July 2012

The Economic Impact of the Kansas Renewable Portfolio Standard

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Executive Summary

In May 2009 Kansas Gov. Mark Parkinson signed several statutes into law (first proposed by his predecessor, Gov. Kathleen Sebelius) that defined a new Renewable Portfolio Standard (RPS) and a timetable for implementation.[1] The legislation transformed a previously voluntary goal into a mandate. The following year, the Kansas Corporation Commission submitted the rules and regulations that would dictate the administration of this RPS.[2] The standard requires that at least 10 percent of electricity generation capacity in Kansas come from renewable sources between 2011 and 2015. Between 2016 and 2019, a 15 percent share of generation capacity must derive from renewable sources, and from 2020 onwards no less than 20 percent of generation capacity must come from renewable sources.

The Beacon Hill Institute has applied its STAMP® (State Tax Analysis Modeling Program) to estimate the economic effects of these RPS mandates. The U.S. Energy Information Administration (EIA), a division of the Department of Energy, provides optimistic estimates of renewable electricity costs and capacity factors. This study bases our estimates on EIA projections, but we also provide three estimates of the cost of Kansas's RPS mandates – low, average and high – using different cost and capacity factor estimates for electricity-generating technologies from other academic literature. Our major findings show:

- The Kansas RPS law will raise the cost of electricity by $644 million for the state's consumers through 2020, within a range of $192 million and $1.042 billion
- Kansas' electricity prices will rise 45 percent by 2020, due to the RPS law
- These increased energy prices will hurt Kansas' households and businesses and, in turn, inflict significant harm on the state economy. In 2020, the RPS will:
- Lower employment by an average of 12,110 jobs, within a range of 3,615 jobs and 19,609 jobs
- Reduce real disposable income by $1.483 billion, within a range of $443 million and $2.402 billion
- Decrease investment by $191 million, within a range of $57 million and $310 million
- Increase the average household electricity bill by $660 per year; commercial businesses by an average of $3,915 per year; and industrial businesses by an average of $25,516 per year.

Introduction

Combined with fluctuations in fossil fuel prices, efforts to promote alternative energy sources have motivated many state governments to respond with public policy initiatives designed to encourage their use.

In May 2009, new Kansas Gov. Mark Parkinson signed legislation for a Renewable Portfolio Standard (RPS) for the state of Kansas.[3] The following year the Kansas Corporation Commission (KCC) detailed the rules and regulations that would govern the RPS.[4] This was an extension of a previous voluntary RPS goal for the state. Combined, these laws require that renewable power must provide a minimum amount of Kansas's electricity generation capacity. From 2011 to 2015, at least 10 percent of generation must be renewable. This amount increases to 15 percent between 2016 and 2019. The RPS tops out at 20 percent in 2020 and maintains that requirement into the future.

The Kansas law is different from many other states' statutes in that the percentage is based upon generation capacity, as opposed to the share of total retail electric sales. A wide range of renewable production technologies are allowed, including wind, solar, landfill gas, current hydropower, new hydropower that is less than 10 megawatts (MW), and a variety of biomass. Additionally, each MW capacity installed after January 1, 2000 counts as 1.1 MWs. There is also a penalty clause in the law: Utilities that do not comply with the RPS regulation will be assessed a penalty equal to double the value of Renewable Energy Credits (RECs) for that year.

Another component of the law – the banking of unused Renewable Energy Credits (RECs) – could help defray costs. RECs are tradable commodities that are certified to represent a unit of production of green energy. The majority of RECs in the US are denominated in megawatt hours (MWh), the typical measurement for most RPSs,

1 Kansas Legislature Statutes. 66-1256 through 66-1262. Internet, available at http://www.kslegislature.org/li/b2011_12/statute/066_000_0000_chapter/066_012_0000_article/066_012_0056_section/066_012_0056_k/.

2 Kansas Register. Christ Biggs, Secretary of State. Vol. 29, No. 44. November 4, 2010. Internet, available at http://www.kssos.org/pubs/register%5C2010%5CVol_29_No_44_November_4_2010_p_1577-1616.pdf.

3 Kansas Legislature Statutes. 66-1256 through 66-1262. Internet, available at http://www.kslegislature.org/li/b2011_12/statute/066_000_0000_chapter/066_012_0000_article/066_012_0056_section/066_012_0056_k/.

4 Kansas Register. Christ Biggs, Secretary of State. Vol. 29, No. 44. November 4, 2010. Internet, available at http://www.kssos.org/pubs/register%5C2010%5CVol_29_No_44_November_4_2010_p_1577-1616.pdf.

meaning the market may be smaller for Kansas utilities. These commodities can be bought and sold between utilities and other producers, or held onto for future years to offset RPS standards.

By producing more green energy than required by the Act, energy suppliers could bank credits to reduce future requirements. However, the Energy Information Administration (EIA) projections made prior to the law's enactment show a baseline scenario in which renewable electricity generation will fall below RPS minimums.[5] Therefore, we think it is unlikely that producers will supply enough renewable energy to trigger significant banking. All green energy produced will go towards the requirement that year, not banked for future consumption. For this reason, we assume that they will have no effect on overall price of production.

Since renewable energy generally costs more than conventional energy, many have voiced concerns about higher electric rates. A wide variety of cost estimates exists for renewable electricity sources. The EIA provides estimates for the cost of conventional and renewable electricity generating technologies. However, the EIA's assumptions are optimistic regarding the cost and capacity of renewable electricity generating sources to produce reliable energy.

A review of the literature shows that in most cases the EIA's projected costs can be found at the low end of the range of estimates, while the EIA's capacity factor for wind to be at the high end of the range. The EIA does not take into account the actual experience of existing renewable electricity power plants. Therefore, we provide three estimates of the cost of Kansas's RPS mandate: low, average and high, using different cost and capacity factor estimates for electricity-generating technologies from the academic literature. The difference between the low and high estimates is larger than expected. This is mainly because EIA projections of renewable capacity in Kansas suggest a heavy reliance on wind power, which has varying estimates of future costs and capacity factors.

One could perhaps justify the higher electricity costs if the environmental benefits – in terms of reduced greenhouse gases (GHG) and other emissions – outweighed the costs. However, it is unclear that the use of renewable energy resources – especially wind and solar – significantly reduces GHG emissions. Due to their intermittency, wind and solar require significant backup power sources that are cycled up and down to accommodate the variability in the production of wind and solar power. A recent study found that wind power actually increases pollution and GHG emissions.[6] Thus, there appear to be few benefits to implementing RPS policies based on heavy uses of wind generation.

Governments enact RPS policies because most sources of renewable electricity generation are less efficient and thus more costly than conventional sources of generation and renewable energy would not become a major source of electricity without a government mandate. The RPS mandate forces utilities to buy electricity from renewable sources and thus guarantees a market for them. These higher costs are passed on to electricity consumers, including residential, commercial and industrial customers.

Increases in electricity costs are known to have a profound negative effect on the economy – not unlike taxes – as prosperity and economic growth are dependent upon access to reliable and affordable energy. Since electricity is an essential commodity, consumers will have limited opportunity to avoid these costs. For the poorest members of society, these energy 'taxes' will compete directly with essential purchases in the household budget, such as food, transportation and shelter.

The Beacon Hill Institute at Suffolk University (BHI) estimates the costs of this RPS law and its impact on the state's economy. To that end, BHI applied its STAMP® (State Tax Analysis Modeling Program) to estimate the economic effects of the state RPS mandate.[7]

Estimates and Results

In light of the wide divergence in the costs and capacity factor estimates available for the different electricity generation technologies, we provide three estimates of the effects of Kansas's RPS mandate using low, average and high cost estimates of both renewable and conventional generation technologies. Each estimate represents the

Table 1: Cost of RPS Mandate in Kansas *(2012 $)*

Costs Estimates	Low	Ave.	High
Total Net Cost in 2020 *($ millions)*	192	644	1,042
Total Net Cost 2012-20 *($ millions)*	739	2,436	3,932
Electricity Price Increase in 2020 *(cents per kWh)*	1.51	5.07	8.20
Percentage Increase (%)	13	45	72
Economic Indicators	**Low**	**Ave.**	**High**
Total Employment *(jobs)*	(3,615)	(12,110)	(19,609)
Investment *($ millions)*	(57)	(191)	(310)
Real Disposable Income *($ millions)*	(443)	(1,483)	(2,402)

5 U.S. Department of Energy, Energy Information Administration, State Renewable Electricity 2007, *Table 5: State Renewable Electric Power Industry New Generation, by Energy Source, 2003-2007,* ftp://ftp.eia.doe.gov/renewables/srp2007.pdf.

6 See "How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market," Bentek Energy, LLC. (Evergreen Colorado: May 2010).

7 Detailed information about the STAMP® model can at http://www.beaconhill.org/STAMP_Web_Brochure/STAMP_HowSTAMPworks.html.

change that will take place in the indicated variable against the counterfactual assumption, or baseline, that the RPS mandate would not be implemented; the Appendix contains details of our methodology. Table 1 displays the cost estimates and economic impact of the current RPS mandate through 2020, compared to a baseline.

The current RPS will impose costs of $644 million through 2020, within a range of $192 million and $1.042 billion. As a result, the RPS mandate would increase electricity prices by 5.07 cents per kilowatt hour (kWh) or by 45 percent, within a range of 1.51 cents per kWh, or by 13 percent, and 8.20 cents per kWh, or by 72 percent.[8]

The STAMP model simulation indicates that, upon full implementation, the electricity price increases due to the RPS law will negatively affect the Kansas economy. The state's ratepayers will face higher electricity prices that will increase their costs, which will in turn put downward pressure on household and business income. By 2020 the Kansas economy will realize 12,110 fewer jobs, within a range of 3,615 and 19,609 fewer jobs, than they would if there was no RPS mandate.

The job losses and price increases will reduce real incomes as firms, households and governments spend more of their budgets on electricity and less on other items, such as home goods and services. By 2020 real disposable income will fall by an average of $1.483 billion, between $443 million and $2.402 billion under the low and high cost scenarios respectively. Furthermore, net investment will fall by $191 million, within a range of $57 million and $310 million.

Table 2 shows how the RPS mandate affects the annual electricity bills of households and businesses in Kansas. In 2020, renewable energy mandates will cost families an average of $660 per year; commercial businesses will spend an extra $3,915 per year; and industrial businesses will spend an extra $25,516 per year. Between 2012 and 2020, the average residential consumer can expect to pay $2,471 more for electricity. A commercial ratepayer would pay $14,663 more during the period, and the typical industrial user would pay $95,560 more.

Table 2: Annual Effects of RPS on Electricity Ratepayers *(2012 $)*

Cost in 2020	**Low**	**Ave.**	**High**
Residential Ratepayer *($ millions)*	197	660	1,069
Commercial Ratepayer *($ millions)*	1,169	3,915	6,340
Industrial Ratepayer *($ millions)*	7,616	25,516	41,316
Total over period (2012-20)	**Low**	**Ave.**	**High**
Residential Ratepayer *($ millions)*	750	2,471	3,989
Commercial Ratepayer *($ millions)*	4,450	14,663	23,669
Industrial Ratepayer *($ millions)*	28,998	95,560	154,253

Conclusion

Kansas has enacted a series of laws that implement RPS mandates based on the idea of promoting green energy policies. In reality these mandates are mere handouts to politically-favored industries. Equally problematic is the lack of transparency between cost and benefit. Not funded directly by higher taxes or debt, the RPS hides its costs in the higher prices to be paid in the future by electricity ratepayers.

The paradigm driving renewable energy found in most RPS mandates is flawed. The typical RPS mandate promotes only certain forms of renewable energy, which are very costly. While Kansas does hold a comparative advantage in wind power due to its location, there is still a very high cost associated with it relative to conventional energy, thereby raising electricity prices for consumers and businesses in Kansas. The cost difference between electricity generated from wind and natural gas is likely to widen further due to the recent slump in natural gas prices.

Supporters of the Kansas RPS use a hidden tax approach that fails to undertake any reasonable cost benefit analysis. The Kansas RPS puts the state's competitiveness further at risk. Kansas electricity ratepayers will pay higher rates, face fewer employment opportunities and watch capital investment flee to other states with more favorable business climates, resulting in net negative effects on the state.

Firms with high electricity usage will be incentivized to move their production, and emissions, out of Kansas to locations with lower electricity prices. Therefore, the Kansas renewable energy mandate will not reduce global emissions, but rather send jobs and capital investment outside the state.

[8] Based on a price of 11.67 cents per kWh for 2020 from the U.S. Department of Energy, Energy Information Agency, Annual Energy Outlook 2011, Table 8. Retail Sales, Revenue, and average Retail Price by Sector, 1990 through 2010. http://www.eia.gov/electricity/state/kansas/. Projections into the future based historical trends.

Electricity Generation Costs

As noted above, governments enact RPS policies because most sources of renewable electricity generation are less efficient and thus more costly than conventional sources of generation. Most people would not choose to pay a higher price, so in order to prop up these industries (which likely would fail without taxpayer subsidies) governments enact renewable energy mandates to force utilities to buy electricity from renewable sources and thus guarantee a market for the renewable sources. These higher costs are passed to electricity consumers, including residential, commercial and industrial customers.

Table 3: Levelized Cost of Electricity from Conventional and Renewable Sources ***(2009 $)***

Plant Type	Year	Capacity Factor	Levelized Capital Costs	Fixed Operations/ Maintenance	Variable O&M (with fuel)	Transmission Investment	Total Levelized Cost
Advanced Coal	2016	0.85	65.3	3.9	24.3	1.2	94.8
	2020		75.84	7.9	25.1	1.2	110.0
	2035		55.4	7.9	25.4	1.19	89.8
Gas	2016	0.87	17.5	1.9	45.6	1.2	66.1
	2020		18.4	1.89	46.7	1.2	68.2
	2035		13.5	1.89	59.0	1.2	75.5
Nuclear	2016	0.9	90.1	11.1	11.7	1	113.9
	2020		89.1	11.1	12.3	1	113.5
	2035		62.3	11.1	14.3	1	88.7
Wind	2016	0.386	83.9	9.6	0	3.5	97.0
	2020		86.4	9.5	0	3.4	99.2
	2035		71.4	9.9	0	3.6	84.9
Solar PV	2016	0.217	194.6	12.1	0	4	210.7
	2025						142.0
	2035						98.0
Biomass	2016	0.83	55.3	13.7	42.3	1.3	112.5
	2025						88.0
	2035						69.0
Hydro	2016	0.514	74.5	3.8	6.3	1.9	86.4
	2025						69.0
	2035						55.0

The EIA estimates the Levelized Energy Cost (LEC), or financial breakeven cost per MWh, to produce new electricity in its *Annual Energy Outlook*.[9] The EIA provides LEC estimates for conventional and renewable electricity technologies (coal, nuclear, geothermal, landfill gas, solar photovoltaic, wind and biomass) assuming the new sources enter service in 2016. The EIA also provides LEC estimates for conventional coal, combined cycle gas, advanced nuclear and onshore wind only, assuming the sources enter service in 2020 and 2035.

While the EIA does not provide LEC for hydroelectric, solar photovoltaic and biomass for 2020 and 2035, it does project overnight capital costs (the capital cost of a project if it could be constructed overnight, excluding the interest cost of funds used during construction) for 2015, 2025 and 2035. We can estimate the LEC for these technologies and years using the percent change in capital costs to extrapolate the 2016 LECs. In its *Annual Energy Outlook*, the EIA incorporates many assumptions about the future price of capital, materials, fossil fuels, maintenance and capacity factor into their forecast. EIA projections in Table 3 show that the LEC for all four electricity sources (coal, gas, nuclear and wind) will fall significantly from 2016 to 2035. The fall in capital costs drives the drop in total system LEC over the period.

Using the EIA change in overnight capital costs for solar and biomass produces reductions in LECs similar to wind from 2016 to 2035. The biomass LEC drops by 38.7 percent and solar by 53.5 percent over the period. These compare to much more modest cost reductions of 5.2 percent for coal, an increase of 14.2 percent for gas, and a drop of 22.1 percent for nuclear over the same period. EIA does provide overnight capital costs for renewable technologies under a "high cost" scenario. However, for each renewable technology the EIA "high cost" scenario projects capital costs to drop between 2015 and 2035.

Table 3 also displays capacity factors for each technology. A capacity factor measures the ratio of electrical energy produced by a generating unit over a period of time to the electrical energy that could have been produced at 100 percent operation during the same period. In this case, the capacity factor measures the potential productivity of the generating technology. Solar, wind and hydroelectricity have the lowest capacity factors due to the intermittent nature of their power sources. EIA projects a 34.4 percent capacity factor for wind power at a national level, but, as explained below, historical data for actual wind farms in Kansas provided us with an average estimate of 38.6 percent.

[9] U.S. Department of Energy, Energy Information Agency, *2016 Levelized Cost of New Generation Resources from the Annual Energy Outlook 2011* (2008/$MWh), http://www.eia.doe.gov/oiaf/aeo/electricity_generation.html, (accessed February, 2012).

Estimating a capacity factor for wind power is particularly challenging. Wind is not only intermittent but its variation is unpredictable, making it impossible to dispatch to the grid with any certainty. This unique aspect of wind power argues for a capacity factor rating of close to zero. Nevertheless, wind capacity factors have been estimated to be between 20 percent and 40 percent.[10] The other variables that affect the capacity factor of wind are the quality and consistency of the wind and the size and technology of the wind turbines deployed. As the U.S. and other countries add more wind power over time, wind turbine technology should improve, but the new locations for power plants (wind farms) will likely have less productive wind resources.

The EIA estimates of LEC and capacity factors paint a particularly rosy view of the future cost of renewable electricity generation, particularly wind. Other forecasters and the experience of current renewable energy projects portray a less sanguine outlook.

Today wind and biomass are the largest renewable power sources and are the most likely to satisfy future RPS mandates, provided that taxpayer subsidies continue. The most prominent issues that will affect the future availability and cost of renewable electricity resources are diminishing marginal returns and competition for scarce resources. These issues will affect wind and biomass in different ways as state RPS mandates ratchet up over the next decade.

Both wind and biomass resources face land use issues. Conventional energy plants can be built within a space of several acres, but a wind power plant with the same nameplate capacity (not actual capacity) would require many square miles of land. The flatlands of Kansas and other central states provide close to ideal opportunities to produce electricity via wind power. After taking into account capacity factors, a wind power plant would need a land mass of 20 by 25 kilometers (roughly 193 square miles) to produce the same energy as a nuclear power plant that can be situated on 500 square meters (roughly .12 acres).[11]

The need for large areas of land to site wind power plants will require the purchase or leasing of vast areas of land by private wind developers, and/or allowing wind production on public lands. In either case, land acquisition/rent or public permitting processes will likely increase costs as wind power plants are built. Offshore wind is vastly more expensive than onshore wind power and suffers from the same type of permitting process faced by onshore wind power plants, as seen in the 10-year permitting process for the planned Cape Wind project off the coast of Massachusetts.

The swift expansion of wind power will also suffer from diminishing marginal returns as new wind capacity will be located in areas with lower and less consistent wind speeds. As a result, fewer megawatt hours of power will be produced from newly built wind projects. Moreover the new wind capacity will be developed in increasingly remote areas that will require larger investments in transmission and distribution, which will drive costs even higher.

The EIA estimates of the average capacity factor used for onshore wind power plants, at 34.4 percent, appears to be at the higher end of the estimates for current wind projects. This figure is inconsistent with estimates from other studies.[12] According to the EIA's own reporting from 137 current wind power plants in 2003, the average capacity factor was 26.9 percent.[13] In addition, a recent analysis of wind capacity factors around the world finds an actual average capacity factor of 21 percent.[14] Moreover, other estimates find capacity factors in the mid-teens and as low as 13 percent.[15]

Kansas is perhaps one of the better locations for wind power. A relatively steady, strong amount of wind leads to wind farms being more productive then the national average. To account for this special case we used more localized capacity factors. We used the high, low and average capacity factor from actual average capacity factors of four wind farms in Kansas.[16]

Biomass is a more promising renewable power source. Biomass combines low incremental costs relative to other renewable technologies and reliability. Biomass is not intermittent and therefore it is distributable with a capacity factor that is competitive with conventional energy sources. Moreover, biomass plants can be located close to urban areas with high electricity demand. But biomass electricity suffers from land use issues even more so than wind.

[10] Renewable Energy Research Laboratory, University of Massachusetts at Amherst, "Wind Power, Capacity Factor and Intermittency: What Happens When the Wind Doesn't Blow?" Community Wind Power Fact Sheet #2a, http://www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_2a_Capacity_Factor.pdf.

[11] "Evidence to the House of Lords Economic Affairs Committee Inquiry into 'The Economics of Renewable Energy'," Memorandum by Dr. Phillip Bratby, May 15, 2008.

[12] Nicolas Boccard, "Capacity Factors for Wind Power: Realized Values vs. Estimates," *Energy Policy* 37, no. 7 (July 2009): 2680.

[13] Cited by Tom Hewson, Energy Venture Analysis, "Testimony for East Haven Windfarm," January 1, 2005, http://www.windaction.org/documents/720 (accessed December 2011).

[14] Boccard.

[15] See "The Capacity Factor of Wind, Lightbucket," http://lightbucket.wordpress.com/2008/03/13/the-capacity-factor-of-wind-power/, (accessed December 2011) and National Wind Watch, FAQ, http://www.wind-watch.org/faq-output.php (accessed December 2011).

[16] Kansas Wind Farm Production and Average Capactiy Factors, January 2002 to September 2008. Based on Energy Information Administration, U.S. DoE and US EIA forms. Internet, available at http://kcc.ks.gov/energy/charts/Wind_KansasWindFarmProductionAverageCapacityFactors.pdf.

The expansion of biomass power plants will require huge additional sources of fuel. Wood and wood waste comprise the largest source of biomass energy today. Other sources of biomass include food crops, grassy and woody plants, residues from agriculture or forestry, oil-rich algae, and the organic components of municipal and industrial wastes.[17] Biomass power plants will compete directly with other sectors (construction, paper, furniture) of the economy for wood and food products as well as arable land.

One study estimates that 66 million acres of land would be required to provide enough fuel to satisfy the current state RPS mandates and a 20 percent federal RPS in 2025.[18] When the clearing of new farm and forestlands are figured into the GHG production of biomass, it is likely that biomass increases GHG emissions.

The competition for farm and forestry resources would not only cause biomass fuel prices to skyrocket, but also cause the prices of domestically-produced food, lumber, furniture and other products to rise. These unintended consequences of government mandates for biofuels are quite large. The lesson is clear: biofuels compete with food production and other basic products, and distort the market.

Calculation of the Net Cost of New Renewable Electricity

To calculate the cost of renewable energy under the RPS, BHI used data from the EIA to determine the percent increase in utility costs that Kansas residents and businesses would experience. This calculated percent change was then applied to calculated elasticities, as described in the STAMP modeling section.

We collected historical data on the total net summer capacity by energy source from 2006 to 2010 and projected its growth through 2025 using historical growth rates.[19] To these totals, we applied the percentage of renewable sales prescribed by the Kansas RPS. By 2020, renewable energy sources must account for 20 percent of total electricity sales in Kansas.

Next we projected the growth in renewable capacity that would have taken place absent the RPS. We used the EIA's state Renewable Electric Power Industry Net Summer Capacity, by Energy Source for 2006 to 2010 for the state of Kansas.[20] As a proxy to grow renewable sources for Kansas we used projections from the 2007 EIA report on Renewable Energy Capacity, Generation and Consumption by Fuel. We used the growth rate of these projections to estimate Kansas's renewable capacity through 2025 absent the RPS.[21]

We subtracted our baseline projection of renewable sales from the RPS-mandated quantity of sales for each year from 2012 to 2025, to obtain our estimate of the annual increase in renewable generation induced by the RPS in megawatt (MW). The RPS mandate exceeds our projected renewables in all years (2012 to 2025). In order to determine the number of megawatt hours (MWhs) that the state would have to add on an annual basis, enabling us to calculate the cost of renewable capacity added and conventional energy displaced, we multiplied the MWs of capacity required by 365.25 times 24 (days per-year time hours per-day). This was then multiplied by .3853, which is the average capacity factor of four wind farms in Kansas.[22] We used the capacity factor for wind power only, because based on current EIA projections all renewable capacity for Kansas will come from wind power. The resulting figure was the amount of MWhs that the state needs to add to meet the RPS requirements. This figure also represents the maximum number of MWhs of electricity from conventional sources that are avoided, or not generated, through the RPS mandate. We will revisit this shortly. Table 4, as follows, contains the results.

Table 4: Projected Electricity Capacity, Renewable Capacity and RPS Requirement

Year	Projected Electricity Capacity MWhs (000s)	Projected Renewable Capicity MWhs (000s)	RPS Requirement MWhs (000s)	Difference MWhs (000s)
2012	12,583	1,079	1,258	179
2013	12,583	1,079	1,258	179
2014	12,464	1,079	1,246	167
2015	12,464	1,079	1,246	167
2016	12,465	1,079	1,870	791
2017	12,466	1,079	1,870	791
2018	12,466	1,079	1,870	791
2019	12,529	1,079	1,879	800
2020	12,700	1,079	2,540	1,461
Total	112,720	9,711	15,038	5,327

17 Biomass Energy Basics, National Renewable Energy Laboratory, Biomass Basics, http://www.nrel.gov/learning/re_biomass.html (accessed Dec., 2010).

18 Hewson, 61.

19 U.S. Department of Energy, Energy Information Agency, Kansas Electricity Profile 2010, "Table 2. State Total Electric Power Industry Net Summer Capacity, by Energy Source, 2006 – 2010 (MW)" http://www.eia.gov/renewable/state/kansas/. (accessed April 3, 2011).

20 U.S. Department of Energy, Energy Information Agency, Kansas Electricity Profile 2010, "Table 3. State Renewable Electric Power Industry Net Summer Capacity, by Energy Source, 2006 -2010 (MW)" http://www.eia.gov/renewable/state/kansas/. (accessed April 3, 2011).

21 U.S. Department of Energy, Energy Information Agency, *Annual Energy Outlook 2007,* "Table 87, Southwest Power Pool" http://www.eia.gov/oiaf/archive/aeo07/supplement/supref.html (accessed April 2012).

22 Kansas Wind Farm Production and Average Capacity Factors, January 2002 to September 2008. Based on Energy Information Administration, U.S. DoE and US EIA forms. Internet, available at http://kcc.ks.gov/energy/charts/Wind_KansasWindFarmProductionAverageCapacityFactors.pdf.

To estimate the cost of producing the additional extra renewable energy under an RPS against the baseline, we used estimates of the LEC, or financial breakeven cost per MWh, to produce the electricity.[23] However, as outlined in the "electricity generation cost" section above, the EIA numbers provide a rather optimistic picture of the cost and generating capacity of renewable electricity, particularly for wind power. A literature review provided alternative LEC estimates that were generally higher and capacity factors that were lower for renewable generation technologies than the EIA estimates.[24] We used these alternative figures to calculate our "high" LEC estimates and the EIA figures to calculate our "low" cost estimates and the average of the two to calculate our "average" cost estimates. Table 5 displays the LEC and capacity factors for each generation technology.

Table 5: LEC and Capacity Factors for Electricity Generation Technologies

	Capacity Factor (percent)	Total Production Cost (cents/MWh)		
		2016	2020	2025
Coal				
Low	74.0	67.41	64.82	63.53
Average	79.5	81.11	87.43	81.72
High	85.0	94.80	110.03	99.91
Gas				
Low	85.0	66.10	68.17	71.84
Average	86.0	70.98	70.71	72.54
High	87.0	75.86	73.25	73.25
Nuclear				
Low	90.0	76.94	59.20	49.33
Average	90.0	95.42	86.36	75.22
High	90.0	113.90	113.52	101.12
Biomass				
Low	68.0	112.50	100.07	87.63
Average	75.5	112.50	101.80	93.00
High	83.0	113.90	103.54	98.36
Wind				
Low	37.4.	97.00	99.22	92.04
Average	38.6	192.34	184.38	171.72
High	39.8	287.67	269.54	251.40

We used the 2016 LEC for the years 2010 through 2018 to calculate the cost of the new renewable electricity and avoided conventional electricity, assuming that before 2016 LEC underestimates the actual costs for those years and for 2017 and 2018, the 2016 LEC slightly overestimates the actual costs. We assumed that the differences will, on balance, offset each other. For 2019 and 2020 we used the 2020 LEC. The assumption is that LEC will decline over time due to technological improvements.

We use the EIA's reference case scenario for all technologies. Since capital costs represent the large component of the cost structure for most technologies, we used the percentage change in the capital costs from 2015 to 2025 to adjust the 2016 LECs to 2025. For the technologies that the EIA does not forecast LECs in 2020, we used the average of the 2016 and 2025 LEC calculations, assuming a linear change over the period.

Once we computed new LECs for the years 2020 and 2025 we applied these figures to the renewable energy estimates for the remainder of the period.

For conventional electricity we assumed that the technologies are avoided based on their costs, with the highest cost combustion turbine avoided first. For coal and gas, we assumed they are avoided based on their estimated proportion of total electric sales for each year. Although hydroelectric and nuclear are not the cheapest technology, we assume no hydroelectric or nuclear sources are displaced since most were built decades ago and offer relatively cheap and clean electricity today.

We also adjusted the avoided cost of conventional energy to account for the lower capacity factor of wind relative to conventional energy sources. We multiplied the cost of each conventional energy source by the difference between its capacity factor and the capacity factor for the renewable source and then by the ratio of the new generation of the renewable source to the total new generation of renewable energy under the RPS. With coal, for example, we multiplied the avoided amount of electricity generation from coal (3.41 million MWhs in 2020) by the LEC of coal ($85.21 per MWh) and then by the difference between the capacity factor of coal and the weighted average (using MWs as weights)

[23] U.S. Department of Energy, Energy Information Agency, *2016 Levelized Cost of New Generation Resources from the Annual Energy Outlook 2011* (2009/$MWh), http://www.eia.doe.gov/oiaf/aeo/electricity_generation.html (accessed February 2012).

[24] For coal, gas and nuclear generation we used the production cost estimates from the International Energy Agencies, Energy Technology Analysis Programs, "Technology Brief E01: Cola Fired Power, E02: Gas Fired Power, E03: Nuclear Power and E05: Biomass for Heat and Power," (April 2010 http://www.iea-etsap.org/web/Supply.asp (accessed February 2012). To the production costs we added transmission costs from the EIA using the ratio of transmissions costs to total LEC costs. For wind power we used the IEA estimate for levelized capital costs and variable and fixed O & M costs. For transmission cost we used the estimated costs from several research studies that ranged from a low of $7.88 per kWh to a high of $146.77 per kWh, with an average of $60.32 per MWh.

The sources are as follows: Andrew Mills, Ryan Wiser, and Kevin Porter, "The Cost of Transmission for Wind Energy: A Review of Transmission Planning Studies," Ernest Orlando Lawrence Berkeley National Laboratory, http://eetd.lbl.gov/EA/EMP (accessed December 2011); Competitive Renewable Energy Zones (CREZ) Transmission Optimization Study, The Electric Reliability Council of Texas, April 2, 2008 http://www.ercot.com/news/presentations/2006/ATTCH_A_CREZ_Analysis_Report.pdf (accessed December 2010); Sally Maki and Ryan Pletka, Black & Veatch, California's Transmission Future, August 25, 2010, http://www.renewableenergyworld.com/rea/news/article/2010/08/californias-transmission-future (accessed December 2011).

Table 6: Low Cost Case RPS Mandate from 2012 to 2020			
Year	Gross Cost (2012 $000s)	Less Conventional (2012 $000s)	Total (2012 $000s)
2012	53,406	27,640	25,766
2013	53,385	27,613	25,772
2014	49,850	25,607	24,243
2015	49,862	25,665	24,197
2016	235,484	121,494	113,989
2017	235,512	121,524	113,989
2018	235,541	121,514	114,027
2019	243,787	138,537	105,249
2020	445,042	252,964	192,078
Total	1,601,868	862,558	739,310

Table 7: Average Cost Case RPS Mandate from 2012 to 2020			
Year	Gross Cost (2012 $000s)	Less Conventional (2012 $000s)	Total (2012 $000s)
2012	105,896	21,701	84,195
2013	105,854	21,689	84,165
2014	98,845	20,178	78,668
2015	98,868	20,203	78,664
2016	466,926	95,559	371,367
2017	466,983	95,570	371,413
2018	467,040	95,587	371,453
2019	453,023	100,487	352,536
2020	827,011	183,473	643,539
Total	3,090,445	654,447	2,435,999

Table 8: High Cost Case RPS Mandate from 2012 to 2020			
Year	Gross Cost (2012 $000s)	Less Conventional (2012 $000s)	Total (2012 $000s)
2012	158,385	22,650	135,735
2013	158,323	22,727	135,596
2014	147,840	20,964	126,876
2015	147,874	21,016	126,858
2016	698,369	100,304	598,065
2017	698,454	100,147	598,307
2018	698,538	100,579	597,959
2019	662,259	91,568	570,691
2020	1,208,980	166,946	1,042,035
Total	4,579,023	646,901	3,932,121

capacity factor of wind (38.6 percent). This process is repeated for each conventional electricity resource.

These LECs are applied to the amount of electricity supplied from renewable sources under the RPS, because this figure represents the amount of conventional electricity generation capacity that presumably will not be needed under the RPS. The difference between the cost of the new renewable sources and the costs of the conventional electricity generation represents the net cost of the RPS. Tables 6, 7 and 8 display the results of our Low, Average and High Cost calculations for the RPS, respectively.

We converted the aggregate cost of the RPS into a cost per-kWh by dividing the cost by the estimated total number of kWh sold for that year. (For example, for 2020 under the average cost scenario above, we divided $643 million into 12,700 million kWhs for a cost of 5.07 cents per kWh.)

Ratepayer Effects

To calculate the effect of the RPS on electricity ratepayers we used EIA data on the average monthly electricity consumption by type of customer: residential, commercial and industrial. (The monthly figures were multiplied by 12 to compute an annual figure.) We calculated the 2010 figures for each year using the average annual increase in electricity sales over the entire period.[25]

We calculated an annual per-kWh increase in electricity cost by dividing the total cost increase – calculated in the section above by the total electricity sales for each year. We multiplied the per-kWh increase in electricity costs by the annual kWh consumption for each type of ratepayer for each year. For example, we expect the average residential ratepayer to consume 13,023 kWhs of electricity in 2020 and we expect the average cost scenario to raise electricity costs by 5.07 cents per kWh in the same year. Therefore we expect residential ratepayers to pay an additional $660 in 2020.[26]

Modeling the RPS using STAMP

We simulated these changes in the STAMP model as a percentage price increase on electricity to measure the dynamic effects on the state economy. The model provides estimates of the proposals' impact on employment, wages and income. Each estimate represents the change that would take place in the indicated variable against a "baseline" assumption of the value that variable for a specified year in the absence of the RPS policy.

Because the RPS requires Kansas households and firms to use more expensive "green" power than they otherwise would have under a baseline scenario, the cost of

[25] U.S. Department of Energy, Energy Information Administration, "Average electricity consumption per residence in KS in 2008," (January 2010) http://www.eia.gov/electricity/sales_revenue_price/index.cfm.

[26] U.S. Department of Energy, Energy Information Agency, *Annual Energy Outlook 2011*, "Table 8: Electricity Supply, Disposition, Prices, and Emissions," http://www.eia.doe.gov/oiaf/aeo/aeoref_tab.html.

goods and services will increase under the RPS. These costs would typically manifest through higher utility bills for all sectors of the economy. For this reason we selected the sales tax as the most fitting way to assess the impact of the RPS. Standard economic theory shows that a price increase of a good or service leads to a decrease in overall consumption, and consequently a decrease in the production of that good or service. As producer output falls, the decrease in production results in a lower demand for capital and labor.

BHI utilized its STAMP (State Tax Analysis Modeling Program) model to identify the economic effects and understand how they operate through a state's economy. STAMP is a five-year dynamic CGE (computable general equilibrium) model that has been programmed to simulate changes in taxes, costs (general and sector-specific) and other economic inputs. As such, it provides a mathematical description of the economic relationships among producers, households, governments and the rest of the world. It is general in the sense that it takes all the flows between important markets, such as the capital and labor markets, into account. It is an equilibrium model because it assumes that demand equals supply in every market (goods and services, labor and capital). This equilibrium is achieved by allowing prices to adjust within the model. It is computable because it can be used to generate numeric solutions to concrete policy and tax changes.[27]

In order to estimate the economic effects of a national RPS we used a compilation of six STAMP models to garner the average effects across various state economies: New York, North Carolina, Washington, Kansas, Indiana and Pennsylvania. These models represent a wide variety in terms of geographic dispersion (northeast, southeast, midwest, the Plains and west), economic structure (industrial, high-tech, service and agricultural), and electricity sector makeup.

First, we computed the percentage change to electricity prices as a result of three different possible RPS policies. We used data from the EIA from the state electricity profiles, which contains historical data from 1990-2008 for retail sales by sector (residential, commercial, industrial, and transportation) in dollars and MWhs and average prices paid by each sector.[28] We inflated the sales data (dollars and MWhs) though 2020 using the historical growth rates for each sector for each year. We then calculated a price for each sector by dividing the dollar value of the retails sales by kWhs. Then we calculated a weighted average kWh price for all sectors using MWhs of electricity sales for each sector as weights. To calculate the percentage electricity price increase we divided our estimated price increase by the weighted average price for each year. (For example, in 2020 for our average cost case we divided our average price of 11.37 cents per kWh by our estimated price increase of 5.01 cents per kWh for a price increase of 44 percent.)

Table 9: Elasticities for the Economic Variables

Economic Variable	Elasticity
Employment	-0.022
Gross wage rates	-0.063
Investment	-0.018
Disposable Income	-0.022

Using these three different utility price increases – 1 percent, 4.5 percent and 5.25 percent – we simulated each of the six STAMP models to determine what outcome these utility price increases would have on each of the six states' economy. We then averaged the percent changes together to determine what the average effect of the three utility increases. Table 9 displays these elasticities, which were then applied to the calculated percent change in electricity costs for the state of Kansas discussed above.

We applied the elasticities to percentage increase in electricity price and then applied the result to Kansas economic variables to determine the effect of the RPS. These variables were gathered from the Bureau of Economic Analysis Regional and National Economic Accounts as well as the Bureau of Labor Statistics Current Employment Statistics.[29]

[27] For a clear introduction to CGE tax models, see John B. Shoven and John Whalley, "Applied General-Equilibrium Models of Taxation and International Trade: An Introduction and Survey," Journal of Economic Literature 22 (September, 1984): 1008. Shoven and Whalley have also written a useful book on the practice of CGE modeling entitled *Applying General Equilibrium* (Cambridge: Cambridge University Press, 1992).

[28] U.S. Department of Energy, Energy Information Agency, Kansas Electricity Profile 2010, Table 8: Retail Sales, Revenue, and Average Retail Price by Sector, 1990 through 2008, http://www.eia.doe.gov/cneaf/electricity/st_profiles/new_mexico.html

[29] See the following: Bureau of Economic Analysis, "National Economic Accounts," http://www.bea.gov/national/; Regional Economic Accounts, http://www.bea.gov/regional/index.htm. See also Bureau of Labor Statistics, "Current Employment Statistics," http://www.bls.gov/ces/.

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The authors would like to thank Frank Conte, BHI Director of Communications, for his editorial assistance.

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