

Scenario Analysis – Appendix to 3-5-07 Presentations Update on Modeling Inputs and Assumptions

Additional information on:

- * Fuel Prices
- * Natural Gas Infrastructure Costs
- * Wind, PV, Demand-Side Profiles
- * Metrics

Appendix – March 5, 2007

3-5-07 APPENDIX MATERIALS on:

**Long Term Fuel Price Forecast for NE Scenario
Analysis: Oil, Natural Gas and Coal**

Overview of Fuel Price Forecast – For Modeling of Scenarios

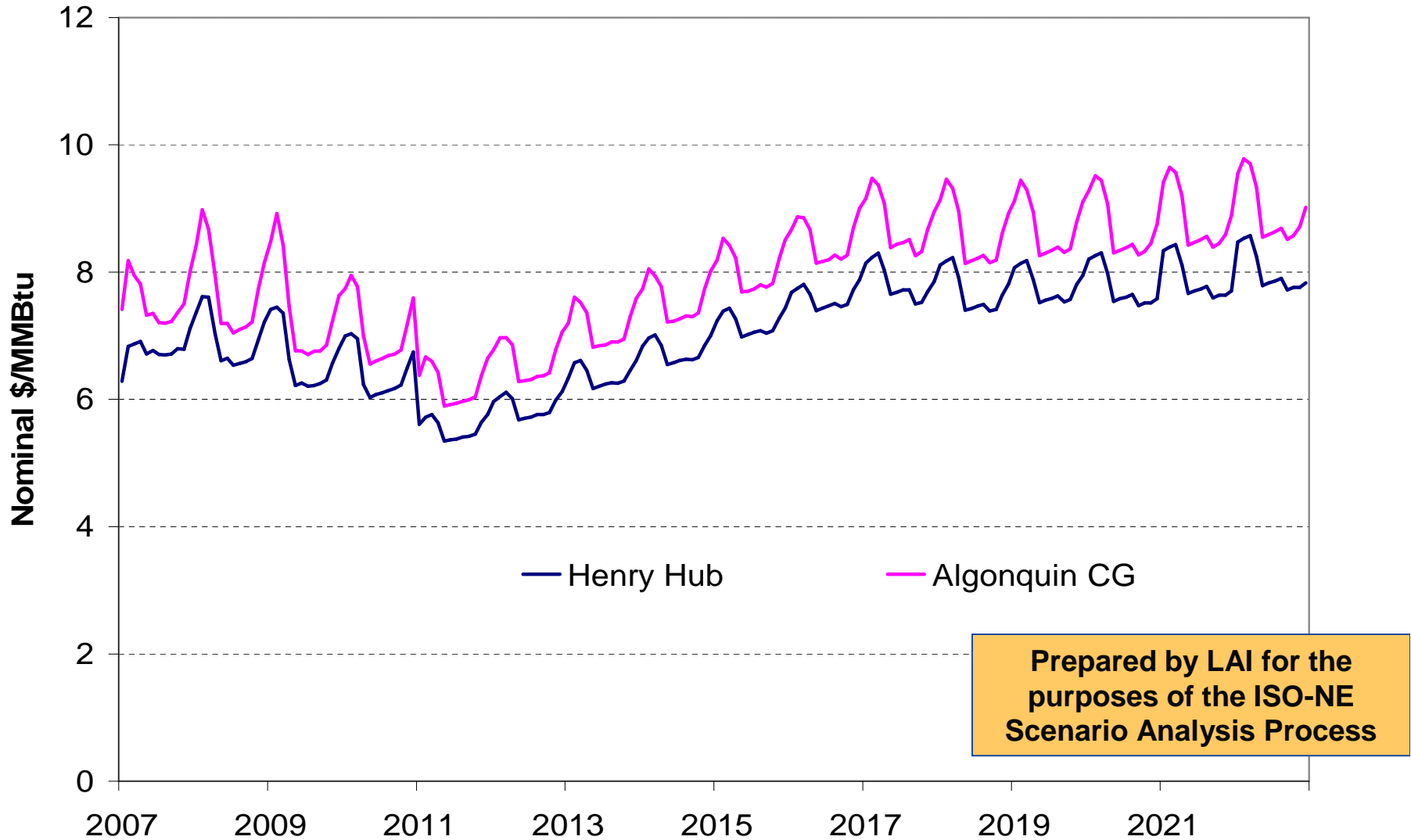
- **Need to use a fuel price forecast for all scenarios**
 - Using Levitan & Associates, Inc. (LAI) “*Conventional Wisdom*” base case forecast, with key inputs including:
 - **Relative stability in OPEC nations**
 - **New oil supplies from Alberta tar sands, Former Soviet Union (FSU), and ultra-deepwater**
 - **Steady worldwide investment in exploration & production (E&P)**
 - **Gradual development of new gas reserves**
 - **Moderate worldwide oil demand growth**
 - **Development of new U.S. supplies in Alaska North Slope & Gulf offshore**
 - High and low fuel price cases used in ISO-NE scenarios:
 - Informed by “high” and “low” fuel price cases in Levitan’s “*Peak Oil*” and “*LNG Overbuild*” cases
 - Reflects a deliberate attempt to model “what if” situations, where fuel prices diverge from normal patterns

Conventional Wisdom Case

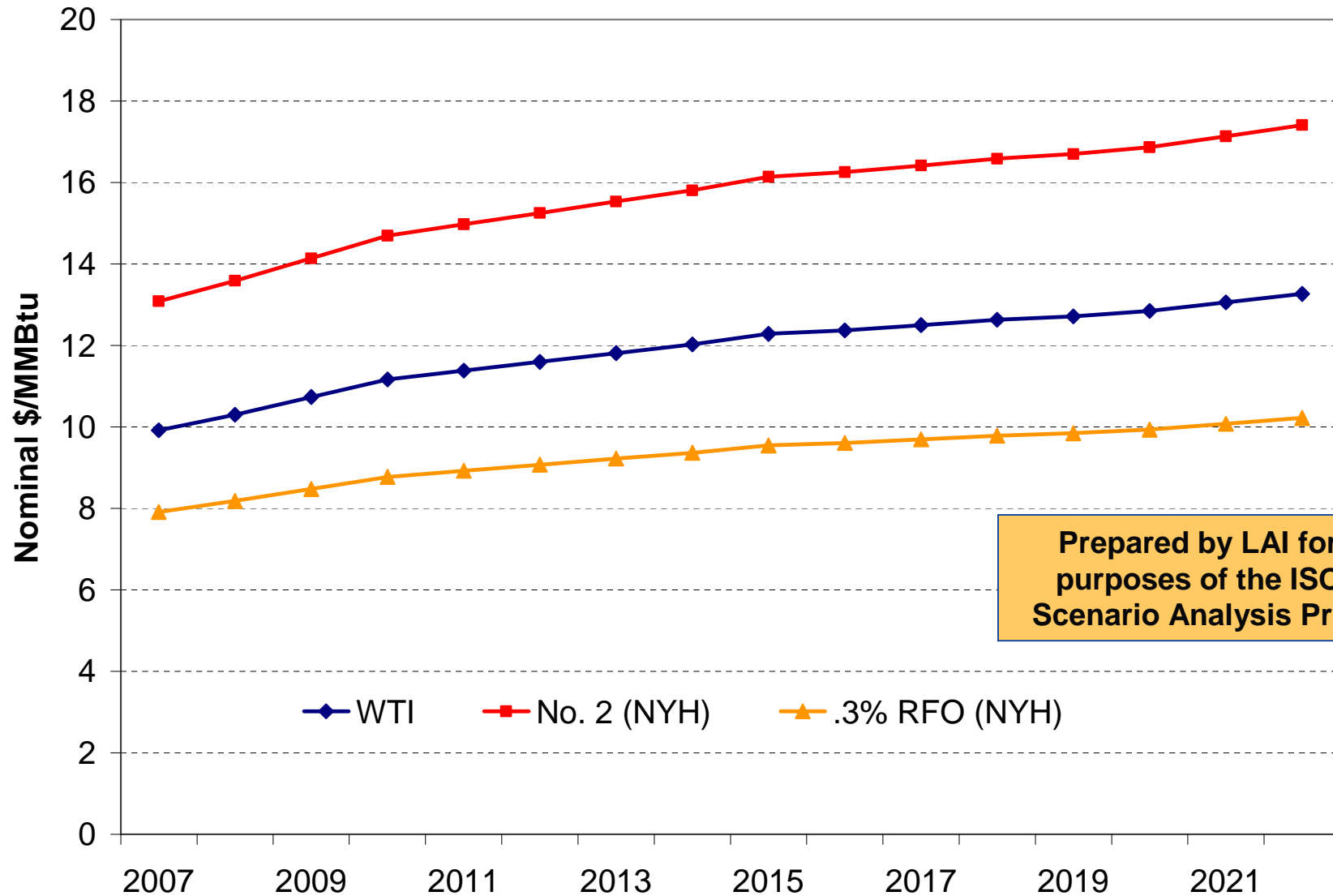
- **Most probable scenario**
- **Key assumptions:**
 - Relative stability in OPEC nations
 - New oil supplies from Alberta tar sands, Former Soviet Union (FSU), and ultra deepwater
 - Steady worldwide E&P investment
 - Gradual development of new gas reserves
 - Moderate worldwide oil demand growth
 - Development of new U.S. supplies: Alaska North slope, Gulf Offshore

**Prepared by LAI for the
purposes of the ISO-NE
Scenario Analysis Process**

Conventional Wisdom Gas Price Forecast

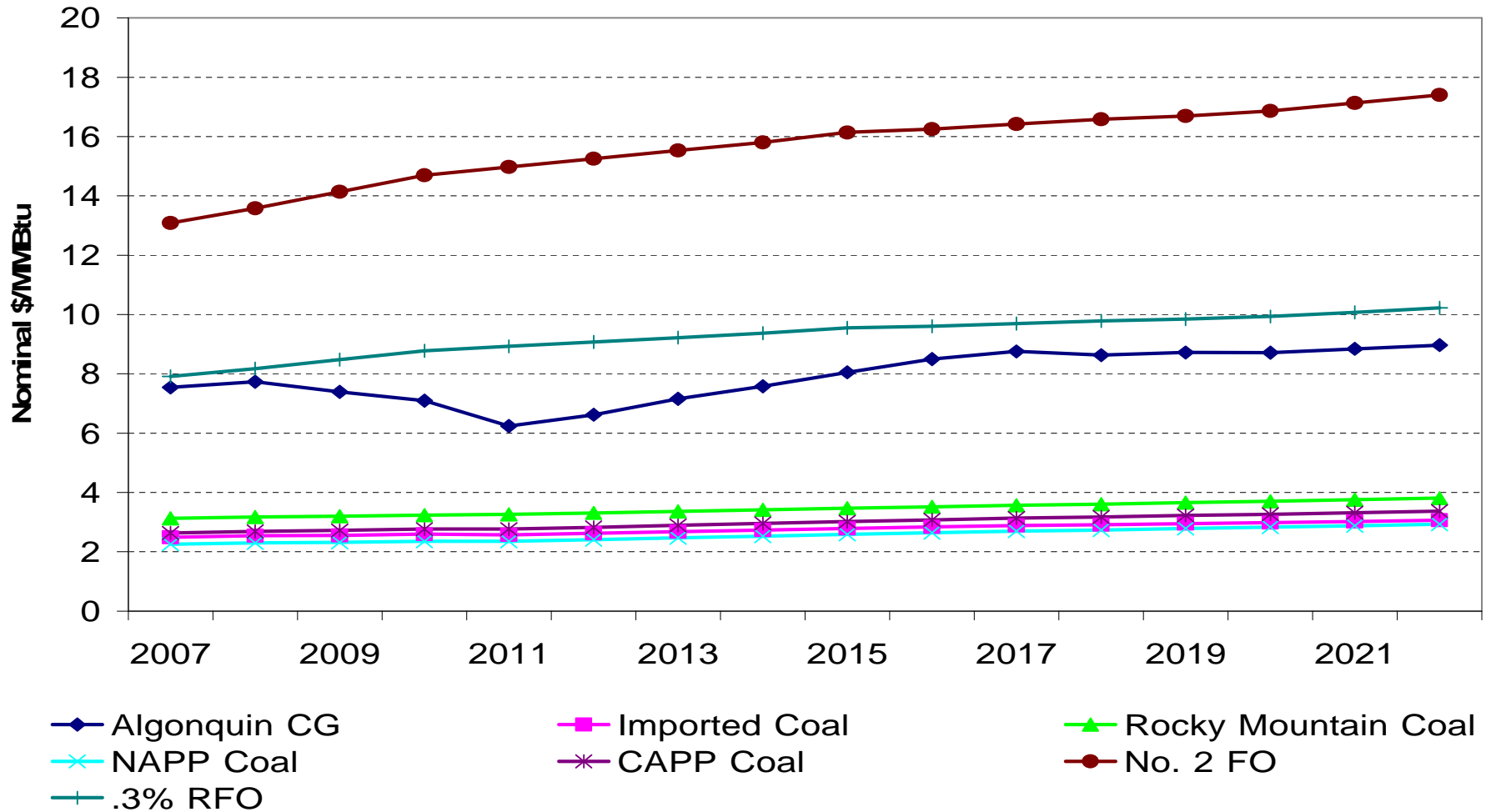


Conventional Wisdom Oil Price Forecast



Prepared by LAI for the purposes of the ISO-NE Scenario Analysis Process

Conventional Wisdom Fuels Comparison



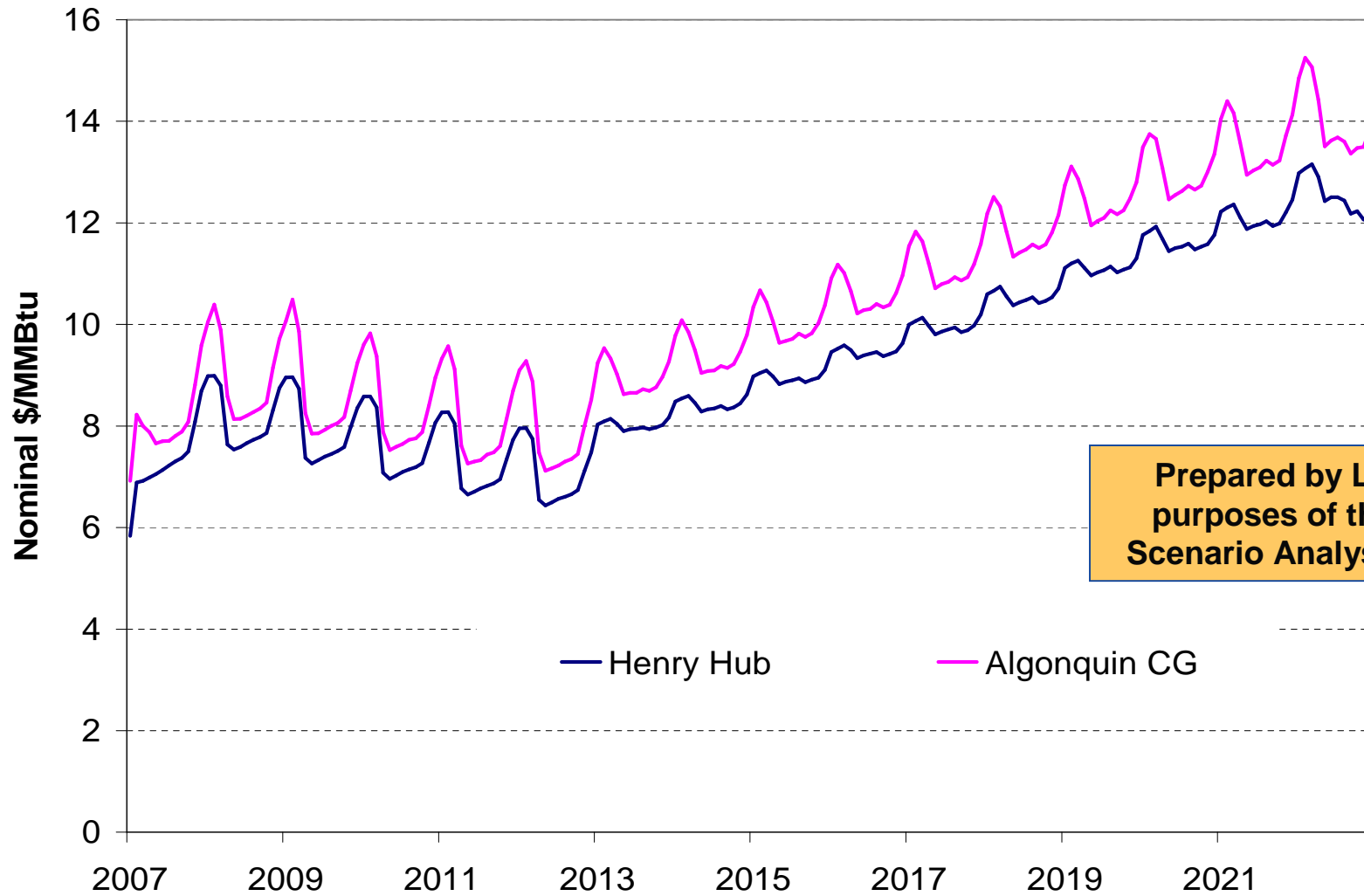
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Peak Oil Case (high fossil fuel prices)

- **World oil production peaks in 2010**
- **Key assumptions:**
 - **Geopolitical tensions in the Middle East, Nigeria and Venezuela reduce OPEC output**
 - **Production elsewhere cannot compensate; increasing world supply/demand imbalance**
 - **Rapid economic growth in India, China, and elsewhere in the developing world drives world demand**
 - **Alaska North Slope not online prior to 2022**
 - **Limited LNG investment**

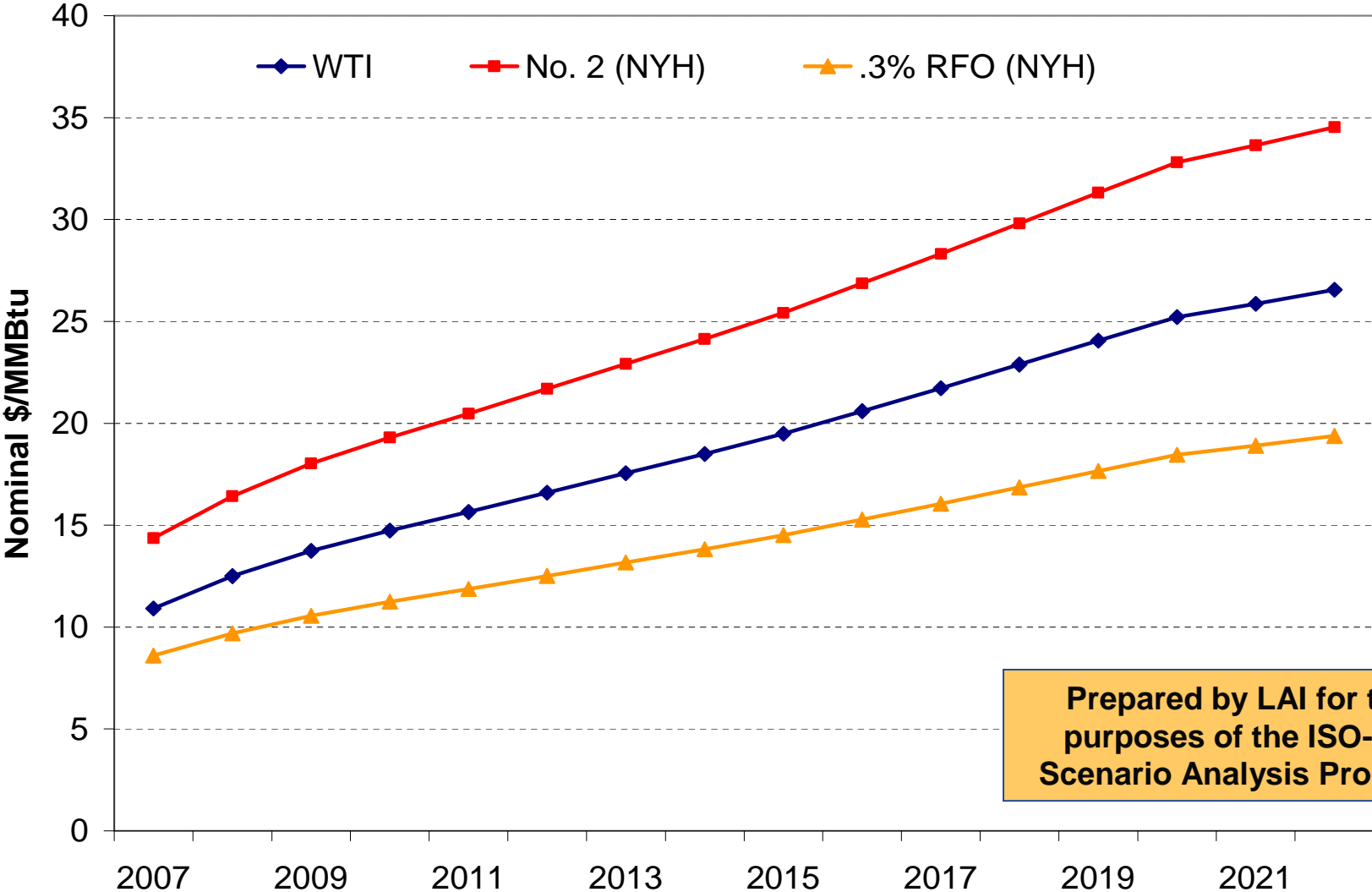
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Peak Oil Gas Price Forecast



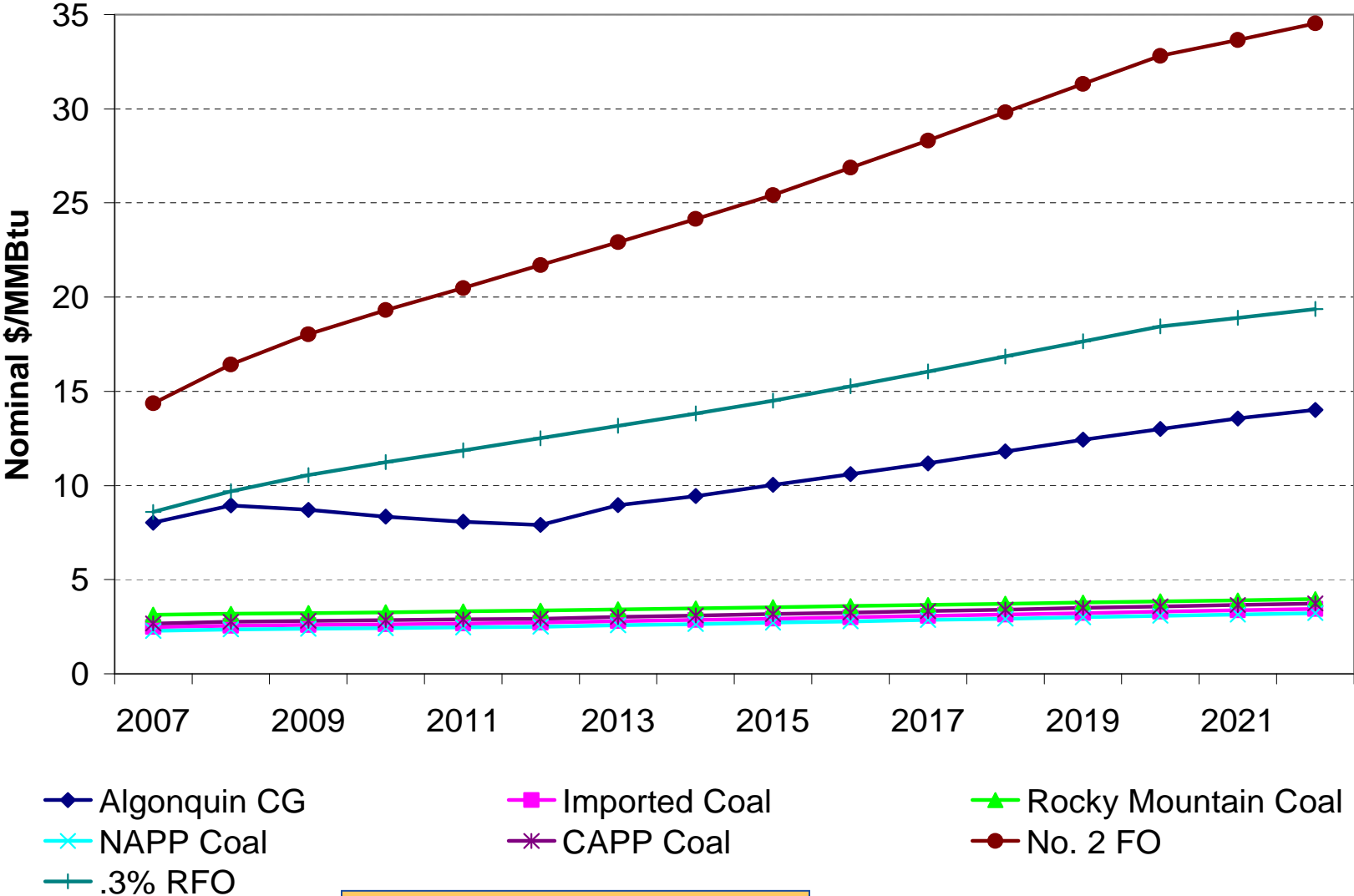
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Peak Oil Case Oil Price Forecast



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Peak Oil Fuels Comparison

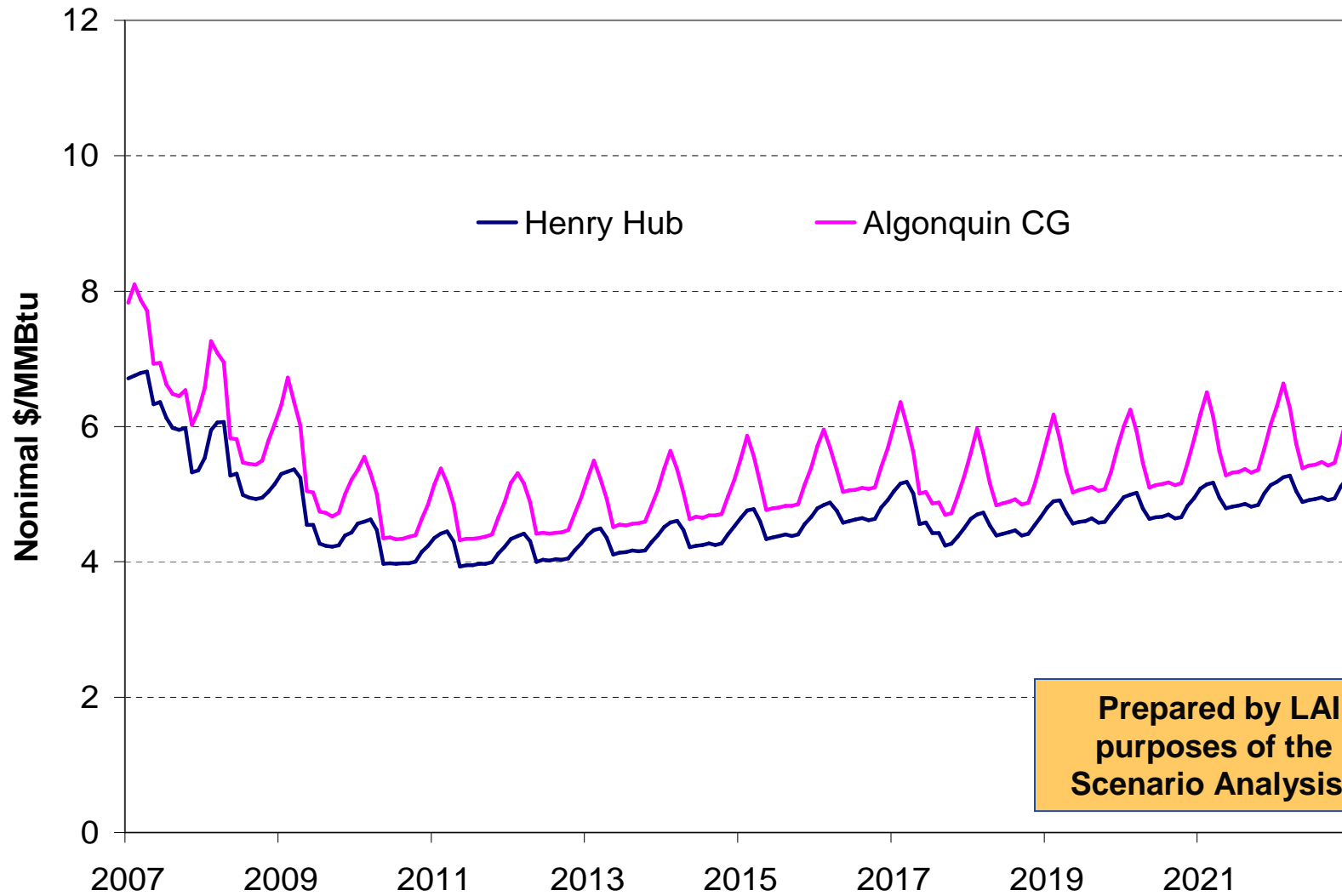


LNG Overbuild Case

- **World energy surplus**
- **Key assumptions:**
 - **Stability in producing nations, strong OPEC production**
 - **Stellar output from non-OPEC producers**
 - **Tempered world oil demand**
 - **Aggressive worldwide development of LNG infrastructure**
 - **Surplus LNG tanker capacity**
 - **Significant U.S. investment in LNG import terminals**
 - **Increased U.S. oil and gas output from deepwater and unconventional fields**

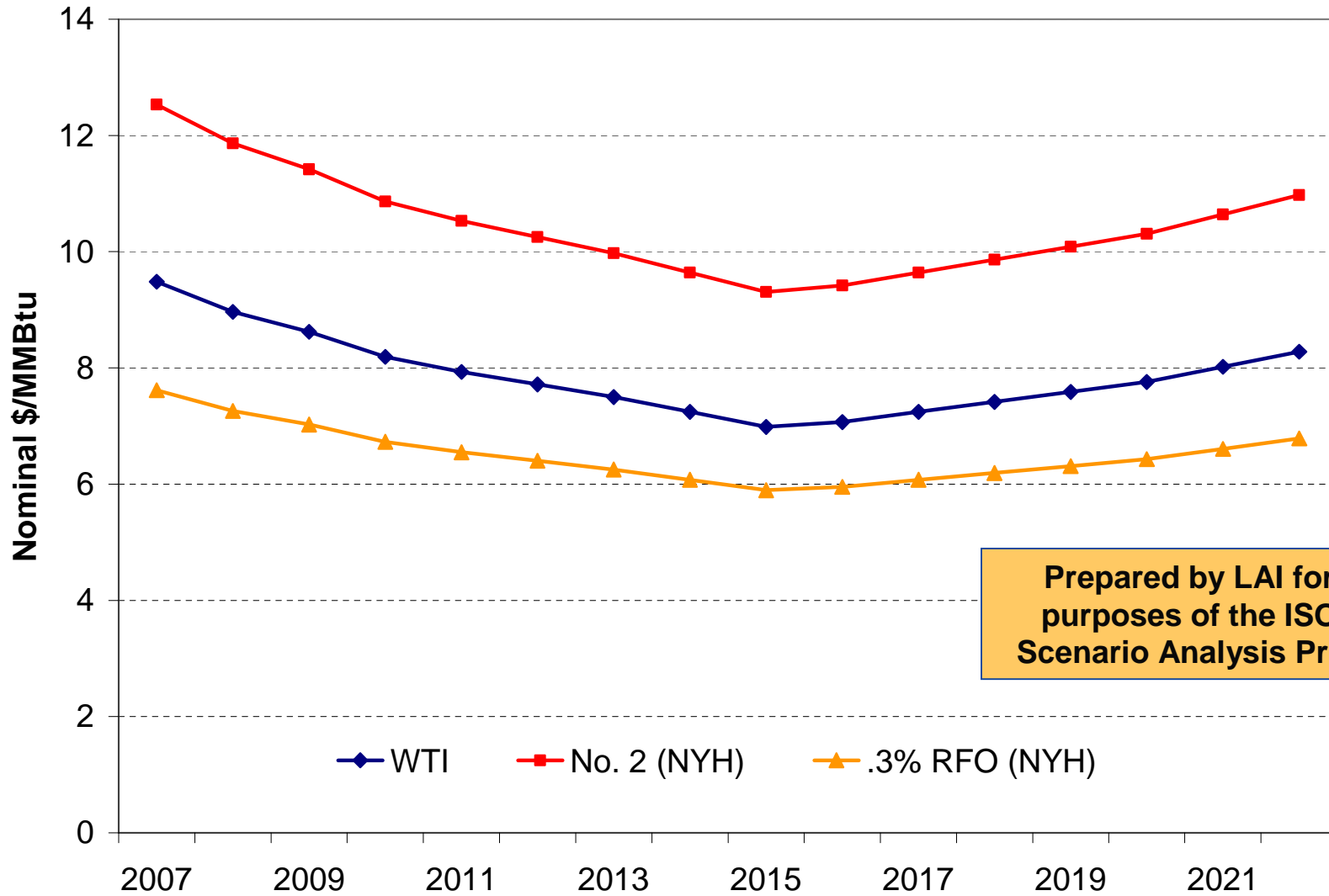
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LNG Overbuild Gas Price Forecast



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LNG Overbuild Oil Price Forecast



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3-5-07 APPENDIX MATERIALS on:

**Assessment of Natural Gas Infrastructure
Requirements to Satisfy Future Fuel Needs of
Electric Power Generators within New England**

Overview of Gas Delivery Infrastructure – For Scenarios with High & Low Gas Needs

- Some scenarios require more or less natural gas utilization than other scenarios:
 - Gas-fired Combined Cycle Scenario – requires more gas
 - Renewable Scenario – requires less gas
- One metric of interest in interpreting the scenarios: the extent to which incremental gas delivery infrastructure would be needed in conjunction with a particular scenario
 - Levitan assessed the fuel requirements of various scenarios and identified the need (or not) for new, incremental gas-delivery infrastructure (e.g., expanded pipelines and/or LNG facilities)
 - A range of gas-delivery investment costs were developed to add to those “high gas utilization” scenarios

Incremental Gas Infrastructure Issues: Several Scenarios Require Gas Assumptions

- **Base case fuel forecast assumes commercialization of a new LNG import terminal - Canaport, which is now under construction in St. John, New Brunswick**
- **Several scenarios in SA will require new gas delivery capacity beyond base case requirements**
- **These scenarios will have incremental gas delivery costs added to their capital costs**
- **Incremental gas delivery costs are estimated as some combination of either pipeline expansion and/or new, regional LNG delivery capacity**

Incremental Gas Infrastructure Issues: Several Scenarios Require Gas Infrastructure

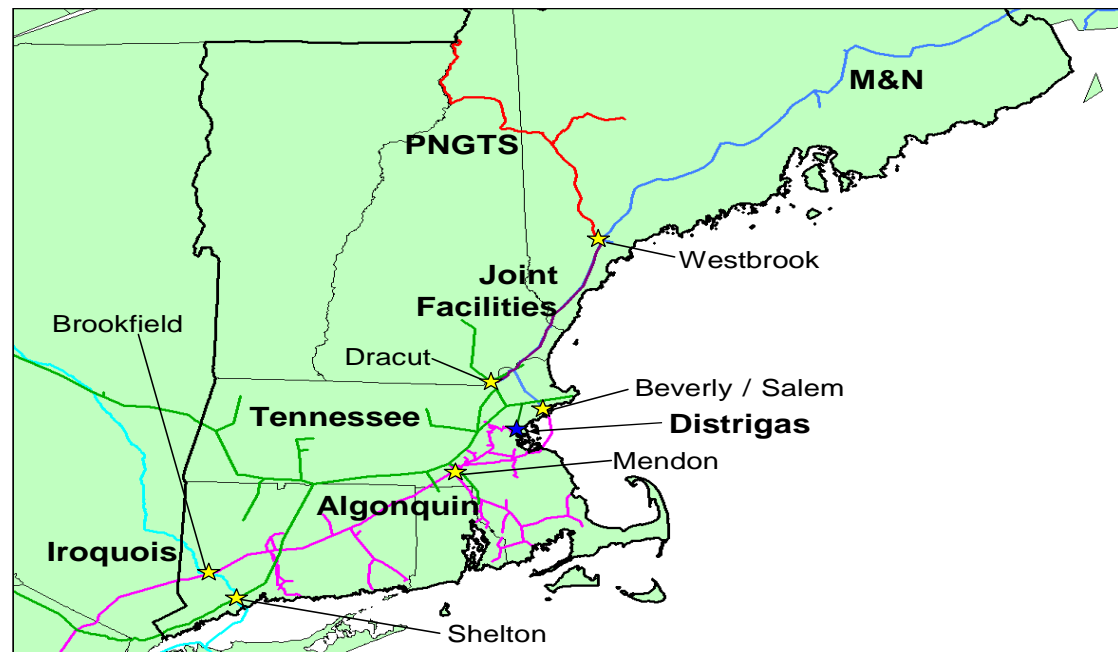
Relative to other scenarios, some require more/less gas:

- Scenario #5 (Gas-fired CCs)
 - assumes the need for considerably more gas
- Two Cases
 - Base Case: 1.0 Bcf/d
 - From Queue: 530 MW CC + 38 MW Fuel Cell
 - Add'l Capacity: 5,400 MW CC
 - Plant Retirement Case: 1.6 Bcf/d
 - From Queue: 530 MW CC + 38 MW Fuel Cell
 - Add'l capacity: 5,400 MW CC
 - Retired capacity to be replaced with add'l 3,500 MW of CC

- Scenario #6 (EE & Renewables) – assumes the need for considerably less gas
- Two Cases
 - Base Case: 260 MMcf/d
 - From Queue: 530 MW CC + 38 MW Fuel Cell
 - Add'l Capacity: 675 MW Fuel Cell
 - Plant Retirement Case: 365 MMcf/d
 - From Queue: 530 MW CC + 38 MW Fuel Cell
 - Add'l capacity: 675 MW Fuel Cell
 - Retired capacity to be replaced with add'l 675 MW of Fuel Cells

Interstate Transportation System Capabilities

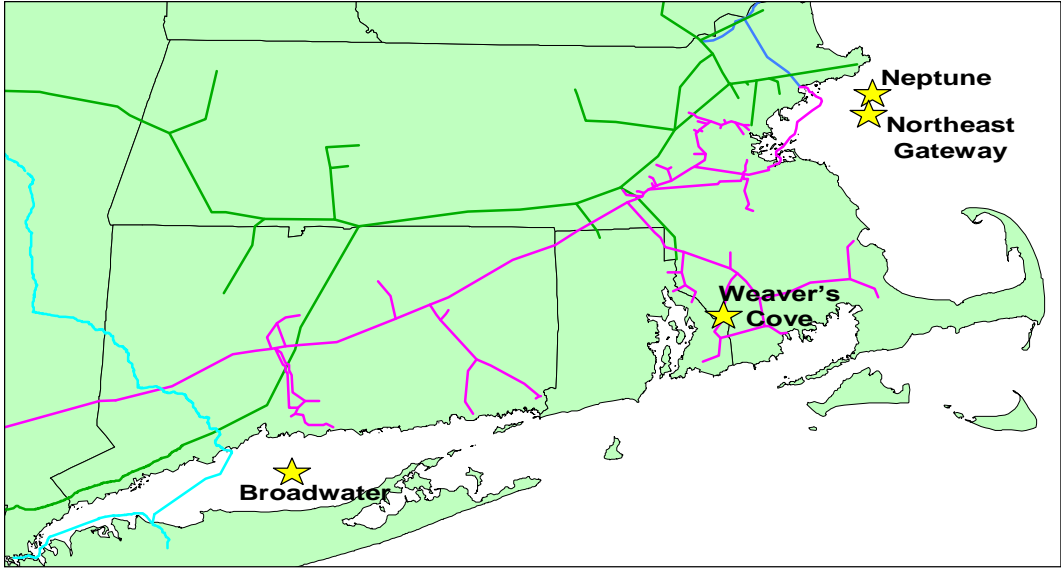
- Algonquin, Iroquois, PNGTS and Tennessee operating at or near capacity on a peak day
- Canaport LNG terminal in New Brunswick will re-energize M&NE, increasing throughput to New England by **0.4 Bcf/d**
 - Baseloaded as incremental supply into all cases



Assumptions for SA re: Mainline Infrastructure Expansions

- **Cost estimation basis**
 - Expansions along existing rights-of-way
 - 2.5% inflation to 2014
 - Scaled to account for “easiest first” solutions (1.25 to 1.5)
- **From Dawn via Union/TransCanada and Tennessee**
 - Based on Tennessee’s Northeast ConneXion-New England
 - \$150 to \$200 million per 100 MMcf/d of add’l capacity
- **From Leidy via Transco and Algonquin**
 - Based on Transco’s Leidy-to-Long Island Expansion and Algonquin’s Ramapo Expansion
 - \$200 to \$250 million per 100 MMcf/d of add’l capacity

Proposed Northeast LNG Terminals



Project	Developer	Peak Regas Capacity (Bcf/d)	Average Regas Capacity (Bcf/d)	Storage Capacity (Bcf equiv.)
Northeast Gateway	Excelerate	0.80	0.40	0.0
Neptune	Suez	0.75	0.40	0.0
Weaver's Cove	Hess LNG	0.80	0.40	4.3
Broadwater	Shell / TransCanada	1.25	1.00	8.0

Assumptions for SA

re: LNG Infrastructure additions

- For each LNG project, additional pipeline capacity needed to bring supply from terminal to market
- Estimates assume new generation located near terminal connections to gas mainline
- **Facilities – proposed in the Northeast**
 - Neptune or Northeast Gateway
 - 16-mile subsea laterals connecting to HubLine
 - ~\$200 million each
 - Weaver's Cove
 - Two laterals connecting to Algonquin G system
 - ~\$50 million
 - Broadwater
 - 22-mile subsea lateral connecting to Iroquois
 - ~\$150+ million

Assumptions for SA Scenario #5 re: Gas Infrastructure Expansion Cost Estimates

- **If new delivery capacity is built to provide sufficient gas for 5,400 MW of new, gas-fired combined cycle power plants, then assumed range of costs:**
\$0.15 billion to 1.5 billion for base case
(assumes some combination of pipeline and/or LNG expansion(s))
- **If there are retirements of existing generating capacity, combined with 5,400 MW of new, gas-fired combined cycle power plants, then assumed range of costs:**
\$0.45 billion to \$3.0 billion for retirement case (CC)
(based on combination of pipeline and/or LNG expansion(s))

Assumptions for SA Scenario #6 - Gas Infrastructure Expansion Cost Estimates

- Assuming Canaport supplies are adequate to meet the increased demand in the Base and Retirement Cases
 - No additional LNG or mainline infrastructure is needed to serve fuel cell gas requirements
- Assume fuel cells are served by gas LDCs and may require expansion behind the LDC citygates
 - Assume fuel cells are dispersed throughout LDC service territory as needed to meet demand and reduce localized system strain
 - LDC expansions needed to serve fuel cell demand are covered under LDC transport-only rates (adjusted for inflation to 2020)
 - Range of “tariffed” delivery/distribution charges:
\$0.1/therm to \$0.43/therm, Winter

3-5-07 APPENDIX MATERIALS on:

**Wind, Photovoltaic and Demand-Side
Resource Profiles**

Overview of Operating Profiles for Certain Renewable and Demand-Side Resources

- Certain renewable projects have constraints on “resource” availability at various times:
 - **Is the wind blowing?**
 - **Is the sun shining?**
 - **At what time of day does a demand-reduction measure reduce use?**
- The availability of the “fuel” (resource) thus affects how much energy (or energy savings) can be produced
- Dispatch modeling needs account for these issues
- ISO sponsored inquiries to inform these “operating” profiles for wind, PV, energy-efficiency, demand-response
- Studies informs treatment of these resources in modeling of various scenarios
- Technical information to be presented later today

Methodology for Estimating Energy (KWH) Benefits of Wind and PV projects

- **To model energy requirements and capital-cost implications, need to determine:**
 - Amount of on-peak capacity assumed to be needed from investment in renewable capacity (i.e., 5400 MW)
 - Given that amount of capacity, the amount and pattern of energy production across the hours/months of a year
 - The “fuel” for some renewables (e.g., wind, solar PV) is limited by natural conditions
 - Use of “profiles” to capture the amount of generation output assumed to be available from a project
 - ISO NE sought to develop composite wind profiles and given actual wind and solar data from NE from separate site

Observations Regarding Studies of Wind and PV Profiles

- Focus here is on energy production, not on-peak ability to provide capacity (“capacity value”)
- To estimate energy output from a renewable resource, need 24 hour profiles for each month
 - Capture expected monthly characteristics across a year
 - Allows qualitative assessment of these energy sources

Observations Regarding Studies of Wind and PV Profiles

- “Qualified Capacity” is the capability credit for a resource to qualify as capacity in the Forward Capacity Market = the reliability contribution of a resource
- To obtain 675 MW of “Qualified Capacity” from the resource (from which KWH would be produced), need to add more capacity:
 - 3,375 MW nameplate for inland sites (assumed 20% effective rating)
 - 3,375 MW nameplate for offshore sites (assumed 20% effective rating)
 - 1,350 MW nameplate for PV facilities (assumed 50% effective rating)

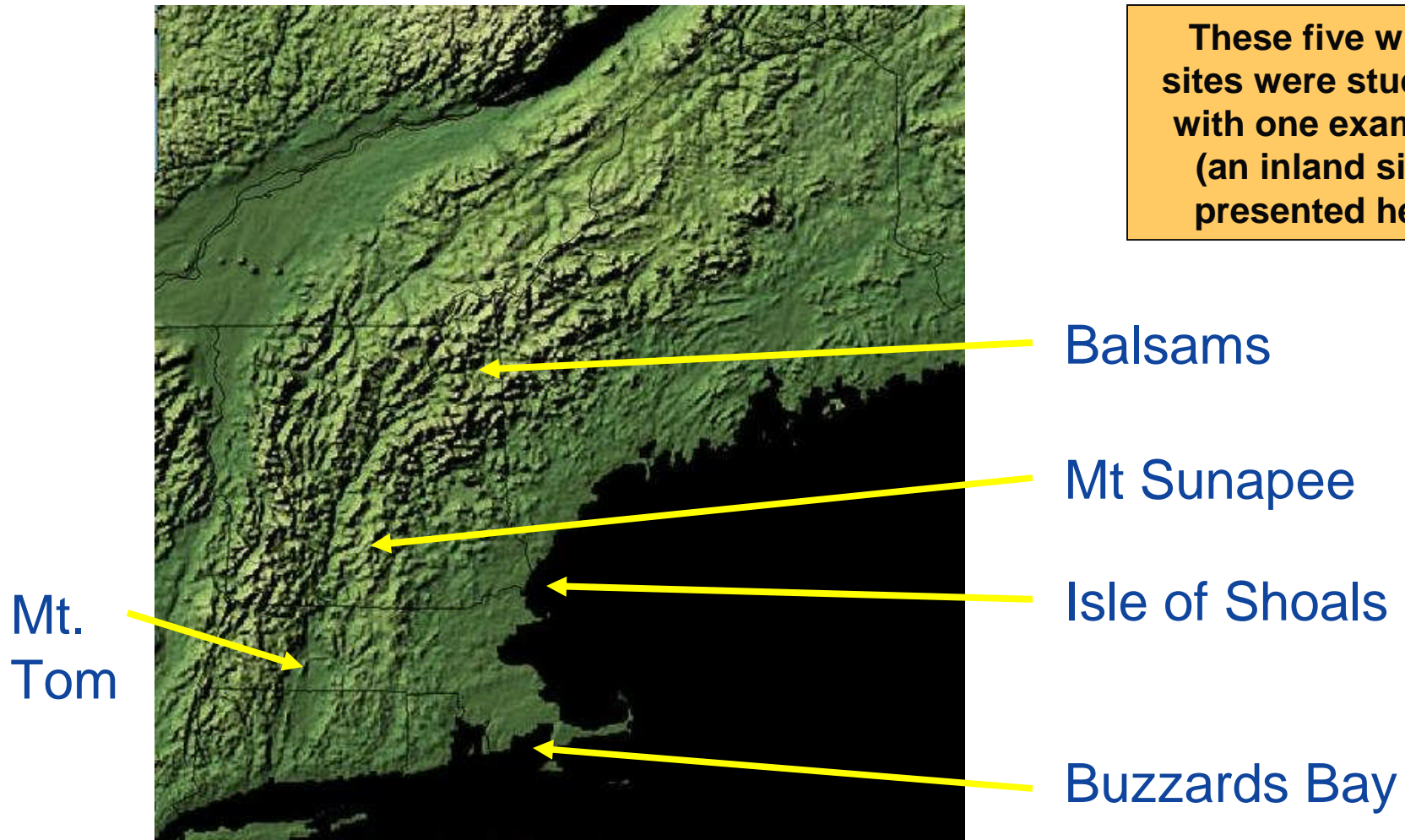
Assumptions regarding % of resource that is treated as “qualified capacity” come from studies in other regions.

Overview of Study of Wind and PV Profiles

- Tony Rogers (UMass) was contracted to study of wind profiles (as input to ISO calculation of energy output from composite wind projects)
 - Preliminary results for three inland sites
 - Mt Tom
 - Balsams (Dixville Notch, NH)
 - Mt Sunapee (NH)
 - Preliminary results for two offshore sites
 - Buzzards Bay
 - Isle of Shoals (offshore NH)
- PV systems also evaluated; preliminary results for 2 sites
 - Hartford
 - Boston
- Data from sites used as proxies for renewable projects, not actual output from individual plants

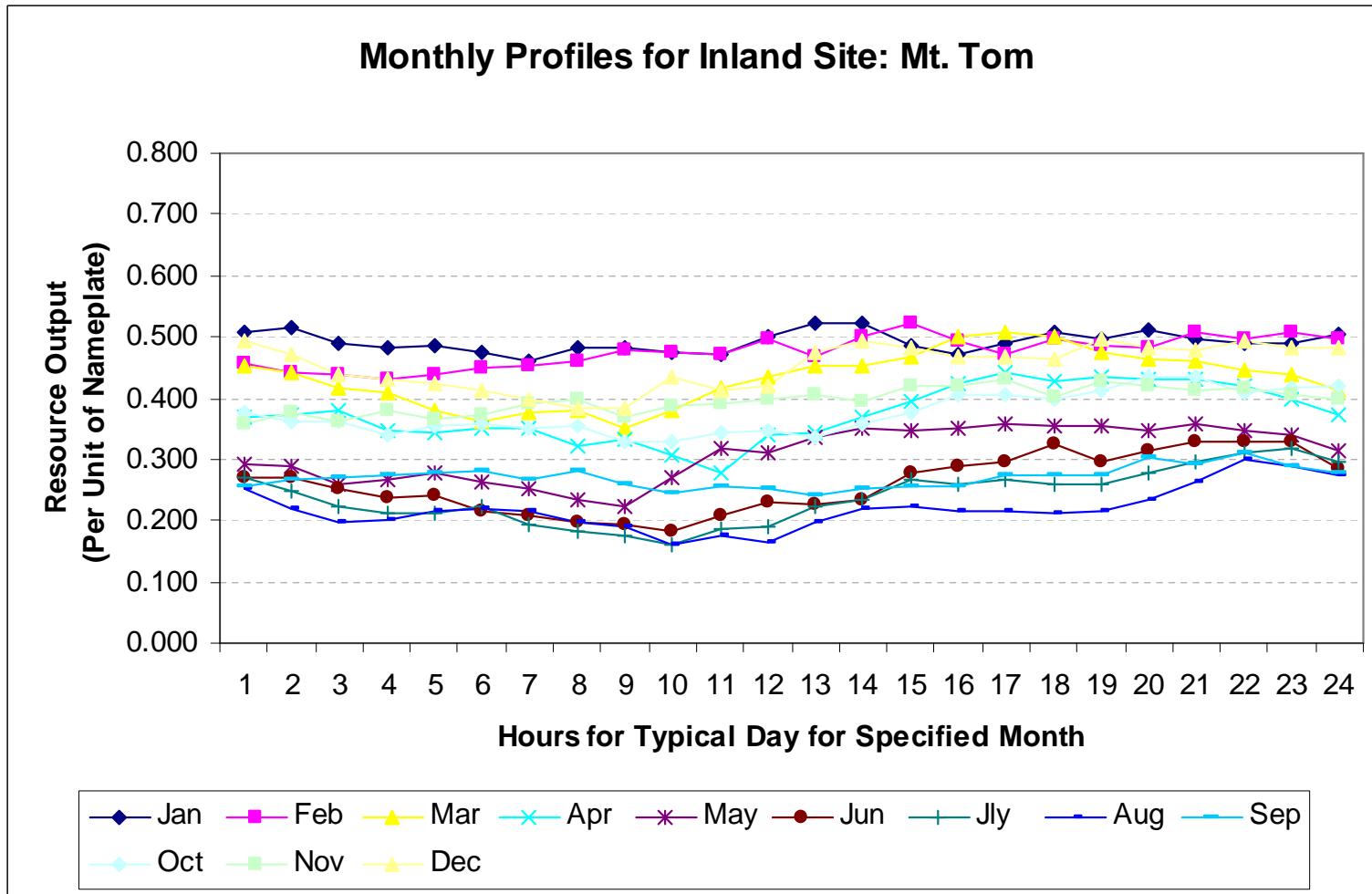
Location of Wind Sites Investigated

These five wind sites were studied, with one example (an inland site) presented here

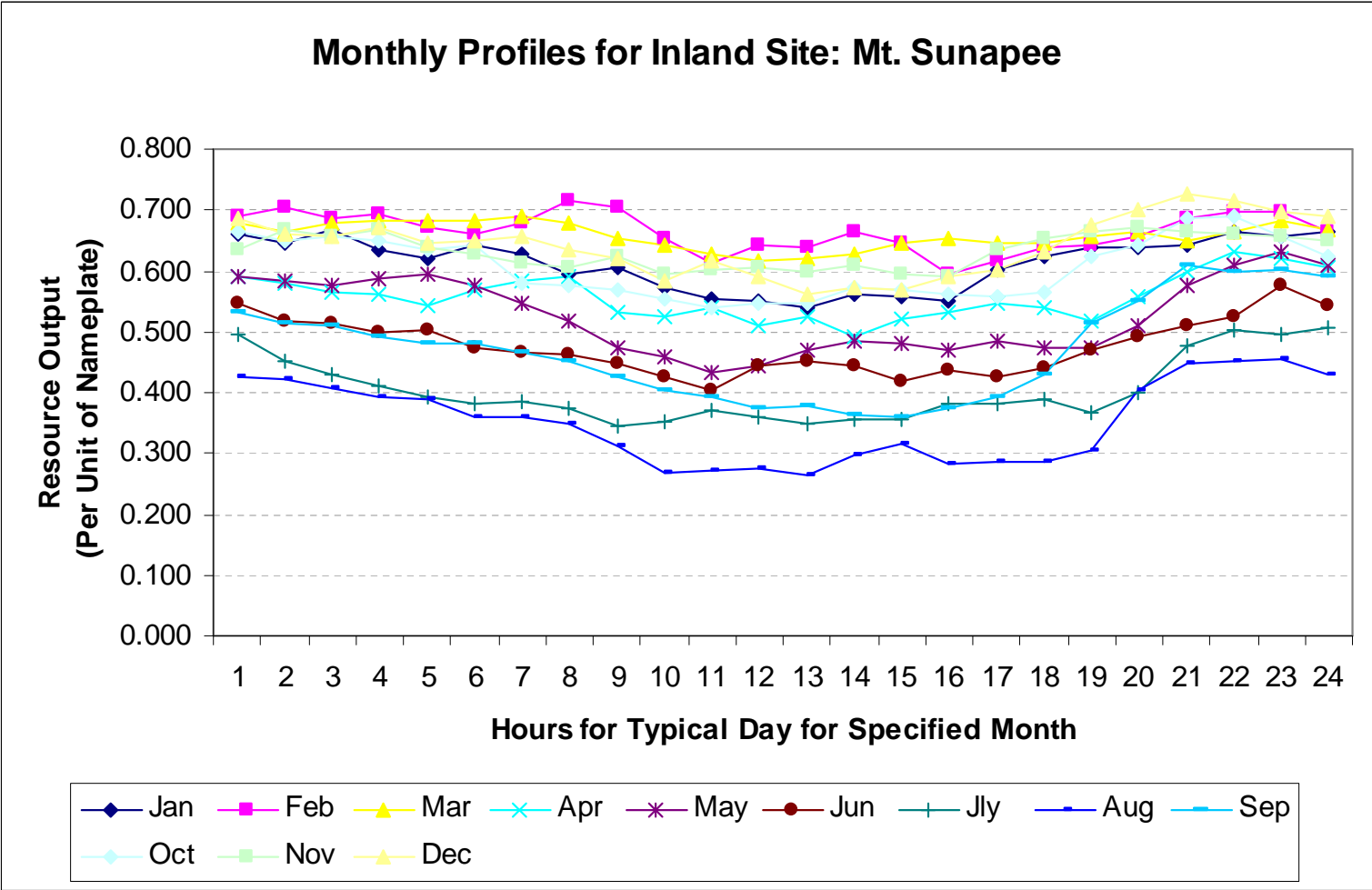


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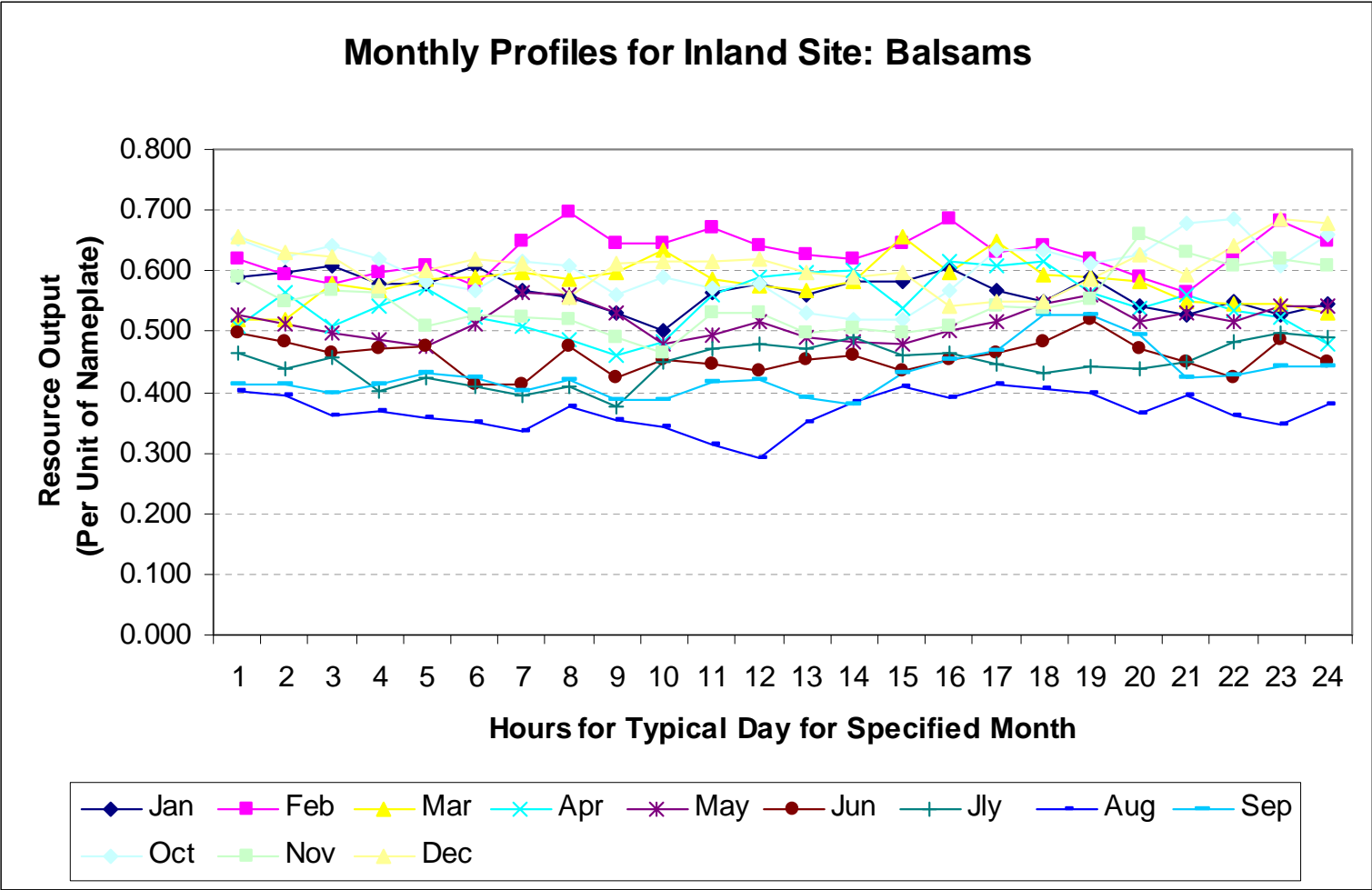
Wind Profiles for Mt. Tom (MA) (inland)



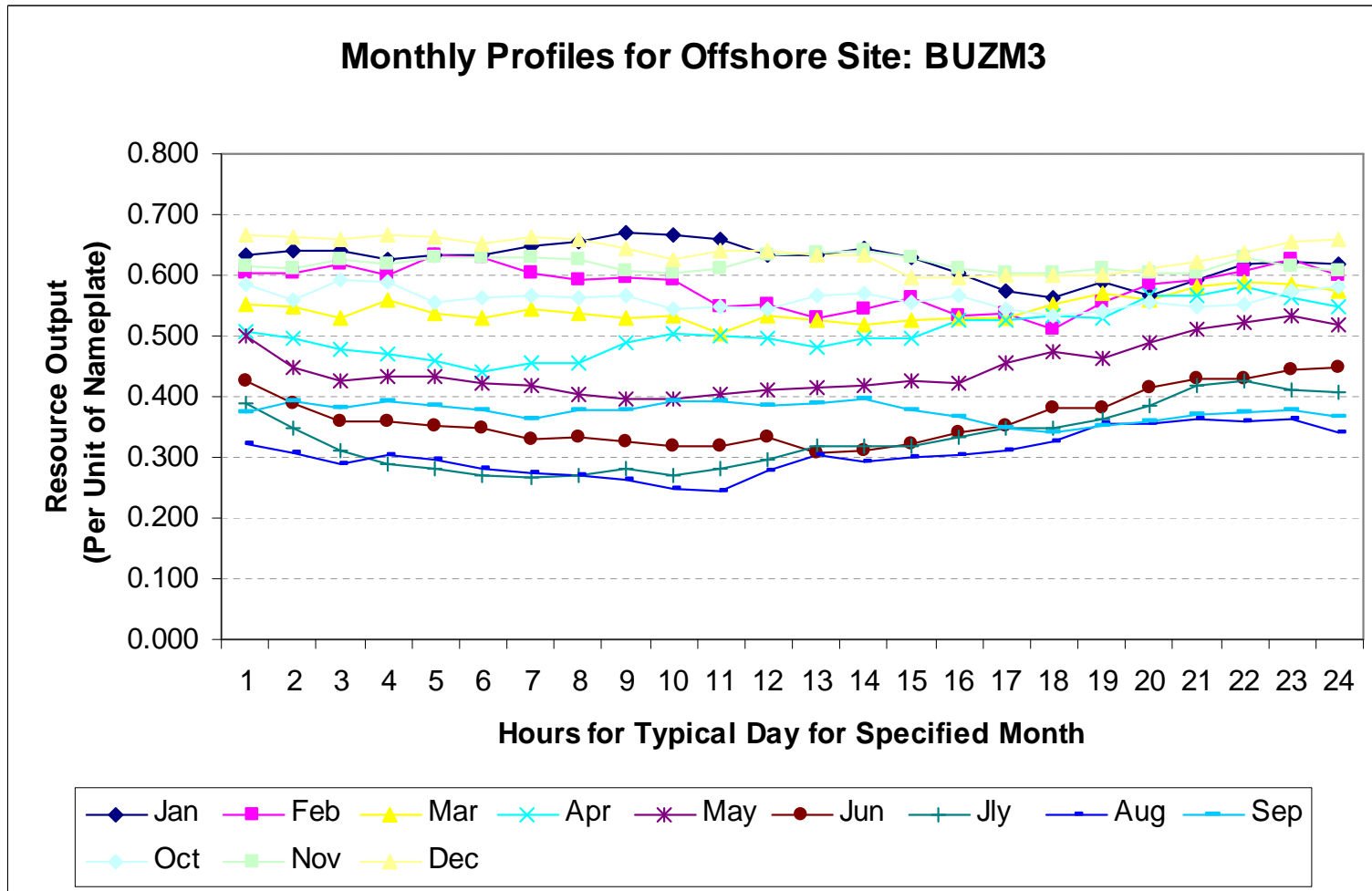
Mt Sunapee (NH) (inland)



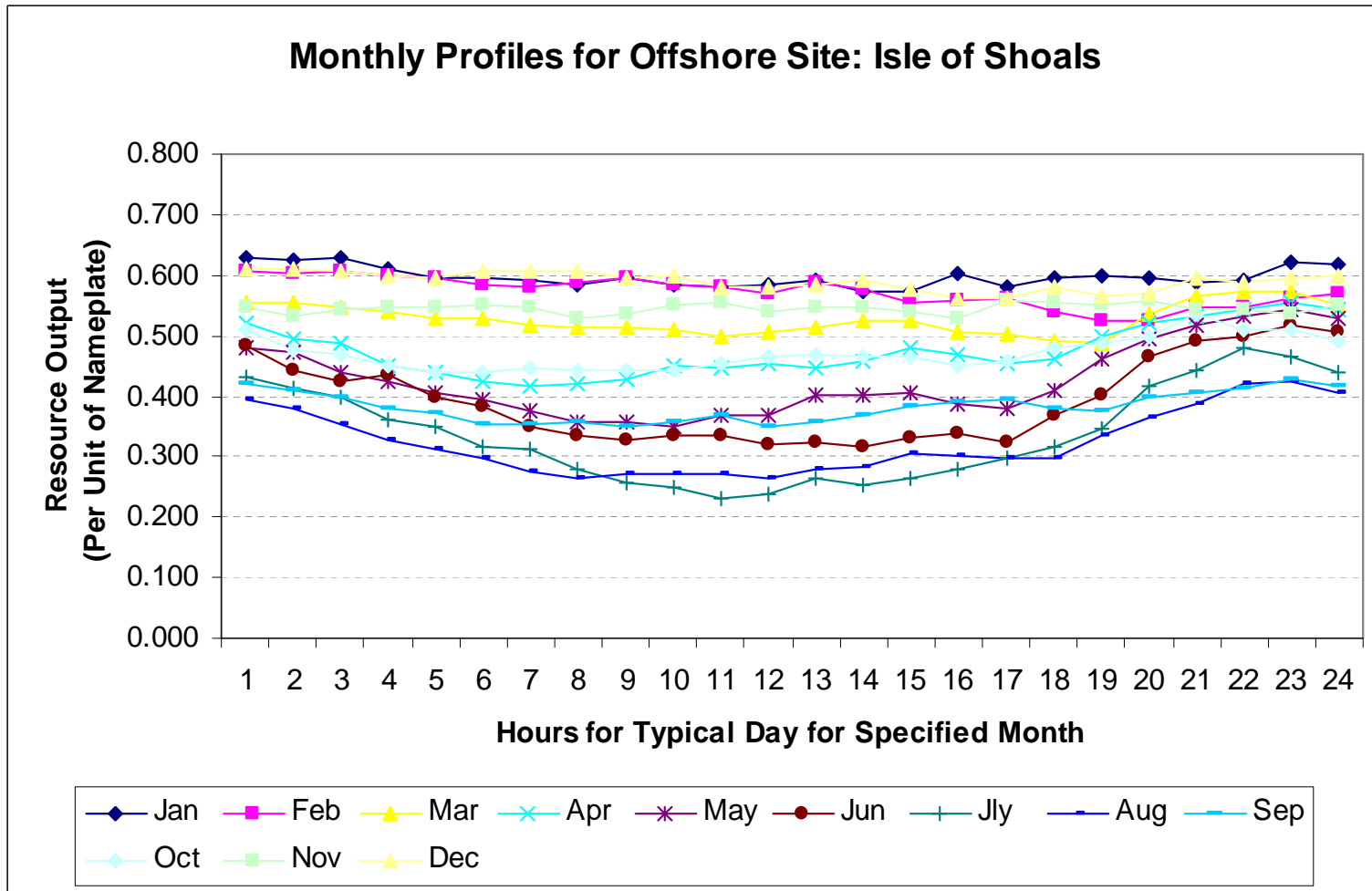
Balsams (Dixville Notch, NH) (inland)



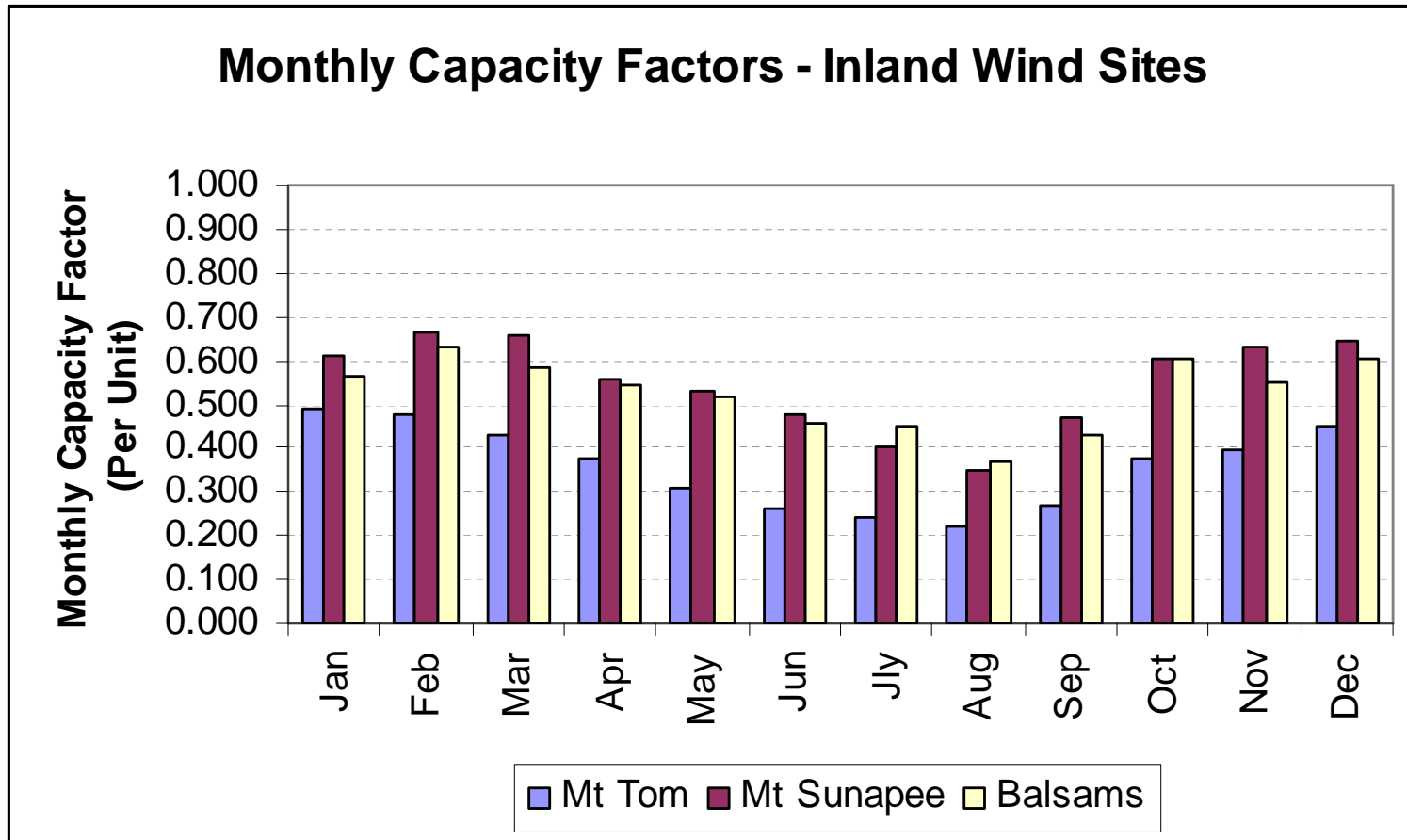
Buzzard's Bay (South of Cape Cod) (off-shore)



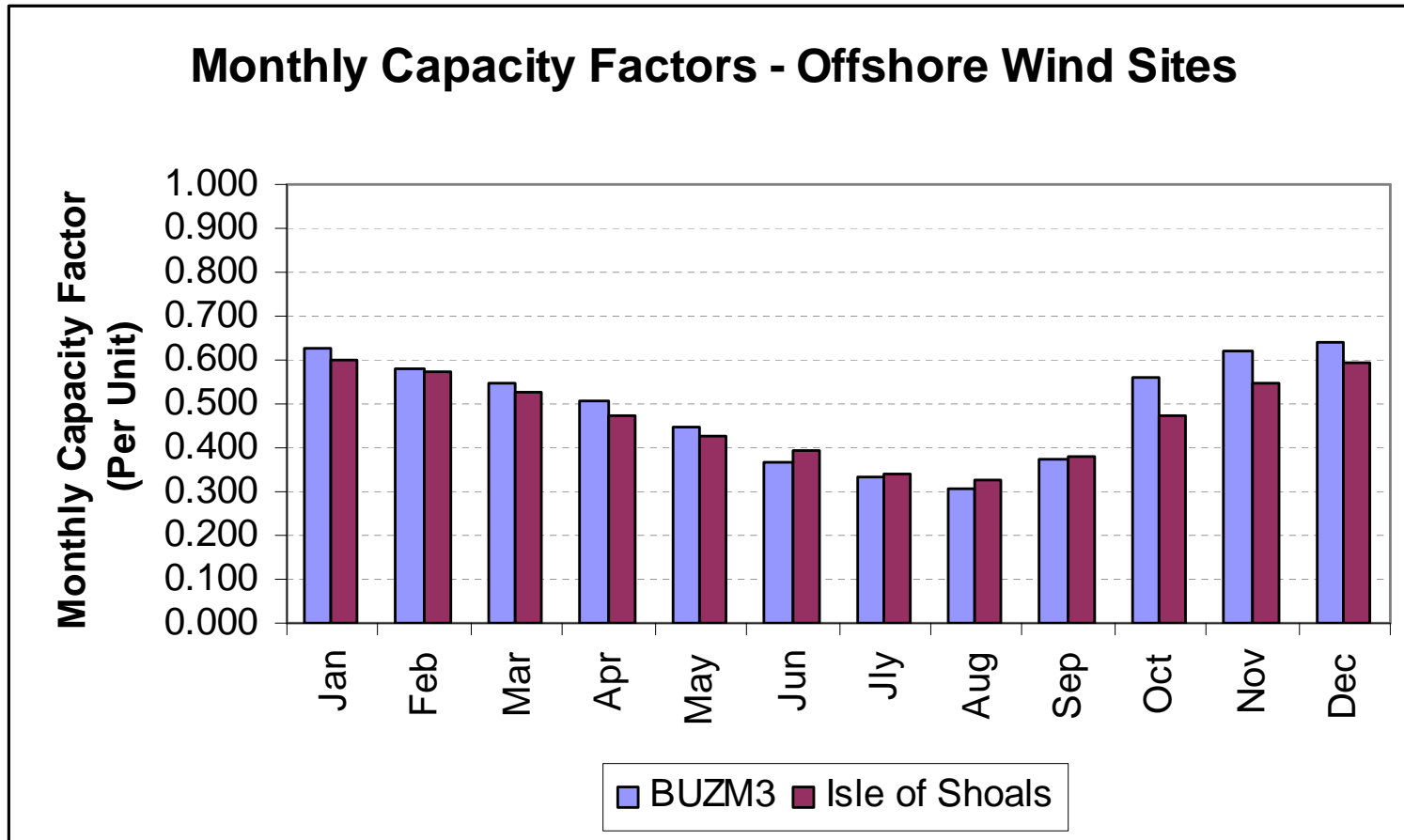
Isle of Shoals, NH (Off-Shore)



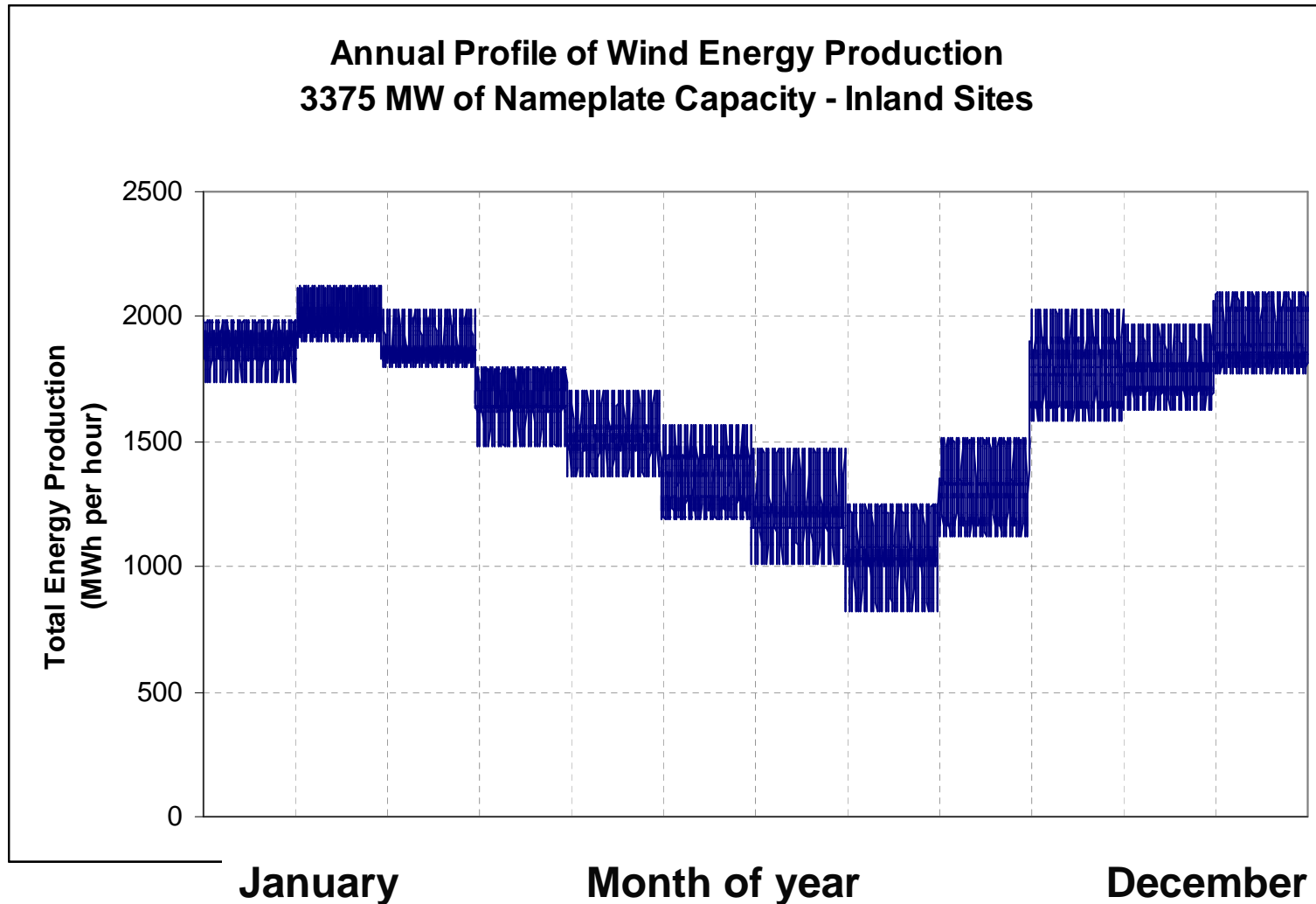
Monthly Capacity Factors – Inland Wind (by month of year)



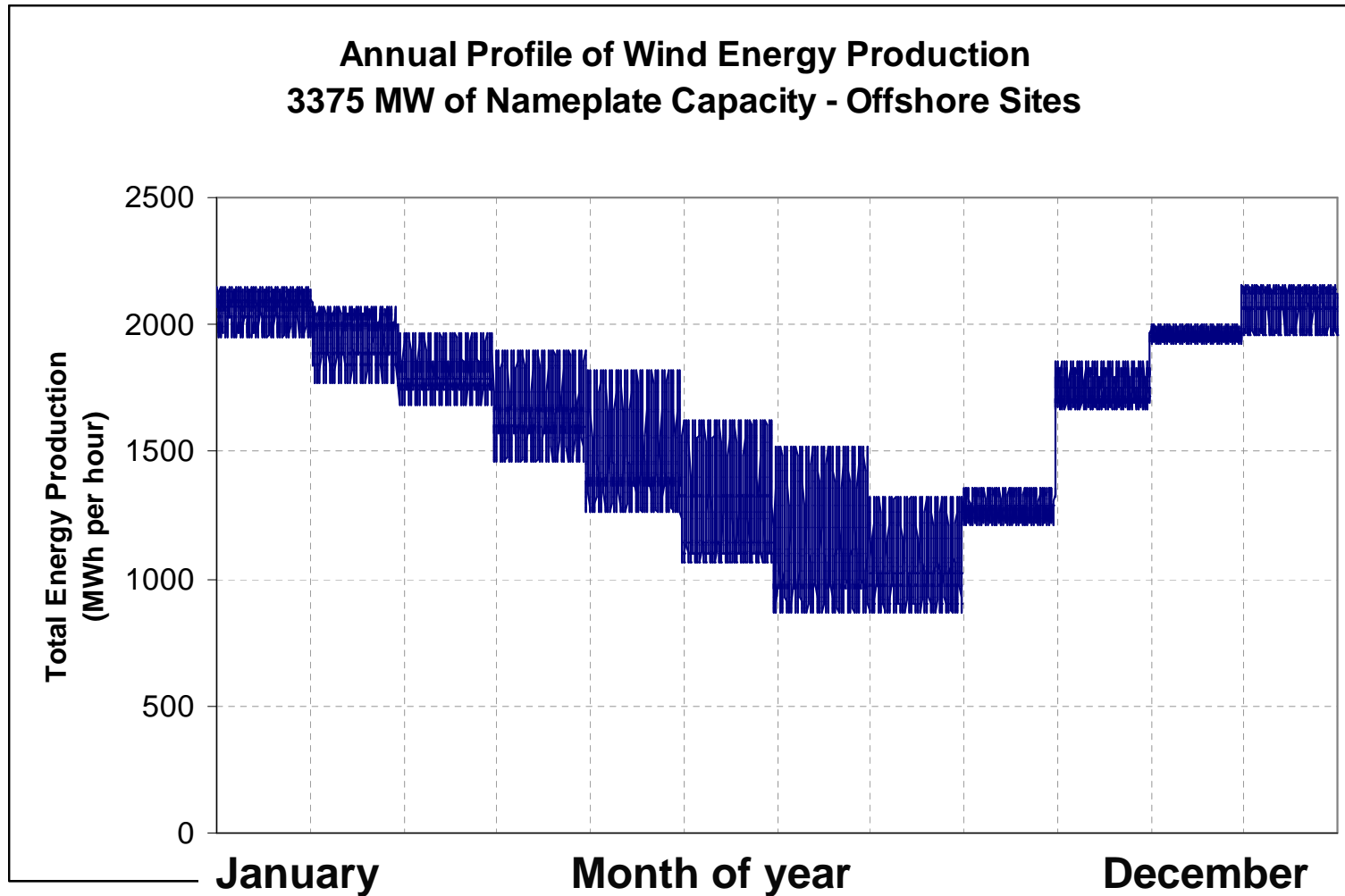
Monthly Capacity Factors – Offshore Wind (by month of year)



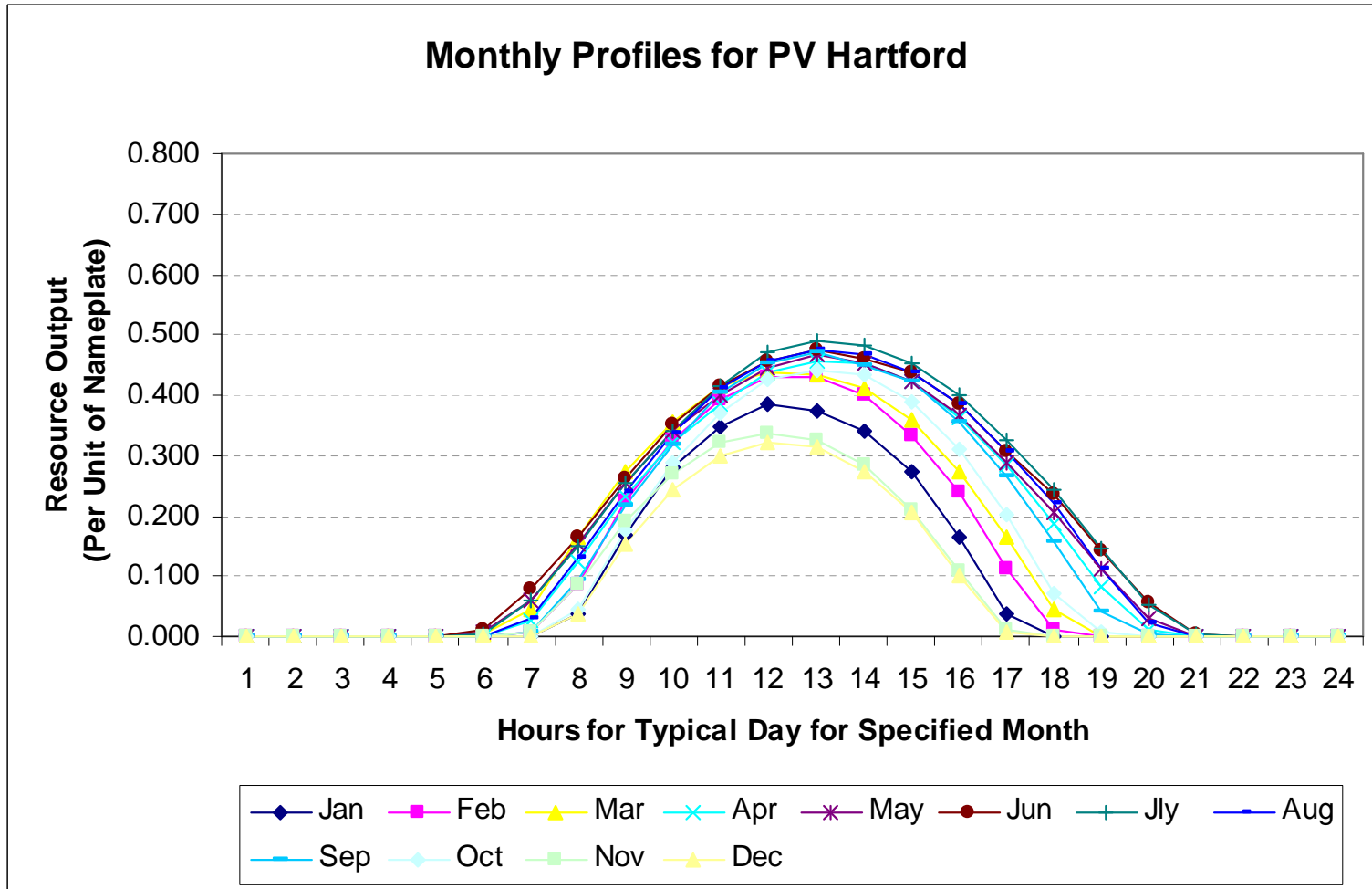
Annual Inland Wind Generation Profile (by month of year)



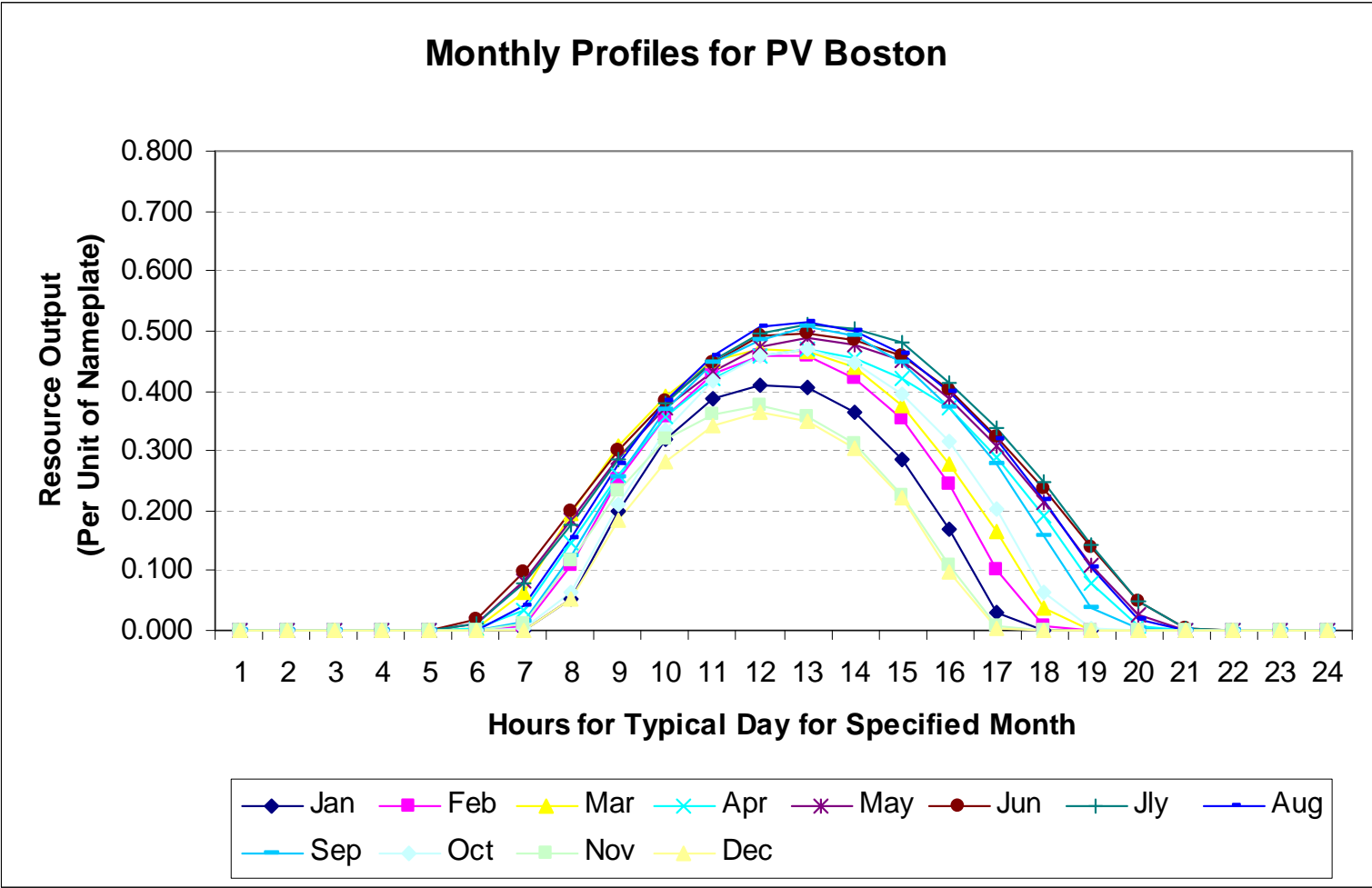
Annual Off-Shore Wind Generation Profile (by month of year)



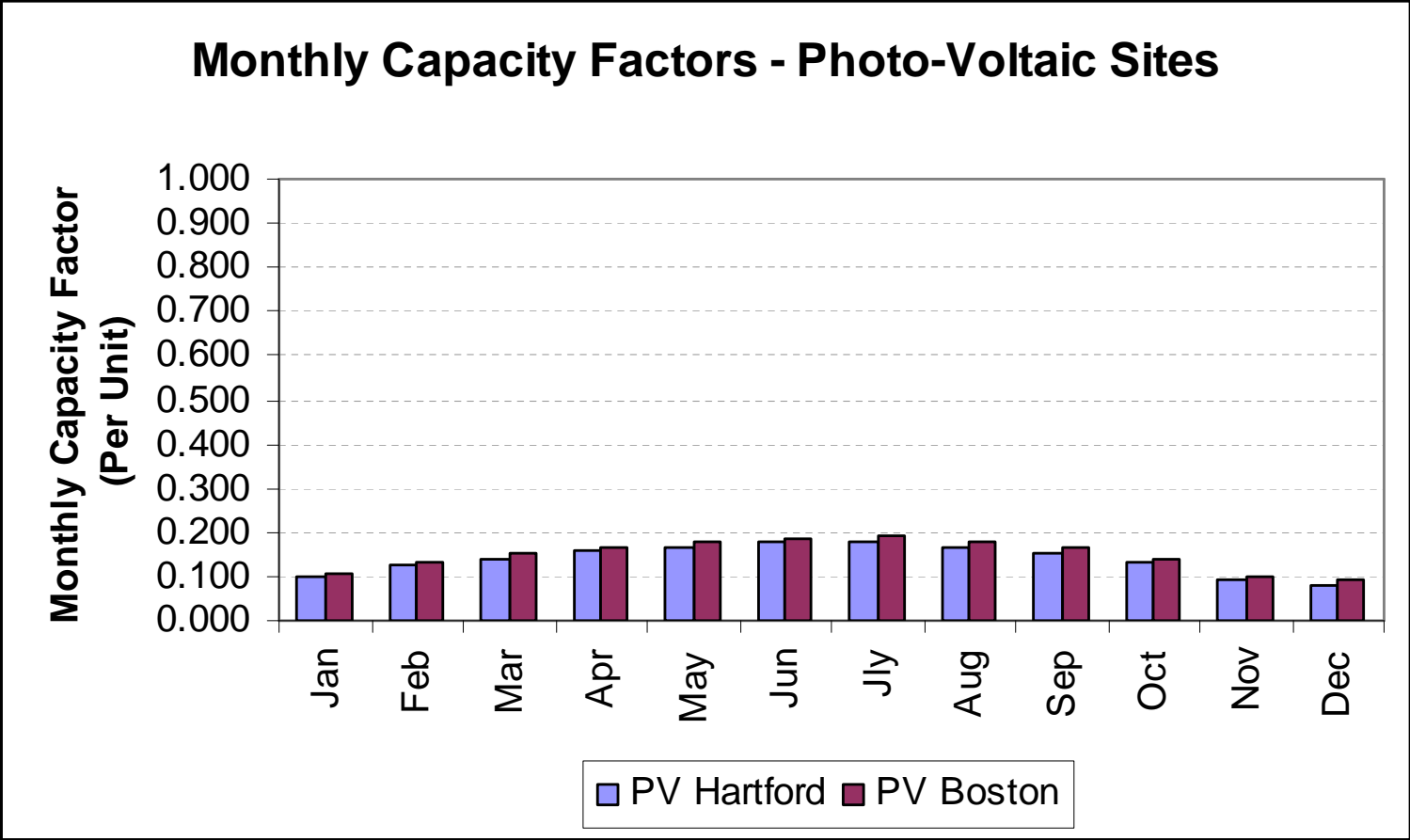
PV - Hartford



PV - Boston

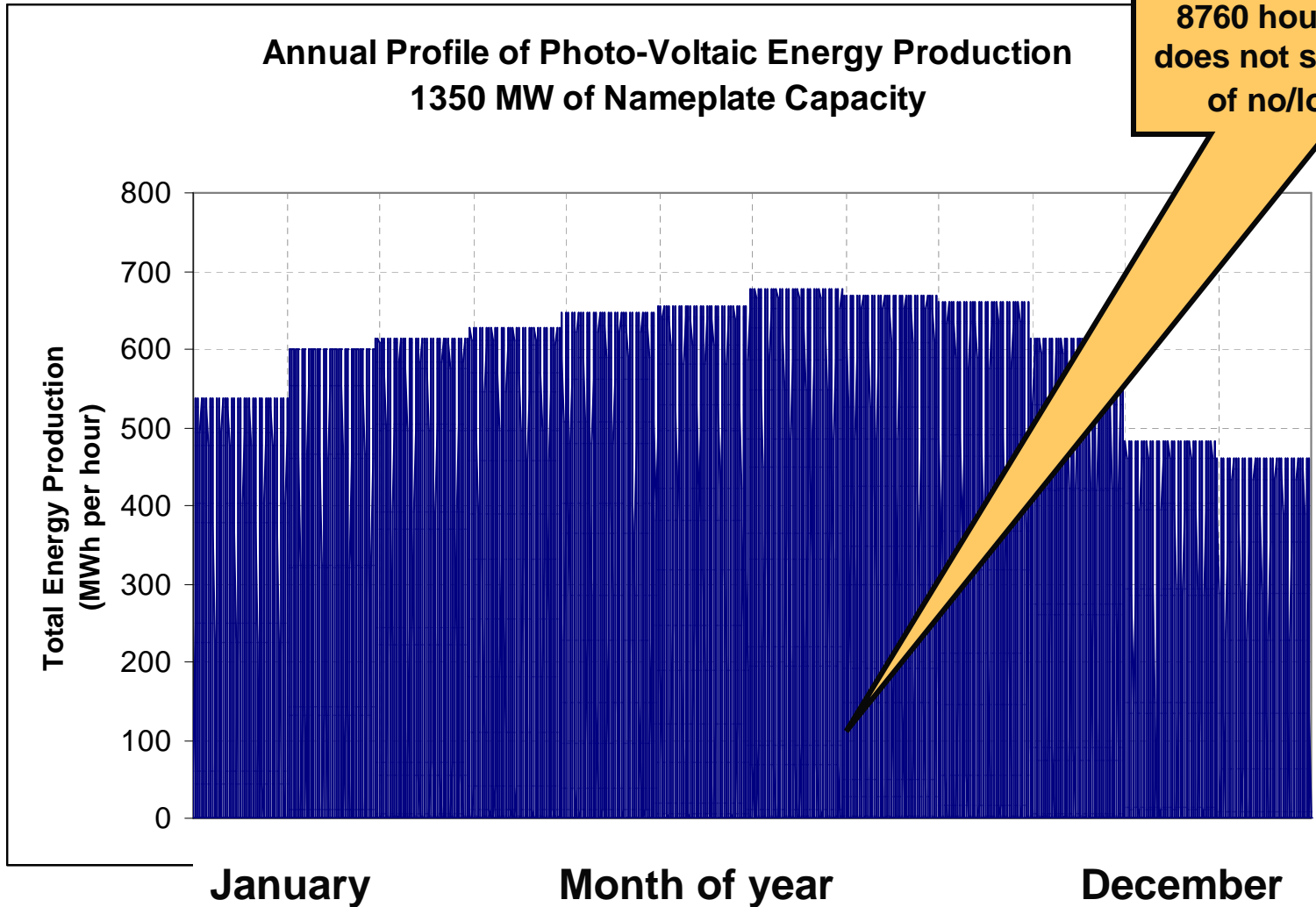


Monthly Capacity Factors – PV



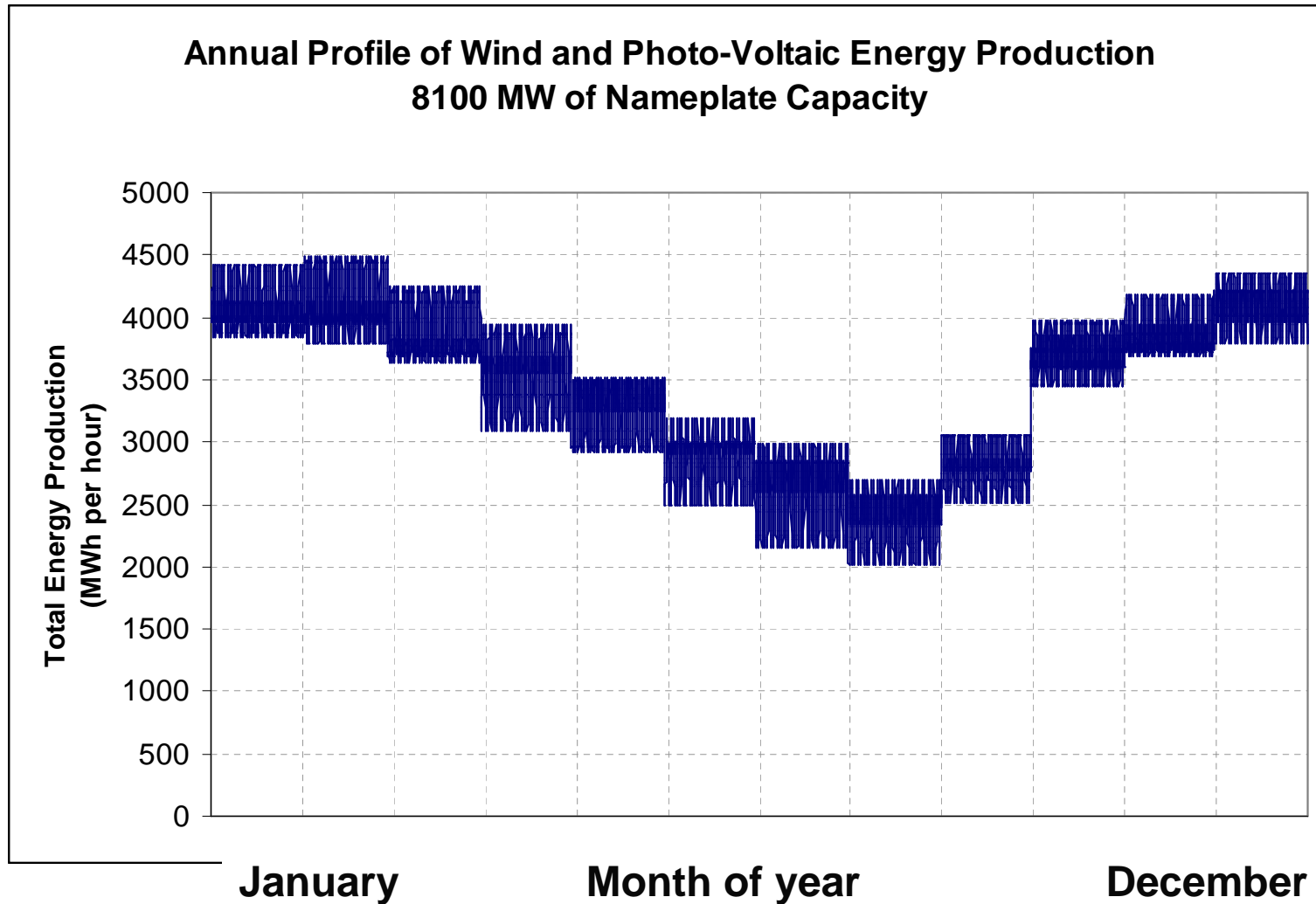
Annual PV Generation Profile

Annual Profile of Photo-Voltaic Energy Production
1350 MW of Nameplate Capacity

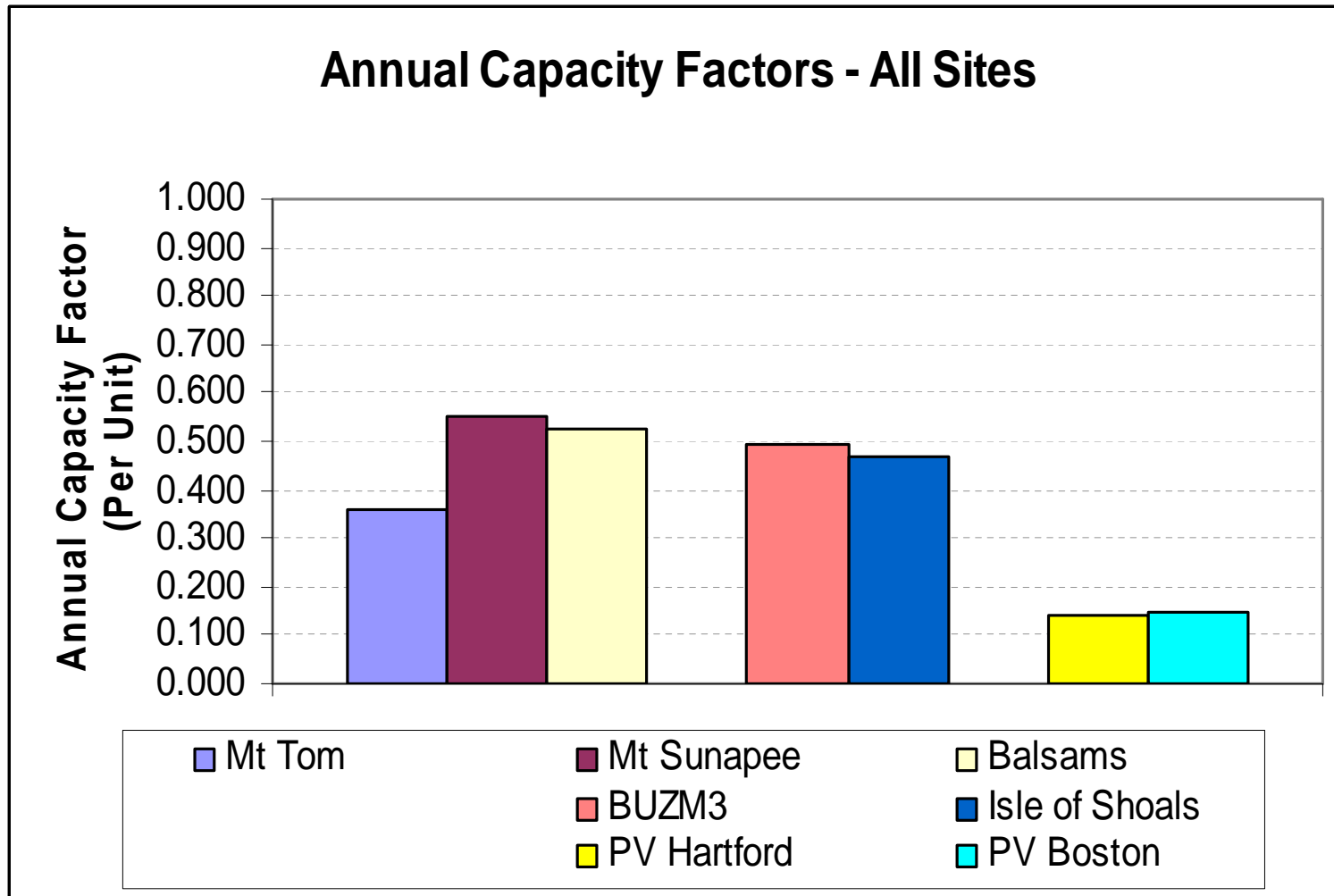


Note: Many hours have no PV energy production; but the plot of the data for 8760 hours on this chart does not show these hours of no/low PV output.

Combined Wind and PV Profile



Annual Capacity Factors – All Sites (Wind & PV)



Annual Energy From Wind and PVs

