Maine Electricity and Waste Inventory, Baseline and Model Inputs

The Center for Clean Air Policy

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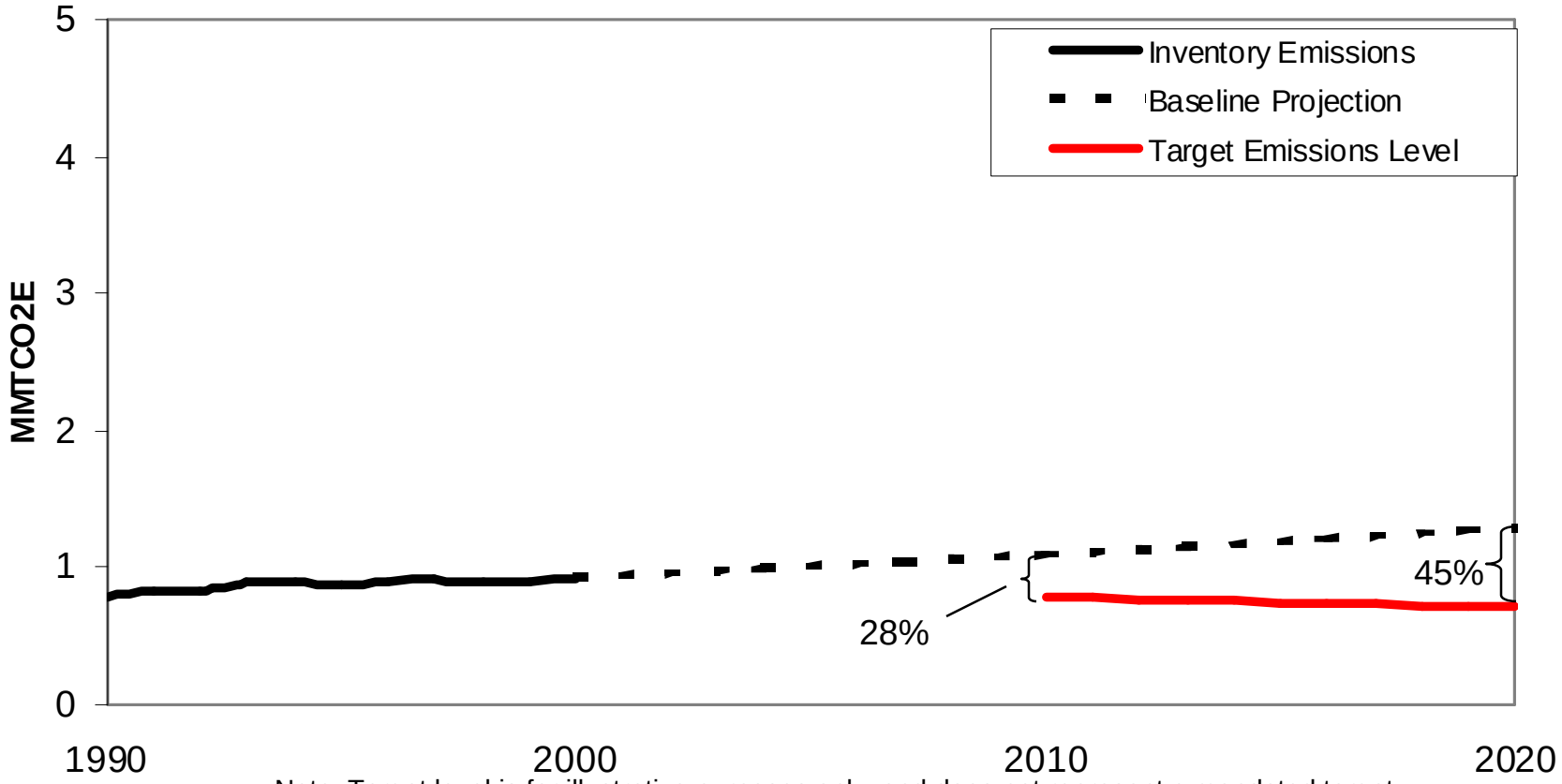
Presentation for Working Group, Meeting #2

- Detailed breakdown of waste inventory
- Discussion of NEMS model inputs
  - **Natural gas prices**
  - **Population and economic forecast for electricity demand**
  - **Cost and performance of generating units**
  - **Renewable supply curve**

Waste Inventory 1990-2000



Note: Target level is for illustrative purposes only, and does not represent a mandated target.
Target line assumes targets of 1990 sector levels by 2010, 10% below 1990 in 2020

Waste Inventory 1990-2000

CO2 Emissions (MMTCO2e)	
Waste	
1990	0.79
1991	0.83
1992	0.83
1993	0.89
1994	0.89
1995	0.87
1996	0.90
1997	0.91
1998	0.89
1999	0.90
2000	0.93

Waste Inventory: Methodology

- Developed by NESCAUM using the US EPA Inventory tool and state-specific information
- Inventory includes all waste that was landfilled or burned in Maine. Includes emissions from waste imports but not exports.
- Sources of waste emissions in inventory appear on the following slide.

Waste Inventory Emissions: Shares by Source

Waste Emissions (percent by source) in 2000		
Municipal & Industrial Landfills	**48.8%**	
Municipal Landfills		63.7%
Industrial Landfills		4.5%
CH4 Avoided		-19.3%
MSW Combustion Emissions	**40.1%**	
CO2		38.1%
N2O		2.0%
Wastewater Emissions	**11.1%**	
CH4		6.7%
N20		4.5%
Total	**100.0%**	**100.0%**

Waste Inventory 1990-2000

Waste Emissions (1,000 MTCO2e)	1990	1991	1992	1993	1994	1995
Municipal & Industrial Landfills	**490**	**499**	**506**	**511**	**514**	**486**
CH4 Emitted	**600**	**609**	**617**	**623**	**626**	**626**
Municipal Landfills	560	569	577	582	585	585
Large	54	55	56	57	57	57
Small	507	514	521	526	528	528
Industrial Landfills	39	40	40	41	41	41
CH4 Avoided	**(110)**	**(111)**	**(111)**	**(112)**	**(112)**	**(141)**
CH4 Flared	(55)	(55)	(55)	(55)	(55)	(87)
Oxidation at Landfills	(54)	(55)	(56)	(57)	(57)	(54)
Municipal Landfills	(51)	(51)	(52)	(53)	(53)	(50)
Industrial Landfills	(4)	(4)	(4)	(4)	(4)	(4)
MSW Combustion Emissions	**202**	**234**	**226**	**279**	**276**	**290**
CO2	**188**	**219**	**211**	**262**	**259**	**272**
Plastics	126	147	141	175	171	181
Synthetic Rubber in MSW	28	31	29	35	34	33
Synthetic Fibers	35	41	41	52	53	59
N2O	**14**	**15**	**15**	**17**	**17**	**17**
Wastewater Emissions	**97**	**98**	**99**	**99**	**100**	**99**
CH4	60	60	60	60	60	60
N20	38	38	39	39	40	39
Total	**789**	**831**	**831**	**889**	**889**	**874**

Waste Inventory 1990-2000

Waste Emissions (1,000 MTCO2e)	1996	1997	1998	1999	2000
Municipal & Industrial Landfills	**484**	**481**	**444**	**449**	**454**
CH4 Emitted	**625**	**622**	**623**	**628**	**634**
Municipal Landfills	584	581	582	587	593
Large	57	57	57	57	58
Small	527	524	525	529	534
Industrial Landfills	41	41	41	41	41
CH4 Avoided	**(141)**	**(140)**	**(179)**	**(179)**	**(180)**
CH4 Flared	(87)	(87)	(129)	(129)	(129)
Oxidation at Landfills	(54)	(53)	(49)	(50)	(50)
Municipal Landfills	(50)	(49)	(45)	(46)	(46)
Industrial Landfills	(4)	(4)	(4)	(4)	(4)
MSW Combustion Emissions	**315**	**330**	**343**	**351**	**373**
CO2	**297**	**312**	**324**	**333**	**355**
Plastics	198	210	219	228	241
Synthetic Rubber in MSW	35	35	36	35	38
Synthetic Fibers	64	66	69	70	75
N2O	**18**	**18**	**19**	**18**	**18**
Wastewater Emissions	**100**	**100**	**101**	**102**	**104**
CH4	60	60	61	61	62
N20	39	40	40	41	42
Total	**899**	**911**	**887**	**902**	**931**

Waste Inventory: Methodology

- Landfills
  - **Total tons of waste landfilled taken from biannual *Solid Waste Generation and Disposal Capacity Report* from the State Planning Office.**
  - **Number of landfills (447) and number of large landfills (3) provided by Maine DEP. Large landfills are those with at least 1.1 million tons of waste in place.**
  - **Accounts for methane emitted and flared using defaults**
  - **Accounts for oxidation of methane, based on EPA estimates that 10% of methane is oxidized (converted) in the top layer of soil cover above the landfill**
- Incineration
  - **Total tons of municipal solid waste (MSW) burned at Maine's four MSW-to-energy plants provided by DEP.**
  - **100% of emissions from electricity from MSW plants included in waste inventory**
  - **Emissions from plastics use national defaults**

Waste Inventory: Methodology

- Industrial waste
  - **Industrial landfill emissions are included. Inventory Tool default assumes industrial emissions are equal to 7% (national default) of total MSW methane emissions.**
- Wastewater
  - **Includes municipal wastewater emissions only. Does not include industrial emissions, which are expected to be small.**

Waste Inventory: Pulp and Paper Waste

- Most pulp and paper waste is stored or burned on-site, and is not included in waste inventory. Is accounted for in forest sector through net carbon emitted or stored.
- Any pulp and paper waste sent to municipal landfills or MSW plants would be included in waste inventory. This quantity is expected to be small.
- Paper incineration in MSW plants: CO_2 emissions from biomass content of paper are not included in the inventory. CO_2 from petroleum content and N_2O emissions from both biomass and petroleum content are included.

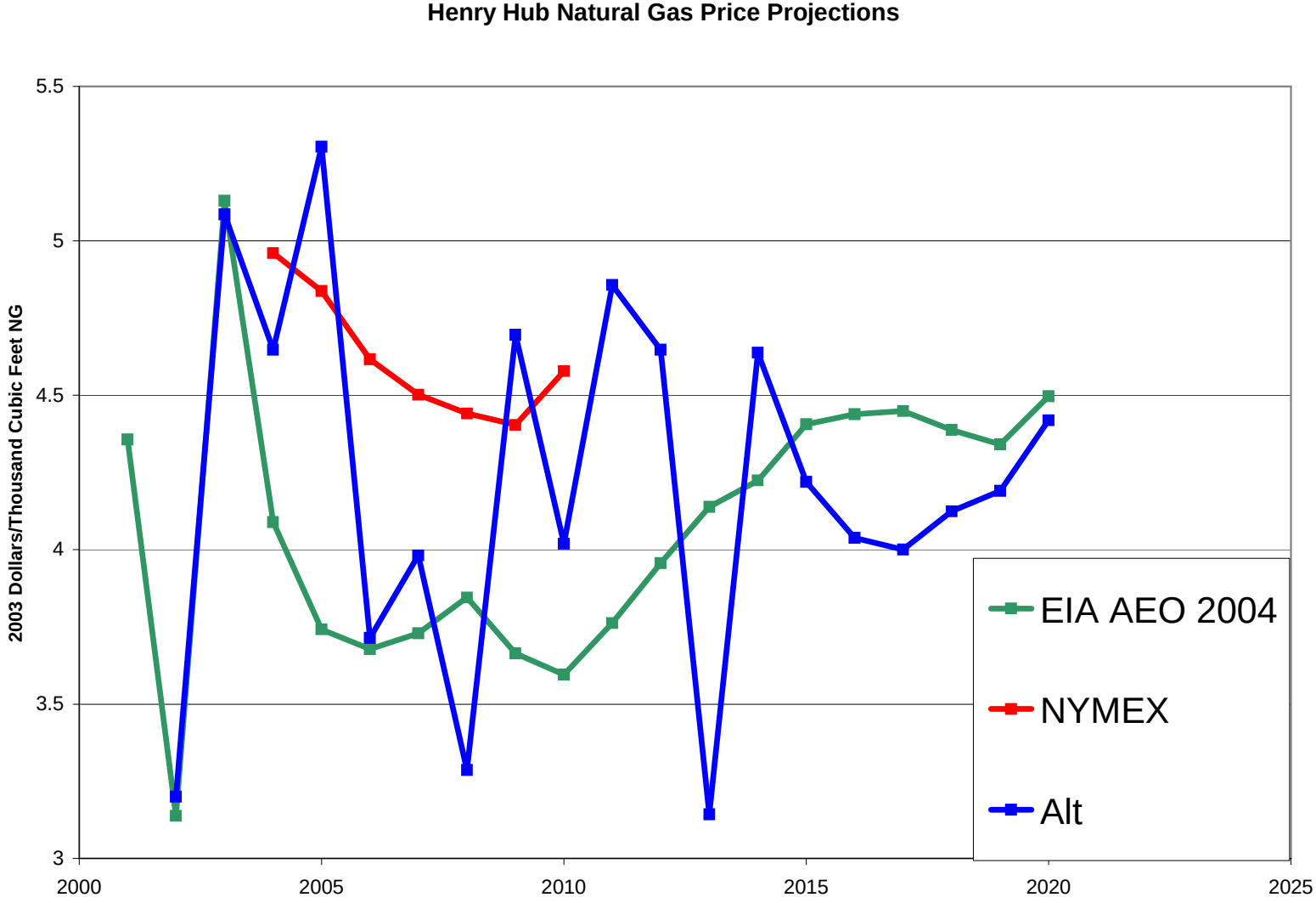
NEMS Model Inputs

- Natural gas prices
- Population and economic forecast for electricity demand
- Cost and performance of generating units
- Renewable supply curve

Natural Gas Price Forecasts

- The following slides display natural gas price forecasts from the following sources:
  - **EIA's Annual Energy Outlook 2004**
  - **An alternative forecast by a respected independent firm**
  - **New York Mercantile Exchange**
- Prices have been adjusted to the Henry Hub value

Natural Gas Price Forecasts



Natural Gas Price Forecasts

2004 Natural Gas Prices (2003 $ per thousand cubic foot)			
Year	**EIA AEO 2004**	**Alt**	**NYMEX**
2002	$3.14	$3.20	
2004	$4.09	$4.65	$4.96
2006	$3.68	$3.71	$4.62
2008	$3.84	$3.29	$4.44
2010	$3.60	$4.02	$4.58
2012	$3.96	$4.65	
2014	$4.22	$4.64	
2016	$4.44	$4.04	
2018	$4.39	$4.12	
2020	$4.50	$4.42	
2004-2010 avg an growth	-2.12%	-2.39%	-1.33%
2004-2020 avg an growth	0.60%	-0.31%	n/a

Maine Electricity Demand Allocation

- NEMS provides results at the regional level, so demand must be allocated to states
- Tellus algorithm allocates demand from region to state using state share of population (for residential and private transportation) and gross state product (for commercial and industrial sectors and freight transport)
- State demand can therefore be changed through selection of state population and gross state product inputs (annual estimates or average growth rates)

Maine Economic and Population Forecasts

Economic Forecast		
	Charles Colgan, USM*	Maine State Planning Office*
Forecast Period	2004-2025	2004-2007
GDP (low)	3.0%	2.85%
GDP (med)	3.5%	
GDP (high)	4.0%	

Population Forecast		
	Charles Colgan, USM*	Maine State Planning Office
Forecast Period	2004-2025	2004-2017
POP (low)	1.00%	0.70%
POP (med)	1.15%	
POP (high)	1.30%	

**Preliminary*

Maine Economic and Population Shares

Population Forecast	2005	2010	2015	2020	2005	2010	2015	2020
New England	13,843,000	14,194,500	14,546,000	14,934,000	Maine Percent of NE Total			
Maine Low (Colgan)	1,331,973	1,399,917	1,471,327	1,546,379	9.6%	9.9%	10.1%	10.4%
Maine Med (Colgan)	1,335,932	1,414,536	1,497,764	1,585,889	9.7%	10.0%	10.3%	10.6%
Maine High (Colgan)	1,339,898	1,429,285	1,524,636	1,626,347	9.7%	10.1%	10.5%	10.9%
Maine Med (ME Pln Of)	1,324,072	1,371,068	1,419,732	1,470,123	9.6%	9.7%	9.8%	9.8%

New England Population through 2020 taken from EIA AEO 2004. Maine population projected from 2003 estimate from Census Bureau.

Economic Forecast (Million 2003 $)	2005	2010	2015	2020	2005	2010	2015	2020
New England*	662,032	779,310	909,433	1,047,200	Maine Percent of NE Total			
Maine Low (Colgan)	47,445	55,001	63,762	73,917	8.1%	7.9%	7.9%	7.9%
Maine Med (Colgan)	48,373	57,451	68,234	81,041	8.2%	8.3%	8.4%	8.7%
Maine High (Colgan)	49,314	59,998	72,997	88,812	8.4%	8.7%	9.0%	9.5%
Maine Med (ME Pln Of)	47,169	54,285	62,474	71,898	8.0%	7.8%	7.7%	7.7%

*Gross Product for New England through 2020 from Economy.com. Gross State Product for Maine projected from 2001 estimate from economagic.com

Maine Renewable Cost and Performance Data

Assumption	2010			2020		
	Wind	LFG	Direct-Fired Biomass	Wind	LFG	Direct-Fired Biomass
Capital Cost ($/kW)	930	1,100	1,579	875	1,100	1,308
Fixed O&M ($/kW-yr.)	17	17	70	17	17	57
Variable O&M ($/MWh)	1	inc w/FO&M	8	1	inc w/FO&M	7
Heat Rate	n/a	10,000	12,322	n/a	10,000	10,066
Fuel Cost ($/MMBtu)						
Step 1	n/a	n/a	1.4	n/a	n/a	1.4
Step 2	n/a	n/a	3.5	n/a	n/a	3.5
Total cost ($/MWh)						
Step 1	28	31	59	28	31	$49
Step 2	31		85	31		$70
Step 3	36			36		
Step 4	44			44		
Step 5	60			60		
Capacity Factor (%)	35%	95%	80%	35%	95%	80%

NEMS Cost and Performance Data: New England Fossil Units

Assumption	Conventional Coal	Coal (IGCC)	Natural Gas/Oil Combined Cycle - conv	Natural Gas/Oil Combined Cycle - advanced	Natural Gas/Oil Combustion Turbine - conv	Natural Gas/Oil Combustion Turbine - advanced
Capital Cost (2002$/kW)						
installed 2005-2011	1,200	1,393	551	623	416	468
installed 2012-2018	1,173	1,338	543	588	411	428
installed 2019-2025	1,148	1,233	534	534	403	399
Availability (%)	85	85	87	87	92	92
Fixed O&M ($/kW-yr.)	25	34	12	10	10	8
Variable costs (incl fuel) ($/MWh)	19, 18, 17	16, 14, 14	37, 39, 42	34, 35, 38	55, 59, 63	46, 48, 51
Minimum Size (MW)	600	550	250	400	160	230
Estimate of total cost (2002$/MWh)						
installed 2005-2011	52	55	50	48	64	55
installed 2012-2018	52	54	52	49	68	57
installed 2019-2025	52	52	55	52	72	60

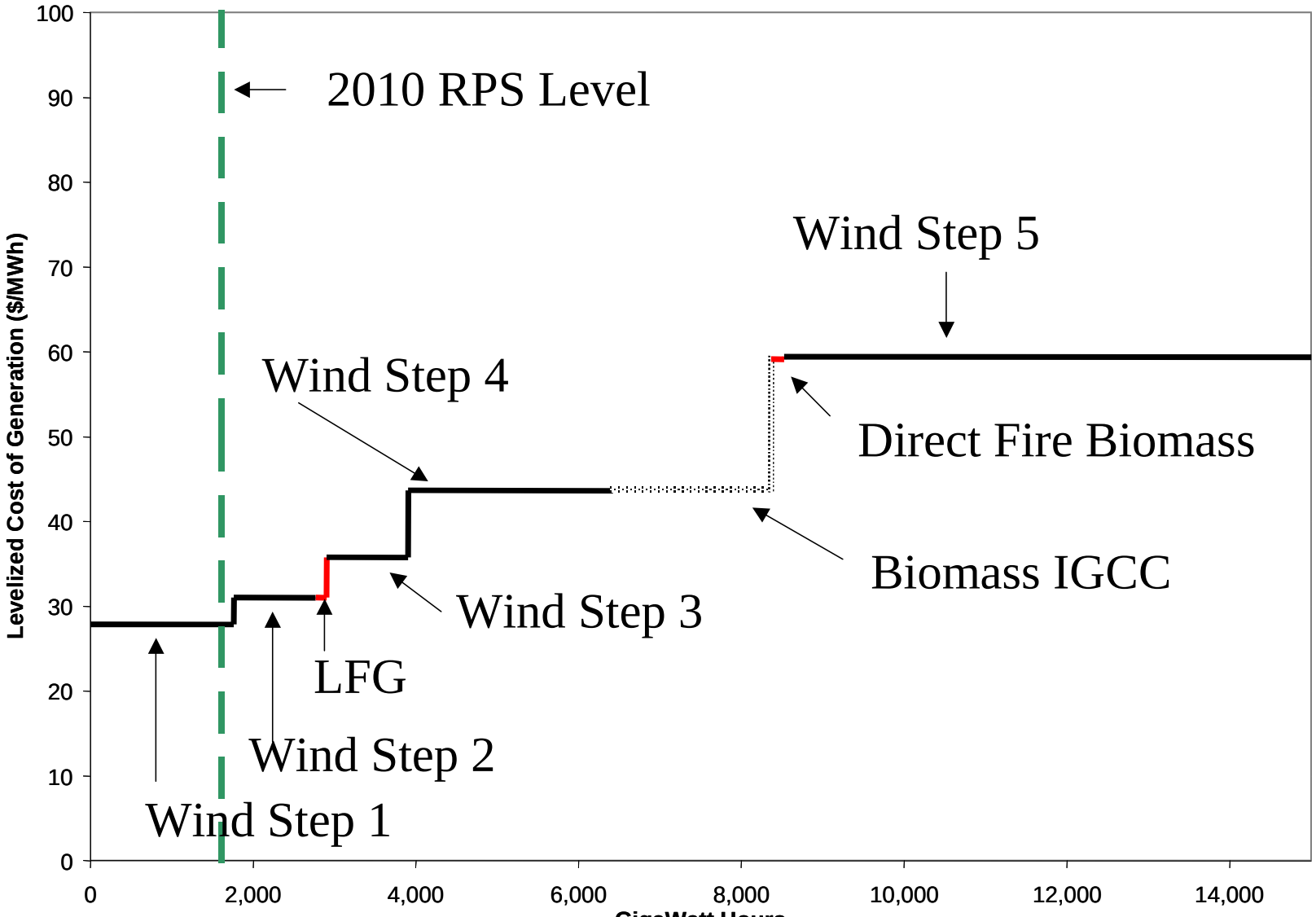
NEMS Cost and Performance Data: New England Non-Fossil Units

Assumption	Nuclear	Biomass	Landfill Gas - High Yield	Landfill Gas - Low Yield	Landfill Gas - Very Low Yield	Wind	Solar PV (central station)
Capital Cost (2002$/kW)							
installed 2005-2011	n/a	n/a	1,477	1,865	2,865	1052	3,893
installed 2012-2018	1,977	1,658	1,477	1,865	2,865	1046	3,363
installed 2019-2025	1,911	1,529	1,477	1,865	2,865	1251	2,929
Availability (%)	92	83	80	80	80	41- 42	23
Fixed O&M ($/kW-yr.)	59	45	100	131	212	26	10
Variable costs (incl fuel) ($/MWh)	5	n/a, 23, 23	0.01	0.01	0.01	0	0
Minimum Size (MW)	161	100	30	30	30	50	5
Estimate of total cost (2002$/MWh)							
installed 2005-2011	n/a	n/a	34	44	69	44	246
installed 2012-2018	63	65	34	44	69	44	224
installed 2019-2025	62	63	34	44	69	52	199

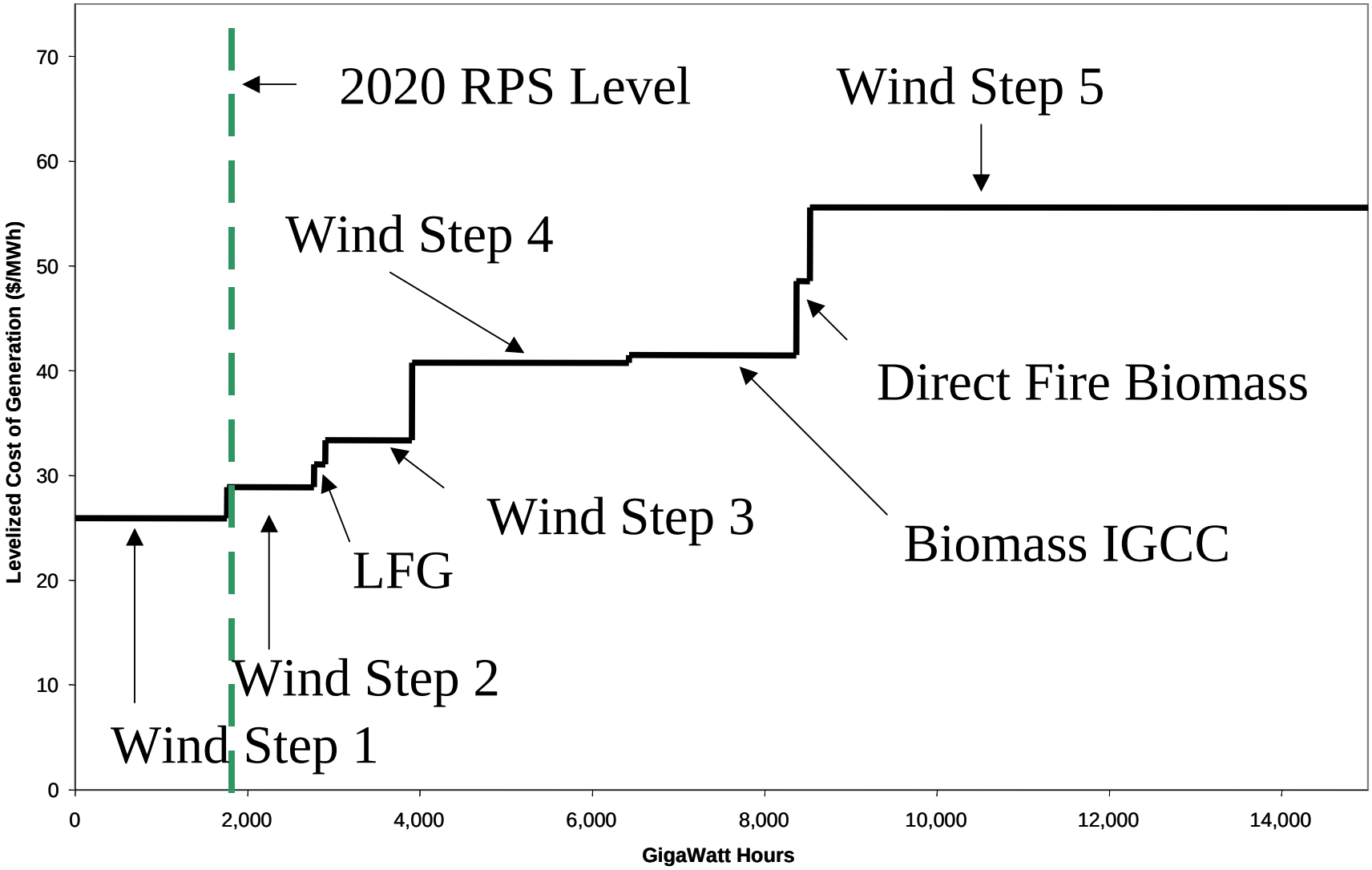
Maine Supply Curve for New Renewables: Methodology

- Includes wind, landfill gas, biomass integrated gasification combined cycle (IGCC) and direct-fired biomass
- Assumes no additional hydro capacity is available for development
- Assumes no new MSW incineration plants will be built

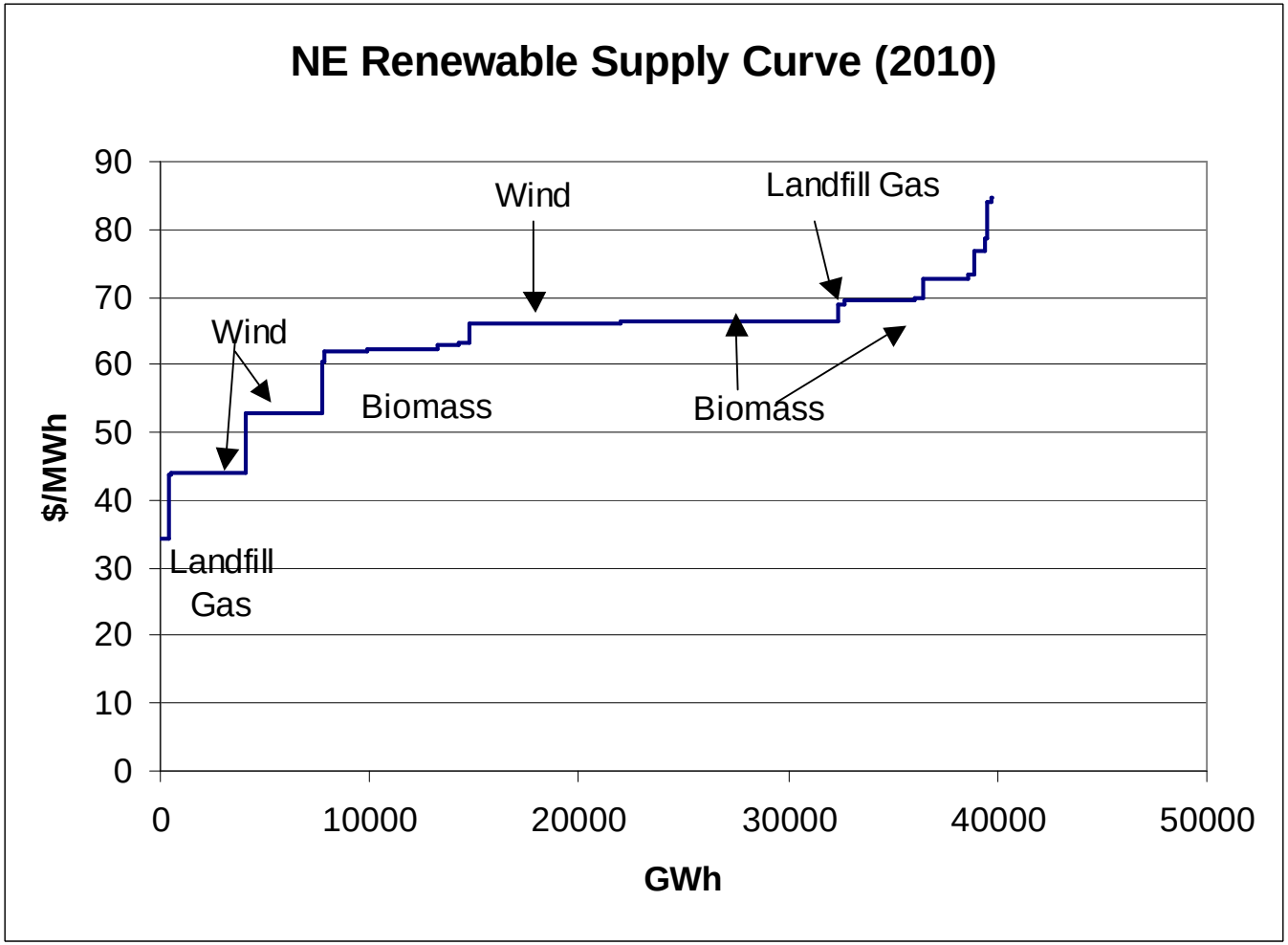
2010 Maine Supply Curve



2020 Maine Supply Curve



New England Renewable Supply Curve from NEMS



Wind: Sources and Assumptions

- Methodology based on procedure used for Connecticut GHG analysis. This methodology has been examined by IEPM and a Maine wind developer, and incorporates information provided by the developer.
- Potential wind capacity in Maine (8,205 MW) taken from National Renewable Energy Laboratory (NREL) assessment, *True Wind Solutions for New England*
- Costs estimated using class 5 wind projects. Capital cost, variable operation and maintenance (O&M) and fixed O&M costs for 2005 developed using an average of costs provided by NREL and another set taken from EIA's *Annual Energy Outlook 2004*.
- Assumes constant capacity factor of 35%, based on input from Maine wind developer
- Federal wind production tax credit assumed to continue through 2020

Wind: Sources and Assumptions

- Costs for 2010 and 2020 developed assuming a 3% drop in capital cost every five years, based on input from Maine wind developer
- Based on the expectations of New York developers for Northeast wind that were used for the Connecticut GHG analysis, it was assumed that 75% of the wind potential identified by NREL would be prohibitively expensive (twice the capital cost). In Maine this would therefore apply to 6,154 MW.
- For the remaining 25% (2,051 MW total), a step function was created to estimate the increasing costs of wind that would be associated with variable interconnection and permitting costs:
  - **Step 1: 574 MW available at 100% of the base capital cost**
  - **Step 2: 328 MW available at 110% of the base capital cost**
  - **Step 3: 328 MW available at 125% of the base capital cost**
  - **Step 4: 821 MW available at 150% of the base capital cost**

Landfill Gas: Sources and Assumptions

- Total potential capacity (19 MW) in Maine provided by Maine DEP to LMOP
- Cost and performance data for landfill gas electric generation units provided by US EPA Landfill Methane Outreach (LMOP) program

Biomass Gasification: Sources and Assumptions

- Data on estimated supply and costs of biomass in Maine taken from study commissioned by the Northeast Regional Biomass Program (NRBP) of Coalition of Northeast Governors: *Securing a Place for Biomass in the Northeast United States: A Review of Renewable Energy and Related Policies*, prepared by Xenergy for CONEG Policy Research Center, Inc., NRBP, March 31, 2003
- Categories of biomass included: Forest Residues, Primary Mill Wastes, Tree Residue
- Study provides quantities of biomass available in each category for <$1.40/MMBtu and <$3.50/MMBtu
- Gasification unit cost and performance data (for New England) taken from EIA NEMS model

Direct-Fired Biomass: Sources and Assumptions

- Data on estimated supply and costs of biomass in Maine taken from study commissioned by the Northeast Regional Biomass Program (NRBP) of Coalition of Northeast Governors: *Securing a Place for Biomass in the Northeast United States: A Review of Renewable Energy and Related Policies*, prepared by Xenergy for CONEG Policy Research Center, Inc., NRBP, March 31, 2003.
- Categories of biomass included: Forest Residues, Primary Mill Wastes, Secondary Mill Wastes, Tree Residue, Urban Wood Wastes
- Study provides quantities of biomass available in each category for <$1.40/MMBtu and <$3.50/MMBtu
- Direct-fired biomass cost and performance data (national) taken from US Department of Energy and EPRI, *Renewable Energy Technology Characterizations*, December 1997