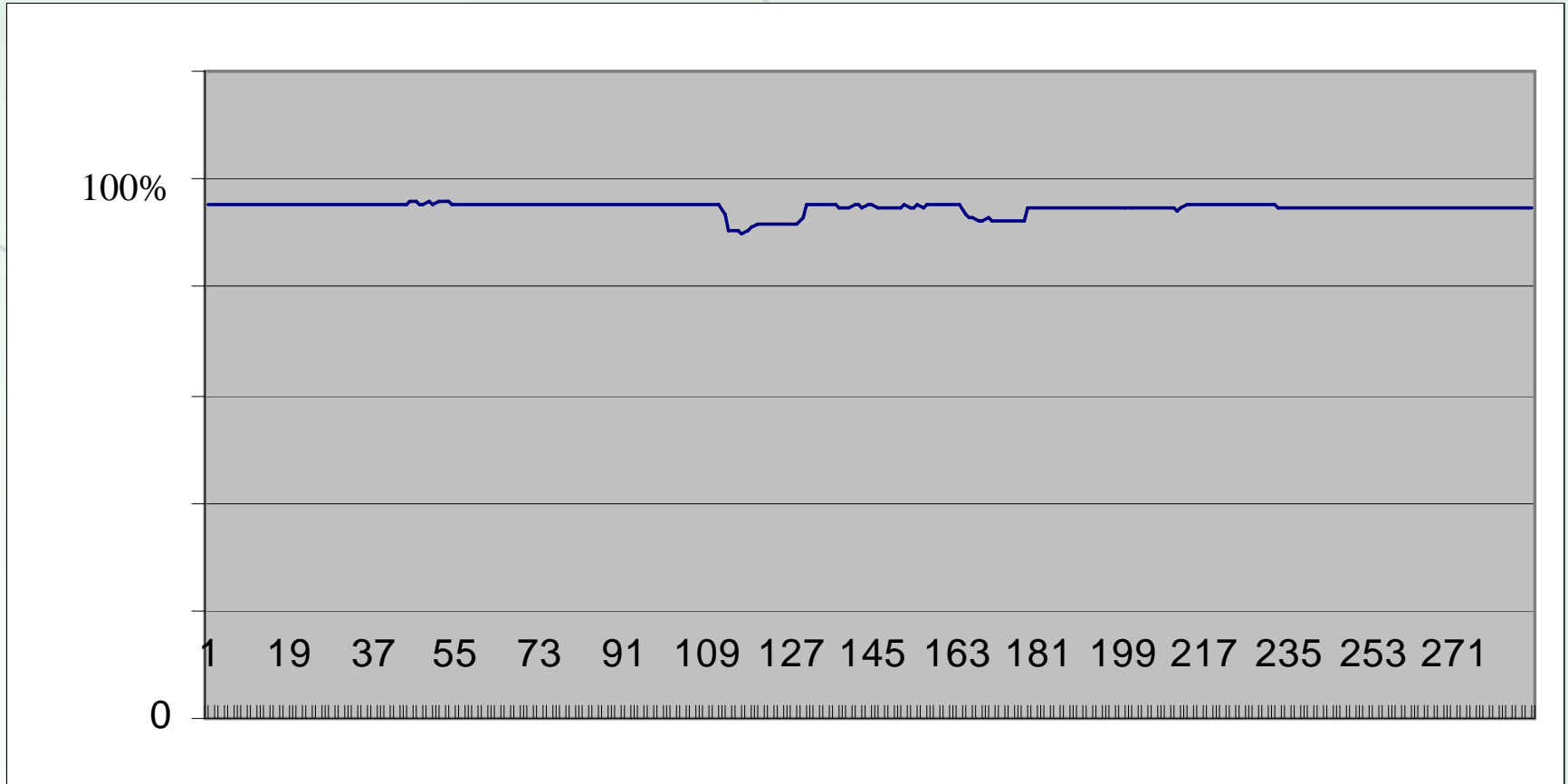


Natural Gas Prices

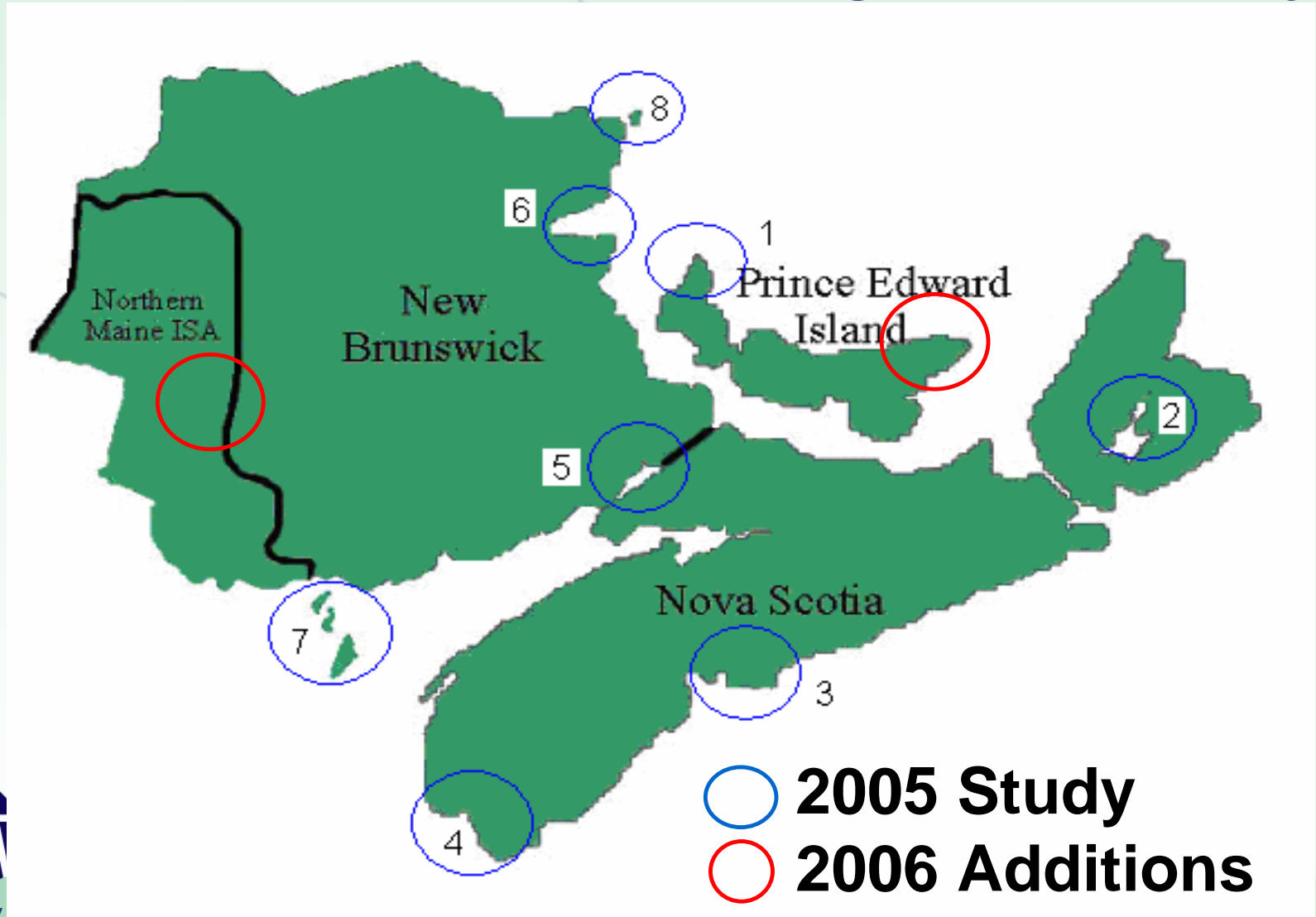
Figure 79. Lower 48 natural gas wellhead prices in three price cases, 1990-2030 (2004 dollars per thousand cubic feet)



Nuclear Plant Output 5 Minute Intervals Over 1 Day

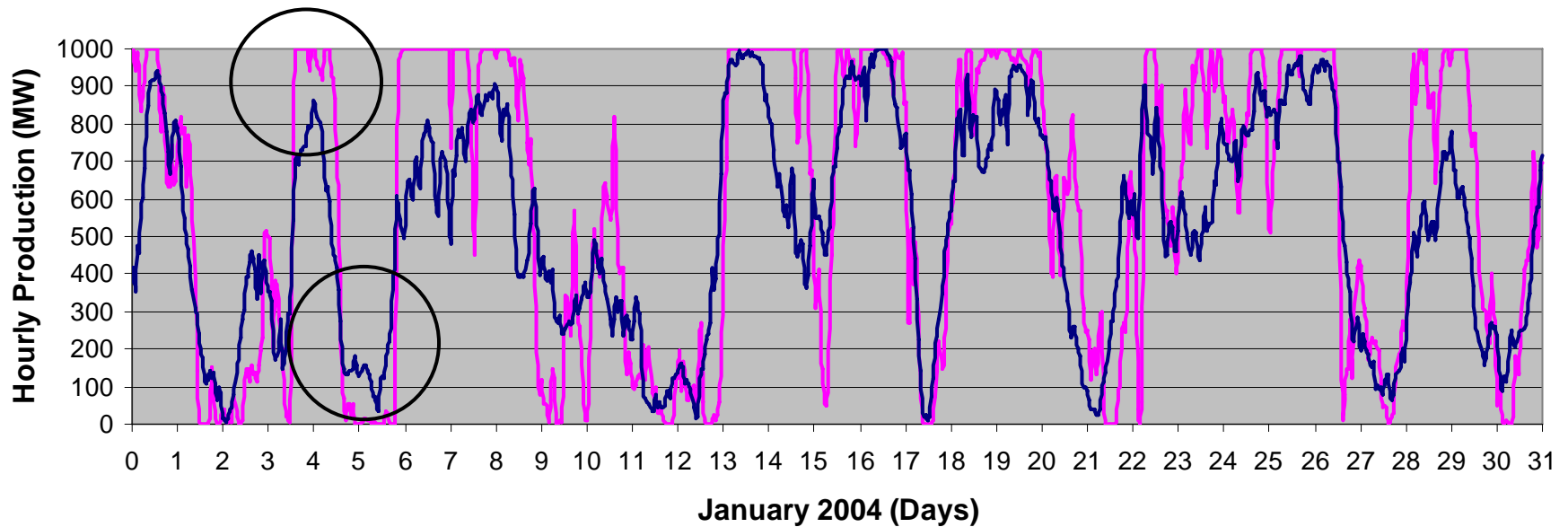


Maritimes Area Wind Integration Study



Simulated Wind Production

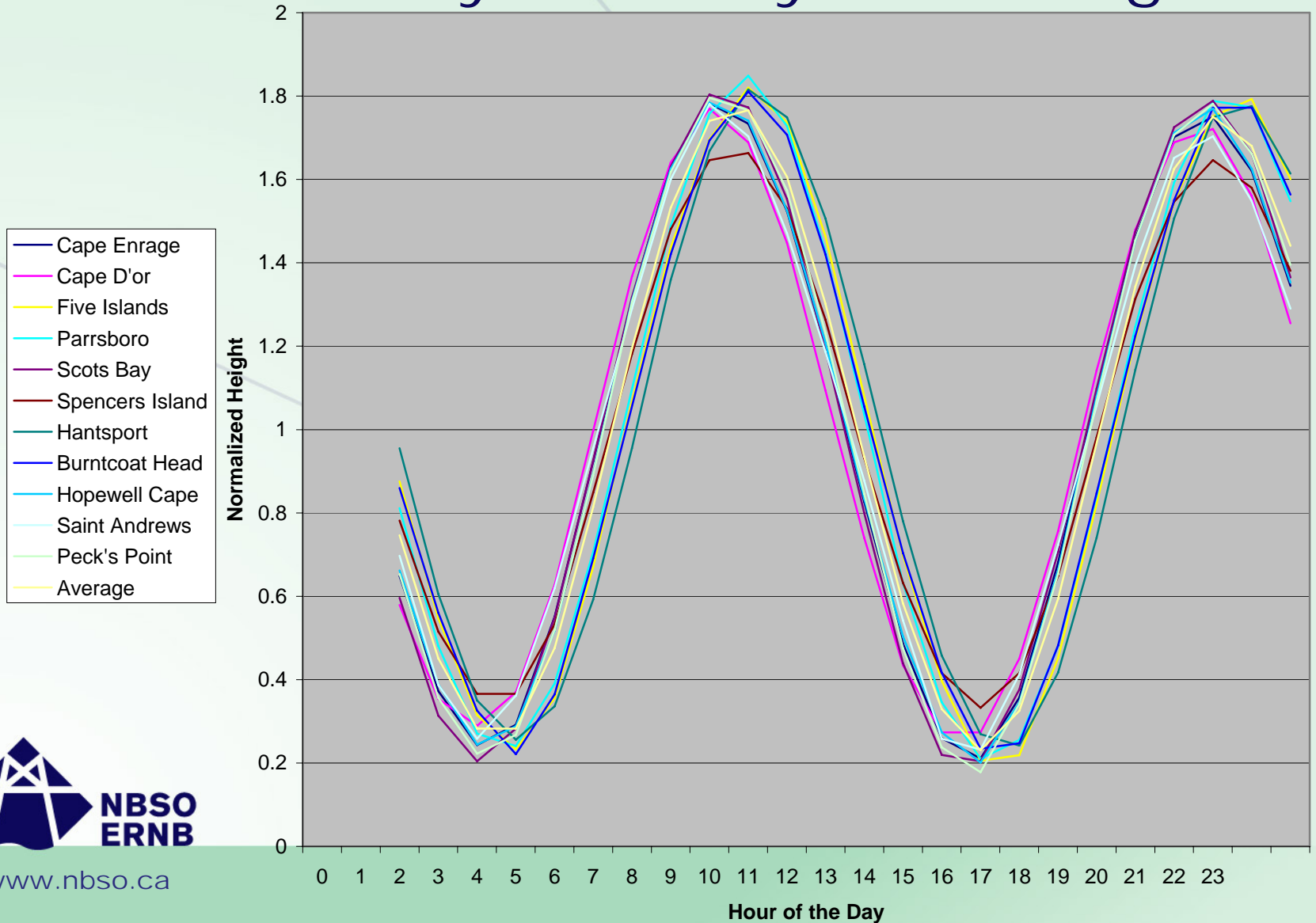
— Typical Single Site, Average 58%
— Maritimes (8 Sites), Average 53%



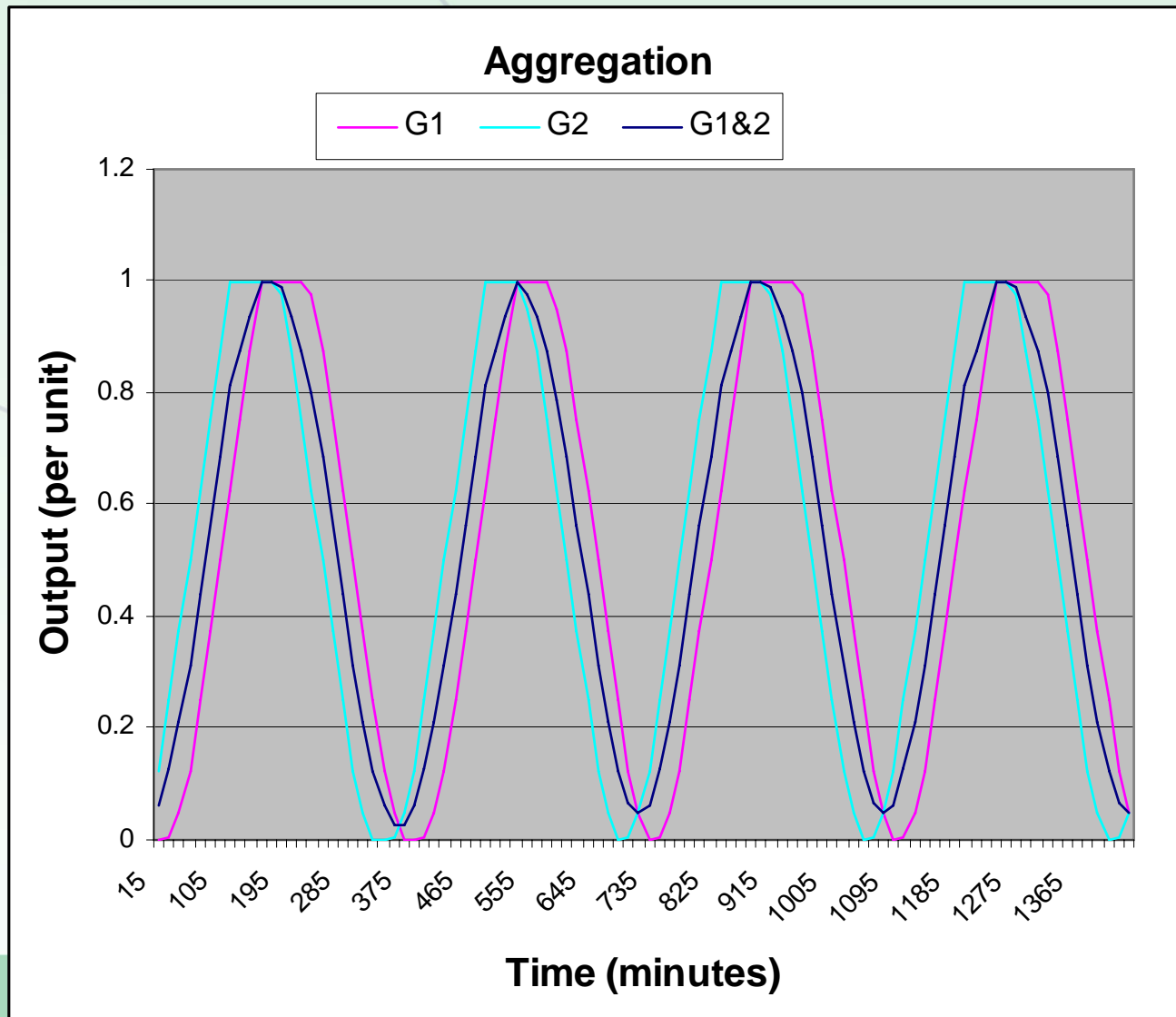
Wind Forecasting Analysis (in MW)

Scenario	Standard Deviation of NB Load Forecast Error	Standard Deviation of Wind Error	Standard Deviation of Total Forecast Error
No Wind	100	0	100
400 MW, 1 site	100	97	139
400 MW, 4 sites	100	57	113

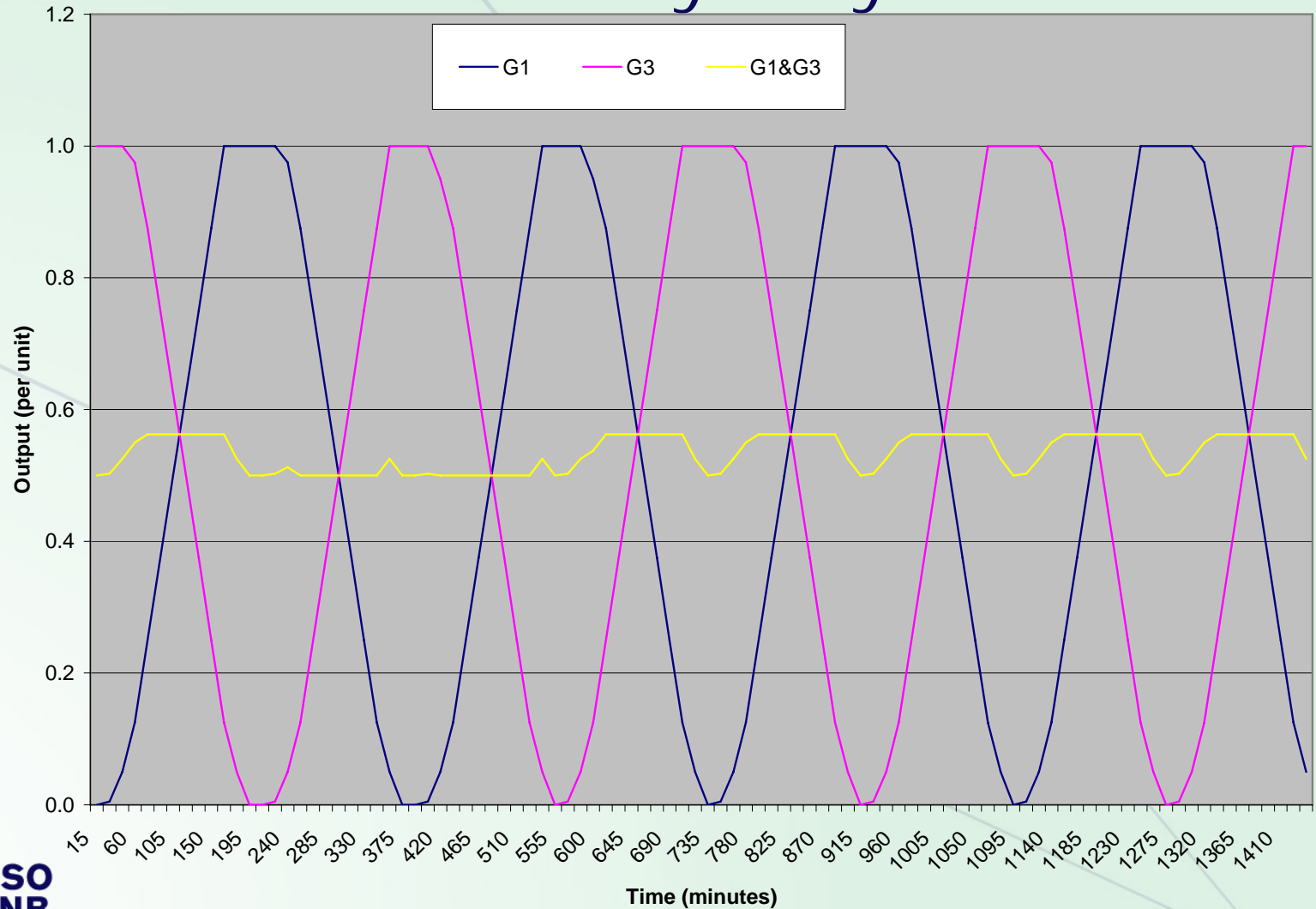
Normalized Bay of Fundy Tide Heights



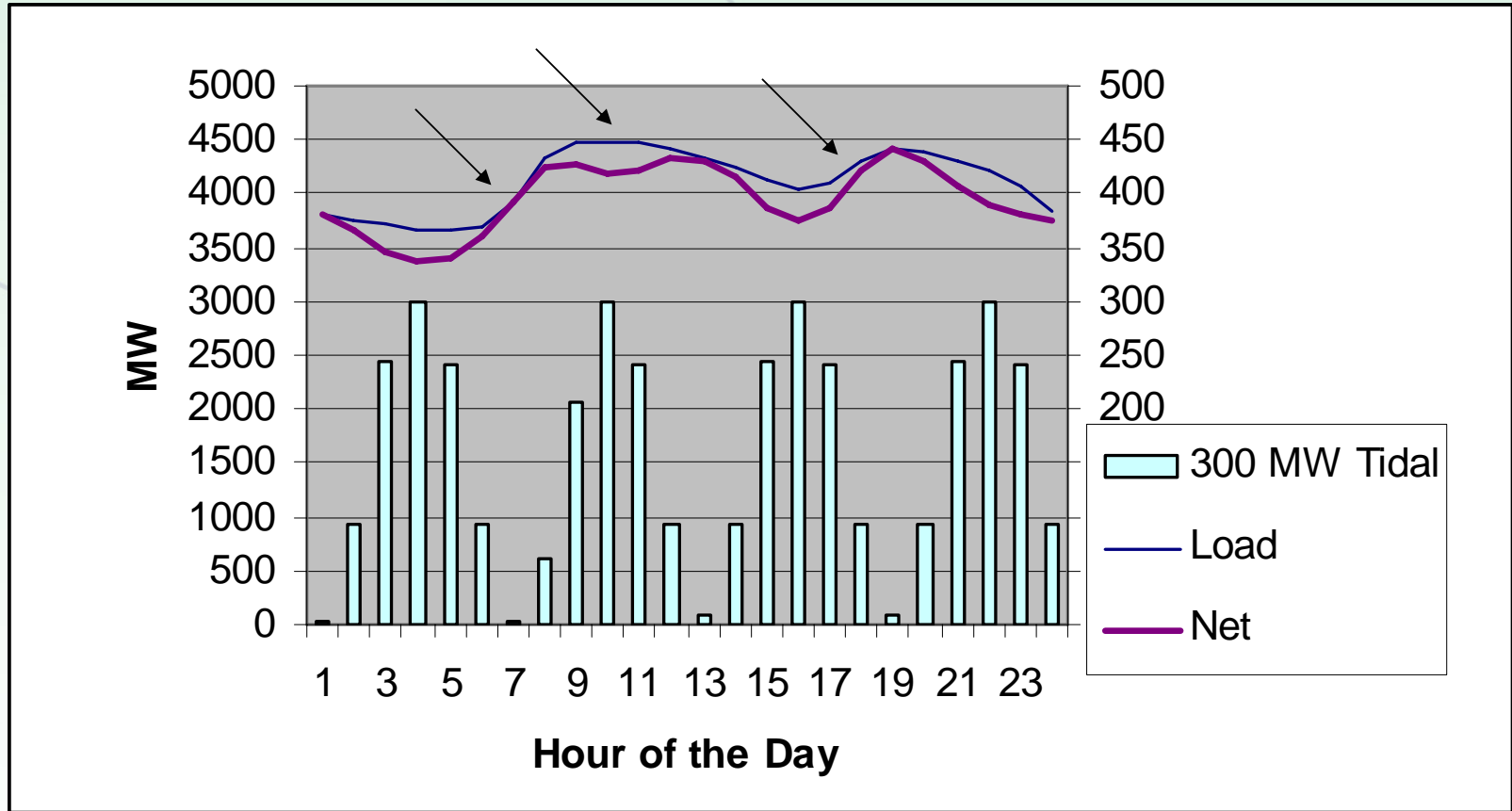
Simulated Bay of Fundy In-Stream Tidal "Saint Andrews" and Cobequid Bay



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



Impact of Tidal on Net Load Served



Wave Power

- ***What would be the characteristics of wave power production in the Maritimes?***
 - 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?***



Ancillary Services

<i>Service</i>	<i>Description</i>	<i>Provided by</i>
<i>Regulation</i>	<i>Minute by Minute Variations on Demand Supply Balance</i>	<i>Generator on AGC</i>
<i>Load Following</i>	<i>Hourly trends in dispatch required</i>	<i>Flexible Dispatchable Generator</i>
<i>Operating Reserves</i>	<i>Quick responding capacity</i>	<i>Dispatchable Generator (or load)</i>
<i>Balancing Energy</i>	<i>Compensation for someone's hourly under (or over) injection (or withdrawal)</i>	<i>Any of the above</i>

Impact of Intermittents on Ancillaries

	<i>Wind</i>	<i>Tidal</i>
<i>Regulation</i>	<i>Increase, but by how much and at what cost?</i>	<i>Little increase?</i>
<i>Load Following</i>	<i>Increase, but by how much and at what cost?</i>	<i>Increase, but by how much and at what cost?</i>
<i>Operating Reserves</i>	<i>No increase?</i>	<i>No increase?</i>
<i>Balancing Energy</i>	<i>Substantial hourly, but averages zero (unbiased forecast)</i>	<i>Low (forecast accuracy)</i>



Is wave power's impact similar to wind's?

Implications of Ancillaries Increase

- ***Providing the ancillaries***
 - Cost of providing the services
 - Fair reimbursement to providers
- ***Fair allocation of the costs***
- ***Ownership of intermittent generation versus ownership of ancillary services resources***
- ***Local consumption versus exports***



Efficient Integration of Intermittents

- ***Low correlation of intermittency***
- ***Better production forecasting***
- ***Intra-hour tie schedule changes***
- ***Dynamic scheduling between areas***
- ***Larger Balancing Areas***
 - More resources
 - Greater diversity of resources
 - Diversity of loads and of intermittent generation
- ***Increase the MW of controlled and responsive generation (and load)***



Pooling of Intermittents

- ***Forecasted production***
- ***Scheduled production***
- ***Delivered production (maximize project owner's realization of value for renewable energy credits?)***
- ***Hourly energy imbalances***



Summary

- ***Power system operation requires continuous balancing of supply & demand***
- ***Unbundled market structure quantifies the cost of the components of delivered power***
- ***Some changes in current power system operations would permit more efficient integration of intermittents***
- ***Technology and site selections can reduce variability and unpredictability***



Questions



Maritimes Area

