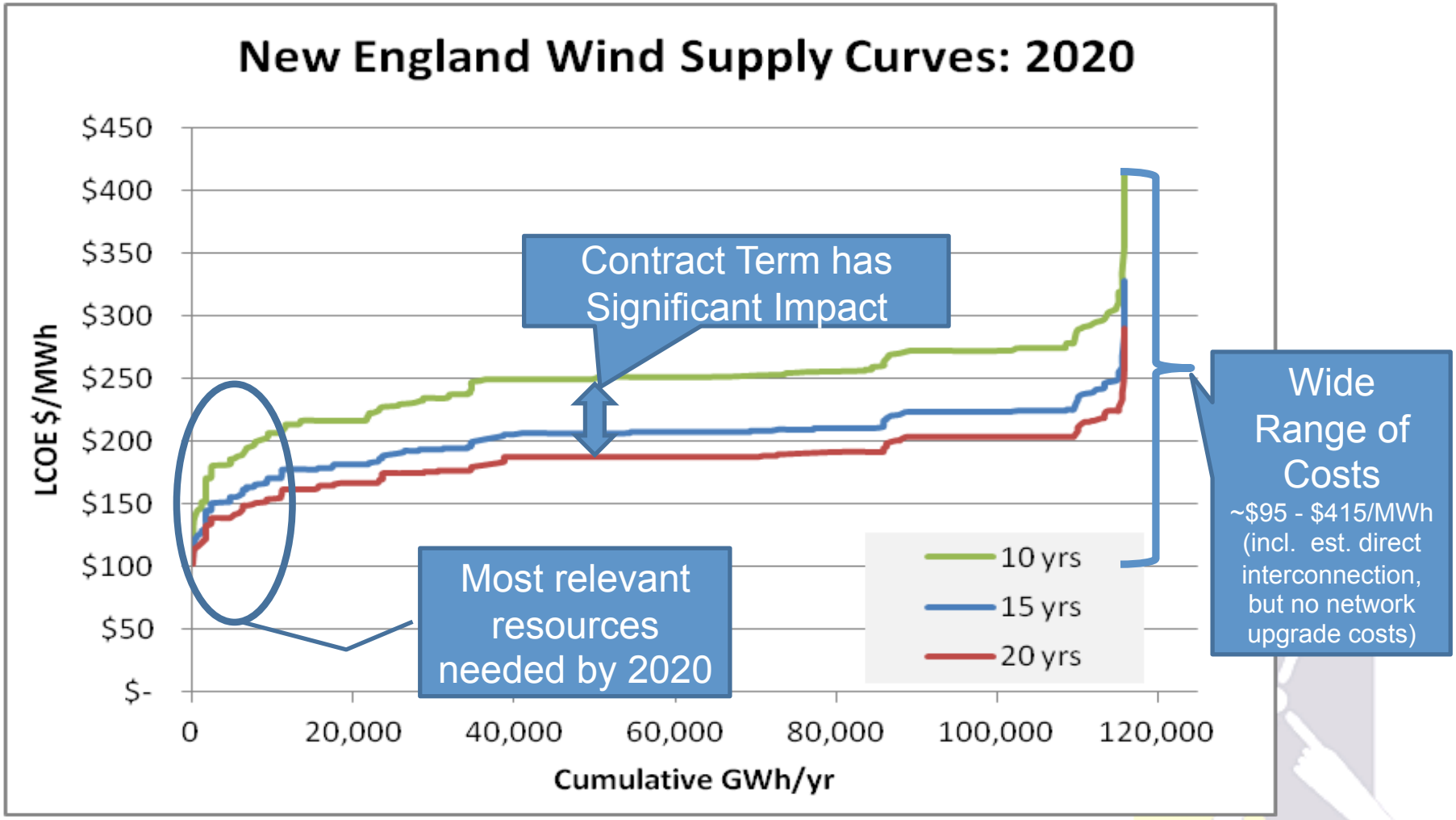
Executive Summary

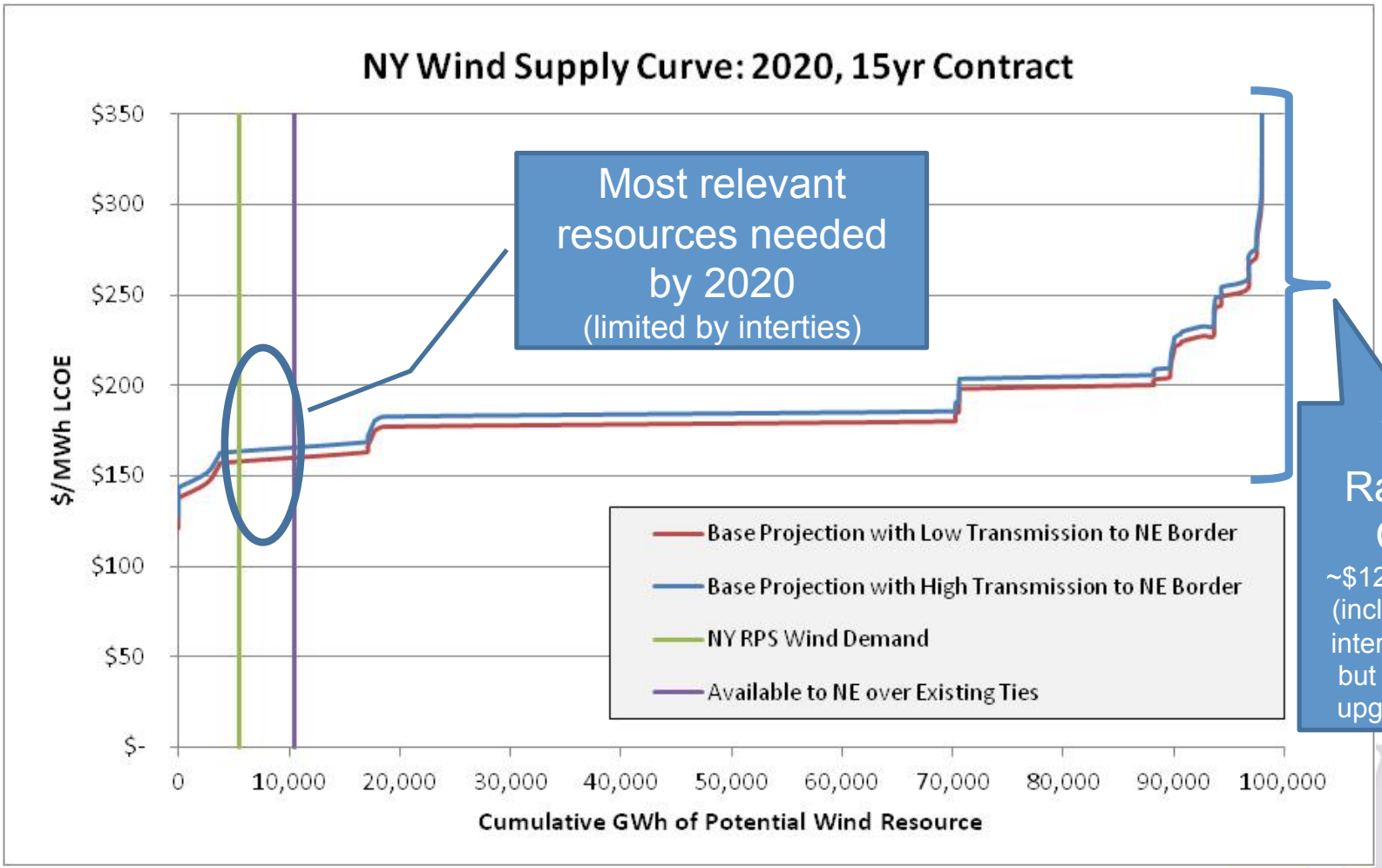
Significant NE Resource Potential

Onshore + Offshore wind > 33 GW



Significant NY Resource Potential

Onshore > 43 GW



Key Observations

- Expected need for incremental renewable energy in New England is small compared to resource potential
  - Need ~7000 GWh / year by 2016, 12,000 GWh/year by 2020
  - Within "expected need" range, max. cost is relatively stable (15 yr term):
    - $165/MWh for 2016 → $177/MWh for 2020 (NE)

Costs likely to be conservatively high due to…	
Reason (sensitivity analysis testing…)	**Potential benefit for marginal resources***
Conservative interest rate assumed for debt finance (compared to today)	~$5-13/MWh lower at today's interest rates
Energy Production calculated using 80m hub height wind speed (many projects using 84 – 100m towers, longer blades → higher power output, lower costs)	~$25-45/MWh lower if project can use 100 m towers (often not feasible)
Assumed no Federal incentives (e.g. Production Tax Credits) available	~$23/MWh lower if current Production Tax Credit was still available
	* 15 yr contracts, 2020

- Analysis = indicative view of possible costs to NE loads
  - Actual costs to consumer will be determined by actual market conditions

Wind Supply Curve Study

Overview and Contents

Scope

Objective: Provide indicative 'supply curve' representing cost & quantity of new on- and off-shore wind resources potentially available in New England & New York.

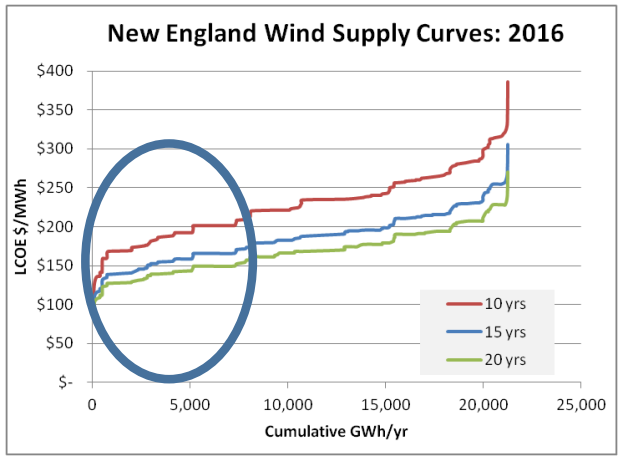
New England

- Snapshots: 2016, 2020
- 3 contract terms:
  - 10, 15, 20 yrs
- Key Sensitivities

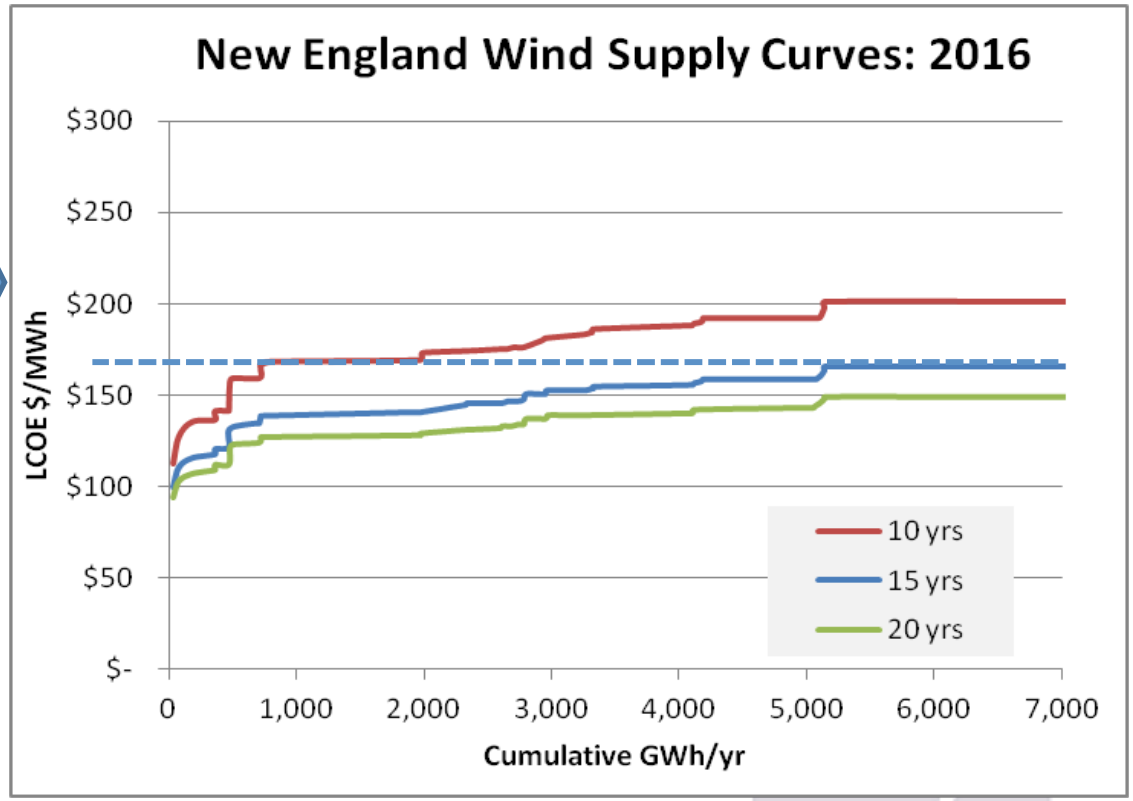
New York

- Snapshot:2020
- 1 contract term:
  - 15 yrs
- Including est. delivery cost basis to NE ("basis")
- After NY's own needs, over existing ties
- Key Sensitivities

2016 New England Wind Supply Curves*



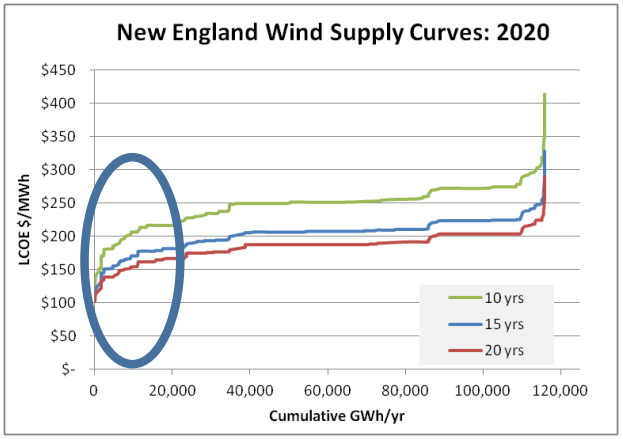
Cost of marginal resource at 7,000 GWh/yr with a 15-yr contract ~$165/ MWh

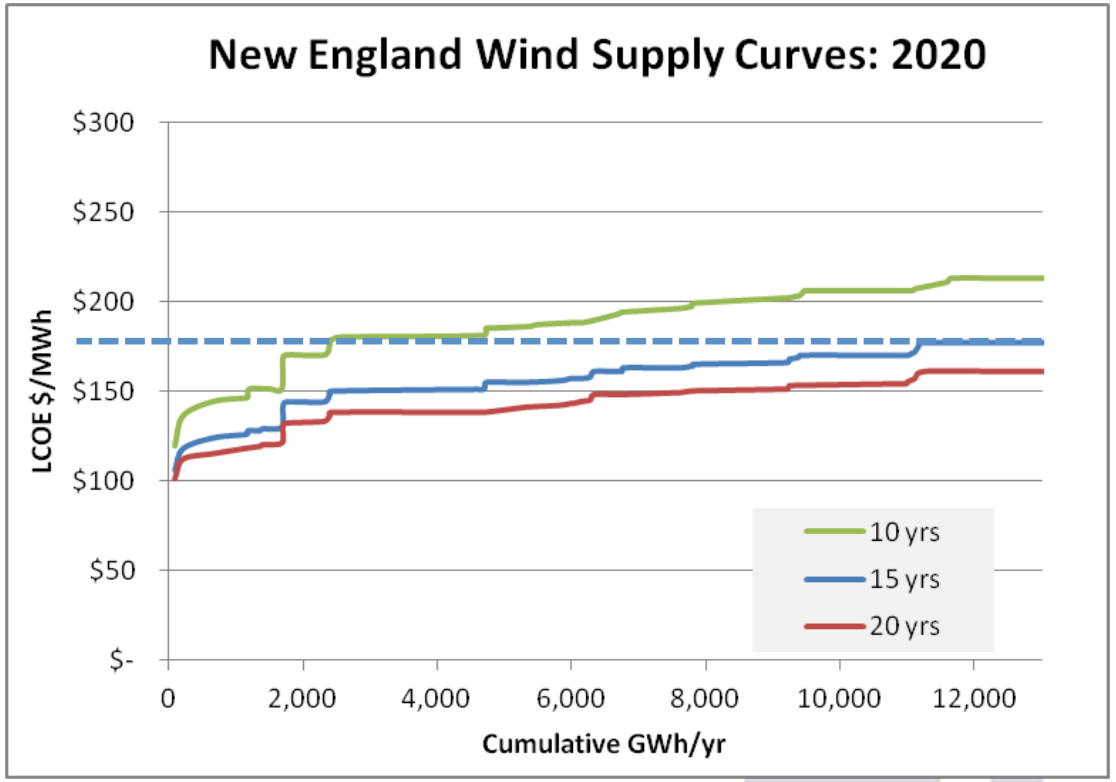


Observation: Rising at lower energy levels, flattening as large scale resources become feasible

* = NESCOE has completed supplemental analyses on specific supply blocks at lower levels of supply curves

2020 New England Wind Supply Curves*



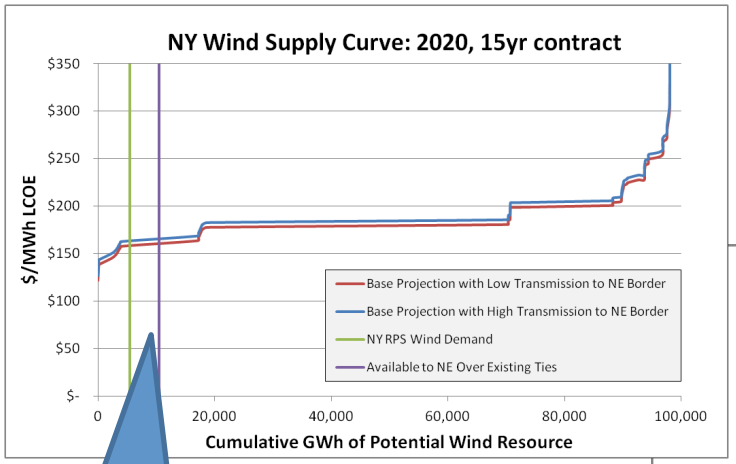


Cost of marginal resource at 12,000 GWh/yr with a 15-yr contract ~$177/MWh

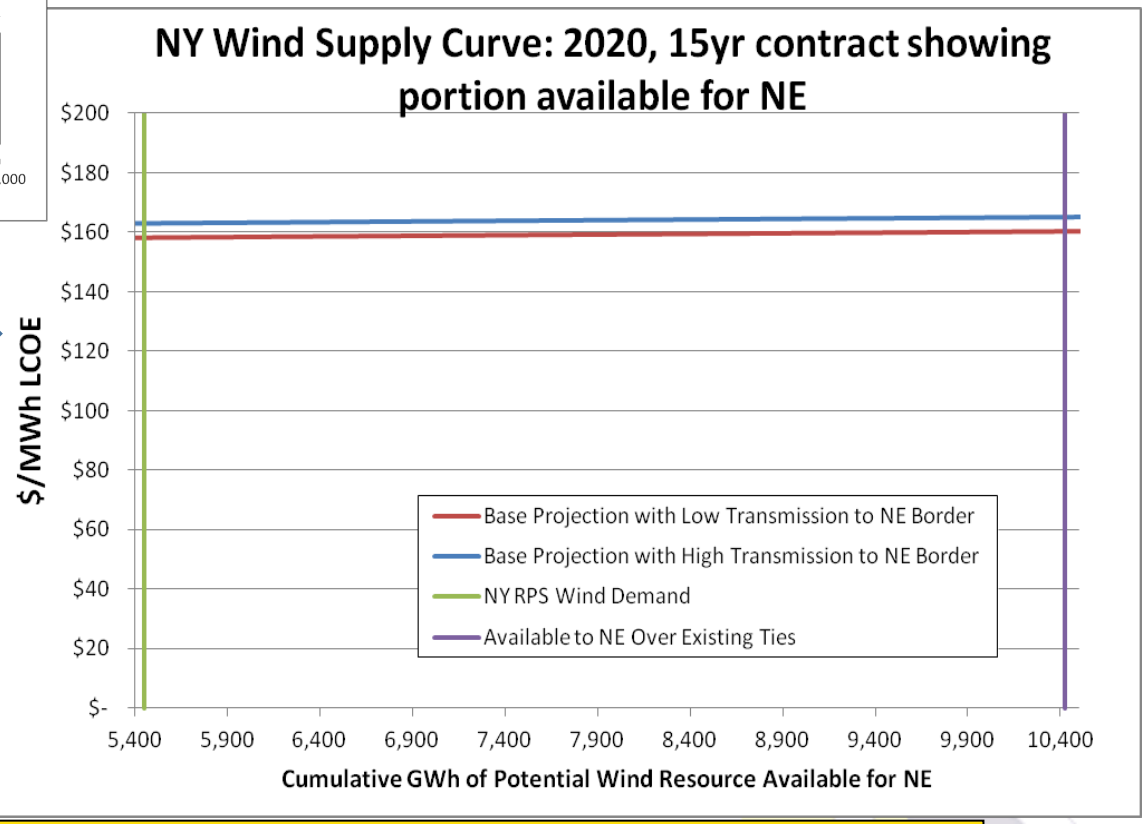
Observation: Rising at lower energy levels, flattening as large scale resources become feasible

* = NESCOE has completed supplemental analyses on specific supply blocks at lower levels of supply curves

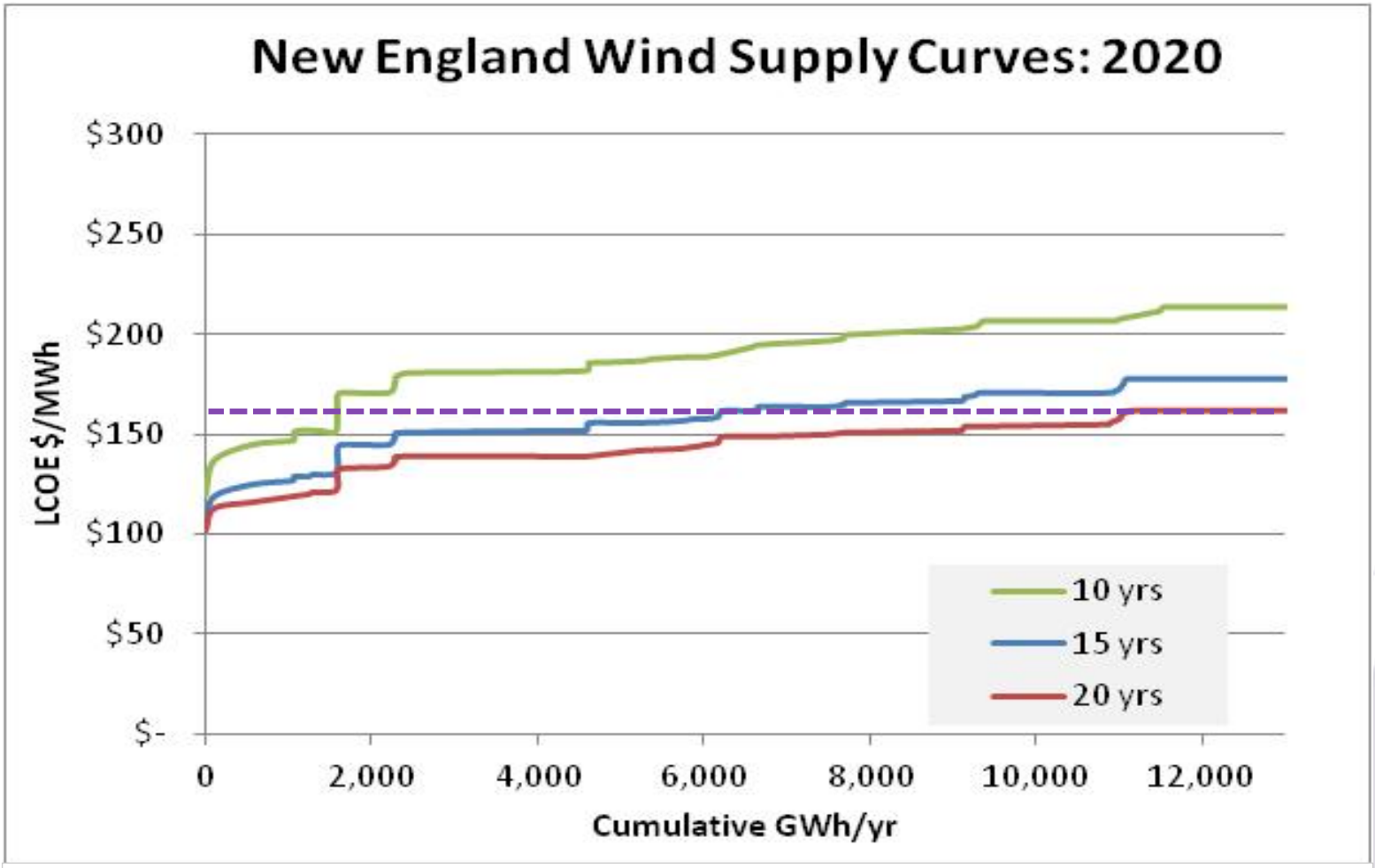
2020 New York Wind Supply Curve



Available to NE over ties, after NY RPS met



Comparison of NY and NE Resources



= LCOE of 15 yr contract for 2,000 MW of NY Supply available for NE

Results – Resource Potential

State	2016		2020	
	MW	GWh	MW	GWh
CT	143	435	382	1,159
MA	1,076	3,865	11,435	45,562
ME	5,901	14,490	18,552	58,568
NH	304	758	583	1,459
RI	180	644	1,500	5,998
VT	408	1,053	1,156	2,993
NY	n/a		43,708	98,113

- 141 separate "supply blocks" evaluated in NE, 49 in NY
  - Supply blocks explained on slide 15
  - Potential per block: from 7 MW, to >3,000 MW for large offshore blocks
- Large amount of wind potential compared to regional need (even if only considering on-shore generation)
- Very large off-shore resources

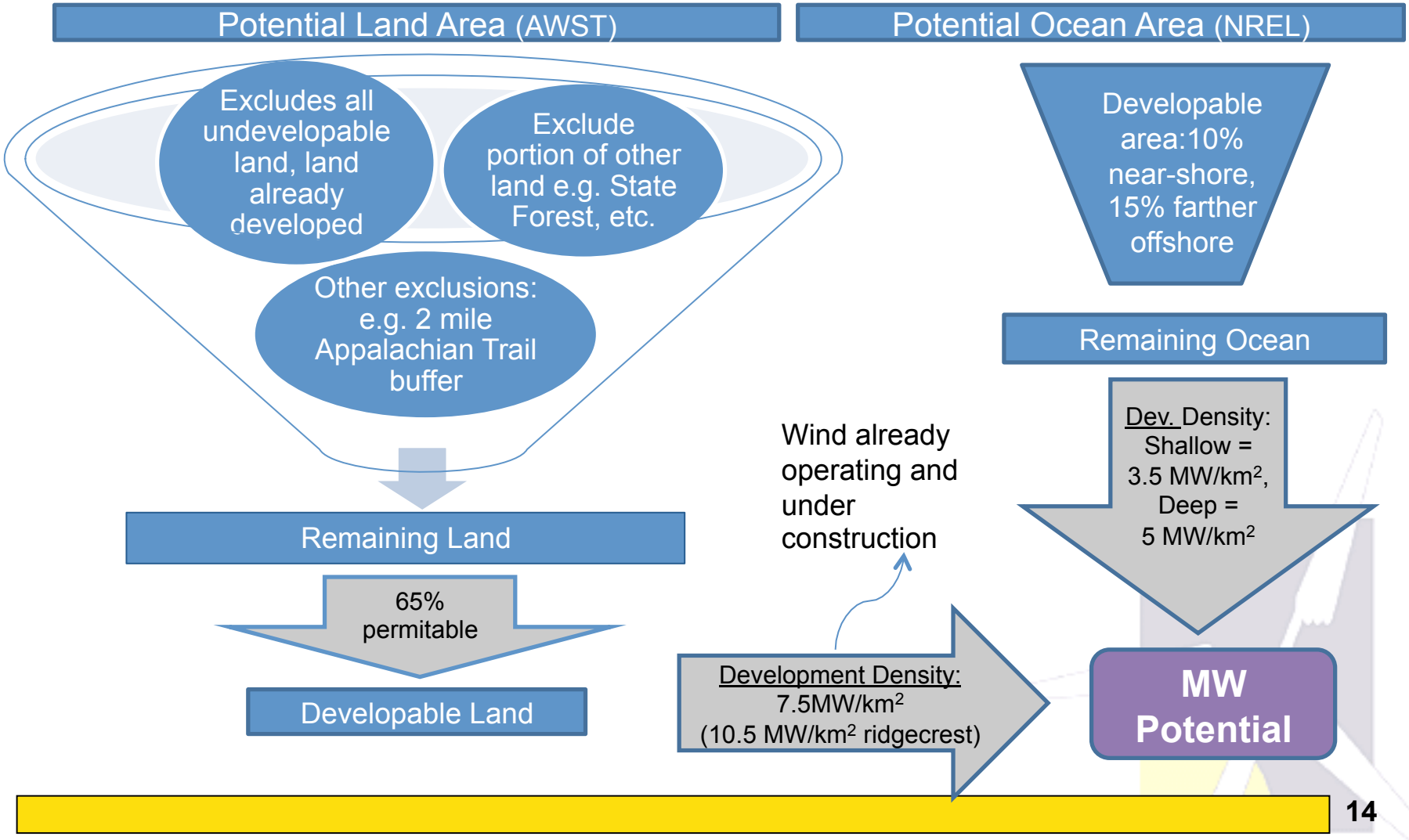
Technology	NE: 2016		NE: 2020		NY: 2020	
	MW	GWh	MW	GWh	MW	GWh
Onshore-Small	333	753	577	1,325	3,338	7,385
Onshore-Medium	733	1,682	1,439	3,361	2,117	4,671
Onshore-Large	4,713	10,750	9,154	21,153	38,253	86,057
Offshore-shallow	1,525	5,325	5,101	18,629	n/a	
Offshore-deepwater	709	2,736	17,335	71,271		

Results: Sensitivity Cases

Sensitivity	Description	Assumption	Impact on 15 yr contract price
Lower Interest Rates	May be appropriate for extended periods of very low economic growth	Cost of debt assumptions consistent with today's historic lows	Lower ~$5-13/MWh lower at today's interest rates
Federal PTC	Continuation of federal financial incentives	Assumed 10 year federal PTC	~$23/MWh lower if current Production Tax Credit was still available
Higher Hub Heights	Some supply blocks have the potential to support turbines with taller towers and longer blades	Upper bound, assumed 8 point increase in capacity factor* at same cost/kW	~$25-45/MWh lower if project can use 100 m towers (often not feasible)

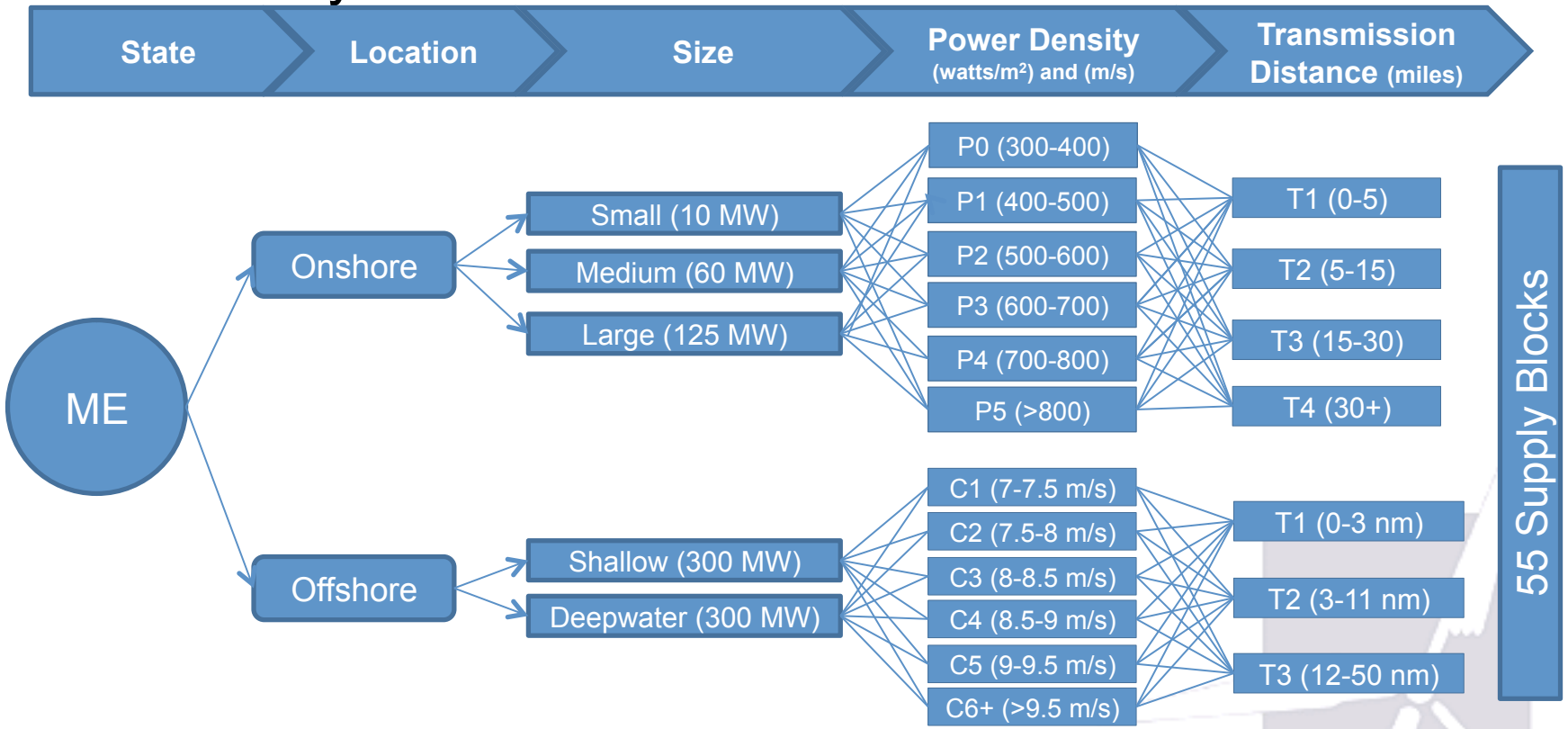
* = approximate adjustment provided by AWST Truepower

Methodology – Resource Potential
(New England and New York)



Methodology – Supply Blocks

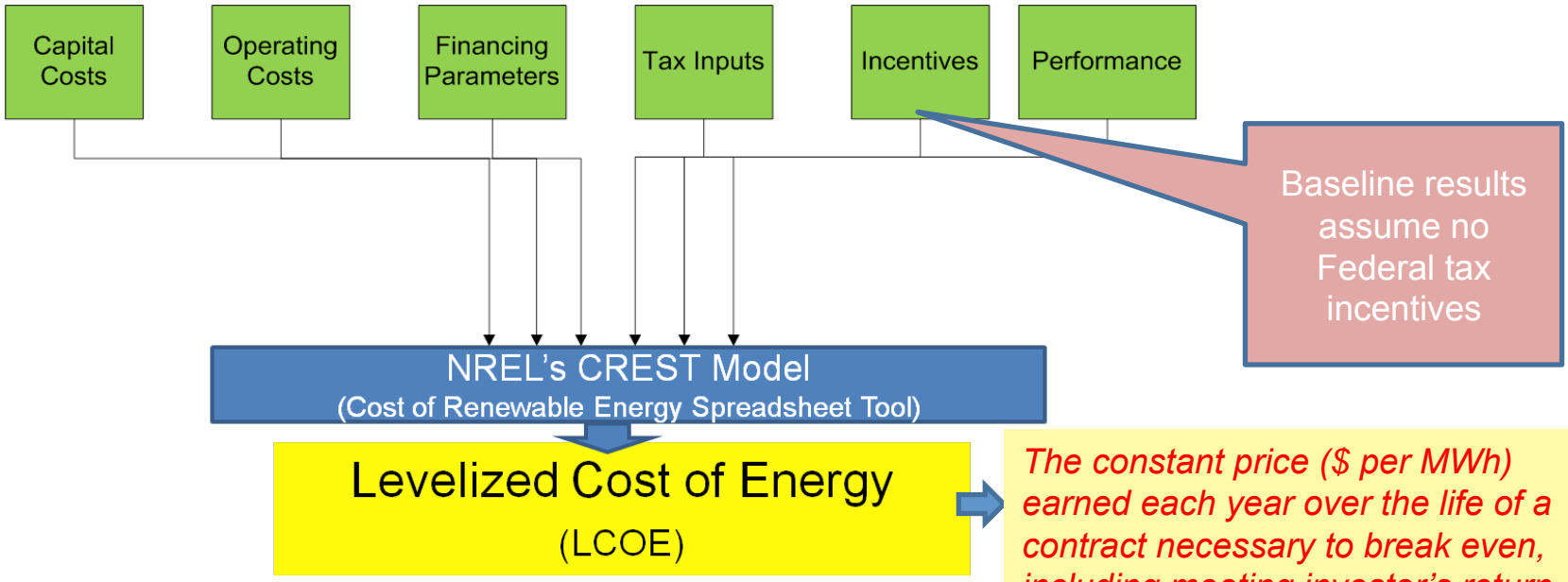
- Each State's MW resource potential split into "supply blocks'" by…



Note: See appendix for detailed assumptions on transmission, power density classifications for NY, and capacity factors associated with each power class.

Methodology - Levelized Cost of Energy

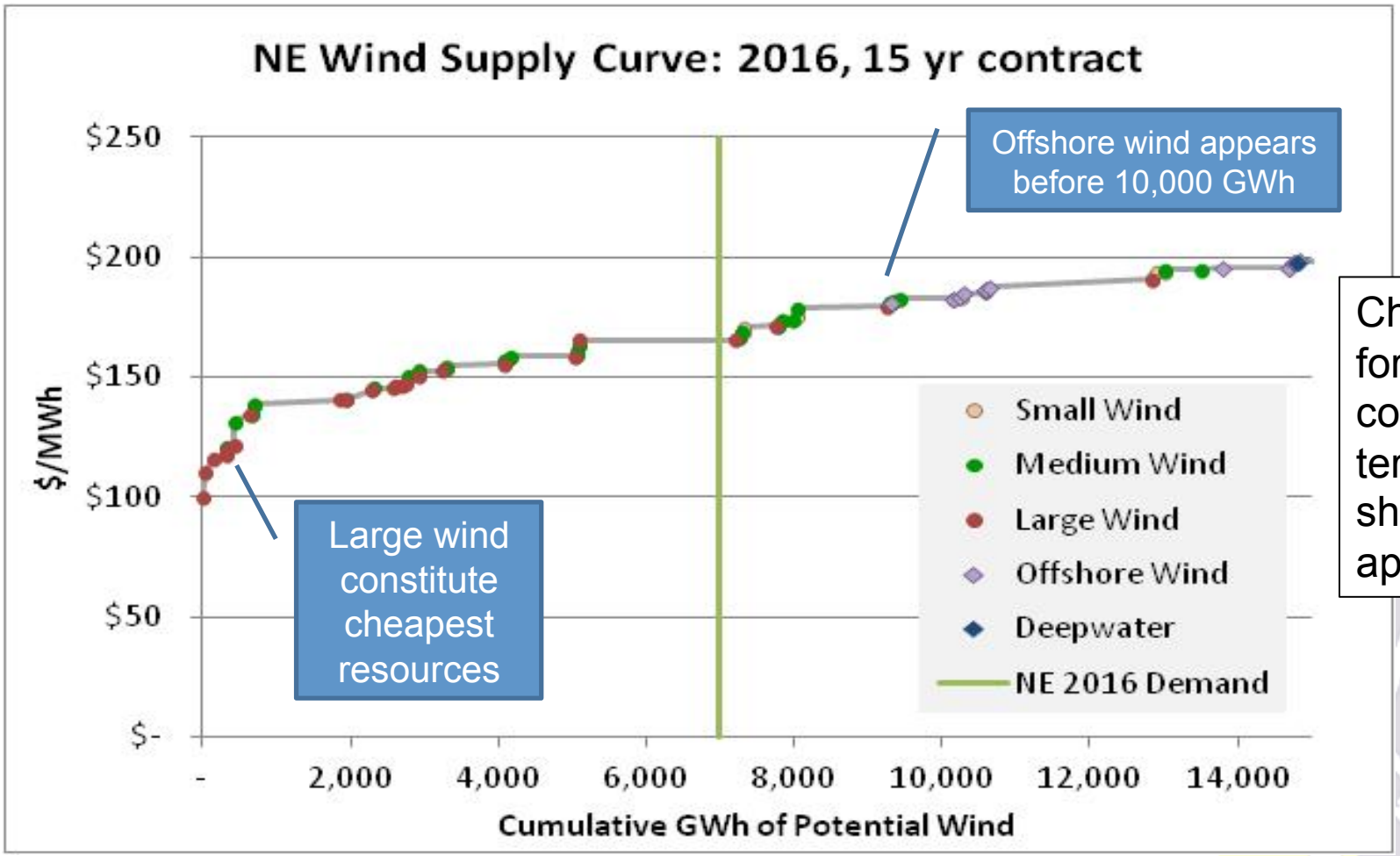
- Each "Supply Block" assigned cost profile & capacity factor



- LCOE calculated for each supply block
- Contract terms modeled (10, 15 & 20 yrs) ➔illustrate impact of revenue certainty on annual costs
- "Supply Curves" show LCOE of marginal resource at different levels of total energy demand

Source Mix, Least-Cost Wind

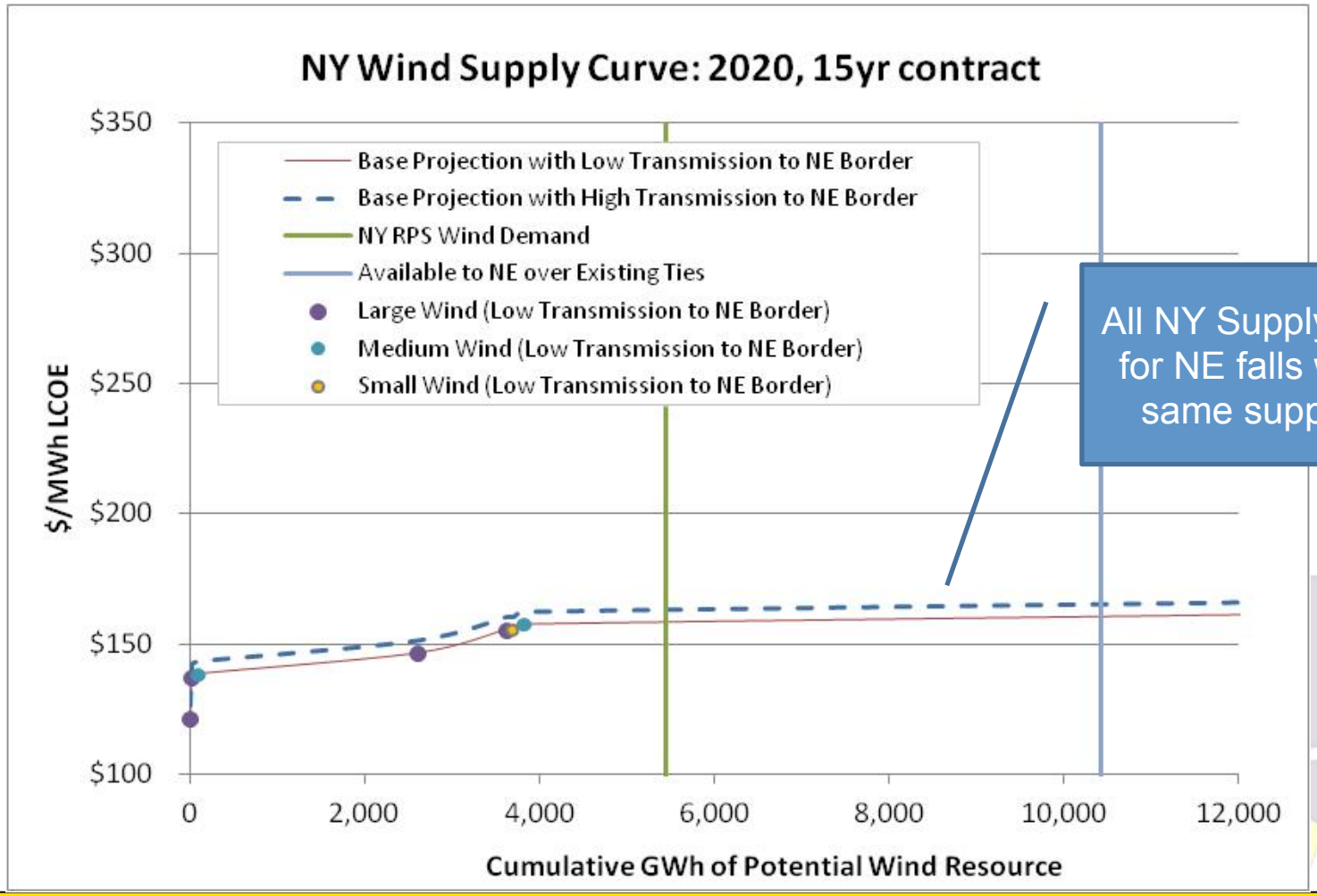
New England



Charts for other contract terms shown in appendix

Source Mix, Least-Cost Wind

New York



All NY Supply available for NE falls within the same supply block

Conclusions

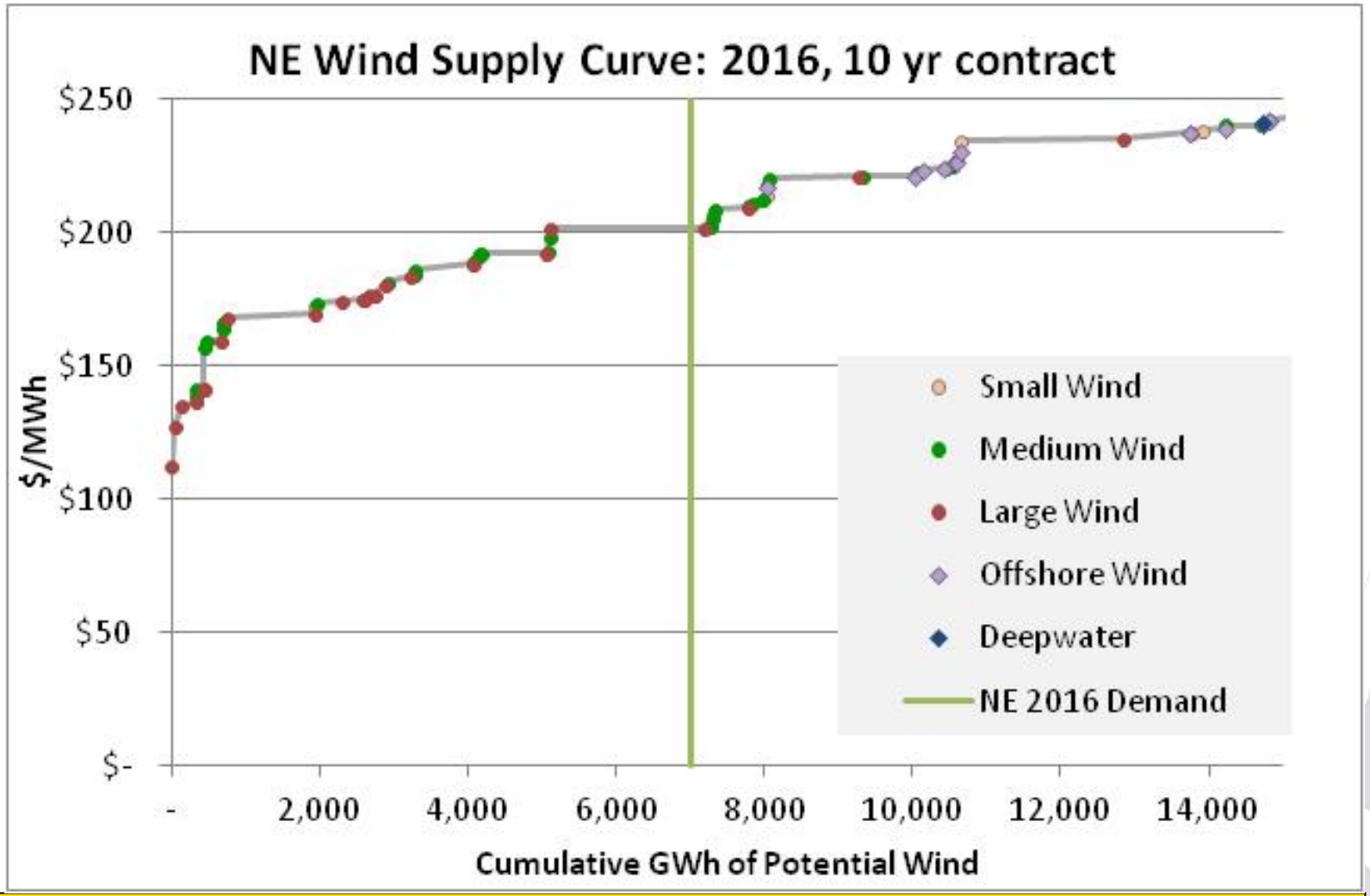
- Resource potential far exceeds regional needs
- Wide range of costs across spectrum of resources
  - Range is narrower for quantities needed by 2016 & 2020
- Longer contract term lowers LCOE
  - Decreases risk to developer, shifts risk to load
- Conservative assumptions may overstate LCOE results
- Offshore Wind somewhat costlier than on-shore at volumes needed, but may be relevant because…
  - *Costs exclude* transmission to load centers
  - Substantial uncertainty re: future cost

Appendix

- Supply curves showing source mix
- Detailed assumptions
  - Resource Potential
  - Cost Profiles
- Data source / further reading

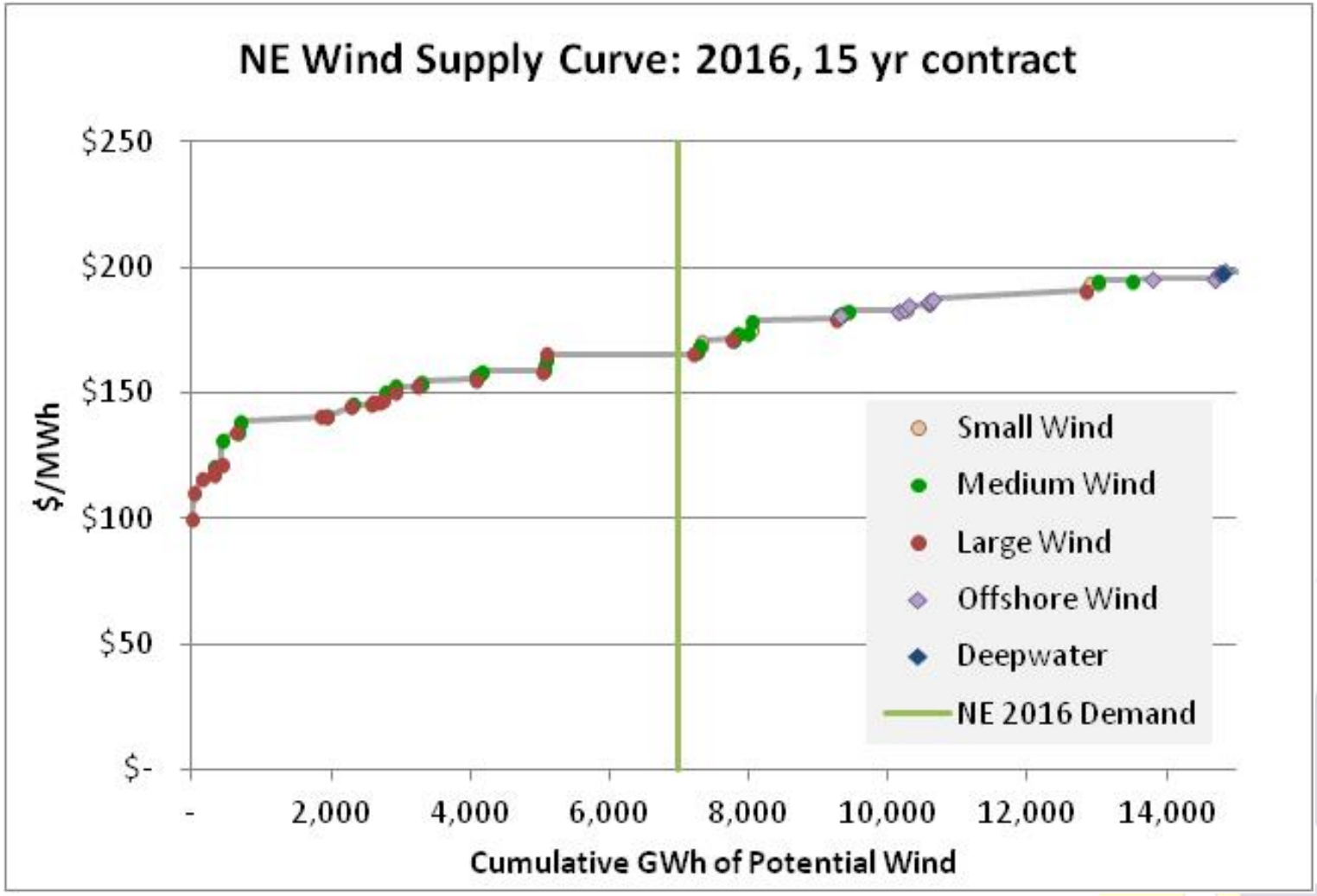
Source Mix, Least Cost Resources

New England



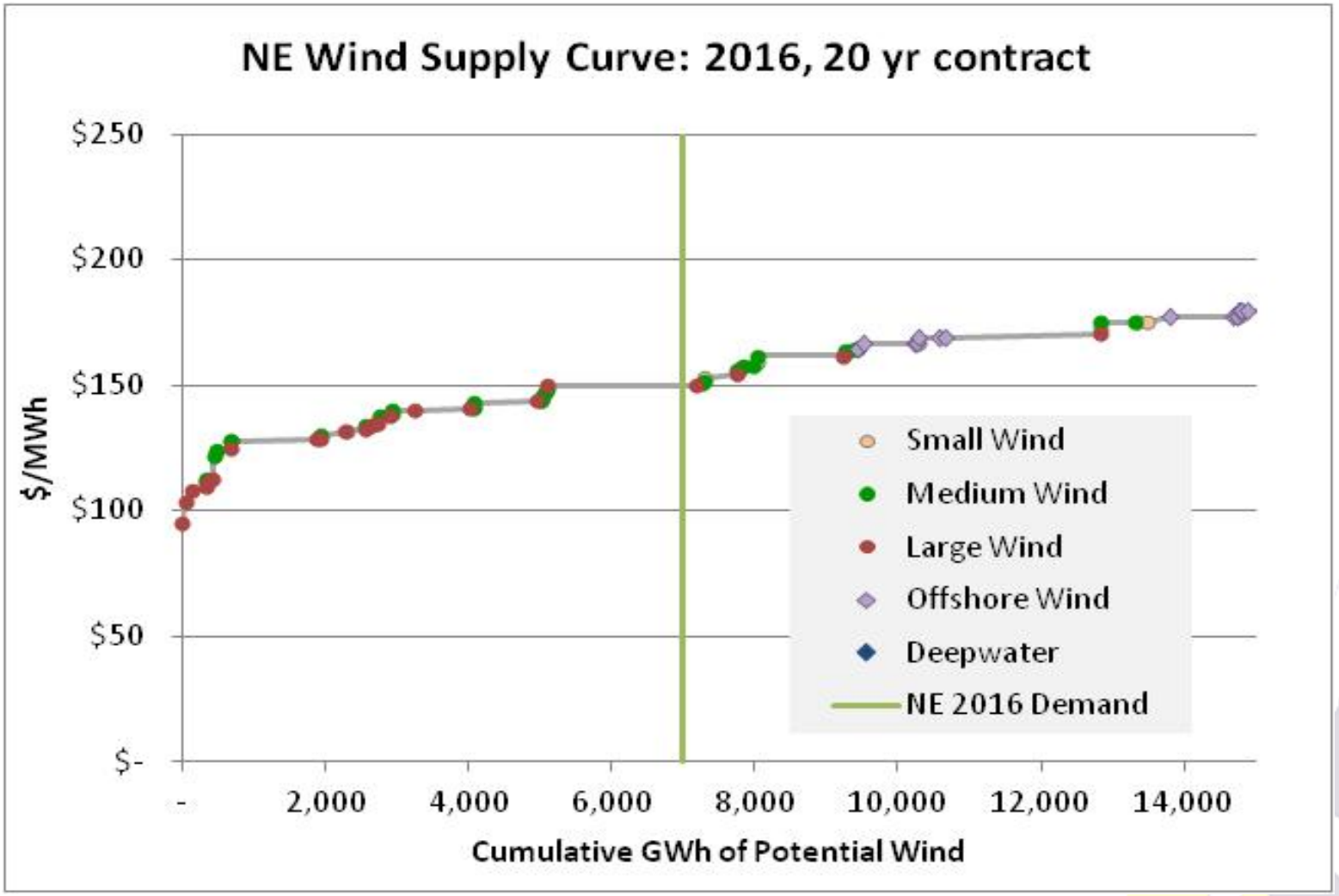
Source Mix, Least Cost Resources

New England



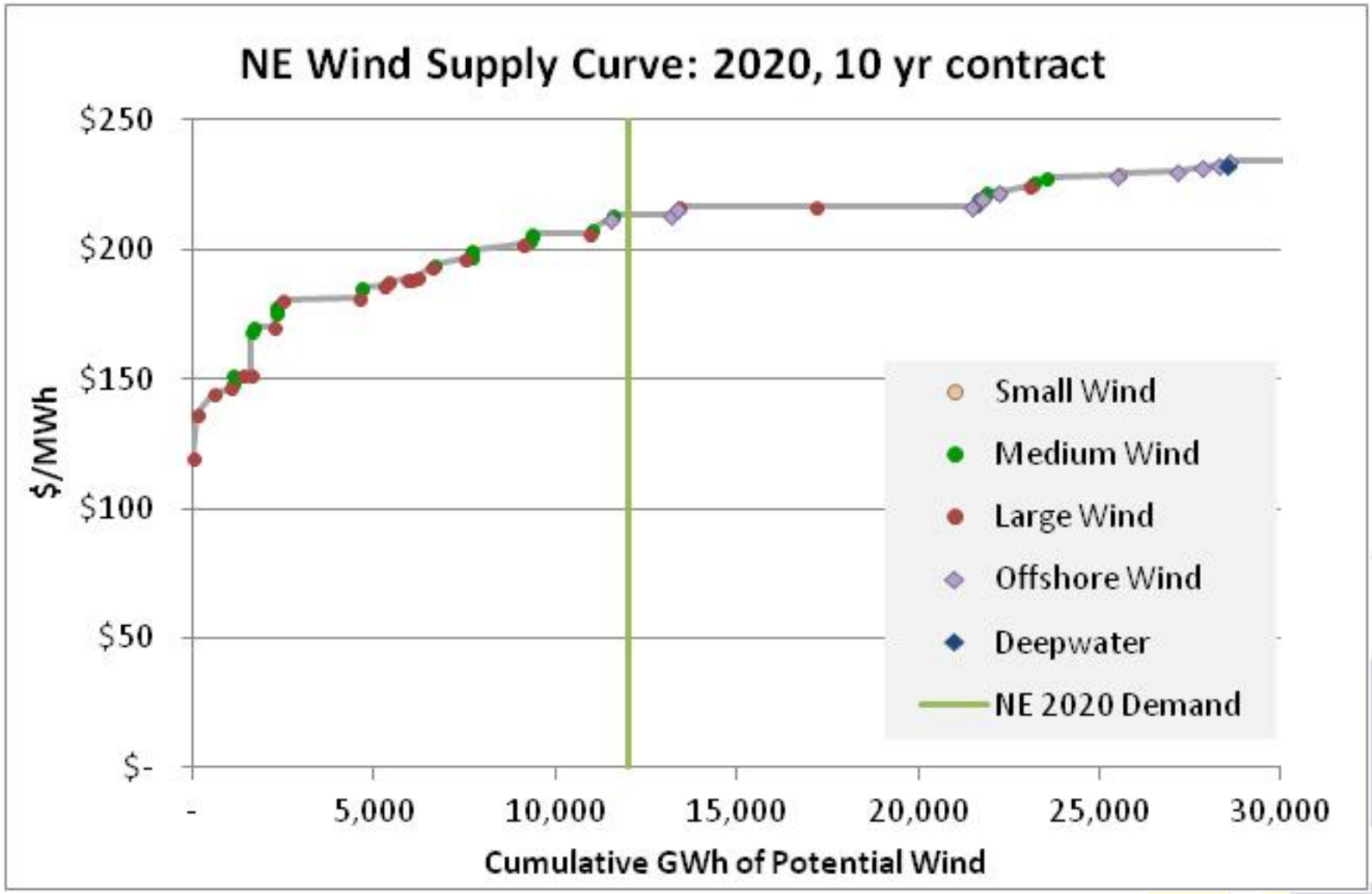
Source Mix, Least Cost Resources

New England



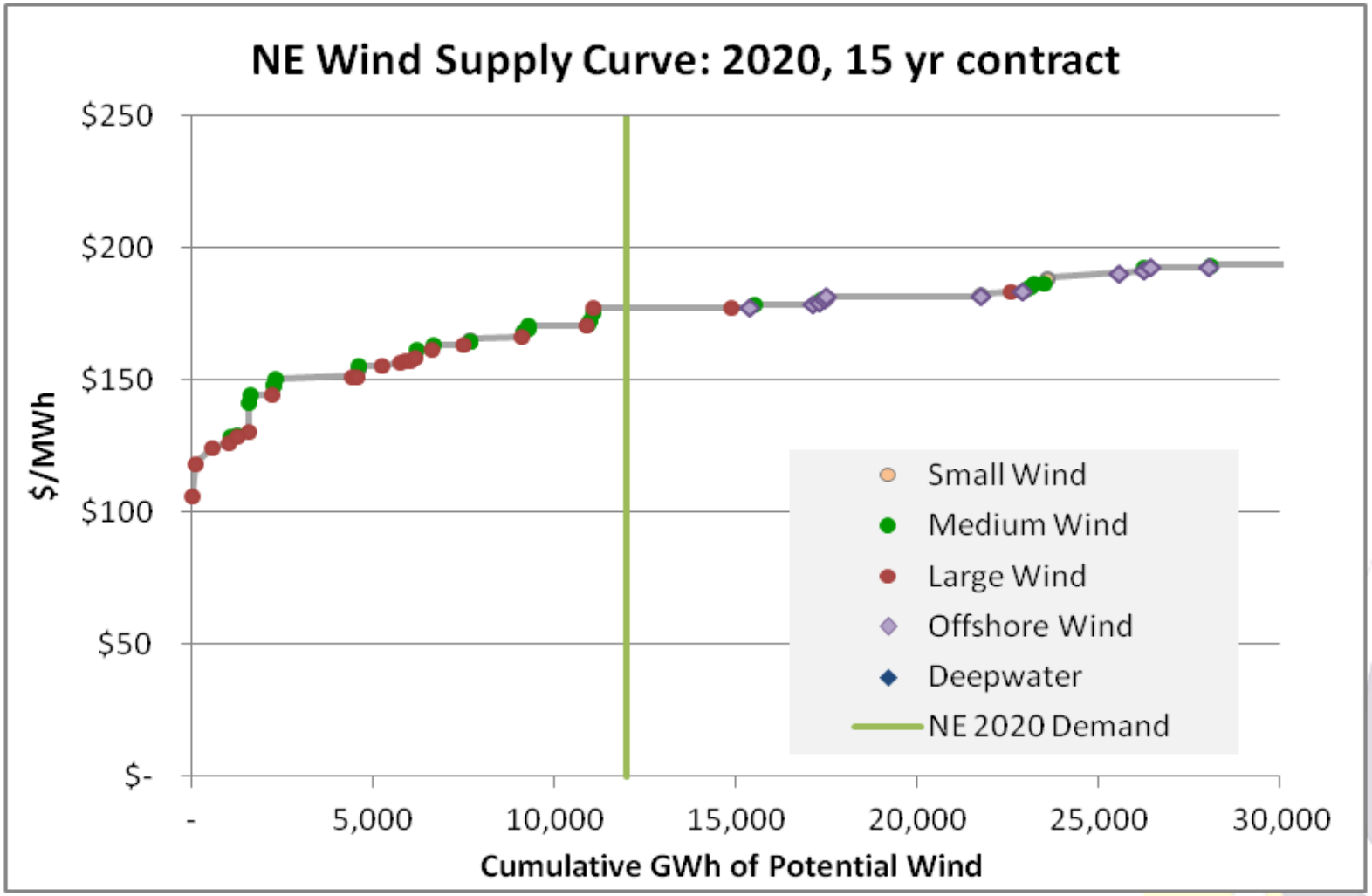
Source Mix, Least Cost Resources

New England



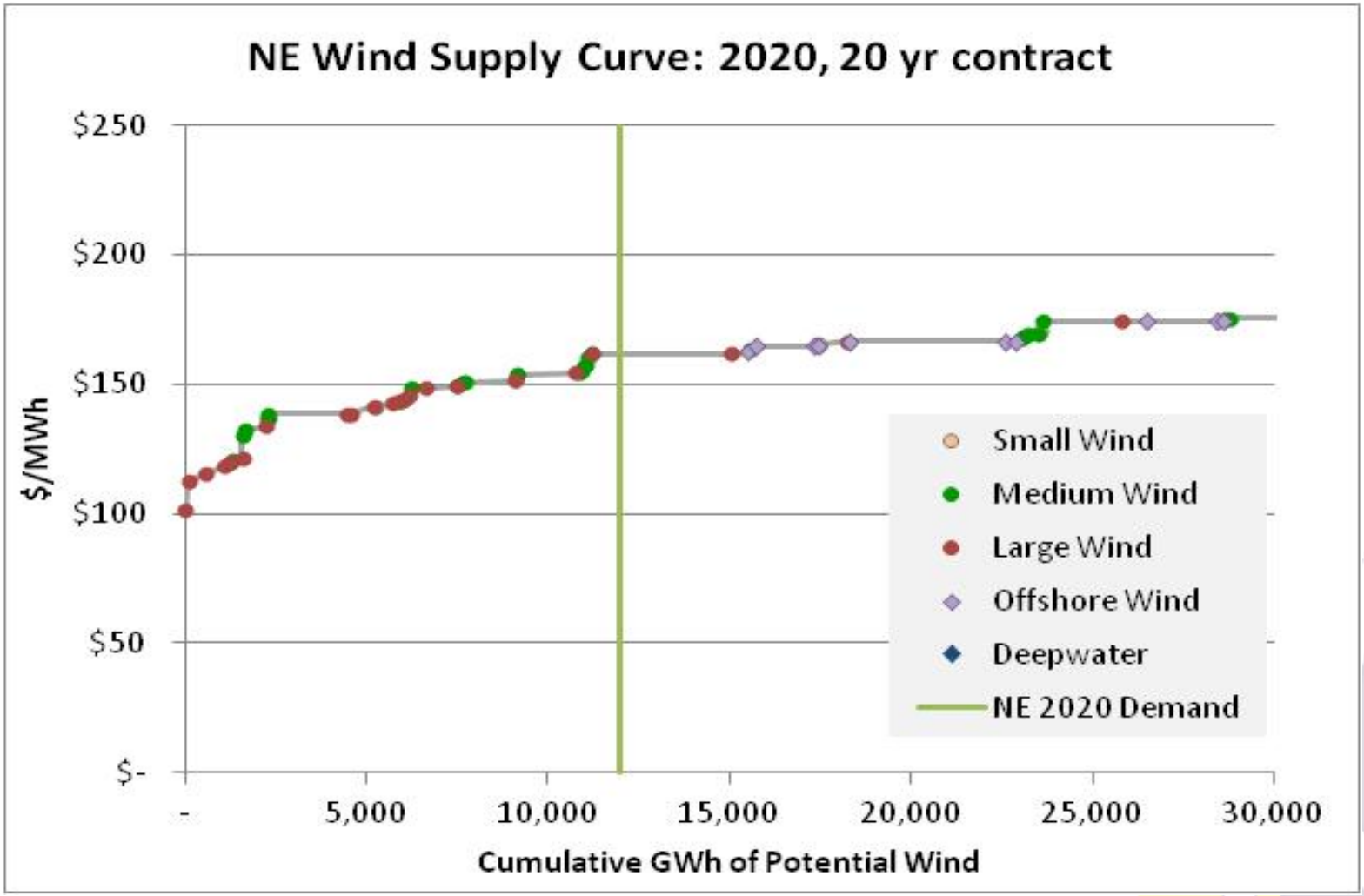
Source Mix, Least Cost Resources

New England



Source Mix, Least Cost Resources

New England



NE Resource Potential Assumptions

First Exclusions: 100% Undevelopable Land

	NREL Analysis	AWS/SEA/LCA Analysis
Protected Lands		
National Historic Preserves	100%	100%
Natural Resource Land	100%	100%
Wildlife Management Areas	100%	100%
State Parks	100%	100%
State and Local Parks	100%	100%
National Historic Parks	100%	100%
National Recreation Areas	100%	100%
National Monuments	100%	100%
National Wildlife Refuges	100%	100%
National Park Service Land	100%	100%
Fish and Wildlife Service Lands	100%	100%
State Parks, Recreation & Historic Lands	100%	100%
Land Use/Land Cover		
Urban Areas	100%	100%
Wetlands & Water bodies	100%	100%
Large Airports	100%	100%
Medium Airports	100%	100%
Small Airports	100%	100%
Existing Wind Farms	NA	100%
Slopes > 20%	100%	100%

Second Exclusions: Partially Undevelopable Land

	This Analysis Excludes…	Notes
Indian Affairs	0%	Projects proposed on Indian lands
Department of Defense	50%	
National Forest	50% (VT=75%)	VT given higher exclusion percentage due to greater permitting challenges
State Forest	50% (VT=75%)	VT given higher exclusion percentage due to greater permitting challenges
Appalachian Trail 2-mile buffer region	100%	Proximity to AT has caused controversy; 2 mile buffer modeled
Ridgecrest: Forest	50% (VT=75%)	VT given higher exclusion percentage due to improbability of development in the density suggested by lower exclusions
Ridgecrest: Agricultural	25%	Low exclusion percentage due to favorable view of wind power on agricultural land
Ridgecrest: Grassland	50% (VT=75%)	VT given higher exclusion percentage due to improbability of development in the density suggested by lower exclusions
Ridgecrest: Other	50% (VT=75%)	VT given higher exclusion percentage due to improbability of development in the density suggested by lower exclusions
Non-Ridgecrest: Forest	50% in ME, VT, NH, CT; 75% in MA and 100% in RI	Higher exclusion percentage in MA and RI to exclude Martha's Vineyard and Block Island
Non-Ridgecrest: Agricultural	0% everywhere but RI, 100% in RI	Higher exclusion percentage RI to exclude Block Island
Non-Ridgecrest: Grassland	25% everywhere but RI, 100% in RI	Higher exclusion percentage RI to exclude Block Island
Non-Ridgecrest: Other	25% everywhere but RI, 100% in RI	Higher exclusion percentage RI to exclude Block Island

NY Resource Potential Assumptions

1st Exclusions: 100% Undevelopable Land			
Protected Lands	**Data Source**	**Date**	**Applied Buffer**
National Historic Preserves	NYS DEC	2007	N/A
Natural Resource Land	NYS DEC	2007	N/A
Wildlife Management Areas	NYS DEC	2007	N/A
Preserve	NYS DEC	2007	N/A
Unique Wildlife Preserves	The Nature Conservancy / NYS DEC	2007	N/A
State and Local Parks	ESRI Parks	2007	N/A
National Historic Parks	ESRI Parks	2007	N/A
National Recreation Areas	ESRI Parks	2007	N/A
National Monuments	ESRI Parks	2007	N/A
National Wildlife Refuges	ESRI Parks	2007	N/A
	USGS National Atlas	2007	N/A
Fish and Wildlife Serivice Lands	USGS National Atlas	2007	N/A
Indian Lands	USGS National Atlas	2007	N/A
Status 1 Lands (Protected Lands)	Analysis	2007	N/A
State Parks, Rec.& Historic Lands	NYS Office of Parks, Recr.& Historic Lands	2006	N/A
Land Use/Land Cover	**Data Source**	**Date**	**Applied Buffer**
Urban Areas	Cover Data: Medium & High Intensity Developed Lands (NLCD Classes 23&24)	2001	Class (23) 0.5 Mi. Class (24) 1 Mi.
Wetlands & Waterbodies	Cover Data: Open Water (NLCD Class 11 & 90-95)	2001	N/A
Large Airports	ESRI Airports	2007	20,000 Feet
Medium Airports	ESRI Airports	2007	10,000 Feet
Small Airports	ESRI Airports	2007	N/A
Existing Wind Farms	AWS Truewind Wind Farm Data - Maple Ridge, Weathersfield, , Fenner, Steel Winds	2007	N/A
Slopes > 20%	Derived From National Elev.Data DEM 30m	2001	N/A

50% Exclusion of…		
Protected Lands	**Data Source**	**Date**
Dept. of Defense Lands	USGS National Atlas	2007
Forest Service Lands	USGS National Atlas	2007
State Forest	NYS DEC	2007
Lands Within the Adirondack and outside the 100% exclusion status (Forest Preserve)	ESRI Parks & analysis	2007
Land Use/ Land Cover	**Data Source**	**Date**
Non Analysis	Slopes ≤ 8 Degrees (NED) and Cover Data: Deciduous , , & Mixed (Classes 41-43)	2001

Assumptions: Capacity Factor Inputs

New England Onshore Capacity Factor Assumptions by Wind Power Class						
Power Class	**0**	**1**	**2**	**3**	**5**	**4**
CT		25.8%	29.6%			
MA		27.5%	33.5%	36.4%	39.3%	41.5%
ME	24.4%	28.5%	31.0%	33.9%	36.8%	41.9%
NH		27.2%	30.0%	31.3%	34.0%	38.9%
RI		39.7%	39.7%			
VT		27.2%	30.7%	34.0%	37.1%	41.3%

New York Capacity Factor Assumptions by Wind Power Class					
Power Class	**3**	**4**	**5**	**6**	**7**
Zone 1	23.4%	26.1%	28.8%	31.2%	42.2%
Zone 2	25.6%	28.8%	32.5%	36.1%	42.5%

Capacity factor inputs for each state and wind power class were levelized to reflect a 0.25%/year production degradation

Offshore Wind		
Class	Wind Speeds	Capacity Factor
1	7.0 - 7.5	33%
2	7.5 - 8.0	36%
3	8.0 - 8.5	40%
4	8.5 - 9.0	43%
5	9.0 - 9.5	46%
6	9.5 - 10.5	50%

Assumptions: Cost Profiles

Cost Inputs for 2020 (rounded)			
Category	Capital Cost ($/kW)	Fixed O&M ($/kW-yr)	Variable O&M (¢/kWh)
Small Wind	3,000	85	0.7
Medium Wind	2,800	80	0.7
Large Wind	2,450	80	0.7
Offshore Wind (Shallow)	4,100	105	1.5
Deep Water Offshore Wind	4,800	120	1.5

Interconnection Cost Estimates in 2020 (rounded)				
Onshore	Distance (miles)	Small Wind (millions $)	Medium Wind (millions $)	Large Wind (millions $)
T1	0-5	1.2	6.6	14.2
T2	5-15	3.6	14.0	26.0
T3	15-30	7.2	25.0	43.9
T4	30+	14.5	47.2	79.5
Offshore	Distance (naut. miles)	Shallow (millions $)	Deep (millions $)	
T1	0-3	22.0	28.3	
T2	3-12	41.0	52.7	
T3	12-50	121.3	155.9	

Assumptions: Financing

Financing Assumptions by Project Type

Technology Category	Cost of Equity	Cost of Debt (Reference Case)	Cost of Debt (Low Interest Rate Case)
Small Wind	13.0%	8.5%	7.0%
Medium Wind	12.0%	8.0%	6.0%
Large Wind	11.0%	7.0%	5.5%
Offshore Wind (Shallow)	14.5%	10.0%	8.0%
Deep Water Offshore Wind	14.5%	10.0%	8.0%

Financing Assumptions by Contract Term

Contract Term (yrs)	Debt Term (yrs)	% Debt (NE)	% Debt (NY)
10	9	62%	n/a
15	14	64%	62%
20	18	65%	n/a

Other Assumptions

- Min.debt coverage ratios of 1.25
- 20 year economic life of project

- For contract terms < 20 years, "residual value" (post-contract period) was calculated based on expected future value of energy, capacity and residual RECs
  - Residual REC value of $5/MWh
  - Energy and Capacity value for NE taken from Avoided Cost of Energy Study (2011)
  - Energy and Capacity Value for NY based on NY ISO's Congestion Assessment and Resource Integration Study (2011) and the 2009 NY State Energy Plan, And EIA's Annual Energy Outlook 2011

Data Sources

- Onshore wind data sets commissioned by SEA from AWS Truepower in late 2007, with updates on capacity factors and development density in 2011
- Offshore wind data from NREL
- Detailed description of data and assumptions in report