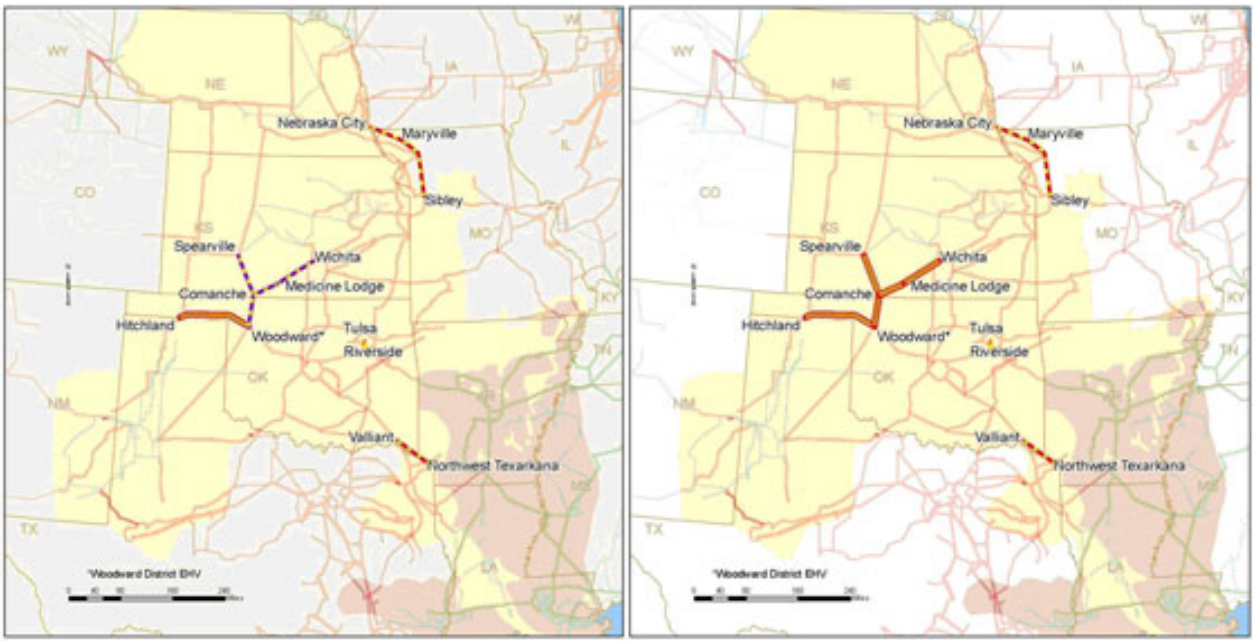
SPP Priority Projects—
Natural Gas Price Reduction



Southwest Power Pool

Benefits of EHV transmission

P. Jeffrey Palermo
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1 Background

The Southwest Power Pool (SPP) staff engaged KEMA, Inc. in December 2009 to assist the evaluation of the proposed Priority Projects that were intended to capture near-term opportunities associated with the heightened focus on electric transmission expansion KEMA was asked to develop a white paper describing the strategic benefits of the Priority Projects. These benefits were to include:

1. Flexibility for future resource planning decisions affecting generation resource decisions and associated supply contracts;
2. Reliability that improves service reliability and restoration times in response to normal and extraordinary events;
3. Fuel diversity and price elasticity in supply and demand of marginal fuels;
4. Right-of-way utilization of the corridors for transmission facilities to avoid "corridor fatigue" and land use/habitat fragmentation issues; and
5. Strategic regional and national benefits including the market response to major topology/congestion changes, or EHV network headroom that enables more efficient and economic management of grid operations and maintenance schedules.

During the course of the work SPP asked KEMA to focus on the third of these—fuel diversity benefits. This report addresses KEMA's work regarding the fuel diversity benefits of the Priority Projects.

2 Transmission functions and benefits

The modern electric power system is one of mankind's greatest engineering achievements. The National Science Foundation declared it the greatest engineering achievement of the 20th century stating "it keeps our factories running—as well as the telecommunications industry, the appliances in our homes, and the lifesaving equipment in our hospitals."[1] The interconnection power system is remarkably complex as it integrates thousands of individual devices each of which has dozens to thousands of components—from large power plants to circuit breakers and circuit disconnects.

1. See www.greatachievements.org.

The electric power system is a "unitary" system—the load, generation and delivery systems must all be in balance at all times. The load and generation must obviously be in balance otherwise the generation would speed up or slow down from the 60 Hz standard frequency. There must also be enough transmission and distribution capacity available for the generation to be delivered to the load.

In this context it is interesting to compare the costs of these different parts of the utility system. On a national basis, generation typically is about 67% of the total cost of electricity, distribution is about 26%, and transmission is about 7%.[2] As will be discussed below, the transmission system is what establishes the market size and can often limit operation of the most economic generating units. In this way the transmission system—representing 7% of the cost—can have a significant impact on the cost of generation—representing 67% of the cost. This means that transmission system has a highly leveraged impact on the total cost of electricity.

In today's utility environment there are a number of generation supply markets. Regardless of the political boundaries of these markets, it is the electric system that defines the technical electrical boundaries. The lack of transmission at a market's boundaries is what limits the free exchange of power between market areas.[3] Some obvious examples include the limited interconnections between ERCOT and SPP, or between ISO-NE and NYISO. There are other famous boundaries that limit power flow into southern California from Arizona and into the Washington–New York City corridor. These were highlighted in the *National Electric Transmission Congestion Study*.[4]

Within a market area it is the transmission system that allows the free exchange of energy, limits market power by including more suppliers within the geographic area, reduces the installed generating capacity required, increases load and generation diversity, and makes possible considerable flexibility in system operation.

3 The relationship of natural gas use and supply price

Economic theory predicts that a decrease in the use of natural gas will lead to an inward shift in the natural gas demand curve, leading to a reduction in natural gas

2. US Energy Information Administration, *Annual Energy Outlook 2009*, updated reference case, Table A8—data for 2007 (tinyurl.com/2007-Electric-Price-components).
3. It also common to find transmission limitations within a market that will result in transmission congestion.
4. U.S. Department of Energy, *National Electric Transmission Congestion Study*, August 2006.

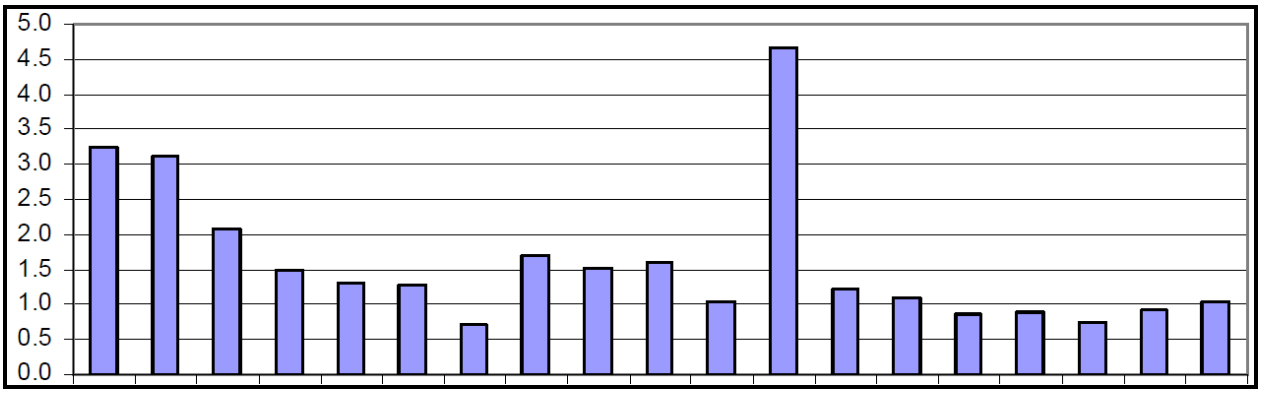
prices. Such reductions benefit consumers by reducing fuel costs to electric generators and by reducing the price of natural gas for direct use in the residential, commercial, industrial, and transportation sectors. The magnitude of the price reduction will vary based on the amount of reduced use of natural gas and the shape of the natural gas supply curve (measured by the inverse price elasticity of natural gas supply).

While there have been many studies of the price elasticity of natural gas—the response of users to changes in gas prices, there have been a smaller number of studies of the supplier's inverse price elasticity of natural gas—the response of supplier prices to changes in demand. Perhaps the most significant of these is a 2005 study by Lawrence Berkeley National Labs.[5] This report focused on the results of 19 studies:

- Seven studies by the Energy Information Administration focused on national renewable portfolio standards (RPS) policies, two of which model multiple RPS scenarios;
- Nine by the Union of Concerned Scientists that studied national RPS policies, three were multiple RPS scenarios, and one also included aggressive energy efficiency investments; and
- Three by the Tellus Institute that evaluated three different standards of a state-level RPS in Rhode Island (combined with RPS policies in Massachusetts and Connecticut).

The inverse elasticity results for these 19 studies are shown in Figure 1.

Figure 1: Range of long-term inverse elasticity results from 19 studies



5. Ryan Wiser, Mark Bolinger, Matt St. Clair, *Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency*, January 2005.

The Lawrence Berkeley National Labs study found that there was reasonable consistency in the average long-term inverse elasticities. While the overall range is between 0.7 and 4.7, the study deemphasized some of the 'outliers' and focused on the elasticities from 13 of 19 analyses falling between 0.8 and 2.0.[6] The highest and lowest study results would mean price reductions from 0.7% to 4.7% for each 1% drop in demand.

We chose to exclude the highest 4 and the lowest 4 cases shown in Figure 1—so the inverse elasticity range is between 0.9 and 1.7. The average inverse elasticity for these 11 studies is 1.2.

While the 2005 Lawrence Berkeley National Labs study is focused on the impact of renewable energy and energy efficiency, the authors made it clear that "these effects are not strictly limited to renewable energy and energy efficiency investments: any non-natural-gas resource that displaces gas use is expected to provide similar consumer benefits."[7]

For this analysis we have assumed an average inverse elasticity for natural gas supply of 1.2.

4 The impact of Priority Projects on SPP gas use

4.1 The two groups of Priority Projects

Staff presented the results of the initial Priority Projects in 2009. They were directed to perform additional analysis on a group of six projects. These projects were referred to as Group 1 and are listed here and shown in Figure 2:

1. Spearville – Comanche – Medicine Lodge – Wichita (765 kV construction and 345 kV operation);
2. Comanche – Woodward District EHV (765 kV construction and 345 kV operation);
3. Hitchland – Woodward District EHV (345 kV DCT1);
4. Valiant – NW Texarkana (345 kV);

6. This would mean that each 1% reduction in national, natural gas demand is expected to lead to a 0.8% to 2% reduction in wellhead gas prices.
7. Testimony Prepared for a Hearing on Power Generation Resource Incentives & Diversity Standards California Senate Committee on Energy and Natural Resources Tuesday, March 8, 2005, 2:30 PM, Dr. Ryan Wiser, Scientist, Lawrence Berkeley National Laboratory, page 5.

5. Nebraska City – Maryville – Sibley (345kV); and
6. Riverside – Tulsa Reactor (138 kV).

The staff was also requested to study an alternative where 345 kV double-circuits are substituted for the 765 kV lines in Group 1. This is referred to as Group 2 listed here and shown in Figure 3:

1. Spearville – Comanche – Medicine Lodge – Wichita (2 x 345 kV);
2. Comanche – Woodward District EHV (2 x 345 kV);
3. Hitchland – Woodward District EHV (2 x 345 kV);
4. Valiant – NW Texarkana (345 kV);
5. Nebraska City– Maryville – Sibley (345 kV); and
6. Riverside – Tulsa Reactor (138 kV).

Figure 2: Group 1 Priority Projects

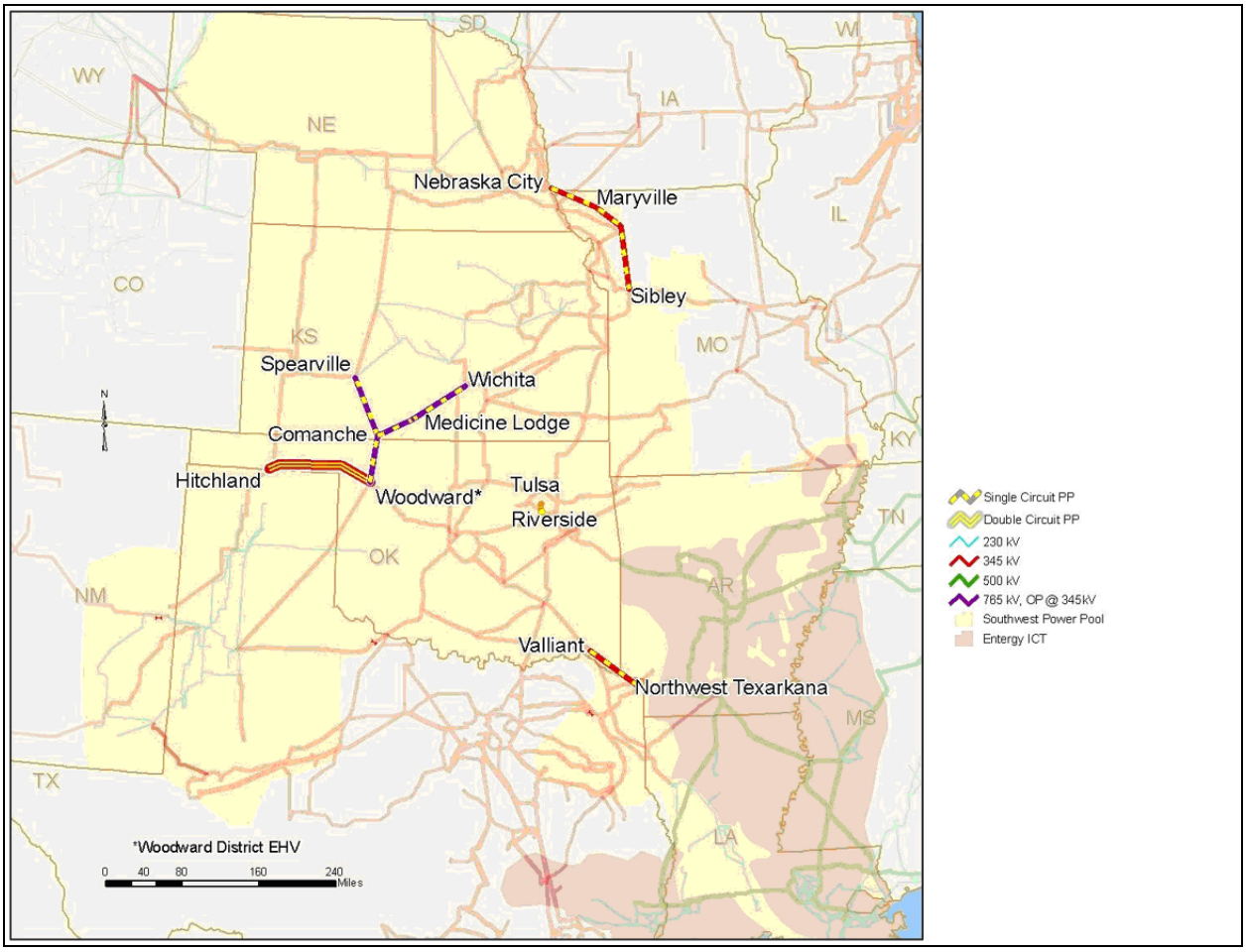
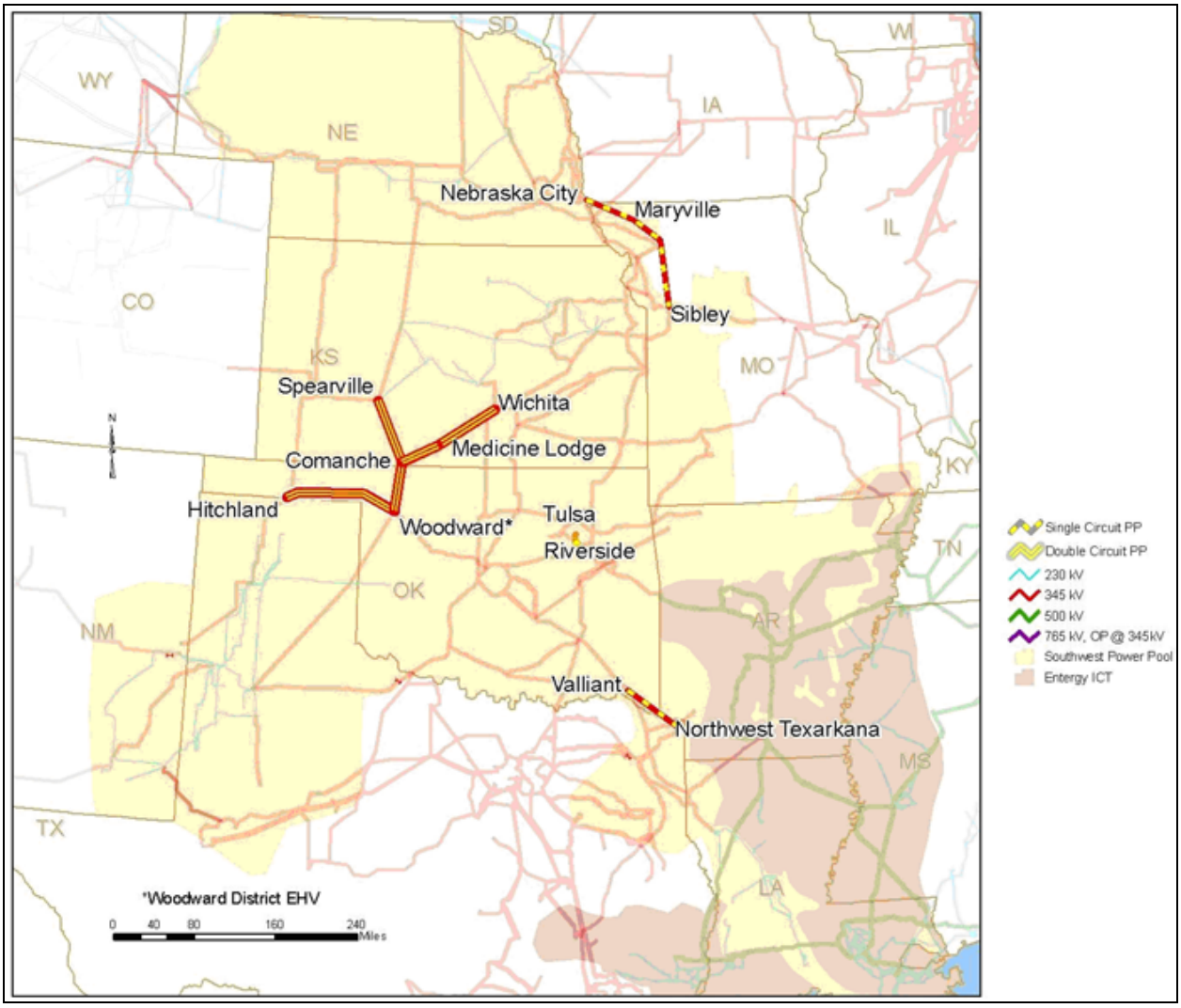


Figure 3: Group 2 Priority Projects



4.2 SPP production-cost analyses

SPP staff has made a series of computer simulations of the SPP system. These simulations estimated the operation and productions costs of the generation located within the SPP footprint. The simulation reports the performance of each generating unit in the system including the electrical output (MWh) and thermal input (MMbtu). In total 18 simulations were made—for three years (2009, 2014 and 2019), two levels of wind penetration (7 GW and 11 GW), and for three transmission topologies (existing system, adding Group 1 Priority Projects, and adding Group 2 Priority Projects).

The results for gas-fueled generators from the production-cost simulations are shown in Table 1. With 7 GW of wind generation the savings in natural gas consumption are slightly more than 5%. With 11 GW of wind the savings are nearly 8%.

Table 1: Production-cost simulation changes for Group 1 and 2 Priority Projects

	2009		2014		2019	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
7 GW wind						
Gas MWh	-5.03%	-5.09%	-5.63%	-5.74%	-4.64%	-4.66%
Gas MMbtu	-4.98%	-5.04%	-5.58%	-5.71%	-4.68%	-4.72%
2009-2019 average					-5.08%	-5.15%
11 GW wind						
Gas MWh	-7.77%	-7.97%	-8.01%	-8.41%	-7.12%	-7.45%
Gas MMbtu	-7.73%	-7.90%	-8.00%	-8.42%	-7.24%	-7.58%
2009-2019 average					-7.66%	-7.97%
Note: The production cost changes are with respect to the base transmission plan for each year.						

Additional detail of the production-cost simulation results are shown in Table 5 at the end of this document. This table shows the electricity production (MWh) and the fuel use (MMbtu) for each type of generation. Of particular interest to this report are the top five sections reporting the results for natural gas generation. The results from these five sections are the source for the data in Table 1, above.

5 Changes in natural gas costs due to Priority Projects

The change in natural gas prices due to the Priority Projects is calculated from three variables:

1. The inverse supply price elasticity (§3, above),
2. The change in use by SPP (see Table 1, above), and
3. The use of natural gas by SPP compared to the nation (discussed here).

The natural gas consumption by end use for 2004-2008 is shown in Table 2. The table lists the total gas use for the nation, total electric use for the nation, and the gas use for electricity by the states in the SPP area plus that of SWPS. The table shows that

27.64% of the natural gas consumed in the US is used to produce electricity and that 1.81% of the nation's use is to produce electricity in the SPP.

Table 2: Natural gas consumption by end use (Mcf)

	2004	2005	2006	2007	2008	Average
U.S. total[8]	22,388,975	22,010,596	21,684,641	23,097,140	23,226,612	22,481,593
U.S. Electricity	5,463,763	5,869,145	6,222,100	6,841,408	6,668,379	6,212,959
% electric	24.40%	26.67%	28.69%	29.62%	28.71%	27.64%
SPP use for electricity[9]						
Arkansas	40,138	48,987	71,056	63,594	64,188	
Kansas	10,474	14,105	22,477	25,560	26,640	
Louisiana	245,361	285,022	195,927	224,419	236,543	
Missouri	24,574	31,831	32,480	41,067	43,009	
10%	2,457	3,183	3,248	4,107	4,301	
Nebraska	3,340	8,066	7,787	10,908	7,230	
Oklahoma	199,907	242,178	278,602	286,686	282,942	
SWPS TX-NM	89,172	110,355	128,745	134,993	132,457	
SPP total	305,350	377,887	440,859	462,253	453,570	407,984
% electric of USA	1.36%	1.72%	2.03%	2.00%	1.95%	**1.81%**

Most of the data in Table 2 is directly from the US DOE database. Since only a small portion of the Missouri generation is in the SPP footprint, we assumed that less than 10% of the state's use would be included. While the amounts for Arkansas and Louisiana are shown they were not included in the totals since electric generation from gas units in both states is less than 1% of the SPP total. It was also necessary to estimate the use by SWPS-TX-NM. The production-cost simulations showed that SWPS used just under 30% of the SPP's total gas as shown in Table 3. This was used to estimate the SWPS gas use in Table 2.[10]

8. Source for national data: http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_a_EPG0_VC0_mmcf_a.htm
9. Source for SPP state data: http://tonto.eia.doe.gov/dnav/ng/ng_sum_lsum_a_EPG0_veu_mmcf_a.htm
10. The calculation is (the sum of the other states {KS, MO, NE, OK}) x 0.2920 ÷ (1 – 0.2920)

Table 3: SWPS share of total natural gas from computer simulation

	MMbtu
SWPS CC	28,339,825
SWPS CT-gas	12,563,041
SWPS St-gas	21,130,504
SWPS gas	62,033,370
Total gas	212,420,030
SWPS share	29.20%

The impact on natural gas prices due to changes in natural gas use is shown in Table 4. The calculations shown in Table 4 mean that:

With 7 GW of wind generation

- Group 1 Priority Projects will reduce gas use by 5.08%
- Group 2 Priority Projects will reduce gas use by 5.15%

With 11 GW of wind generation

- Group 1 Priority Projects will reduce gas use by 7.66%
- Group 2 Priority Projects will reduce gas use by 7.97%

Table 4: Impact of the Priority Projects on SPP natural gas prices

		Δ by Group		
		1	2	Notes
7 GW wind				
1	Δ gas MMbtu	-5.08%	-5.15%	See Table 4
2	Inverse price elasticity of supply	1.2	1.2	See Figure 1 and the discussion at the end of §3
3	SPP share of nation gas use	1.81%	1.81%	See Table 2
4	SPP-only price impact	-0.111%	-0.112%	Product of lines 1, 2 and 3
5	Inverse price elasticity of supply	1.2	1.2	Same as line 2
6	US electric share of national gas use	27.64%	27.64%	See Table 2
7	US price impact	-1.69%	-1.71%	Product of lines 1, 5 and 6
11 GW wind				
8	Δ gas MMbtu	-7.66%	-7.97%	See Table 4
9	Inverse price elasticity of supply	1.2	1.2	See Figure 1 and the discussion at the end of §3
10	SPP share of nation gas use	1.81%	1.81%	See Table 2
11	SPP-only price impact	-0.167%	-0.173%	Product of lines 8, 9 and 10
12	Inverse price elasticity of supply	1.2	1.2	Same as line 9
13	US electric share of national gas use	27.64%	27.64%	See Table 2
14	US price	-2.54%	-2.64%	Product of lines 8, 12 and 13

The price impact is the product of: 1) The inverse supply price elasticity, 2) The change in use by SPP, and 3) The SPP natural gas share of the nation. These calculations are shown in Table 4. To demonstrate the calculations consider the case with 7 GW of wind and the Group 1 transmission additions and the US price impact:

- The inverse supply price elasticity from Figure 1 and the discussion at the end of §3 — 1.2
- The change is gas MMbtu from Table 4 — -5.08%
- The electricity from supply natural gas share of the nation Table 2 — 27.64%
- The resulting price impact is the product — 1.69%

If other regions of the nation make similar improvements to their transmission systems as the SPP the price reduction of natural gas will be about 1.7% for the 7 GW cases and 2.6% for the 11 GW cases.[11] There are a number of states that have adopted mandates for renewable energy penetration. Most have adopted a goal of 20% renewable generation by 2020. It is, thus, almost certain that most other areas of the nation will make transmission system improvements to accommodate the increased amounts of wind and other renewable generation.

11. If the SPP were the only system to make these types of transmission changes the impact on natural gas prices would be much smaller—about 0.11% for the 7 GW cases and 0.17% for the 11 GW cases. In either case, the reduced price of natural gas will affect all users of natural gas in all areas of the country.

Table 5: Annual computer simulation results summary

	7GW wind									11 GW wind								
	2009			2014			2019			2009			2014			2019		
	Base	Group 1	Group 2	Base	Group 1	Group 2	Base	Group 1	Group 2	Base	Group 1	Group 2	Base	Group 1	Group 2	Base	Group 1	Group 2
CC (gas)																		
MWh	20,248,338	19,242,451	19,264,221	25,686,605	24,165,043	24,187,352	34,064,155	32,488,204	32,514,295	19,876,947	18,319,570	18,288,124	25,118,802	23,035,957	22,982,671	33,310,968	31,005,180	30,946,136
MMbtu	148,464,262	141,089,379	141,274,033	188,975,639	177,593,565	177,806,844	251,512,708	239,677,463	239,898,966	145,803,872	134,350,961	134,152,141	184,905,690	169,312,105	168,977,942	246,138,568	228,795,038	228,428,557
CT-gas																		
MWh	2,314,055	2,290,825	2,303,428	2,851,806	2,720,201	2,713,613	3,983,788	3,825,506	3,815,815	2,252,294	2,262,941	2,280,835	2,745,547	2,612,278	2,606,417	3,822,401	3,666,242	3,648,672
MMbtu	21,172,422	21,019,828	21,192,094	27,375,479	26,165,134	26,137,083	40,230,759	38,600,440	38,531,576	20,610,024	20,797,133	21,015,499	26,295,499	25,035,349	25,020,285	38,546,891	36,918,782	36,766,113
ST-gas																		
MWh	4,206,807	3,889,243	3,839,180	6,283,108	5,976,559	5,920,701	9,286,415	8,826,353	8,797,607	4,018,700	3,532,629	3,495,864	5,914,556	5,426,466	5,348,850	8,792,288	7,984,112	7,911,479
MMbtu	42,783,346	39,728,322	39,245,604	64,137,552	61,073,905	60,534,118	95,032,806	90,386,951	90,106,636	40,905,118	36,141,725	35,778,477	60,413,896	55,547,646	54,743,279	90,032,556	81,881,679	81,118,595
Subtotal gas																		
MWh	**26,769,200**	**25,422,520**	**25,406,829**	**34,821,519**	**32,861,803**	**32,821,665**	**47,334,358**	**45,140,063**	**45,127,717**	**26,147,941**	**24,115,140**	**24,064,823**	**33,778,904**	**31,074,701**	**30,937,938**	**45,925,657**	**42,655,534**	**42,506,287**
MMbtu	**212,420,030**	**201,837,529**	**201,711,731**	**280,488,670**	**264,832,604**	**264,478,045**	**386,776,274**	**368,664,853**	**368,537,178**	**207,319,014**	**191,289,819**	**190,946,117**	**271,615,085**	**249,895,100**	**248,741,506**	**374,718,015**	**347,595,498**	**346,313,264**
Δ Gas																		
MWh	**0**	**-1,346,680**	**-1,362,370**	**0**	**-1,959,716**	**-1,999,853**	**0**	**-2,194,295**	**-2,206,641**	**0**	**-2,032,801**	**-2,083,118**	**0**	**-2,704,203**	**-2,840,966**	**0**	**-3,270,123**	**-3,419,369**
		-5.03%	**-5.09%**		**-5.63%**	**-5.74%**		**-4.64%**	**-4.66%**		**-7.77%**	**-7.97%**		**-8.01%**	**-8.41%**		**-7.12%**	**-7.45%**
MMbtu	**0**	**-10,582,501**	**-10,708,299**	**0**	**-15,656,065**	**-16,010,625**	**0**	**-18,111,421**	**-18,239,096**	**0**	**-16,029,195**	**-16,372,897**	**0**	**-21,719,985**	**-22,873,578**	**0**	**-27,122,517**	**-28,404,751**
		-4.98%	**-5.04%**		**-5.58%**	**-5.71%**		**-4.68%**	**-4.72%**		**-7.73%**	**-7.90%**		**-8.00%**	**-8.42%**		**-7.24%**	**-7.58%**
11-yr average								**-5.08%**	**-5.15%**								**-7.66%**	**-7.97%**
CT gen																		
MWh	42,900	42,783	42,389	143,628	136,668	135,265	340,339	320,937	321,448	42,554	43,277	42,696	141,888	133,099	128,667	339,257	313,762	308,872
MMbtu	443,289	441,697	437,154	1,482,550	1,409,938	1,395,900	3,510,271	3,306,484	3,312,715	439,409	446,525	440,494	1,464,562	1,374,325	1,330,719	3,498,160	3,233,912	3,186,603
CT-oil																		
MWh	8,661	8,676	8,860	177,048	160,359	158,806	396,083	355,940	353,853	8,349	8,421	8,422	175,126	159,732	157,718	387,016	349,820	344,327
MMbtu	96,911	96,978	99,510	2,384,000	2,153,129	2,131,810	5,255,002	4,712,844	4,685,651	92,678	93,569	93,599	2,358,973	2,145,740	2,117,794	5,136,520	4,637,955	4,564,375
ST-coal																		
MWh	165,398,689	167,185,470	167,305,133	163,999,019	165,569,391	165,652,027	167,721,729	169,013,079	169,044,217	161,096,123	161,493,976	161,504,722	159,050,214	158,141,942	157,939,975	163,395,387	162,605,765	162,439,586
MMbtu	1749912657	1638824125	1638567196	1734648113	1751868495	1752772410	1774916478	1788872631	1789177487	1704395406	1709286927	278,767,655	1682127043	1535889736	1533940299	1590324766	1582576424	1719381181
ST-nuclear																		
MWh	18,837,055	18,837,055	18,837,055	18,963,127	18,963,127	18,963,127	21,300,351	21,300,351	21,300,351	18,837,055	18,837,055	18,837,055	18,963,127	18,963,127	18,963,127	21,300,351	21,300,351	21,300,351
MMbtu	197,974,883	197,974,883	197,974,883	199,192,409	199,192,409	199,192,409	223,743,648	223,743,648	223,743,648	197,974,883	197,974,883	197,974,883	199,192,409	199,192,409	199,192,409	223,743,648	223,743,648	223,743,648
Total																		
MWh	**211,056,505**	**211,496,505**	**211,600,267**	**218,104,341**	**217,691,349**	**217,730,890**	**237,092,859**	**236,130,369**	**236,147,585**	**206,132,022**	**204,497,869**	**204,457,718**	**212,109,260**	**208,472,601**	**208,127,426**	**231,347,667**	**227,225,231**	**226,899,423**
MMbtu	**410,935,113**	**400,351,086**	**400,223,277**	**483,547,628**	**467,588,080**	**467,198,165**	**619,285,194**	**600,427,828**	**600,279,191**	**405,825,984**	**389,804,795**	**389,455,092**	**474,631,028**	**452,607,574**	**451,382,428**	**607,096,343**	**579,211,013**	**577,807,890**
Δ Total																		
MWh	**0**	**440,000**	**543,762**	**0**	**-412,992**	**-373,451**	**0**	**-962,490**	**-945,274**	**0**	**-1,634,153**	**-1,674,305**	**0**	**-3,636,658**	**-3,981,834**	**0**	**-4,122,435**	**-4,448,243**
		0.21%	**0.26%**		**-0.19%**	**-0.17%**		**-0.41%**	**-0.40%**		**-0.79%**	**-0.81%**		**-1.71%**	**-1.88%**		**-1.78%**	**-1.92%**
MMbtu	**0**	**-10,584,027**	**-10,711,836**	**0**	**-15,959,548**	**-16,349,464**	**0**	**-18,857,366**	**-19,006,003**	**0**	**-16,021,188**	**-16,370,891**	**68,805,044**	**-22,023,455**	**-23,248,600**	**201,270,359**	**-27,885,329**	**-29,288,453**
		-2.58%	**-2.61%**		**-3.30%**	**-3.38%**		**-3.05%**	**-3.07%**		**-3.95%**	**-4.03%**		**-4.64%**	**-4.90%**		**-4.59%**	**-4.82%**