First Two Loops of SPP EHV Overlay Transmission Expansion

Analysis of Benefits and Costs

Performed on behalf of Electric Transmission America, OGE Energy Corp. and Westar Energy

September 26, 2008

Outline

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Overview

- **This presentation summarizes the benefits and costs of the proposed first two loops of the SPP EHV Overlay study, including the Prairie Wind and Tall Grass transmission projects ("Two Loop project"), comprised of:**
  - Approximately 600 miles of 765 kV lines in service in 2013/2014 in western Kansas and Oklahoma (1st loop).
  - An additional 600 miles of 765 kV lines in service in 2015/16 in the Texas Panhandle and southwest Oklahoma (2nd loop).
- **The benefits quantified include:**
  - Power supply costs in SPP
  - Reduction in losses in SPP
  - Economic incentive for construction of new wind power in SPP
  - CO_2 emissions
  - Local jobs, earnings, taxes, and economic output

New Transmission

- **Three transmission projects not originally included in the 2010 SPP load flow model[1] were added to the Base Case:**

Line	Voltage
Wichita – Reno - Summit	345
Rose Hill – Sooner	345
Woodward – Northwest	345

- **The new 765 kV Two Loop lines were included in the Change Case and are envisioned to be constructed in two steps.**

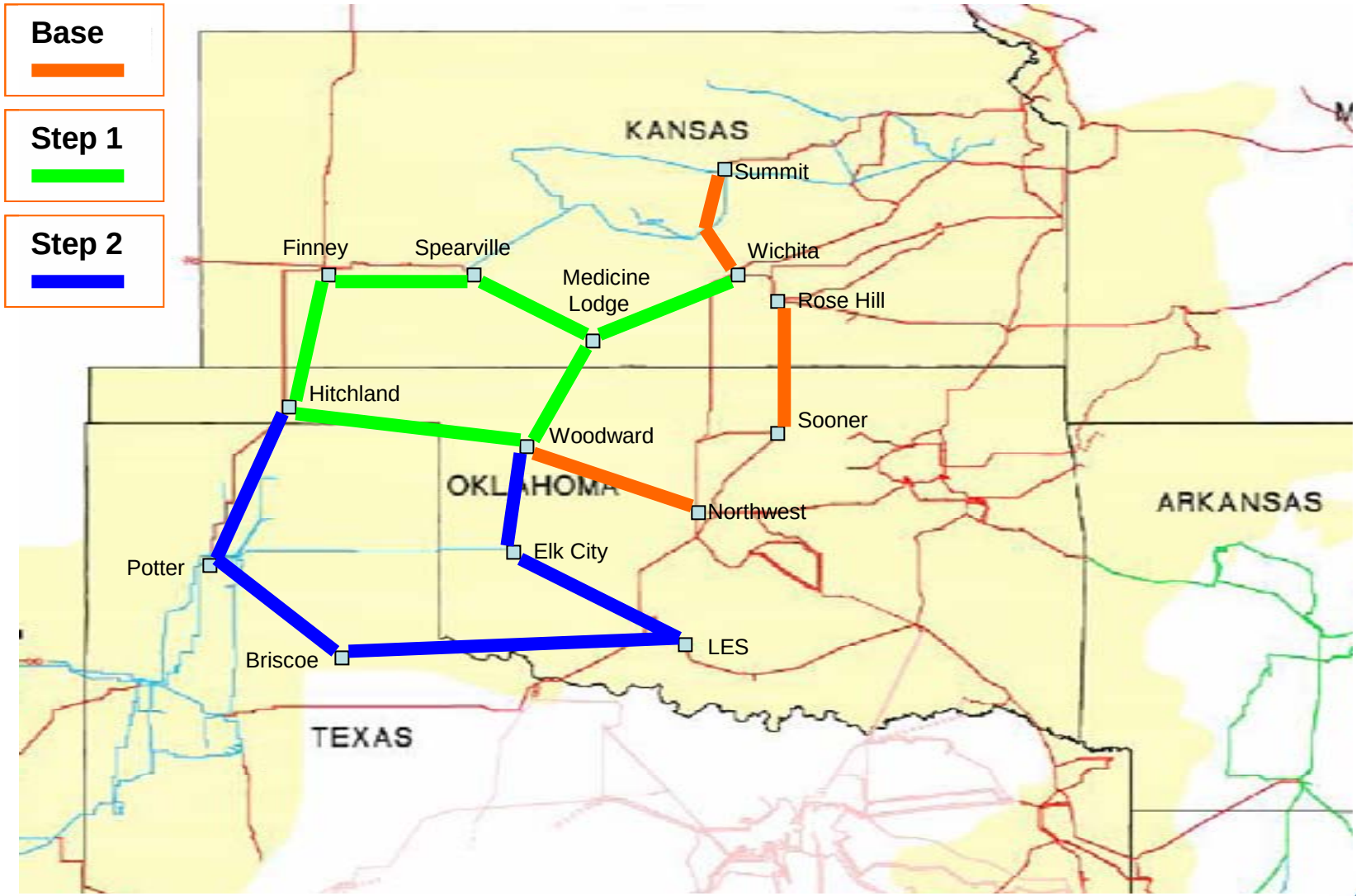
Two Loop Project Transmission Lines

Step 1		Step 2	
Line	**In-Service**	**Line**	**In-Service**
Wichita – Medicine Lodge	2013	Hitchland – Potter	2016
Spearville – Medicine Lodge	2013	Woodward – Elk City	2015
Medicine Lodge – Woodward	2013	Potter – Briscoe	2016
Woodward – Hitchland	2013	Briscoe – LES	2016
Hitchland – Finney	2014	LES – Elk City	2015
Finney – Spearville	2014		

[1] NERC Multiregional Modeling Working Group (MMWG) 2005 series load flow case for the summer of 2010.

New Transmission Lines in Base Case

New Transmission Lines in Change Case



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Wind Power Assumptions

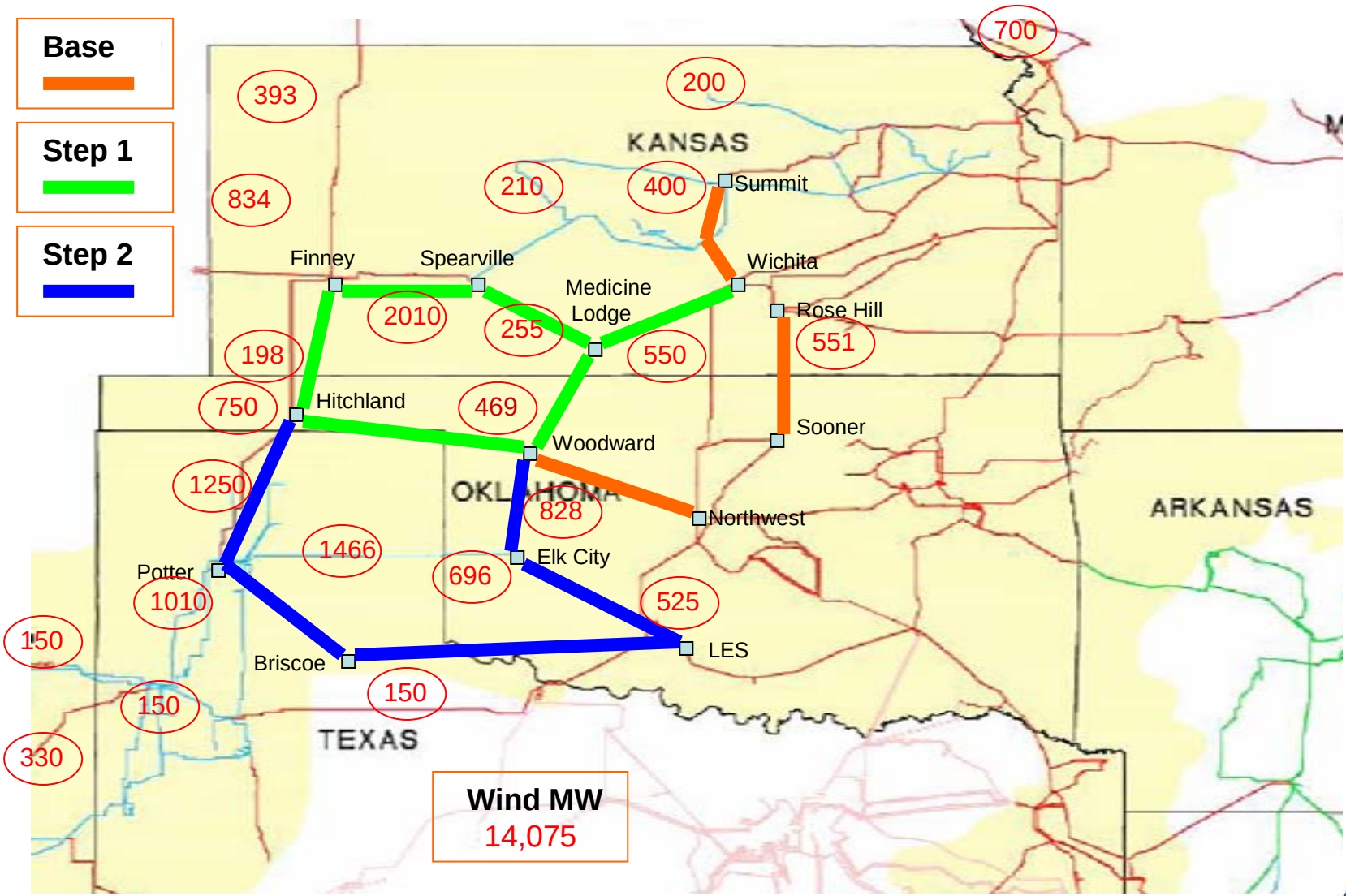
- **14 GW of new wind power in SPP not already under construction was included in the Change Case using active SPP generation requests.**
  - 13.5 to 20.7 GW of new SPP wind was used in the March 2008 EHV Overlay Study.
  - Study sensitivities with 14 and 24 GW of new wind included in the Change Case indicated that the new wind power was more economic with 14 GW.

New SPP Wind Power in Change Case

	Wind (MW)
Kansas	5,601
Missouri	701
New Mexico	480
Oklahoma	3,268
Texas	4,026
Total	14,075

- **Given physical constraints on the SPP system, no additional new wind not already under construction was included in the Base Case.**
  - 2.5 GW of wind currently in operation or under construction in SPP was included in both the Base Case and the Change Case.

Change Case: New Wind Locations



Note: Wind Capacity locations are grouped by one or more counties.

Summary of Benefits and Costs

- **Benefits:**
  - **SPP Power Supply Cost Benefits**: $2.8 billion (08$) annually
    - **CO_2:** Nearly 30 million tons of CO_2 emissions per year avoided.
  - **Losses:** An additional $100 million benefit in reduced power losses in SPP.
  - **RPS:** More than 20% of SPP demand supplied by renewable energy.
  - **Local impacts:** Over 10,000 SPP jobs during construction, and 5,000 during operation; $60 million per year in property taxes, and $500 million per year in economic output.
- **Costs:**
  - **Cost of the EHV Overlay facilities needed to complete the Two Loop Project:** $400 to $500 million per year
  - **New wind costs:** $1.75 billion per year net of production tax credit
- **We conclude that the Two Loop project yields substantial net benefits to SPP.**

Summary of Benefits and Costs

- **Breakdown of Net Power Supply Cost Benefits of the Two Loop project:**

Net Power Supply Benefits (millions)		
+ Energy Benefits/(Costs)		
Supply Cost Savings	$2,766	
Reduced Loss Benefits	$96	
Wind Energy Revenue	($1,867)	
Total		$995
+ Wind Cost Credit/(Shortfall)		
Wind Energy Revenue	$1,867	
Wind Revenue Requirement	($2,447)	
Wind Production Tax Credit	$713	
Wind Market Revenue net of Cost		$133
- Transmission Cost		$400 - $500
= Net Benefits		$628 - $728

- **Wind energy revenues are more than sufficient to cover the fixed cost of the new wind capacity.**
  - The wind production tax credit is an important factor in the Power Supply Cost benefits to SPP.
  - RPS considerations would make the economic comparison more favorable to the Two Loop project as the cost of the new wind would be compared to the cost of other renewable capacity.
- **Local economic impacts and the public benefits of responding to current and potential future state RPS standards are in addition to the Power Supply Cost benefits.**

Benefits: SPP Power Supply Costs

- **SPP benefits were measured using the change from the Base Case in Total SPP Supply Cost:**
  - SPP production costs *plus* Purchase Costs for imports into SPP *minus* Sale Revenue for exports from SPP

Total SPP Supply Cost = **SPP Units Production Costs** + **Purchase Costs for SPP Imports** - **Sales Revenue for SPP Exports**

  - GE MAPS runs were performed for 2016, with CO_2 emission costs assumed to be $18 per ton (08$) in that year.
    - This CO_2 cost is towards the lower end of public estimates that range from $10 to $40 or more per ton.
    - CRA incorporated this CO_2 cost into the estimated natural gas prices (higher), coal prices (lower), and electricity demand (lower).
  - The decrease in the SPP Supply Cost in the Change Case was $2,766 million (08$) for the year 2016, a reduction of 25% or $11.9/MWh.
  - The significant decrease in Supply Cost is largely because of wind power being included in the Supply Cost at a zero production cost.
  - The economic impact including the fixed cost of the new wind capacity is discussed in the following section.

Benefits: SPP Power Supply Costs

- **CO_2 Emissions**
  - The increase in SPP wind generation in the Change Case results in a reduction in SPP CO_2 emissions.

SPP CO_2 Emissions, 2016
(Millions of Tons)

	Base Case	Change Case	Decrease %
SPP CO_2 Emissions	198.9	169.0	15%

  - As shown, the SPP CO_2 emissions decrease by 15%, or 30 million tons in 2016.
  - At the assumed $18/ton cost for CO_2 emissions, the economic value of this reduction is $538 million.

Benefits: SPP Power Supply Costs

- **Loss Benefits**
  - The reduction in power losses in SPP that would result from Base Case to the Change Case was separately analyzed.
  - The average energy losses on 765 kV lines is generally less than 1%.
    - For comparison, the average loss on double-circuit 345 kV lines is in the 5% range.
  - About 1,600 GWh of energy is saved annually in SPP with the construction of the Two Loop project.
  - Using the new wind power avoided cost of $60/MWh, this 1,600 GWh yields $96 million in additional power supply cost benefits.
    - $60/MWh is the $2,766 million of SPP Supply Cost Savings divided by the 46,000 GWh of generation from the 14 GW of new wind in the Change Case
  - This benefit in loss-related Power Supply Costs is in addition to the SPP Total Supply Costs benefit quantified above.

Benefits: Wind Power Economics

Annual revenue requirement for the 14 GW of new wind

- **Capital and operating costs from a model developed for wind power projects by the U.S. Department of Energy.**
  - $1400/kW capital cost @ 11% = $154/kW-year
    - Of the $1400/kW in capital cost, $51/kW covers the transmission costs to reach the EHV facilities needed to complete the Two Loop project.
    - Annual fixed charge rate of 11% based on a 20 year operating life, 5 year tax life, and financing assumptions (80% debt @ 10% & 20% equity @16%) from the DOE model.
  - $26/kW-year in operating costs (incl. royalties and property taxes).
  - Annual Revenue Requirement ("ARR") of $180/kW-year
- **Capacity Credit:**
  - A normalized $6/kW-year was credited
    - Based on a 10% wind capacity value and new capacity being needed in SPP after 2020.
  - Decreases ARR to $174/kW-year
- **Production Tax Credit**
  - A normalized federal tax credit of $15.5/MWh or $51/kW-year at 37% capacity factor
    - Current credit is $20/MWh but applies only for the first 10 years of operation.
    - Does not include any state-specific production tax credits that may be available.
- **ARR Net of Production Tax Credit**
  - 123 $/kW-year or 38 $/MWh at a 37% capacity factor.
  - For 14,075 MW of new wind, this is an annual cost of $1,734 million.

Benefits: Wind Power Economics

- **The 14 GW of new wind in the Change Case operates at the maximum 37% capacity factor (indicating prices at the wind locations are generally positive) and produces 46,000 GWh annually.**
- **We then analyzed whether the energy revenues received by the new wind power in the Change Case is enough to cover the annualized cost (i.e., revenue requirement) of the new wind power.**

Energy Revenue for 14 GW of New Wind Power in Change Case in Comparison to Annual Wind Revenue Requirement

	Revenue in Change Case	Revenue Requirement	Production Tax Credit	Net Revenue Requirement	Net Benefit/ (Shortfall)
Wind Revenue ($/MWh)	40.6	53.2	(15.5)	37.7	2.9
Wind Revenue ($/kW-year)	132.6	173.8	(50.7)	123.1	9.5
Wind Revenue (M$)	1,867	2,447	(713)	1,734	133

- **As shown, the Change Case provides energy revenues to the new wind capacity of $1,867 million, or $133 million more than the $1,734 million annual revenue requirement (net of production tax credit) of the new wind capacity.**

Benefits: Supply Costs with Wind Power Recovery

- **Based on the above, taking into account new wind fixed cost recovery, the aggregate SPP Supply Cost impact is as follows:**

Aggregate SPP Power Supply Cost Benefits (millions of dollars)

+ Energy Benefits/(Costs)		
Supply Cost Savings	$2,766	
Reduced Loss Benefits	$96	
Wind Energy Revenue	($1,867)	
Total		$995
+ Wind Cost Credit/(Shortfall)		
Wind Energy Revenue	$1,867	
Wind Revenue Requirement	($2,447)	
Wind Production Tax Credit	$713	
Wind Market Revenue net of Cost		$133
= **Total Power Supply Cost Benefits**		$1,128

- **We conclude that the Two Loop project provides substantial Power Supply Cost benefits, including consideration of the new wind fixed cost recovery.**

Benefits: Local Economic Impacts

- **The local economic impacts in SPP resulting from the construction and operation of 14 GW of new wind power and the construction of the Two Loop project were estimated using a model developed for wind power projects by the U.S. Dept. of Energy.**

Local Economic Impacts from Construction and Operation

	Construction Period	Operating Period
New Jobs	10,255 (4-year average)	5,488
Earnings (M$)	1,380	229
Economic Output (M$)	4,416	496
Property Taxes (M$)	--	58

- **The $20 billion in construction expenditures create an average of more than 10,000 jobs in SPP during the roughly four-year construction period.**
- **During operation, the wind facilities would create over 5,000 jobs in SPP, $60 million in annual property taxes, and $500 million per year in economic output in SPP.**

Costs: Transmission

- **Transmission Costs**
  - We estimated the cost of the Two Loop project to between $2.7 and $3.4 billion.
    - The $2.7 billion figure is based on data in the March 2008 SPP EHV Overlay.
    - Projected construction costs likely have increased since those estimates were made. For purposes of this study, we assumed a range of an additional 25% in cost.
  - Applying an assumed 15% charge rate, this yields roughly $400 million to $500 in annual costs for the project.
  - This cost would be netted from the net benefits discussed above.

Benefits: By State

- **Total Supply Cost benefits by state were estimated using a simplified method to allocate the SPP-wide benefits to each state.**
  - The simplified allocation is based on generation impacts by control area and the use of jurisdictional shares to further allocate to the state level.
  - Losses and wind cost recovery was allocated on a similar basis. The resulting allocation of the $1,128 million of Supply cost Benefits is:

Estimated Annual Power Supply Cost Benefits by State

	Benefits (M$ 08)
Arkansas	34.6
Kansas	196.3
Louisiana	12.6
Missouri	218.6
New Mexico	30.3
Oklahoma	428.8
Texas	110.9
Total	**1127.9**

  - Local economic impacts by states are on the following page.

Benefits: By State (cont.)

- **The local economic impacts were evaluated for the four states with new wind units related to the Two Loop project.**

Construction Period

	Kansas	New Mexico	Oklahoma	Texas
New Jobs (4-yr avg)	4,131	351	3,247	2,497
Earnings (M$)	536	45	388	410
Economic Output (M$)	1,818	129	1,315	1,255

Operating Period (annual impacts)

	Kansas	New Mexico	Oklahoma	Texas
New Jobs	1,955	269	1,610	1,654
Earnings (M$)	76	10	69	74
Economic Output (M$)	182	20	129	165
Property Taxes (M$)	--	2	34	21

Appendix 1:
Calculation of Benefits

Total Supply Cost

- **SPP Total Supply Cost impacts**
  - Total variable generation costs in SPP (including fuel, variable O&M, start-up and cost of environmental emission permits)
    - The costs for the share of jointly owned units located in SPP owned by entities outside of SPP is excluded.
    - The costs for the share of jointly owned units located outside of SPP owned by SPP entities is included.
  - PLUS cost of off-system purchases (computed hourly as inflow of power into SPP times LMP)
  - MINUS revenues from off-system sales (computed hourly as outflow of power from SPP times LMP)

Total Supply Cost (cont.)

- **To estimate off-system purchase costs and sales revenues, we applied an analytic methodology developed with Missouri stakeholders for the CRA Aquila cost-benefit study**
  - For all tie-lines into the SPP region, the hourly flow on the tie-line, and hourly prices on either side of the tie-line is obtained from the GE MAPS model run.
  - A split-savings price using the hourly prices on either side of the tie-line, adjusted for applicable wheeling charges, is calculated.
  - The into-SPP tie-lines were grouped into one of the following neighboring entities:
    - AECI, Entergy, ERCOT, MISO, Mid-American, OPPD, NPPD and WECC.

Total Supply Cost (cont.)

- For each SPP “neighbor”, using the sum of the hourly tie-line flows to that neighbor, we assess whether SPP is importing or exporting in the hour.
  - If importing, the weighted average split savings prices for importing tie-lines to that neighbor in the hour is calculated and multiplied by the imports in the hour.
  - If exporting, the weighted average split savings price for exporting tie-lines in that hour is calculated and multiplied by the exports in the hour
- These purchase and sales impacts are then summarized across the year and across all neighbors.
- Note: flows across the into SPP tie-lines were adjusted for the SPP share of jointly owned units not located in SPP.

Total Supply Cost (cont.)

- **Given the time and difficulty in performing a similar analysis for entities within SPP, the total supply cost impact by state was estimated using a simplified allocation process.**
  - The SPP-wide benefit was allocated to each control area based on the absolute value of the change in each area's production cost.
    - Note that the new wind power has a production cost of zero.
  - The presumption is that those control areas with:
    - Decreased production cost are purchasing additional power at a price equal to the decrease in production cost minus a margin.
    - Increased production cost are exporting additional power at a price equal to the increase in production cost plus a margin.
  - The control areas benefits were then allocated to customers in each state based on jurisdictional shares, and then aggregated by state.
    - Loss benefits and wind cost recovery were allocated using the same method.

Estimation of Local Economic Impacts

- **14 GW of new wind capacity assumed**
  - Of this, the small amount of new wind in Missouri was not considered in the local economic impact assessment.
- **Analysis includes both direct and indirect economic impacts**
- **Wind analysis based on NREL JEDI* model and assumptions,**
  - Adjusted for latest IMPLAN multipliers, and
  - $10,000 per year per 1.5 MW turbine royalty.
- **25% of transmission construction budget assumed to be from local sources (craft labor, local construction materials).**
  - IMPLAN construction multipliers applied.
- **Wind property taxes as percent of construction cost estimated as:**
  - Kansas: 0%; New Mexico: 0.4%; Oklahoma: 0.75%; Texas: 0.4%.
- **Transmission operations were not included in the analysis.**
- **The model calculates construction jobs in terms of FTE-year, a construction period of 4 years was assumed.**

*** Job and Economic Development Impact (JEDI) Model: Tool to Calculate Economic Impacts from Wind Projects; National Renewable Energy Laboratory, http://www.nrel.gov/analysis/jedi/about_jedi.html. NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy**

Appendix 2:
Input Assumptions

Modeling Footprint

- **CRA explicitly modeled the US portion of Eastern Interconnection, Manitoba Hydro, Ontario and Saskatchewan.**
  - Flows across boundaries with other Canadian markets were modeled using historical data
- **Monitored constraints for SPP originate in the following sources:**
  - A list of flowgates provided by the Southwest Power Pool
  - The list of flowgates published on the Midwest ISO website
- **Monitored constraints for other parts of the Eastern Interconnection are derived from the similar sources.**
  - However, only essential constraints in these areas were retained in the model for purposes of this study: constraints that were binding in prior CRA studies plus those associated with 500kV and higher circuits

GE MAPS

- **GE-MAPS is a detailed economic dispatch and production-costing model for electricity networks**
  - GE-MAPS determines the least-cost security constrained units commitment and dispatch of generating units to satisfy a given demand
  - Units are dispatched according to their variable costs.
- **GE-MAPS simulates the chronological operation of generating units and transmission systems on an hourly basis**
- **Outputs include hourly dispatch of generating units, transmission loading and locational marginal prices (LMPs) for all generators and load areas**

SPP Non-Wind Generation Additions

Year	*Unit Name*	*State*	*Type*	*Installation Date*	*Capacity (MW)*
2008	Riverside GT1	OK	GT	Jan-2008	80
	Riverside GT2	OK	GT	Jan-2008	80
	Emporia Station (Aero 1)	KS	GT	May-2008	160
	Emporia Station (Frame 1)	KS	GT	May-2008	160
	Hobbs Generating Station	NM	CC	Jun-2008	550
2009	Rodemacher 5	LA	STc	Sep-2009	600
	Emporia EC Phase 2 (Frame)	KS	GT	May-2009	300
2010	Iatan 2	MO	STc	Jun-2010	850
	Southwest Power St. ST2	MO	STc	Oct-2010	300
2011	Murray Gill EC new GT1	KS	GT	Jan-2011	150
	Murray Gill EC new GT2	KS	GT	Jan-2011	150
2012	J. W. Turk	AR	STc	Oct-2012	600
2016	NEOSHO CC	KS	CC	Jan-2016	500

GT: Combustion (Gas) Turbine; CC: Combined Cycle; STc: Steam Coal

Seams Charges

- **Seams charges are applied in GE-MAPS based on the "friction" involved in transactions across markets and wheeling charges.**
  - The $/MWh seams charges used were developed in the 2007 AmerenUE cost-benefit study in conjunction with Missouri stakeholders.

		Commitment	Dispatch Seams Charge		
		Seams	Wheeling		
From	To	Charge	Off-peak	Friction*	Total
MISO	PJM	10	0	2	2
MISO	All Other	10	3	3	6
PJM	MISO	10	0	2	2
PJM	Other	10	2	3	5
SPP (excl. Cleco)	All	10	2	3	5
- Cleco	All Other	10	2	5	7
LG&E	All	10	1	5	6
Entergy	All	10	2	5	7
AECI	All	10	2	5	7
TVA	All	10	2	5	7
MEC	All	10	3	5	8
All Other	All Other	10	2	5	7

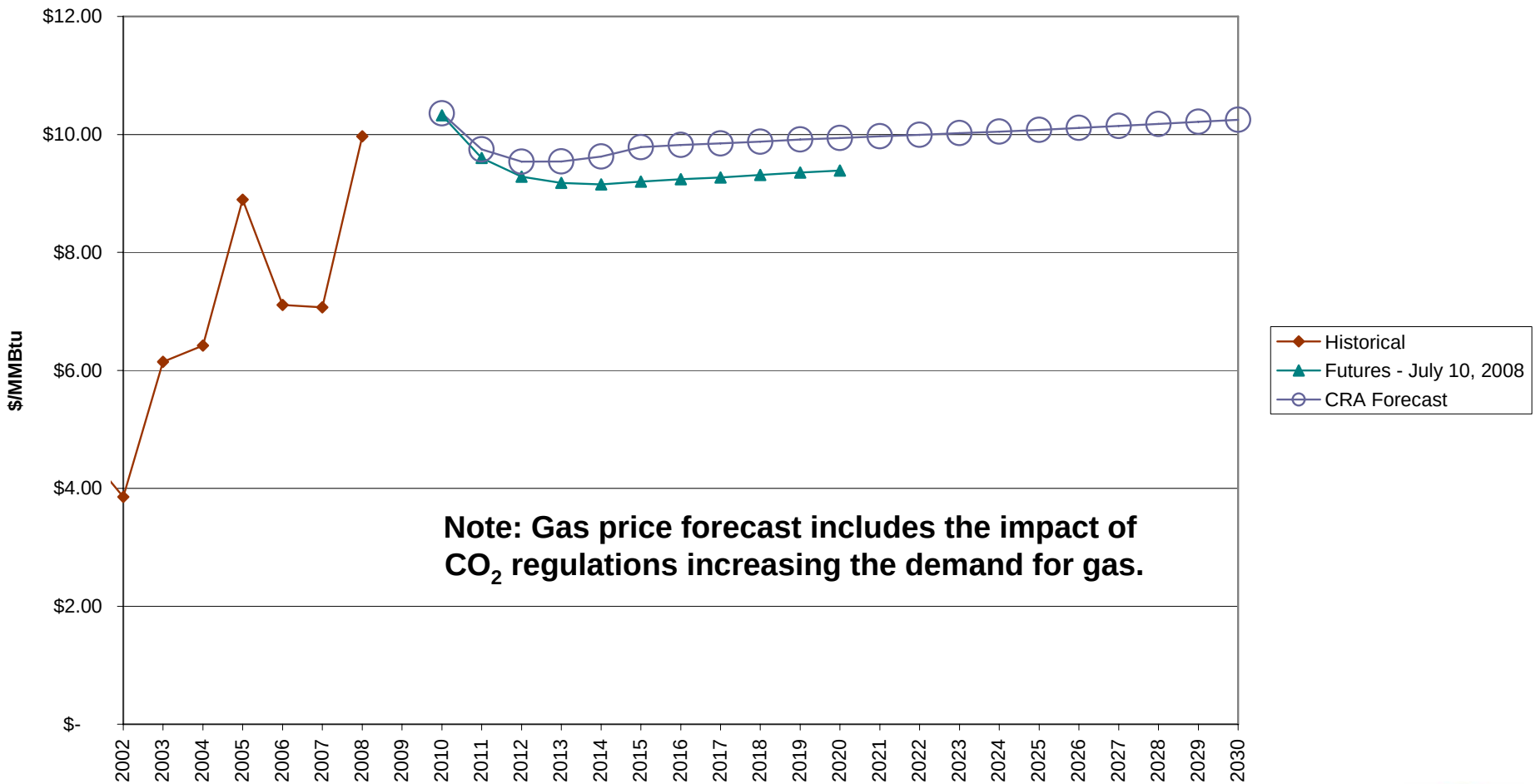
* $3 dispatch friction hurdle for flows out of active managed markets
* Non market areas not expected to be as efficient hence higher dispatch friction hurdle of $5
* Non-firm off peak hourly wheeling rate used in addition to friction
* PJM to/from MISO friction set at $2 given extensive seams management process

Electricity Demand and Fuel Prices

- **We used the CRA MRN model to evaluate the impact of CO_2 prices on regional electricity demand and fuel prices.**
  - CO_2 prices were included at $15/ton in 2012 increasing at 5% real per year.
  - The resulting natural gas prices are shown on the following pages.
- **Using these inputs, the CRA NEEM model was then run with the new wind units installed to assess the economics of:**
  - Building additional generation capacity on top of what has already been assumed
  - Retiring additional capacity
  - Mothballing capacity
- **We concluded that:**
  - No additional generation capacity will be economic before 2020
  - No SPP capacity should retire
  - Some SPP capacity could be temporarily mothballed but all returned into service prior to 2020

Natural Gas Price Forecast

Figure 1: Natural Gas Spot Prices at Henry Hub: History and Projections (2007$/MMBtu)



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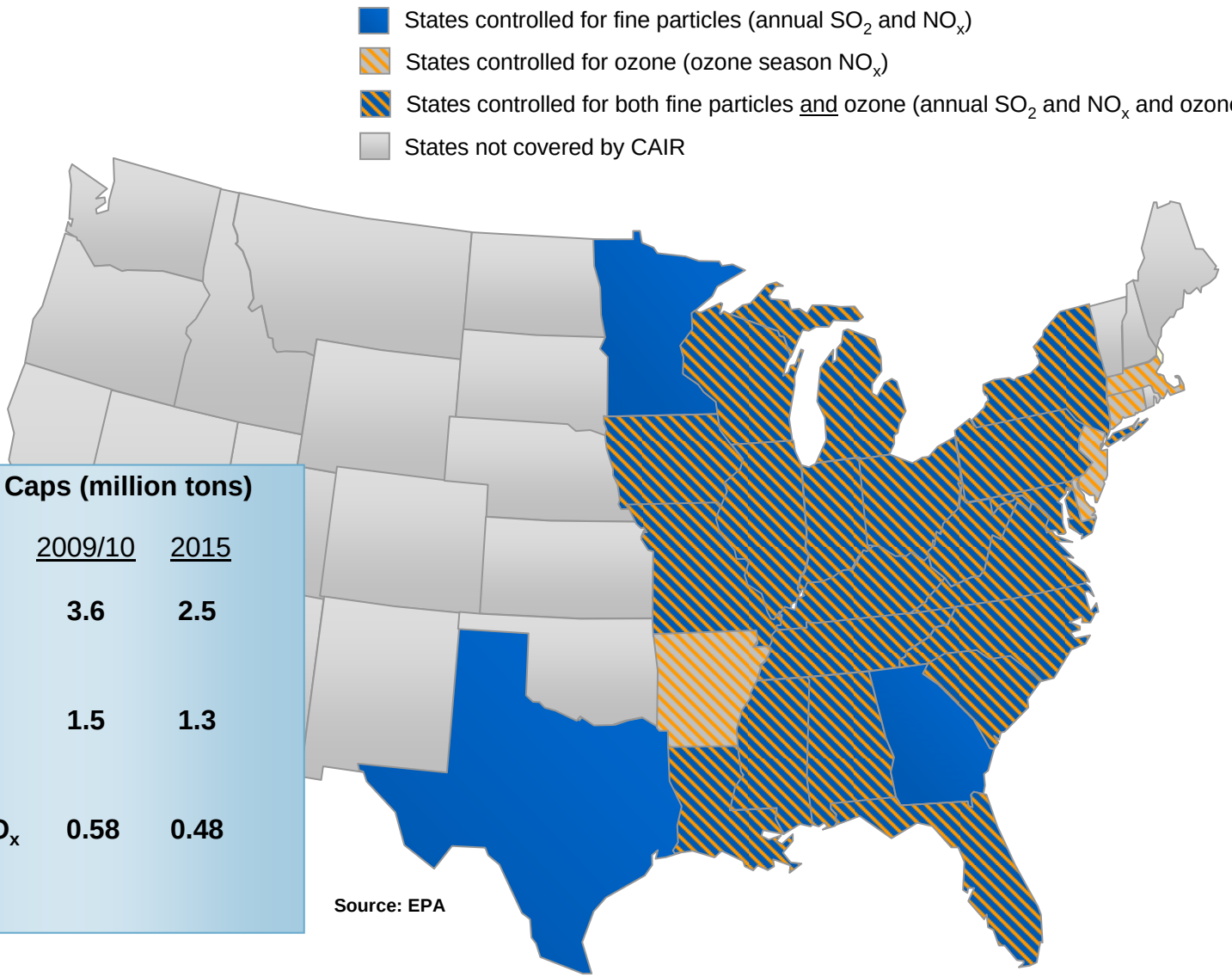
Emission Allowance Prices

- **The NEEM model was also used to develop emission allowance prices under the assumed carbon prices.**
- **Title IV SO_2 – Cap & Trade, annual, entire US**
- **Clean Air Interstate Rule ("CAIR") Issues**
  - SO_2 – Cap & Trade, continuation of Title IV market with trade-in ratios changing over time for Eastern US
  - NO_x (Annual and Ozone Season) – Cap & Trade, Eastern US, to replace SIP Call
  - CAIR was recently struck down by a federal appeals court panel. However, for purposes of this study, the regulations embodied in the CAIR rules were assumed to be applicable by 2014.

Proposed CAIR Regions

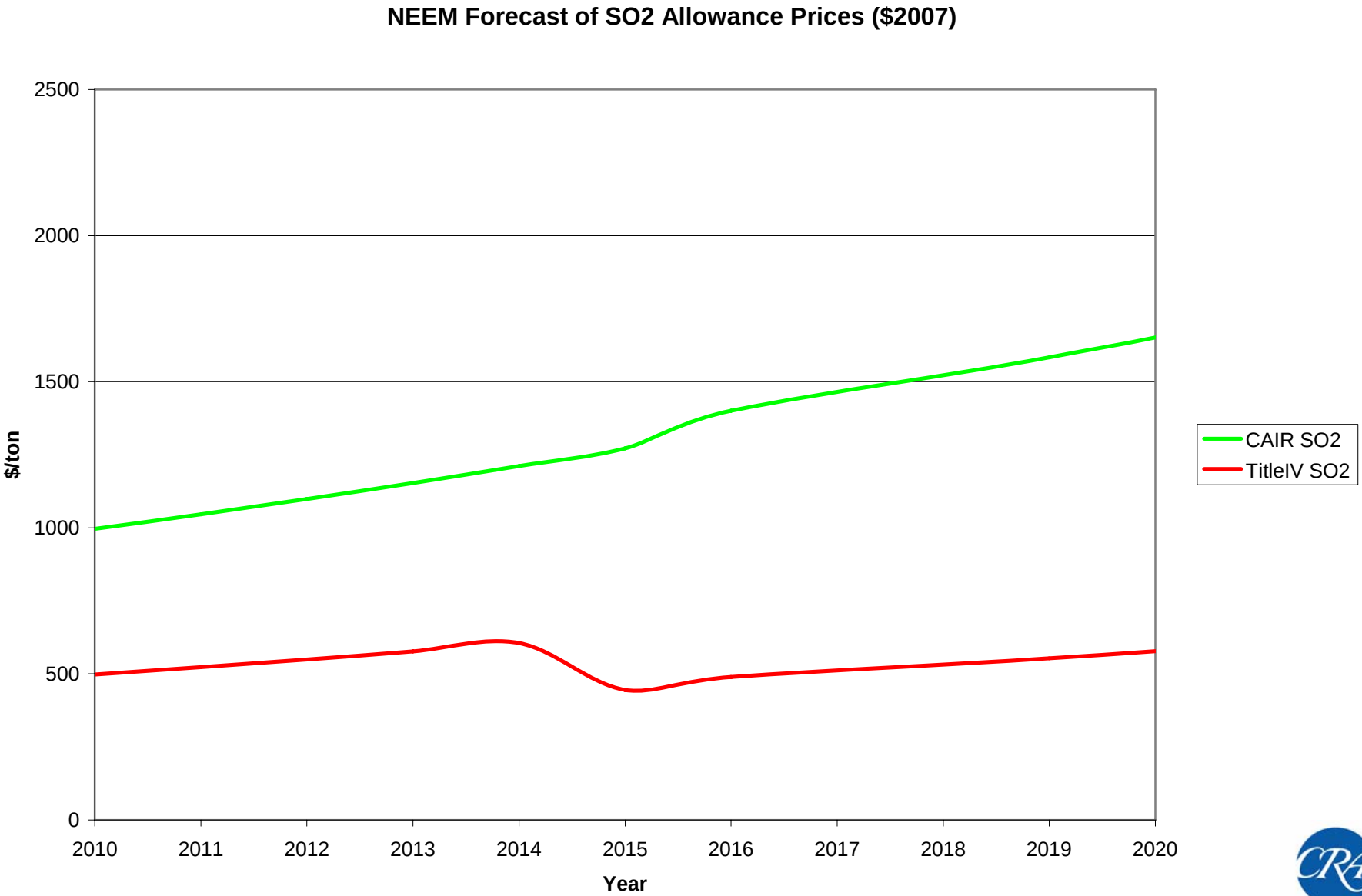


Emission Caps (million tons)

	2009/10	2015
Annual SO_2 (2010)	**3.6**	**2.5**
Annual NO_x (2009)	**1.5**	**1.3**
Seasonal NO_x (2009)	**0.58**	**0.48**

Source: EPA

NEEM Forecast of SO_2 Emission Prices



NEEM Forecast of NO_x Permit Prices for CAIR Regions