Estimating Avoided Emissions from Renewable Resources

Jim Platts – ISO New England

WRI – USEPA – CEC Workshop
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Objectives

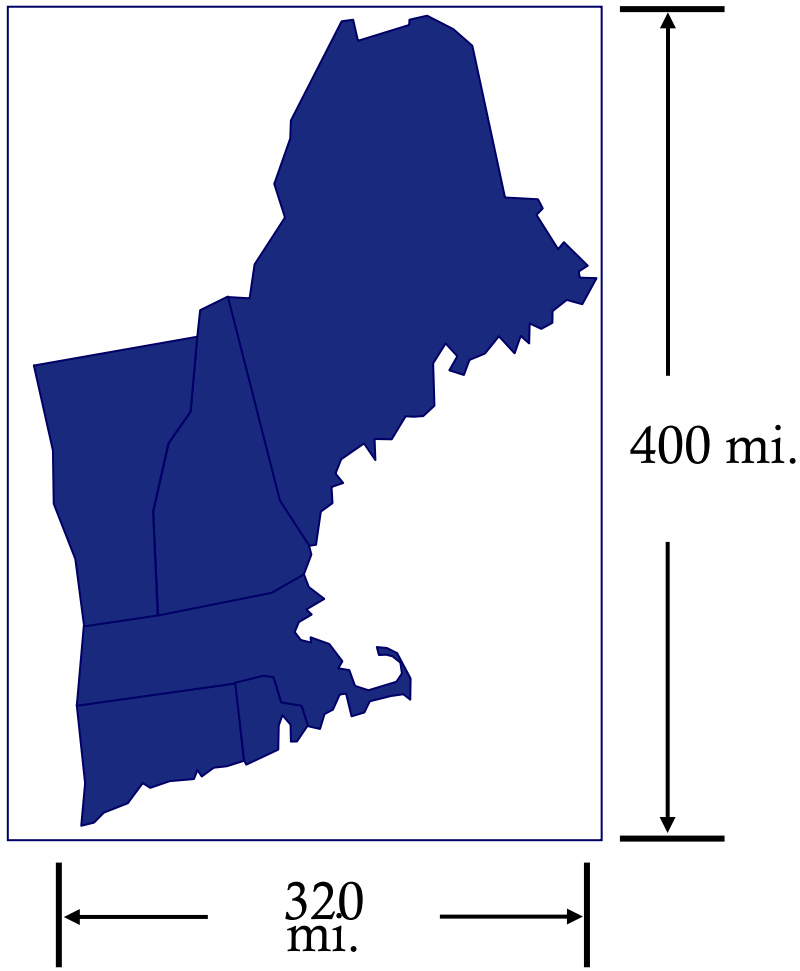
1. Describe NEPOOL's Marginal Emission Rate Analysis (MEA)

2. Describe how the MEA could be used to estimate avoided emissions from a 1000 MW and 100 MW wind farm

3. Describe how to estimate the avoided emissions from a 5 MW landfill gas project

New England's Electric Power System

- Serves 6.5 million customers; 14 million people
- 350+ generating units
- 8,000+ miles of transmission lines
- 12 interconnections to neighboring systems
- 31,000 MW of total supply
- Peak demand: 25,348 MW on 8/14/02
- $7.0 billion annual energy market
- Headquarters in Holyoke, MA

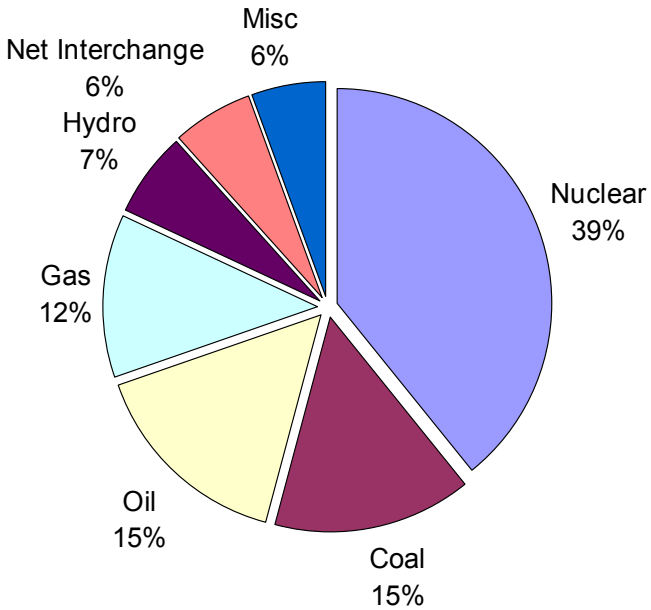


ISO New England, Inc.

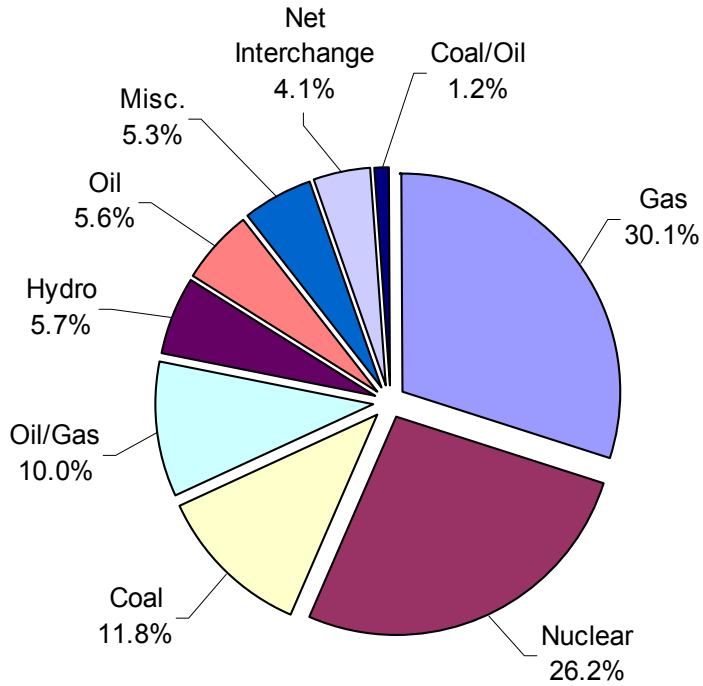
- Is a private, not-for-profit corporation created in 1997 to administer New England's deregulated wholesale electric power system.
- **Is Responsible for**:
  - Power system reliability
  - Deregulated market administration
  - Regional transmission planning
- Is in transition to becoming a Regional Transmission Organization (RTO)

New England's Energy Sources: 1993 and 2003

1993



2003



Sources: ISO NE 1993 Annual Report and

ISO NE Regional Transmission Expansion Plan 2004

2003 NEPOOL Marginal Emission Rate Analysis

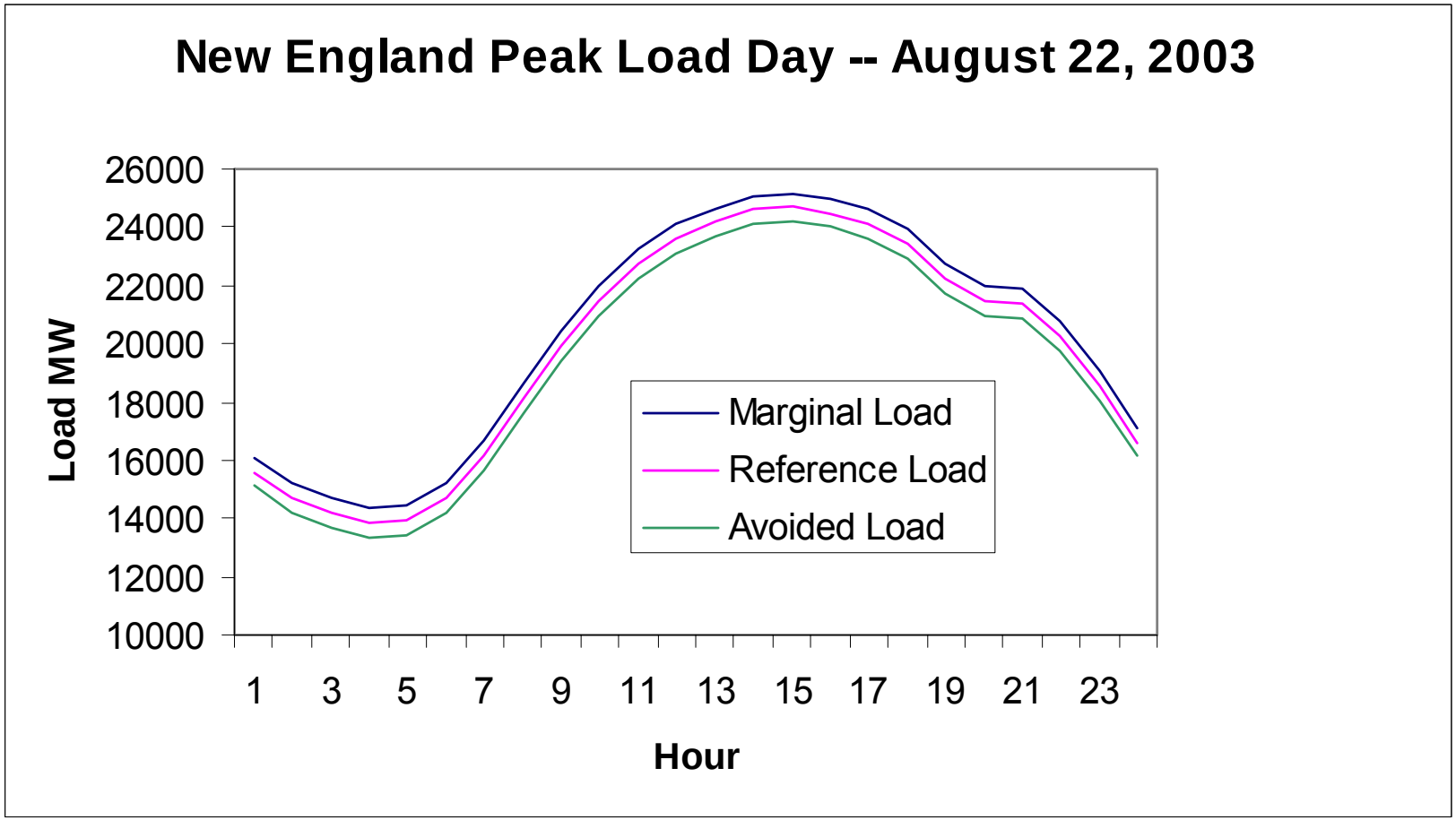
- The NEPOOL Marginal Emission Rate Analysis (MEA) Report is developed by ISO-NE for New England Power Pool's (NEPOOL) Environmental Planning Committee (EPC).

- **Rationale for Analysis:**
  - Originally done to support applications for obtaining Massachusetts NO_X Emission Reduction Credits (ERCs) resulting from impacts from Demand Side Management (DSM) programs.
  - Such applications were filed under the Mass. ERC banking & trading program effective January 1, 1994, for inventoried sources of NO_X, VOCs and CO_2
  - NEPOOL MEA Report has been performed annually since 1993 (public domain).

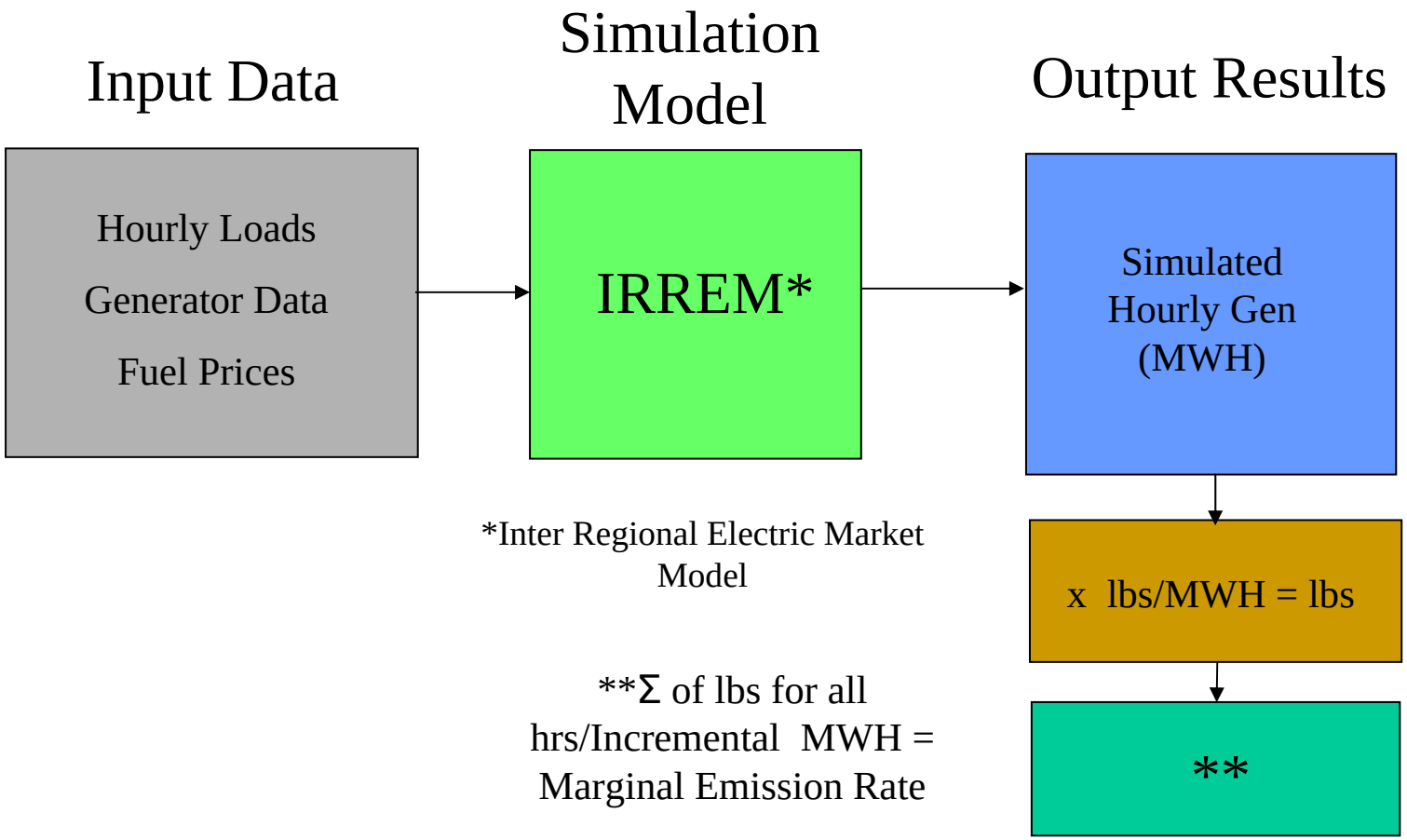
2003 NEPOOL Marginal Emission Rate Analysis

What are Marginal Emission Rates & how are they calculated?

- Use a production simulation model to replicate annual historical system operations for a "Reference Case"
- Develop a "*Marginal Case*" which '*increases*' all hourly loads by the amount of the DSM contribution to calculate the amount of additional (marginal) emissions that would have been emitted if DSM programs were not in place
- Conversely, the "A*voided Emissions*" resulting from a renewable resource could be calculated by a '*decrease*' in the hourly loads representing generation from that resource.
- Calculate the difference in total emissions between the two cases and convert to a rate in Lbs/MWh. The resultant values of "*Marginal (or Avoided) Emission Rates*" can then be quantified for SO_2, CO_2 & NO_X or any other modeled pollutant.


New England Peak Load Day -- August 22, 2003
Load MW
26000
24000
22000
20000
18000
16000
14000
12000
10000
1
3
5
7
9
11
13
15
17
19
21
23
Hour
Marginal Load
Reference Load
Avoided Load

MEA Data and Model Overview



*Inter Regional Electric Market Model

**Σ of lbs for all hrs/Incremental MWH = Marginal Emission Rate

2003 NEPOOL Marginal Emission Rate Analysis

Description of Methodology

Geographic Scale = Power Pool = NEPOOL

- 6 New England states = 1 Control Area operated by ISO-NE
- Overall impacts on aggregate generating unit emissions (entire fleet)

Type of Emissions = Seasonal & annual marginal emissions rates

- Emission rates of all incremental generation required to serve the incremental load is quantified in Lbs/MWh & Lbs/MBtu
- Calculation of NEPOOL Marginal Heat Rate

Temporal Scale = Chronological hourly emissions aggregated

- On-peak and off-peak ozone & non-ozone season and annual average
- Incremental generation and emissions by State and Market Load Zone

2003 NEPOOL Marginal Emission Rate Analysis

Modeling:

- Used IRREM model for chronological simulation of New England's energy market
- IRREM models short-run marginal cost methodology (no bids)
- One bus modeling – Effect of real-time transmission constraints are captured in the historical generation patterns
- Replicate system operation of units in 2003 within 25% of actual unit monthly energies

2003 NEPOOL Marginal Emission Rate Analysis

Assumptions:

- DSM programs modeled at 500 MW in all hours
  - Although approx. 1,500 MW of DSM reported by load serving entities
  - No modeling of load response programs/initiatives
- Discrete generator seasonal capacity ratings
- Discrete generator maintenance & forced outages
- Actual historical hourly loads for NEPOOL system (1 Control Area)
  - Pumped storage pumping loads included in hourly loads
  - Subtract actual hourly net interchange with neighboring systems (New York, Hydro-Quebec, New Brunswick)
  - Equates to modeling only native generation impacts

2003 NEPOOL Marginal Emission Rate Analysis

Assumptions (cont):

- Some generation modeled as limited energy units:
  - All hydro facilities: dispatchable, run-of-river & pump storage
- All dispatchable units operated in accordance to system economics (merit order)
- 2003 New England historical fuel prices used (Source: EIA):
- Unit specific 2003 generating unit emission rates:
  - As reported to US EPA Acid Rain Division (Scorecard captures about 75% of emissions)
- Other units:
  - US EPA's E-Grid 2002 Ver 2.0 or typical default rates

2003 NEPOOL Marginal Emission Rate Analysis

Incremental generation and emissions by state and season:

- Tons of emissions of SO_2 & NO_X and Ktons of emissions of CO_2
- By Power Pool and sub-divided by state: CT, RI, MA, ME, NH & VT
- By ozone & non-ozone season & annual

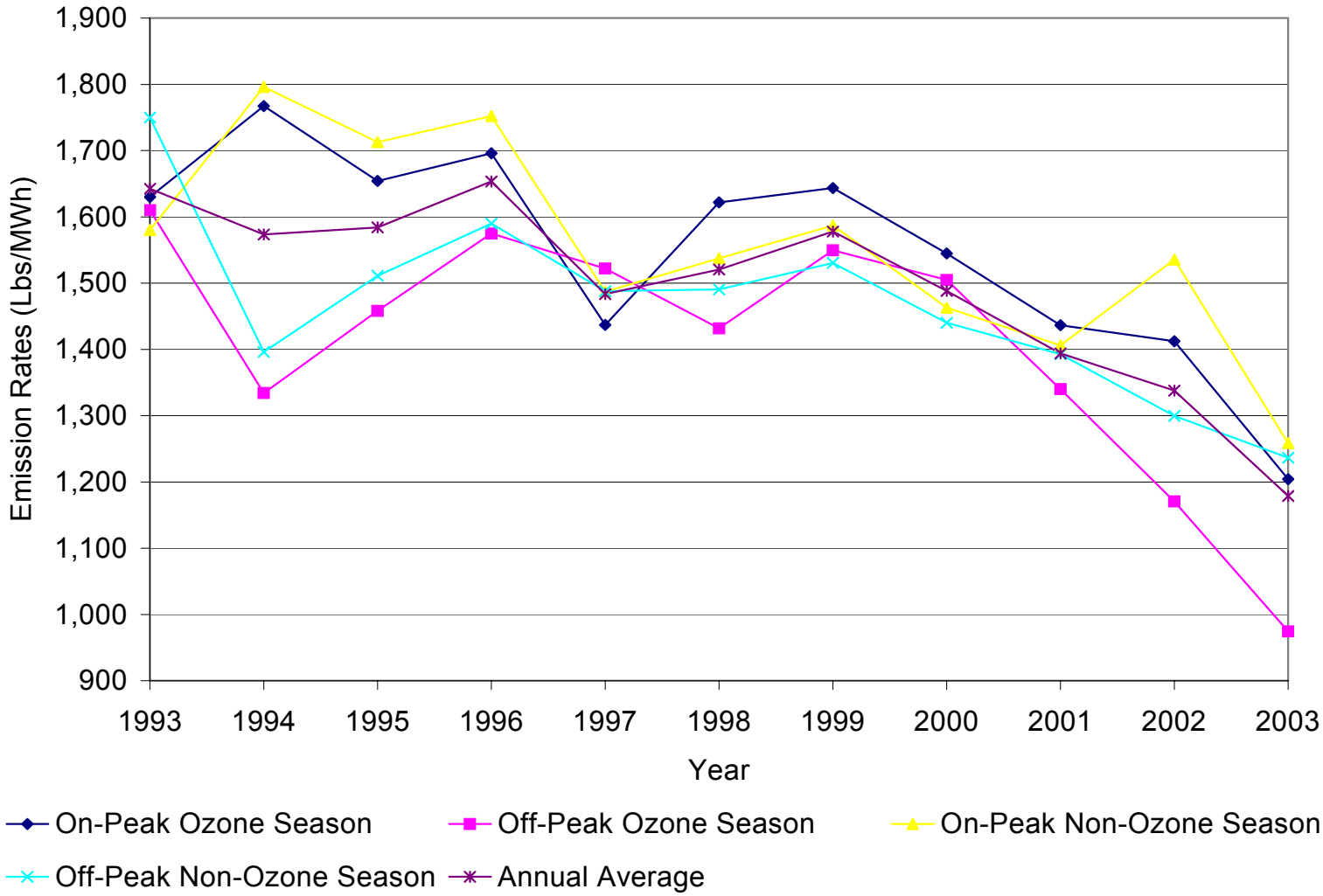
Track new generation additions in NEPOOL by:

- Unit type, capacity rating and location, fuel type
- Log historical commercialization information

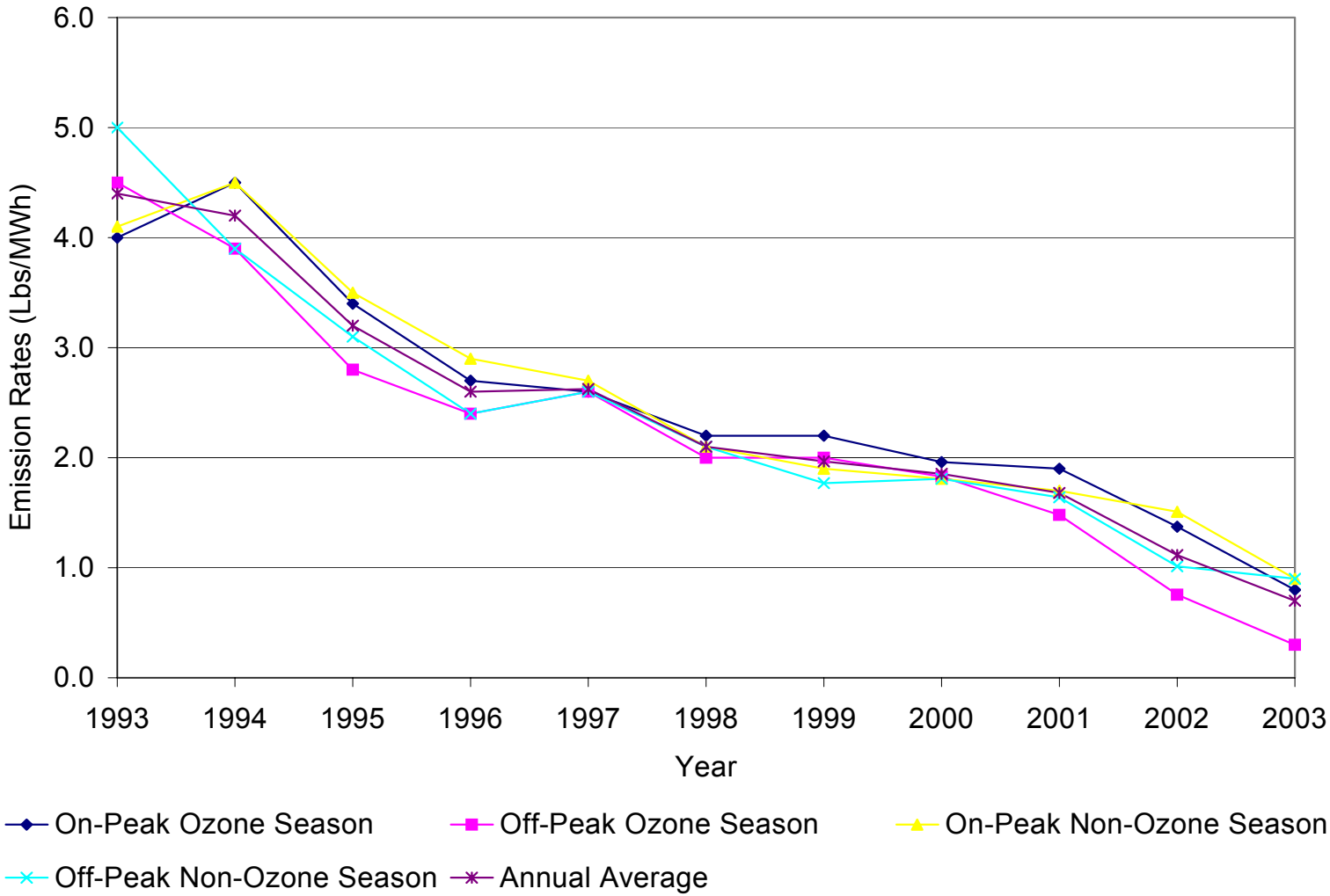
Compare "Reference Case" aggregate NEPOOL emissions against the US EPA reported emissions

- Calculate delta and that should approximate non-US EPA reported emissions

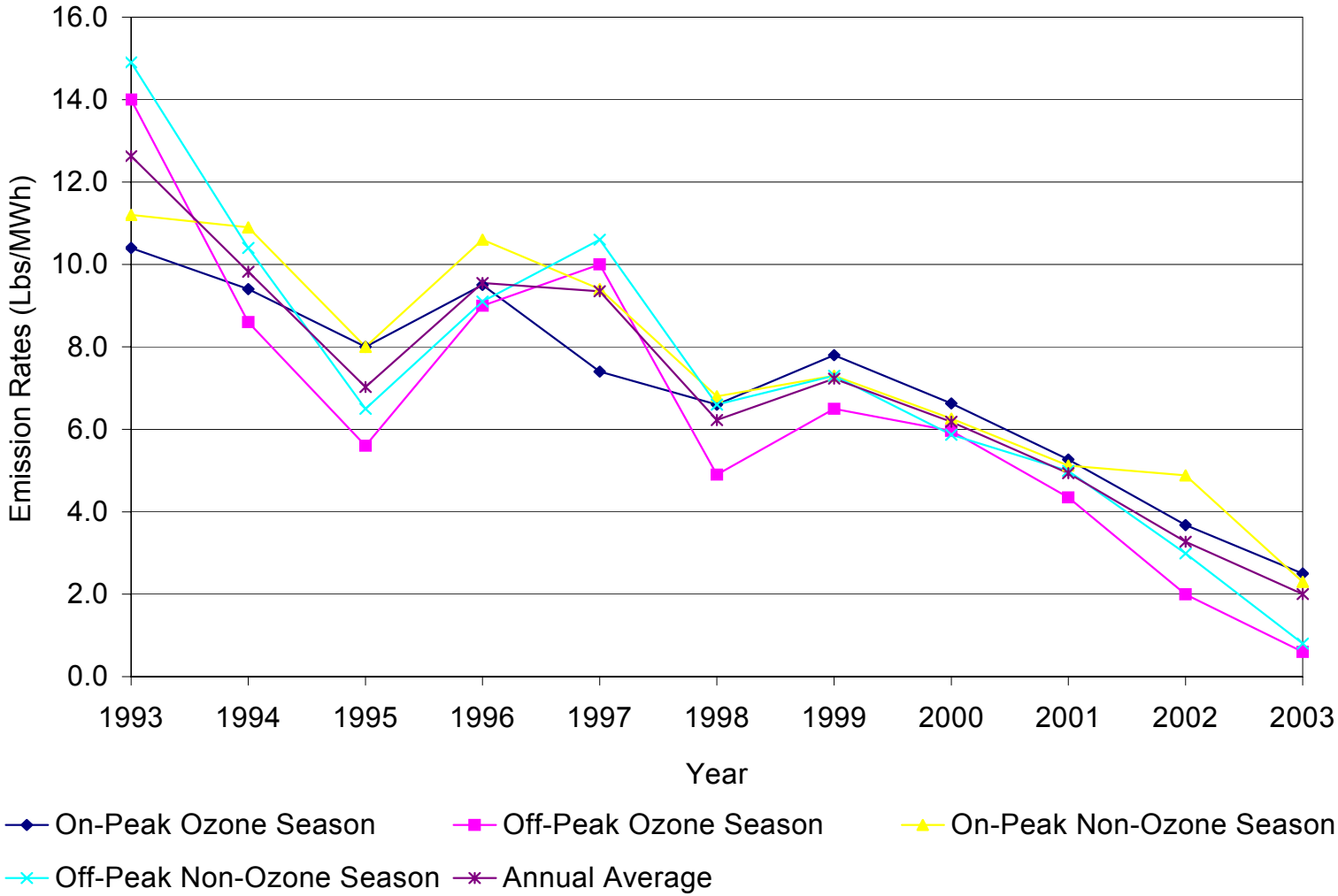
2003 NEPOOL CO_2 Marginal Emission Rates



2003 NEPOOL NO_x Marginal Emission Rates



2003 NEPOOL SO_2 Marginal Emission Rates



2003 NEPOOL Marginal Emission Rate Analysis

Marginal Heat Rate:

- The marginal heat rate is a useful metric and a global conversion factor

$$\frac{\text{(Marginal Case Fuel Consumption – Reference Case Fuel Consumption)}}{\text{(Marginal Case Generation – Reference Case Generation)}} = \text{MBtu/MWH}$$

- NEPOOL Marginal Heat Rates: MBtu/MWH (decreasing trend)
  - 1999 = 10.013
  - 2000 = 9.279
  - 2001 = 9.610
  - 2002 = 8.660
  - 2003 = 8.250

2002 NEPOOL Marginal Emission Rate Analysis

2002 NEPOOL MEA Report – Evaluation of Parameters

Accuracy:

- Receives peer review by the NEPOOL EPC

Practicality/Feasibility:

- Manpower: 1 FTE-month: Data collection, input, debugging, benchmarking and results review
- Ease of Development: Follows initial methodology with refinements over time to enhance overall accuracy & quality
- Public Replication:
  - Can use similar production simulation model
  - Generation capacity and loads on ISO website
  - Generation heat input, MWH and emissions available at EIA and EPA websites.

2003 NEPOOL Marginal Emission Rate Analysis

Evaluation of Parameters:

Transparency:

- Inputs, methodology, outputs & results are fully disclosed/documented (i.e. MEA Report is public)

Conservativeness:

- Questionable or unknown inputs are set to reasonable default values

Congruency:

- Generic methodology with New England specific granularity

Estimating Avoided Emissions from the Cape Wind Project

- Cape Wind is a proposed 420 MW project of 130 wind turbines to be located offshore between Cape Cod and Nantucket Is.
- Estimated annual capacity factor is 38%
- Daily summer winds correlate with the summer peak load
- Winter winds provide highest energy
- More info at www.capewind.org

Cape Wind's Projected Energy and Avoided Emissions

	MWH
April 03	150,390
May 03	108,910
June 03	49,267
July 03	109,517
August 03	112,954
September 03	89,717
October 03	148,365
November 03	145,959
December 03	219,112
January 04	212,333
February 04	146,670
March 04	198,067
Total	1,691,261

Avoided CO_2 equals

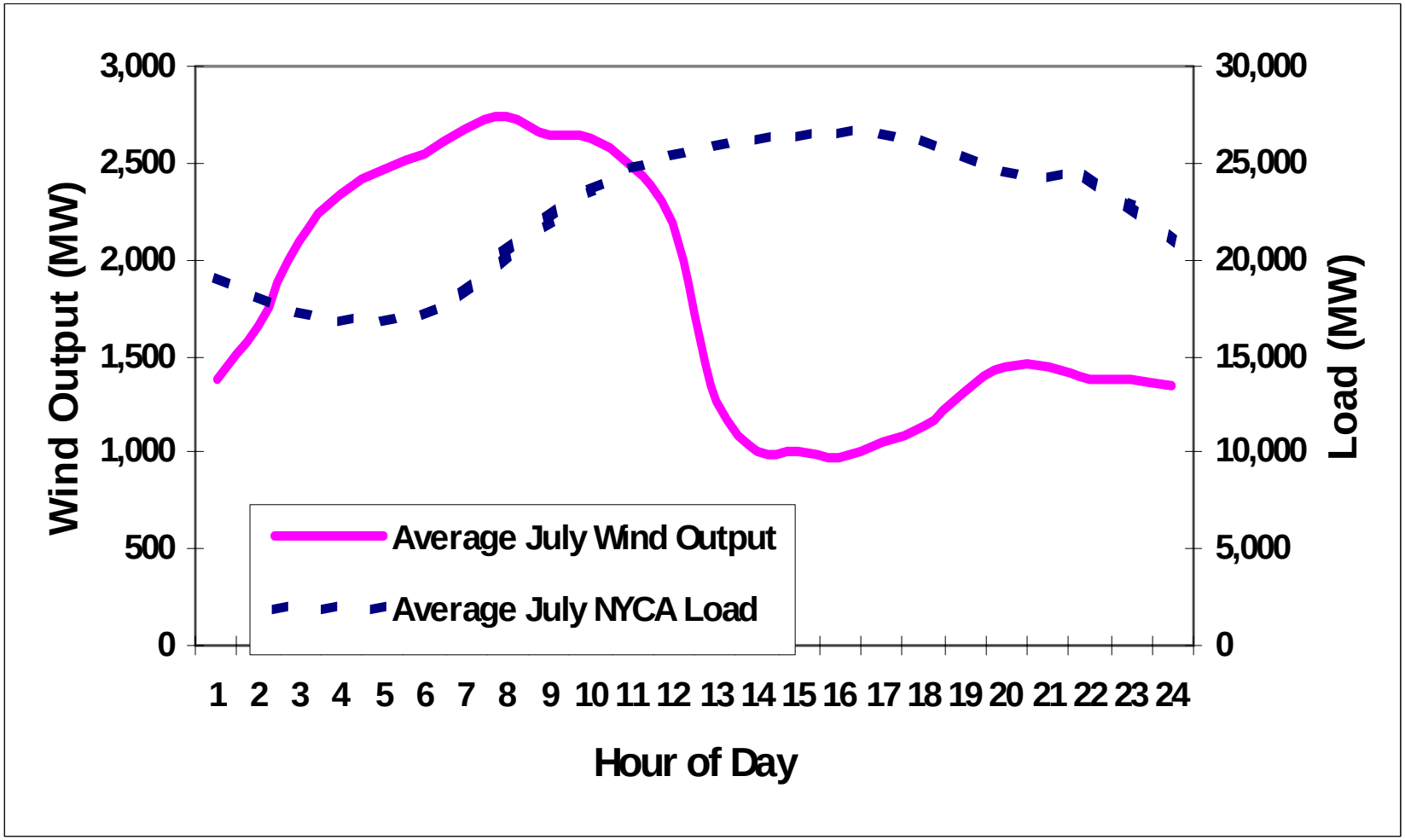
1,179 lbs/MWH x

1,691,261 MWH/2,000

= 996,998 tons

Source: DOE and Cape Wind Associates

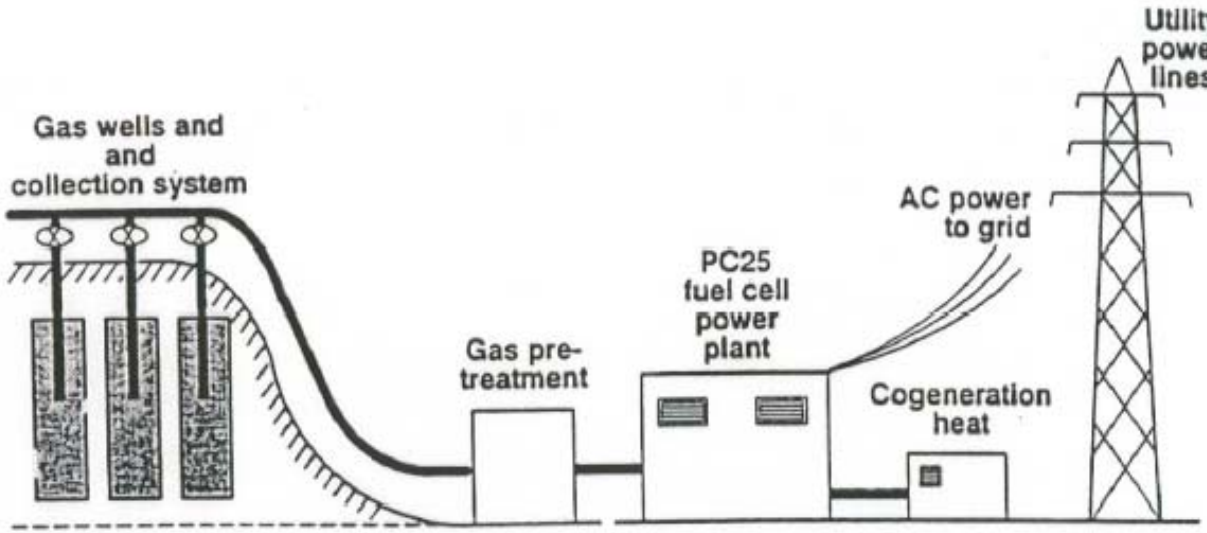
Average hourly output forecast for 101 wind sites and New York Control Area average load for July



Landfill Gas Project: Avoided Emissions

- A 42 acre landfill in Groton, CT was flaring low BTU landfill gas (LFG). Composition: CH_4 – 57%, CO_2 – 41%
- In 1996 the Town of Groton, EPA, Northeast Utilities and International Fuel Cells installed a 200 kW fuel cell at the landfill with a gas cleanup system to generate electricity from the CH_4 the LFG. This was a demonstration project.
- The calculation of avoided GHG emissions is based on
  - The CO_2 emissions from the fuel cell being the same as those emitted by flaring CH_4
  - The fuel cell generation avoids CO_2 emissions from an equivalent amount of marginal energy from the grid.
  - The CO_2 in the LFG is ignored since it is from normal decay of the landfill waste.
- The results can be scaled to 5 MW.

Landfill Gas Project: Avoided Emissions



Landfill Gas

- Methane and NMOC mitigation
- Low-Btu fuel
- Heavily contaminated

Contaminant Removal

- Remove sulfur and halides

Energy Conversion

- Energy sold offsite
  - operating revenue
  - energy offset
  - environmental benefit
- Very low emissions at site

Landfill Gas Project: Avoided Emissions

- Base Case – Flaring Methane
  - $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
  - A 1 ton reduction of CH_4 has the same global warming effect as 21 tons of CO_2 (Difference in GWP)
  - Flaring a ton of CH_4 releases 2.75 tons of CO_2 to the atmosphere (molecular weight difference)
  - The net reduction of CO_2 equivalent from flaring is 18.25 tons

Landfill Gas Project: Avoided Emissions

- Fuel Cell Case (Used ~20% of LFG)
  - Converts 20% of CH_4 to CO_2 through fuel cell's reformer
    - $CH_4 + 2H_2O \rightarrow 4H_2 + CO_2$
    - Same reduction as flaring
  - But the fuel cell's generation avoids marginal generation from the grid and its corresponding emissions of CO_2
  - Scaling to 5 MW:
    - 1179 lb/MWH* x 5 MW x 8760 hr x 0.7 / 2000 = 18,074 tons/yr of avoided CO_2.

*ISO NE 2003 marginal CO_2 rate

Observations by ISO New England

- The calculation of marginal system emissions is a useful method to determine emissions reductions from DSM. Similarly, it can be used for determining avoided emissions from clean renewable projects.

- Simulating the actual hourly loads from a large renewable project, especially for wind, and netting them from the system hourly load, could provide a more accurate estimate of the avoided emissions from the project than annual marginal rates.

- Small projects like landfill gas may need to account for the GWP of landfill gas in addition to using the annual avoided system emissions method.

Jim Platts

(413) 540-4516 –*jplatts@iso-ne.com*

System Planning
ISO New England Inc.
One Sullivan Road
Holyoke, Massachusetts
01040-2841
www.iso-ne.com