Empowering Kentucky

A no-regrets plan to create jobs, improve health, lower bills, and invest in a just transition while cutting harmful emissions

Prepared for Kentuckians for the Commonwealth

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The full Empower Kentucky Plan was developed with input from more than 1,200 Kentuckians, a diverse range of stakeholders, and state and national energy experts, including Synapse. Many of the individuals and organizations who provided valuable input, guidance, and support are acknowledged by KFTC at www.empowerkentucky.org.

The Empower Kentucky Plan is published at www.empowerkentucky.org, along with an environmental justice analysis of Kentucky produced by KFTC and this analysis by Synapse.

EXECUTIVE SUMMARY

This report examines Kentuckians for the Commonwealth's "Empower Kentucky" future: a plan in which the future energy sector prioritizes both environmental outcomes and the local economy. We find that relative to a business-as-usual future in which no new policies are implemented, the Empower Kentucky Plan increases jobs, decreases residential electric bills, and leads to significant environmental benefits for public health and the global climate.

In the Empower Kentucky Plan, we assume that Kentucky and the rest of the states achieve compliance with the Clean Power Plan. However, the Empower Kentucky Plan goes beyond the Clean Power Plan. It describes ways Kentucky can achieve a higher-job, lower-bill, lower-carbon future through energy efficiency, renewables, and investments in a just transition for affected workers and communities, whether or not the Clean Power Plan is implemented in its proposed form.

Our analysis and findings follow.

For years, Kentucky's electric system has been founded on a reliance on coal to produce inexpensive electricity for local industry, for residents, and for regional exports. This dependence on coal has come with the cost of creating pollutants that cause harm to Kentucky's citizens and the global climate. However, this status quo is beginning to change. From 2013 to 2016, 2,900 megawatts (MW) of coal electric-generating capacity retired in Kentucky, equal to about 16 percent of the pre-2013 coal fleet. Over the next 15 years, as coal's role diminishes, Kentucky will increasingly rely on instate natural gas generation and imports of electricity from Kentucky's neighbors.

Energy markets across the United States have entered a period of rapid change, driven by many factors. Kentucky policymakers must make a decision: should they double-down on increasingly expensive, risky, and dirty fossil-fueled power? Or should they chart a path to a clean energy future in which Kentuckians reap the benefits of good jobs, clean air, and lower electricity bills?

In this analysis, we analyze a Reference case—a business-as-usual future in which no changes are made to state policy—and an Empower Kentucky Plan, in which investments in renewables and energy efficiency increase and a modest carbon price adder is implemented. Importantly, we find that only incremental, positive changes are needed to change the business-as-usual case into a future which results in Kentucky meeting its emission reduction goals. At the same time, they catalyze an economically just transition for Kentuckians by reducing monthly electric bills, creating thousands of new jobs, and directly investing in measures that benefit affected workers and communities.

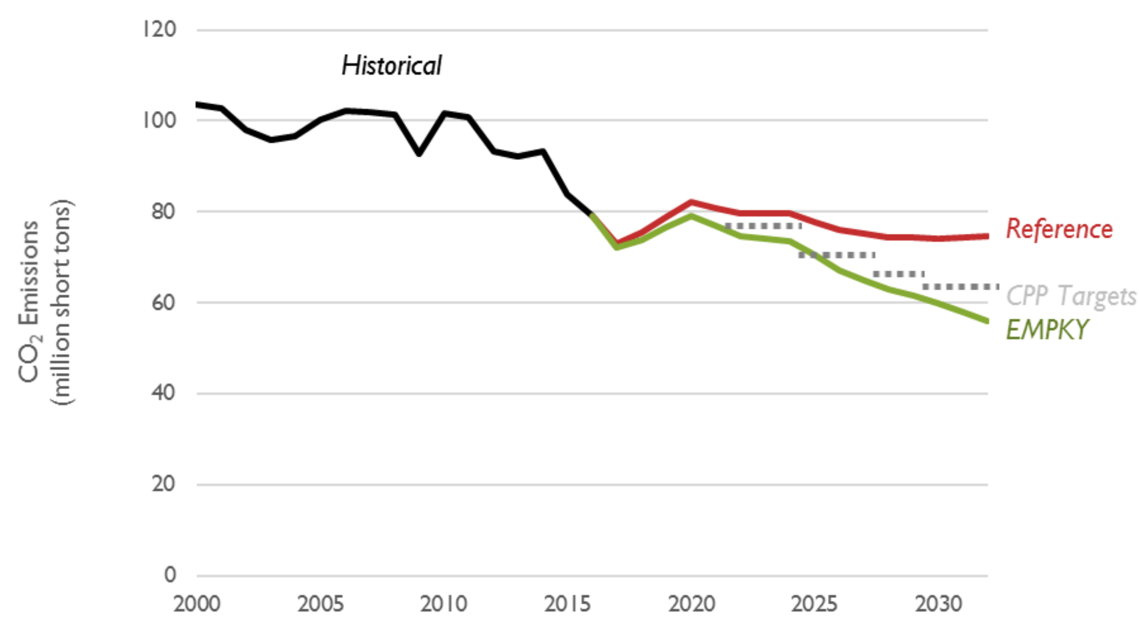
An Empower Kentucky Plan creates 46,300 more job-years for Kentuckians than a business-as-usual future over 15 years.

From 2018 to 2032, 46,300 more total job-years are created under the Empower Kentucky Plan, equivalent to an average of 3,100 new jobs in each year, relative to the Reference case. Many of these jobs are created through expanding energy efficiency programs in Kentucky.

The Empower Kentucky Plan exceeds the Clean Power Plan's requirement by cutting carbon dioxide emissions by 37 million tons from 2012 to 2032, a 40 percent reduction.

Under the Empower Kentucky Plan, Kentucky's electric power sector produces 56 million short tons of carbon dioxide (CO_2) emissions in 2032, or 40 percent less than were emitted in 2012 (see Figure ES-1). From 2022 to 2032, the Empower Kentucky Plan produces 6 percent fewer emissions than is required for Kentucky to comply with the federal Clean Power Plan. CO_2 emissions under the Empower Kentucky Plan are 14 percent lower than under the Reference case. CO_2 pollution declines under the Reference case, but not by enough to meet Clean Power Plan targets.

Figure ES-1. Projected in-state CO_2 emissions in the Reference case and Empower Kentucky Plan (EMPKY)



Synapse Energy Economics, 2017

The Empower Kentucky Plan reduces harmful pollutants that threaten the health of Kentuckians.

Compared to a business-as-usual future, the Empower Kentucky Plan reduces pollutants in 2032 by 13 thousand short tons of sulfur dioxide (SO_2) and 13 thousand short tons of nitrogen oxides (NO_X). Over the 15-year-period of 2018 to 2032, this results in a cumulative reduction of 93 thousand short tons of SO_2 and 132 thousand short tons of NO_X. SO_2 and NO_X are major precursors to acid rain and smog, and both can cause or worsen asthma, emphysema, bronchitis, and heart disease.

The Empower Kentucky Plan saves customers money, reducing average residential bills by 10 percent compared to the business-as-usual case in 2032.

Implementing energy efficiency, renewables, and carbon pricing reduces residential electric bills by $13 per month in 2032 relative to the business-as-usual future. These net cost savings are due to reduced purchases of fossil fuels, implementing energy efficiency measures, and avoided costly environmental retrofits. The Empower Kentucky Plan leads to average residential electric bills 10 percent lower than the reference case in 2032.

The Empower Kentucky Plan invests $387 million in a just transition for Kentucky's coal workers and communities.

A key objective of the Empower Kentucky Plan is to ensure a just transition for workers and communities most affected by the shift to a clean energy economy. Under this plan, 20 percent of all carbon pricing revenue—$387 million—is re-invested in job training and education; financial support for affected workers and communities; local infrastructure and job creation initiatives; and support for local innovation and entrepreneurship.[1]

Over the 15-year period, the low price on CO_2 emissions from instate and imported electricity generation imposed under this plan will generate almost $1.9 billion in total revenue. Of that, 20 percent is dedicated to support just transition efforts. The remaining $1.5 billion will be re-invested in efforts to accelerate energy efficiency across the economy and state. It can be expected that a share of those energy sector investments will also benefit affected workers and communities, in addition to the $387 million directed towards just transition strategies.

The Empower Kentucky Plan invests $11 billion in energy efficiency across the economy and prioritizes savings for low-income customers.

In the Empower Kentucky Plan, utilities will invest $11 billion in energy efficiency programs between 2018 and 2032 and achieve cumulative energy savings 17 percent lower than the business-as-usual case.

Fifty-five percent of all energy savings come from Kentucky's commercial and industrial sector, and 45 percent from residential customers. Within those overall efficiency goals, the Empower Kentucky Plan calls for 18 percent of all energy savings to come from projects and programs benefitting low-income customers and communities. That low-income standard is higher than some leading states are achieving today, a reflection of Kentucky's higher average household electricity consumption and lower median household incomes.

The Empower Plan also builds 1,000 MW of new combined heat and power capacity by 2032 as a cost effective approach to achieve energy savings in commercial and industrial sectors. Combined heat and

[1] To learn more about KFTC's plan for a just transition for the state's coal workers, and economy as a whole, see: https://www.kftc.org/sites/default/files/docs/resources/kftcs_just_transition_framework.pdf and www.empowerkentucky.org.

power systems allow facilities to generate heat or hot water and electricity from the same energy source, often located on-site, and produce significant, low-cost energy savings.

The Empower Kentucky Plan results in a cleaner and more diverse energy system in Kentucky by 2032, while system costs are just 7 percent higher and average residential bills are lower.

Under the Empower Kentucky Plan, the share of Kentucky's electricity generated from coal falls to 61 percent in 2032, compared to 87 percent in 2015 and 68 percent in the Reference case. The same number of coal plant retirements are expected over the next 15 years under both scenarios. In the Empower Kentucky Plan, Kentucky will build 0.8 GW less natural gas than in the Reference case, while installing 1 GW more solar (including more than 600 MW of distributed solar), building 600 MW more wind, and increasing imports by just 3 percentage points. Overall system costs for the Empower Kentucky Plan are just 7 percent higher than the reference case, while average bills are lower due to greater energy efficiency.

Conclusion

If Kentucky embarks on a clean energy future as envisioned in the Empower Kentucky Plan, its citizens will benefit from lower electric bills, cleaner air and water, more jobs, and more support for workers and communities affected by our energy transition, all while exceeding the state's obligation to reduce harmful climate emissions.

CONTENTS

1. KENTUCKY'S ELECTRICITY FUTURE

For years, Kentucky's electric system has been founded on a reliance on coal to produce inexpensive electricity for local industry and regional exports. This reliance on coal has come with the cost of creating pollutants that cause harm to Kentucky's citizens and the global climate. Since electrification began, well over 90 percent of electricity produced in Kentucky every year has come from coal plants.

This status quo is beginning to change. From 2013 to 2016, 2,900 megawatts (MW) of coal electric-generating capacity retired, equal to about 16 percent of the pre-2013 coal fleet. Coal's share of Kentucky's electric generation fell below 90 percent for the first time in 2015, to 87 percent, and dropped even further to 83 percent in 2016. Over the next 15 years, as coal's role diminishes, Kentucky will increasingly rely on instate natural gas generation and imports of electricity from Kentucky's neighbors.

These shifts in the energy landscape have been caused in part by sustained low natural gas prices, aging coal plants with inferior heat rates that need costly environmental retrofits, and Kentucky's excellent electrical connections to other states. Other changes taking place in electricity systems around the country have impacted the Commonwealth. Renewables continue to plummet in price. Energy efficiency and combined heat and power (CHP) measures, resources that are already cost-effective, have risen to prominence. State and regional policies that put a price on carbon dioxide (CO_2) and limit the output of this harmful greenhouse gas have also come into effect.

In 2015, the United States Environmental Protection Agency (EPA) promulgated the Clean Power Plan, a federal regulation aimed at reducing CO_2 emissions through a switch to renewables, energy efficiency, and natural gas. On February 9, 2016, the United States Supreme Court issued an unprecedented stay on the Clean Power Plan while its fate was being decided in lower courts. At this time, the Clean Power Plan's fate is uncertain, but having been promulgated, it cannot simply be wiped away.[2]

At this moment, Kentucky policymakers must make a decision: should they double-down on increasingly expensive, risky, and dirty fossil-fueled power? Or should they embrace a clean energy future in which Kentuckians reap the benefits of clean jobs, clean air, and lower electricity bills while investing in a just transition and meeting obligations to protect the climate?

[2] The Supreme Court has already found in the 2007 decision *Massachusetts vs. Environmental Protection Agency* that the EPA is required to regulate carbon dioxide emissions. Even if the EPA were to proceed with all the notices, hearings, etc. associated with pulling back on the Clean Power Plan, the agency would still be required to issue regulations addressing carbon dioxide emissions.

1.1. Kentucky's electricity present

In most states, the electric system is managed by one or two main operators. In some cases, these operators are large, vertically-integrated electric utilities that own power plants and transmission lines and deliver electricity to customers. In other cases, operational responsibility has been delegated to independent authorities. These authorities are in charge of maintaining reliability and overseeing electricity markets in which multiple electricity utilities participate.

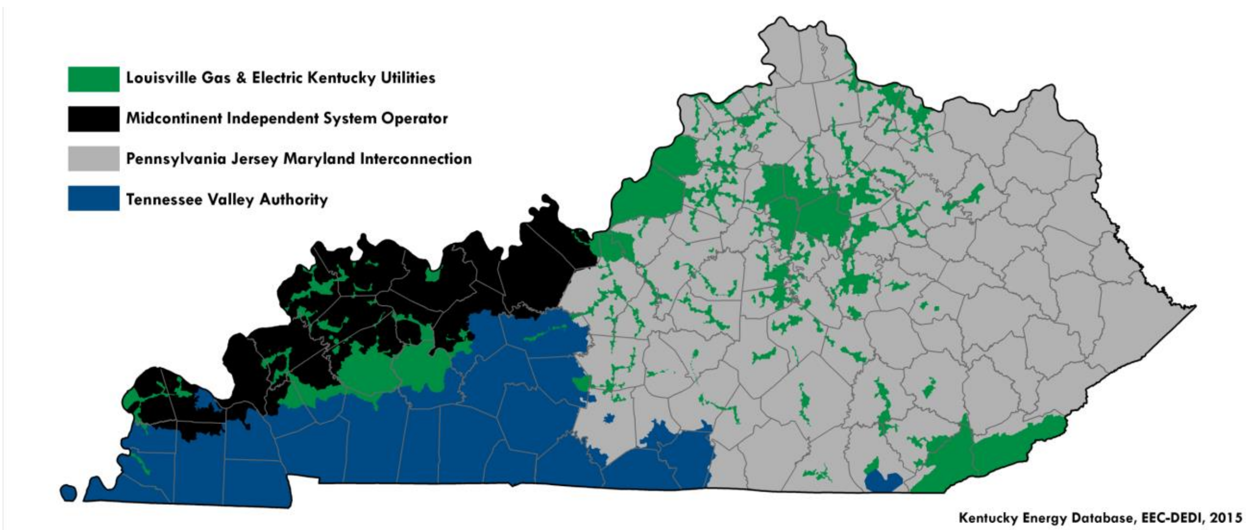
Kentucky has a unique system, divided into four different balancing regions (see Figure 1). While one region (Louisville Gas and Electric / Kentucky Utilities) is entirely contained within the Commonwealth, the three other areas are constituent regions of larger balancing regions:

1. Tennessee Valley Authority in southwestern Kentucky operates as part of the larger TVA region encompassing Tennessee and other southern states.

2. The eastern part of Kentucky, which includes utilities such as East Kentucky Power Cooperative, Kentucky Power, and Duke Energy Kentucky, is part of the PJM Interconnection, which coordinates electricity dispatch from New Jersey to Illinois.

3. In the northwestern part of the state, utilities such as Big Rivers Electric Cooperative are dispatched as part of the Midcontinent ISO (MISO), which encompasses states from Montana to Michigan and as far south as Louisiana.

Figure 1. Kentucky balancing authority areas as of 2015



Source: Kentucky Energy Profile 2015, page 23. Available at http://energy.ky.gov/Kentucky_Energy_Profile/Kentucky%20Energy%20Profile%202015.pdf

Capacity, generation, and sales

Kentucky's utility landscape is currently dominated by coal and few utilities. As of December 2016, 65 percent of the total electric generating capacity in Kentucky came from coal (see Table 1). More than three-quarters of all capacity was concentrated in just three utilities—the newly-merged Louisville Gas & Electric / Kentucky Utilities (LG&E/KU), Tennessee Valley Authority (TVA), and East Kentucky Power Cooperative (EKPC).

Table 1. Electric generating capacity (GW) existing as of December 2016.

Utility	Utility Type	Coal	Natural Gas	Hydro	Oil & Other	Total
LG&E/KU	Utility	6.1	3.3	0.1	0.0	9.5
TVA	Utility	4.1	0.3	0.2		4.6
EKPC	Utility	2.0	1.7		0.0	3.6
Big Rivers	Utility	1.5			0.1	1.6
Duke	Utility	0.8				0.8
US Army Corps of Engineers	Utility			0.5		0.5
City of Owensboro	Utility	0.4				0.4
Kentucky Power Co	Utility		0.3			0.3
Other	Merchant		1.2	0.0	0.0	1.2
Other	Industrial		0.0		0.1	0.1
Other	Utility		0.1	0.2	0.0	0.3
Total		**14.9**	**6.8**	**1.0**	**0.2**	**22.9**

Source: EIA 860 2016M

In 2016, 83 percent of electricity was generated from coal plants (see Table 2). At the same time, 78 percent of generation also came from the same three utilities: LG&E/KU, TVA, and EKPC.

Table 2. Electric generation in 2016 (TWh)

Utility	Utility Type	Coal	Natural Gas	Hydro	Oil & Other	Total
LG&E/KU	Utility	29.1	6.4		0.0	35.5
Tennessee Valley Authority	Utility	16.5	0.2	0.9	0.0	17.7
East Kentucky Power Coop, Inc	Utility	9.1	0.3		0.1	9.5
Big Rivers Electric Corp	Utility	6.5			1.2	7.6
Duke Energy Kentucky Inc	Utility	3.7			0.0	3.7
USCE-Nashville District	Utility			1.3		1.3
City of Owensboro - (KY)	Utility	1.9	0.0		0.0	2.0
Kentucky Power Co	Utility		0.5			0.5
Other	Merchant		0.5	0.0	0.0	0.5
Other	Industrial		0.2		0.4	0.6
Other	Utility	0.1	0.1	1.2	0.1	1.4
Total		**66.9**	**8.3**	**3.5**	**1.7**	**80.3**

Source: EIA 923 2016

As with electric production, sales of electricity are relatively concentrated among just three utilities: LG&E/KU, Kenergy Corp, and Kentucky Power (see Table 3). Nearly nine-tenths of Kentucky's sales are produced from either investor-owned utilities or electric cooperatives. A large share of Kentucky's electric sales—40 percent—are sold to industrial customers, compared to the national average of 26 percent. These industrial electric sales are very concentrated: despite consuming 40 percent of all electricity sales in Kentucky, industrial customers make up less than 1 percent of all electricity customers.

Table 3. Electricity sales in 2015 (TWh)

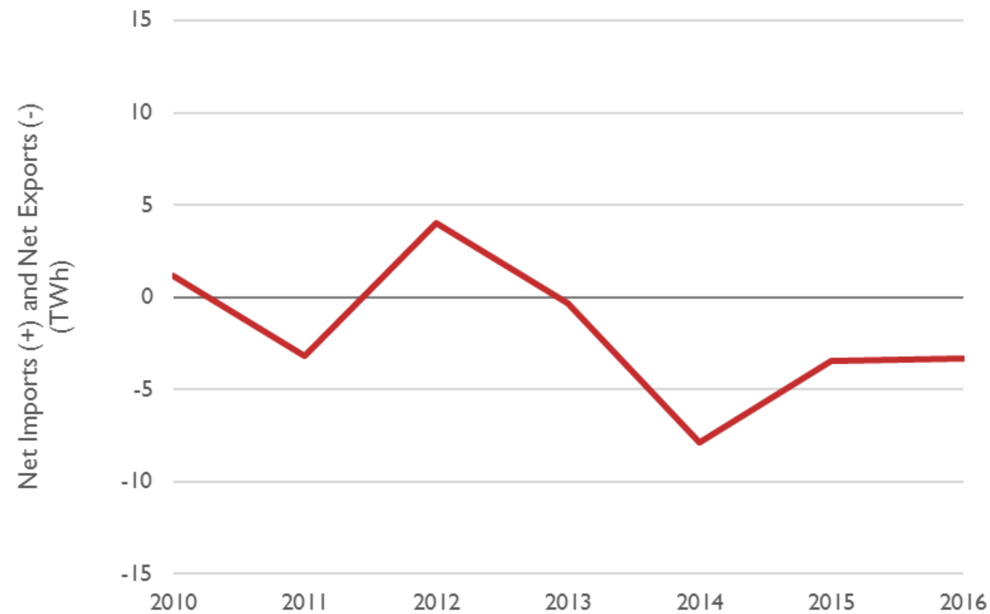
Utility	Utility Type	Residential	Commercial	Industrial	Total
LG&E/KU	Investor Owned	10.1	10.3	9.7	30.0
Kenergy Corp	Cooperative	0.7	0.3	7.7	8.8
Kentucky Power Co	Investor Owned	2.2	1.3	2.7	6.2
Duke	Investor Owned	1.4	1.8	0.8	4.0
TVA	Federal		0.4	2.6	3.0
Owen Electric Coop Inc	Cooperative	0.7	0.3	1.1	2.1
Warren Rural Elec Coop Corp	Cooperative	0.8	0.4	0.7	1.9
Blue Grass Energy Coop Corp	Cooperative	0.8	0.2	0.3	1.3
South Kentucky Rural E C C	Cooperative	0.8	0.1	0.4	1.3
Pennyrile Rural Electric Coop	Cooperative	0.6	0.3	0.3	1.2
Salt River Electric Coop Corp	Cooperative	0.7	0.2	0.2	1.1
Other	Municipal	1.9	2.2	2.1	6.1
Other	Cooperative	5.2	1.7	1.5	8.4
Other	Investor Owned		0.0	0.0	0.0
Other	Federal		0.0	0.0	0.0
Other	Other	0.2	0.1	0.2	0.5
Total		**26.2**	**19.6**	**30.3**	**76.0**

Note: Detailed sales data for 2016 was not available at the time of this report's publication.
Source: EIA 861

Imports and exports

Since 2010, Kentucky has alternated between being a minor net importer and a minor net exporter of electricity (see Figure 2). Most recently, as Kentucky's in-state electric sales have declined, Kentucky has tended to be a net exporter: in 2016, 4 percent of Kentucky generation was exported while 96 percent was consumed in-state.

Figure 2. Kentucky generation and net energy for demand (inclusive of electric sales and losses)



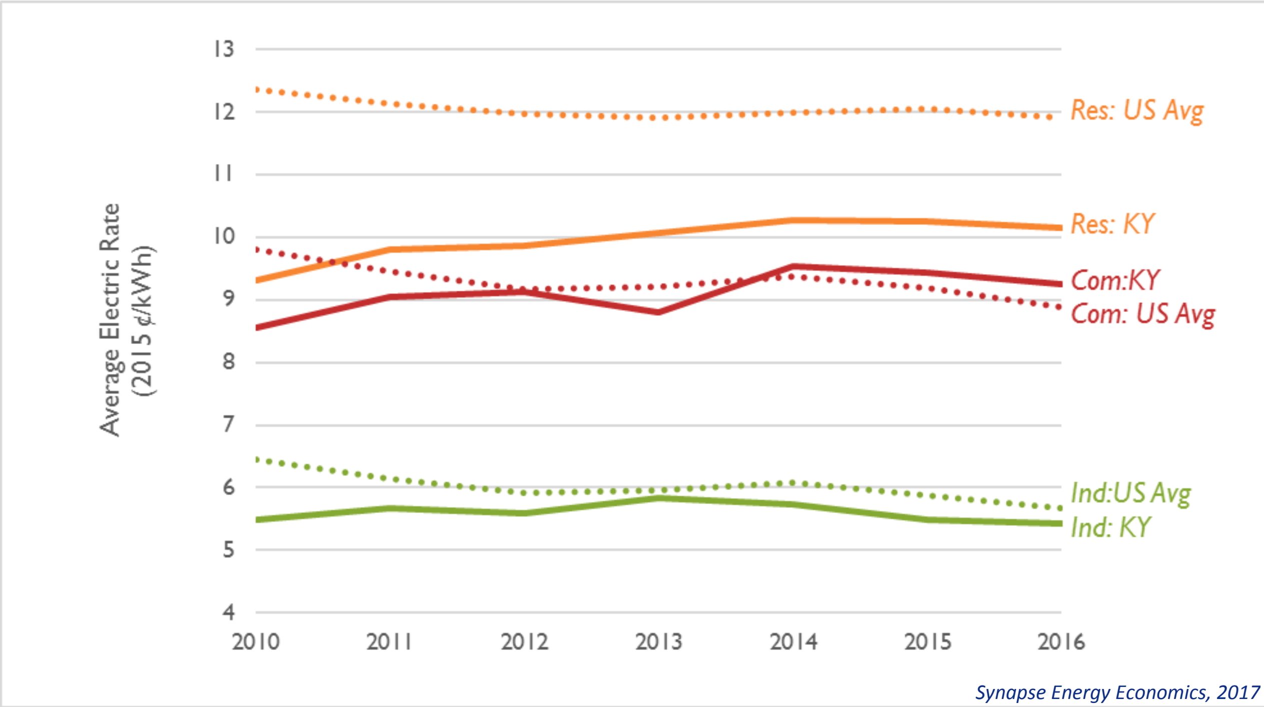
Synapse Energy Economics, 2017

Sources: EIA 861; EIA 826; EIA State Electricity Profile for Kentucky

Rates and bills

From 2010 to 2016, residential customers in Kentucky paid for electricity at rates 17 percent below the national average (see Figure 3). Over this same time period, the difference between Kentucky and the United States average commercial and industrial rates has narrowed, and average rates for commercial customers in Kentucky now exceed the national average. In 2016, electric rates for industrial customers in Kentucky were 5 percent below the national average, compared to 17 percent in 2010.

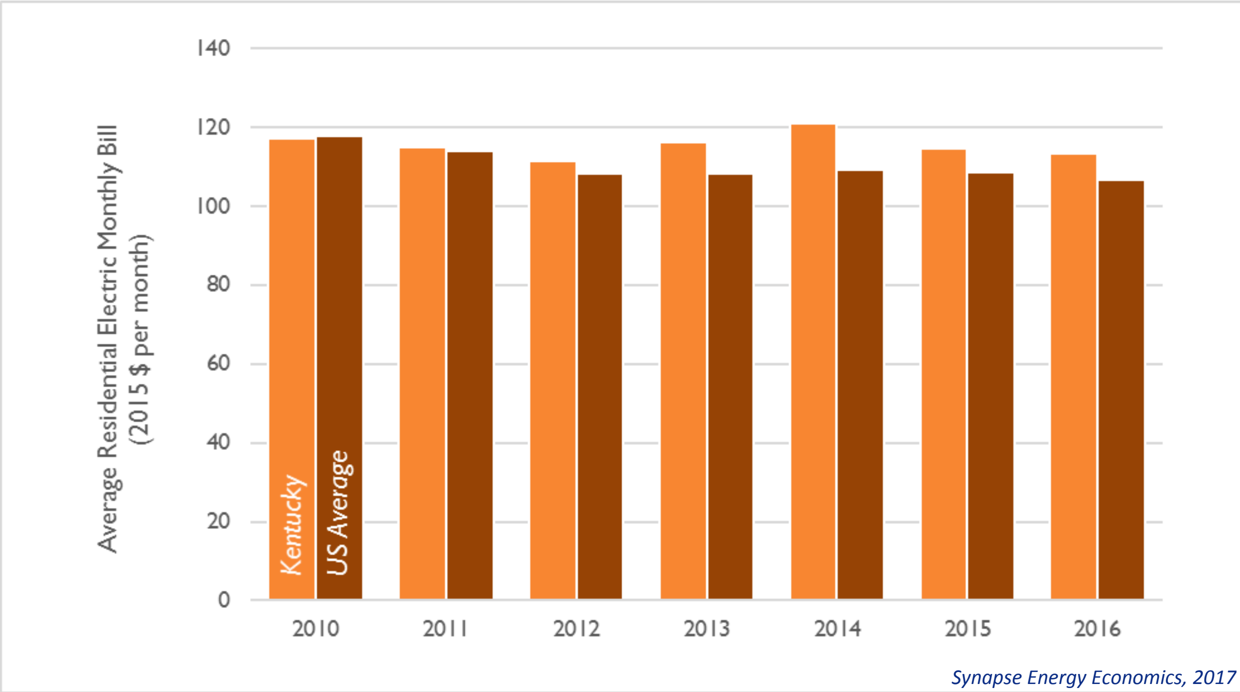
Figure 3. Average electric rates in Kentucky and United States for the residential sector (Res), the commercial sector (Com), and the industrial sector (Ind)



Source: EIA 861; EIA 826
Note: The y-axis on this figure begins at 4 cents per kWh, not 0 cents per kWh.

Residential customers in Kentucky typically consume significant energy for both cooling and heating, with this energy generally sourced from electricity rather than natural gas or oil. Because of this unique pattern of end-use consumption, residential customers in Kentucky typically use more electricity than other customers around the country. Because of this increased usage, and in spite of lower-than-average electricity rates, from 2010 to 2016, residential customers paid monthly bills 5 percent higher than the United States average (see Figure 4). Over these seven years, Kentucky residential customers' rates and bills have increased by 9 percent and 3 percent, respectively. At the same time, residential rates and bills in many other states have remained flat or have even fallen.

Figure 4. Average monthly electric bill for typical residential customers in Kentucky and the United States



Source: EIA 861; EIA 826

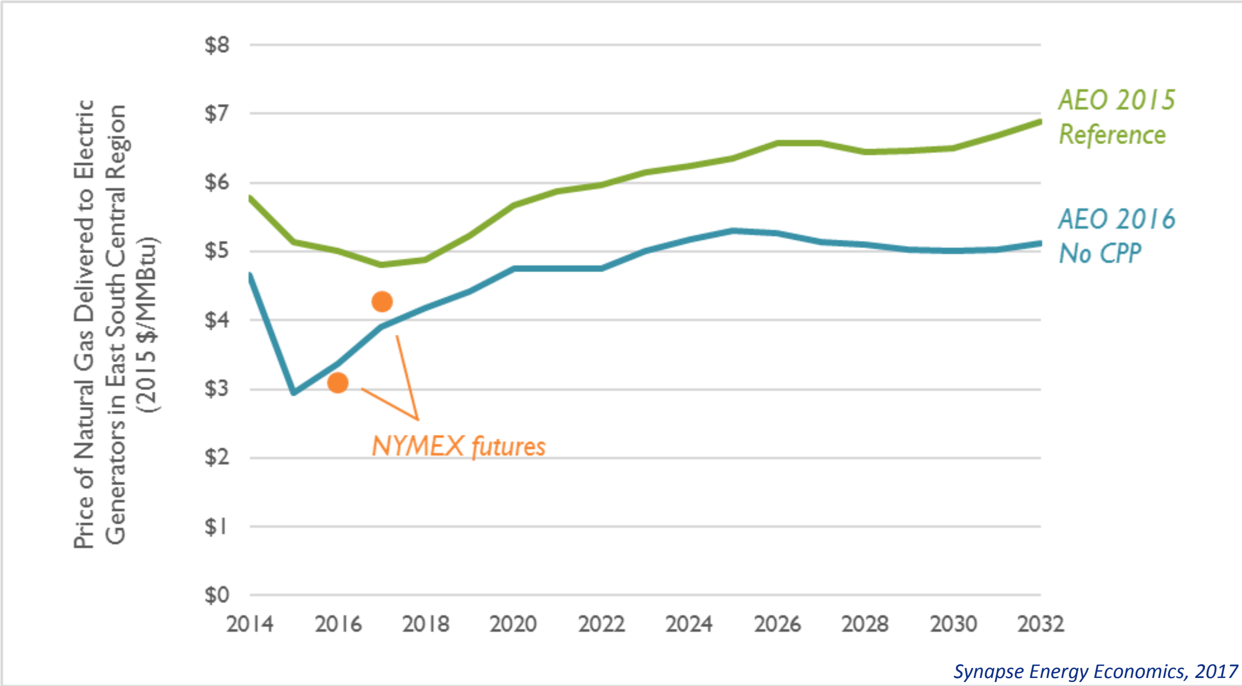
1.2. Looking to the future

Kentucky is already beginning a shift away from dirty, expensive coal generation. As a result of changing natural gas prices, lowered expectations for electricity sales, and low future costs of energy efficiency and renewables, Kentucky utilities should continue to adjust their plans to ones that provide clean, cost-effective electricity to Kentucky ratepayers.

Low natural gas prices

Many utilities are beginning to take advantage of low natural gas prices, and expectations that these prices will remain low for the foreseeable future (see Figure 5 for natural gas price forecasts from NYMEX and the Energy Information Administration's (EIA) Annual Energy Outlook (AEO)). Currently, over 800 MW of new natural gas combined-cycle capacity has been constructed in Kentucky, while an additional 1,900 MW is proposed or under construction.

Figure 5. Natural gas prices delivered to electric power generators in the Kentucky region



Sources: AEO 2015, AEO 2016, NYMEX data as of July 2016
Notes: Since this analysis was conducted, the EIA has released an AEO 2017, which forecasts average 2017-2030 natural gas prices delivered to electric power generators in the East South Central census region (of which Kentucky is member) to be 7 percent lower than the same estimates from AEO 2016.

Lowered expectations for electricity sales

Even as these new natural gas-fired power plants are built, Kentucky's utilities face a second change in the traditional electricity paradigm: sales of electricity have plummeted relative to historical levels, and forecasts of future sales remain low compared to past growth. Between 2010 and 2015, Kentucky's electric sales fell at an average annual rate of -4.34 percent.[3] Kentucky's Energy Cabinet estimates that sales will remain essentially flat for the foreseeable future, while both the Annual Energy Outlook 2016 Reference case and an aggregation of Kentucky utility Integrated Resource Plans forecast that electric sales will grow by about 0.87 percent per year (see Table 4 and Figure 6).

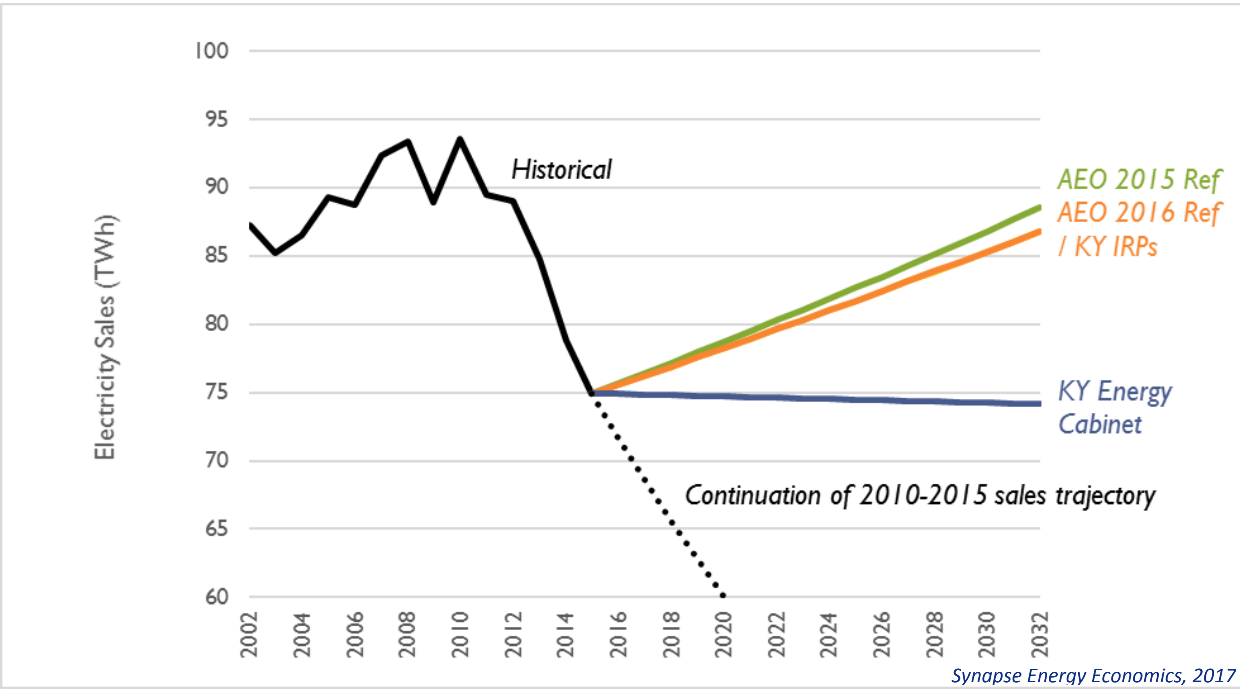
[3] Note that this rate of change is a substantial departure from previous years. This decrease is tied to reductions in residential sales (which dropped by 6 percent during this period), but is also largely tied to industrial sales reductions, which decreased by 28 percent during this time period. For example, by itself, the cessation of operations at the uranium enrichment plant in Paducah, Kentucky reduced TVA's electricity demand by 5 percent over a five-year period. See https://www.washingtonpost.com/business/economy/tennessee-valley-authority-to-close-8-coal-fired-power-plants/2013/11/14/be1e4f1e-4d60-11e3-9890-a1e0997fb0c0_story.html?utm_term=.dcca54b14b6c for additional information.

Table 4. Potential sales forecasts to implement in this modeling analysis

	Cumulative Annual Growth Rate
Historical average: 2010 to 2015	-4.34%
AEO 2015 Reference case	0.99%
AEO 2016 Reference case	0.87%
KY IRPs	0.87%
KY Energy Cabinet	-0.06%

Note: The historical cumulative average growth rate (CAGR) is calculated for the period between 2010 and 2015. CAGRs for all other series are calculated for the period between 2016 and 2032.

Figure 6. Historical sales and sales forecasts in Kentucky



Notes: Since this analysis was conducted, the EIA has released an AEO 2017, which forecasts electricity sales delivered to the East South Central census region (of which Kentucky is member) to have a 2016-2032 CAGR of 0.79 percent, relative to the AEO 2016 Reference Case forecast of 0.87 percent. The y-axis on this figure begins at 60 TWh, not 0 TWh. Historical sales and the trajectory continuation are inclusive of energy efficiency performed in Kentucky.

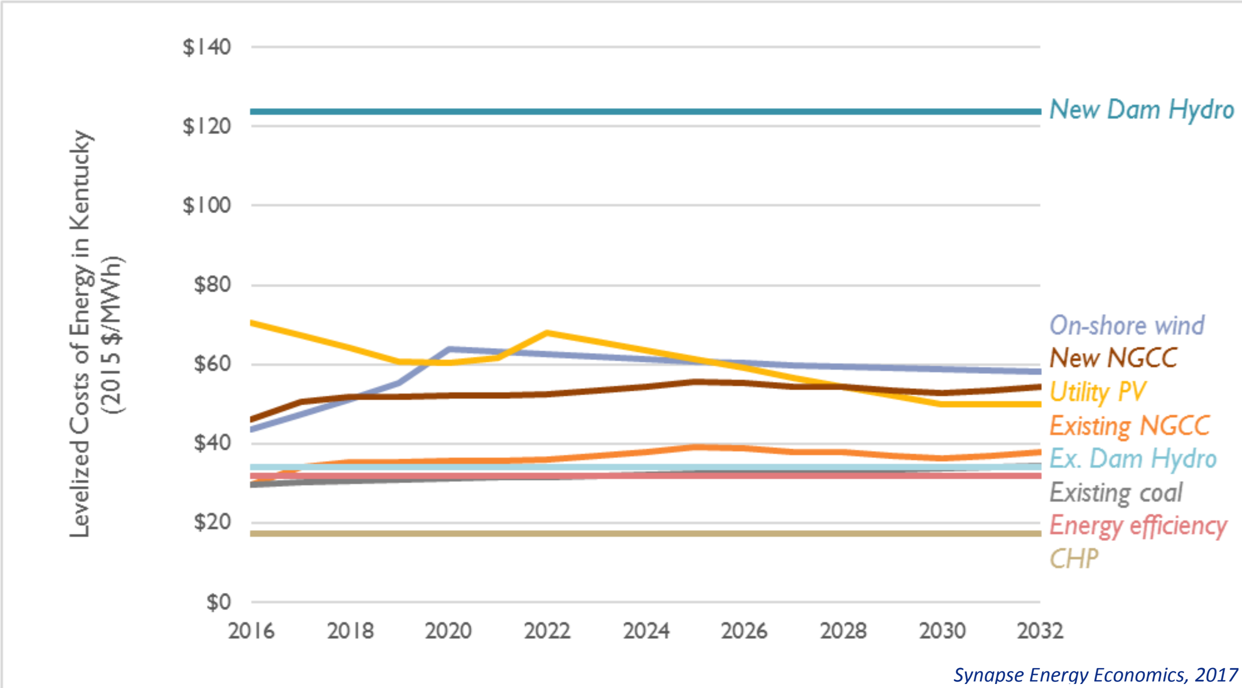
Changes in expected resource costs

Despite the recent tack to natural gas, Kentucky utilities would be remiss to ignore the shifts that other states are making towards renewables and energy efficiency. Energy efficiency and combined heat and power measures are already among the most cost-effective resources that utilities can procure, while solar and wind are also becoming competitive, even relative to existing generation (see Figure 7). Throughout the study period, combined heat and power (or "CHP"—technology which generates heat and electricity from the same source for commercial or industrial customers) is the most cost-effective resource on a levelized basis, although its potential may be smaller than other resources.[4] In the mid-2020s, energy efficiency is likely to supplant existing coal as the most cost-effective resource on average in Kentucky. Over this same time period, the costs of producing power from existing natural gas combined-cycle units (NGCCs) and the costs of installing new generation turbines at existing unpowered dams are expected to be marginally higher than the average price of producing power from existing coal units.

Other than combined heat and power, energy efficiency, and new hydro generation at existing dams, the most cost-effective new resources in the near term are new natural gas combined-cycle units and new on-shore wind facilities. In the near- to mid-term, certain tax benefits, such as the production tax credit (PTC) for wind and the investment tax credit (ITC) for solar expire, increasing the costs of renewables relative to new natural gas-fired plants. At the same time, however, these technologies' costs are expected to fall quickly as a result of technological enhancements. For these reasons, by 2028, new utility-scale solar photovoltaics (PV) are estimated to be as cost-effective as building a new NGCC unit in Kentucky.

[4] A levelized cost of energy is an "average" cost of energy that assumes any up-front capital costs are amortized or spread over the lifetime of the resource and are added to any fuel, operating, or maintenance costs.

Figure 7. Levelized costs of energy



Notes: Costs of coal are weighted using both newer and older existing units. These costs do not include the costs of installing new environmental retrofits. Costs do not include the price of building new transmission to new plants (such as wind, hydro, or utility PV plants, which may be located in more remote parts of the grid). Tax credits such as the PTC and ITC are included for both wind and utility PV. Costs of "existing" resources do not include sunk costs. Distributed PV is not shown. While costs of distributed PV are expected to see declines similar to utility-scale PV, a significant share of the costs for distributed PV are paid for privately by the developers or owners of those systems.
Sources: All costs except for energy efficiency are shown using the current ReEDS default price trajectories for units in Kentucky. Energy efficiency costs are calculated using Synapse research.

Environmental regulations and pricing carbon

Over the past five years, many Kentucky power plants have undergone significant retrofits to comply with environmental regulations. These regulations aim to reduce emissions of harmful sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter, and heavy metals (such as mercury).[5] In many other cases, rather than invest in costly upgrades at struggling power plants, utilities have chosen to close these generating units and obtain electricity from less-expensive sources. In the near future, the remaining coal plants will need to contend with the enforcement of these same environmental policies (which may require further, more stringent retrofits), as well as recent regulations to protect Kentucky's drinking and recreation water from damaging coal ash spills and voluminous cooling water withdrawal.

At the same time, many utilities have begun to plan for the regulation of CO_2. In 2014, EPA issued a draft Clean Power Plan, followed by a final version in August 2015. The Clean Power Plan is meant to reduce

[5] SO_2, NO_X, and particulate matter are major precursors to acid rain and smog and can cause or worsen asthma, emphysema, bronchitis, and heart disease. Mercury and other heavy metals have been associated with birth defects and impacts on the nervous, digestive, immune respiratory, and renal systems.

emissions of CO_2 from electric generators to 32 percent below 2005 levels by the year 2030 by increasing the use of renewables, energy efficiency, and natural gas. Despite many analysts showing that the Clean Power Plan was unlikely to cause significant costs to consumers, a number of states and utilities sued the federal government in an effort to stop the regulation.[6]

In February 2016, the United States Supreme Court made an unprecedented decision to stay the implementation of the plan during its litigation in lower courts. While current federal politics make the near-term future of the Clean Power Plan uncertain, the EPA is mandated under the 2007 Supreme Court decision *Massachusetts vs. Environmental Protection Agency* to regulate CO_2 emissions.[7] Whether it takes the form of the Clean Power Plan or some other approach, federal regulation of greenhouse gas emissions is unavoidable.

Rather than waiting for the federal government, some states are forging ahead with their own approach to reducing greenhouse gas emissions. Since 2010, nine states in the northeast have participated in the Regional Greenhouse Gas Initiative (RGGI), a regional market that imposes a cost on CO_2 from electric generators.[8] California created its own law, AB32, which mandates California to reduce emissions to 1990 levels by 2020 and established targets and regulations aimed at reducing CO_2 emissions in later years. In November 2016, Washington state voters narrowly rejected a measure to implement a carbon tax. Despite this, Washington and other states are exploring ways to create their own greenhouse gas legislation or to join existing programs like RGGI and AB32.

Further, many individual utilities now recognize the need to incorporate carbon prices into their integrated resource plan (IRP) exercises and account for the cost of carbon when making resource procurement decisions. As noted in Synapse's *Spring 2016 National Carbon Dioxide Price Forecast*:

> History has shown a steady increase in the number of utility planning processes that include a CO_2 price:
>
> - None of the 15 IRPs published from 2003-2007 reviewed by Synapse included a CO_2 price forecast.
> - Of the 56 IRPs from 2008-2011 reviewed, 23 included a CO_2 price forecast.
> - Of the 115 IRPs released in 2012-2015 and reviewed by Synapse, 66 include a CO_2 price in at least one scenario, including 61 with a CO_2 price in their reference case scenario.

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6 For a review of modeled Clean Power Plan costs, see http://www.wri.org/sites/default/files/The_Economic_Impacts_of_the_Clean_Power_Plan.pdf

7 *Massachusetts v. Environmental Protection Agency*, 549 U.S. 497 (2007)

8 More information available at www.rggi.org.

- Moreover, of the 24 IRPs in the Synapse review that were released in 2014-2015, 20 included a CO_2 price in at least one scenario. Of these, 19 includes a CO_2 price in their reference case scenario.[9]

The trend towards including the cost of carbon in resource planning has not passed over Kentucky: in their 2014 joint IRP, Louisville Gas & Electric and Kentucky Utilities considered a carbon price that grew from $17 per short ton in 2020 to $48 in 2029;[10] Big Rivers Electric Corporation modeled both a $10 and $30 tax per metric ton in 2014;[11] Duke Energy Kentucky modeled a Reference Case scenario in 2014 with carbon prices starting at $17 per ton in 2020 and increasing to $53 per ton in 2034.[12] Kentucky Power's 2013 IRP included a cost of carbon in its preferred portfolio at a base price of $15 per ton[13] and its 2016 draft IRP considers CO_2 prices ranging from $3 per ton in 2024 to $20 per ton in 2030.[14]

Given rapidly changing energy markets and stricter pollution standards, Kentucky policymakers have been presented with a choice. They can continue to adhere to traditional approaches to generating electricity from fossil fuels, despite strong signals that that doing so exposes Kentuckians to many risks, including increased consumer costs and environmental degradation. Or Kentucky can forge its own path to a low-risk, clean energy future in which residents see a just transition to lower electric bills, improved public health, and local job creation.

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9 Luckow, Patrick, et al. *Spring 2016 National Carbon Dioxide Price Forecast*. Synapse Energy Economics. March 16, 2016. Available at: http://www.synapse-energy.com/sites/default/files/2016-Synapse-CO2-Price-Forecast-66-008.pdf

10 Kentucky Public Service Commission. 2016. *Staff Report on the 2014 Integrated Resource Plan of Louisville Gas and Electric Company and Kentucky Utilities Company.* Case No. 2014-00131. Page 14. Available at: http://psc.ky.gov/agencies/psc/industry/electric/irp/201400131_032016.pdf

11 Kentucky Public Service Commission. 2015. *Staff Report on the 2014 Integrated Resource Plan of Big Rivers Electric Corporation*. Case No. 2014-00166. Page 11. Available at: http://psc.ky.gov/agencies/psc/industry/electric/irp/201400166_122015.pdf

12 Kentucky Public Service Commission. 2015. *Staff Report on the 2014 Integrated Resource Plan of Duke Energy Kentucky, Inc.* Case No. 2014-00273. Page 36. Available at: http://psc.ky.gov/agencies/psc/industry/electric/irp/201400273_082015_sr.pdf

13 Kentucky Public Service Commission. 2014. *Staff Report on the 2013 Integrated Resource Plan of Kentucky Power Company*. Case No. 2013-00475. Page 48. Available at: http://psc.ky.gov/agencies/psc/industry/electric/irp/201300475_20141113.pdf

14 Kentucky Public Service Commission. 2016. *2016 Integrated Resource Plan of Kentucky Power Company Volume A - Public Version*. Case No. 2016-00413. Page 33. Available at: http://psc.ky.gov/pscecf/2016-00413/jkrosquist%40aep.com/12202016110531/KPCO_2016_IRP__Volume_A___Public__Version.pdf

2. EMPOWERING KENTUCKY

To investigate the costs and benefits of pursuing a clean energy future for Kentuckians, Synapse conducted analysis using the National Renewable Energy Laboratory's (NREL) Regional Energy Deployment System (ReEDS) model.[15] ReEDS is a long-term capacity expansion and dispatch model of the electric power system in the lower 48 states. Synapse has adapted its in-house version of the ReEDS model to allow for more detailed outputs by state and sector and to permit differentiation of energy efficiency expectations by state. We modeled two scenarios through 2032:

- **Reference case:** This is a future in which Kentucky continues on a business-as-usual trajectory. Energy efficiency and renewables are added at minimal levels. Natural gas plays a much larger role than it has historically in Kentucky, and coal continues to be a dominant part of the state's energy. In this scenario, we assume the Clean Power Plan is not implemented for Kentucky or any other state.

- **Empower Kentucky Plan:** In this case, Kentucky pursues a three-fold strategy: it invests in cost-effective energy efficiency and combined heat and power, establishes an aggressive renewable portfolio standard (RPS) of 25 percent by 2030, and creates a carbon dioxide price that rises from $1 in 2018 to $3 in 2030. In this case, we assume that Kentucky and all other states meet the carbon reductions mandated under the Clean Power Plan. While coal and natural gas continue to play significant roles in this scenario, generation from those sources declines, relative to the Reference case.

The following sections give an overview of the key policies in the Empower Kentucky Plan, detail how Kentucky's electric sector is expected to change under both scenarios, and discuss the impact of those changes on emissions, costs, and jobs.

2.1. The Empower Kentucky Plan

The Empower Kentucky Plan differs from the Reference case in several key ways: the implementation of a renewable portfolio standard, increased energy efficiency measures, and a Kentucky-specific CO_2 price adder. The Empower Scenario also includes provisions to prioritize energy programs that benefit low-income residents and commercial and industrial customers, expand distributed solar installations, and limit electric generation from biomass. More information on each of these policies is available in Appendix B.

In the Empower Kentucky Plan, we also assume that Kentucky and the rest of the states achieve compliance with the Clean Power Plan. However, the Empower Kentucky Plan goes beyond the Clean Power Plan—it achieves a lower-carbon, lower-bill, and higher-job future through energy efficiency and renewables, whether or not the Clean Power Plan is implemented in its proposed form.

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[15] More information on ReEDS is available at http://www.nrel.gov/analysis/reeds and in Appendix A.

Renewable portfolio standard

Under the renewable portfolio standard put in place in the Empower Kentucky Plan, 25 percent of all Kentucky sales must be covered through the purchase of renewable energy certificates (RECs) by 2030 and all later years. These RECs can be purchased from new wind, solar, or hydroelectric generators in Kentucky, or in any state electrically connected to Kentucky. This policy also requires that 1 percent of electric sales are met through distributed solar by 2030 and all later years.

Energy efficiency

Under the Empower Kentucky Plan, Kentucky utilities increase their implementation of cost-effective energy efficiency from current levels of about 0.38 percent savings per year to a level of 2.5 percent savings per year by 2030—a level comparable to many successful programs in the country today. This level of savings is sustained through 2032, and by that year, this will result in cumulative energy efficiency savings of 17 percent in the Empower Kentucky Plan, compared to cumulative savings of 3 percent in the Reference case. Utilities will prioritize energy efficiency programs for low-income customers and communities. Savings from low-income energy efficiency programs will account for 18 percent of all energy efficiency savings. Achieving the plan's overall energy efficiency goals will require an $11 billion investment over 15 years, creating new jobs and energy savings in communities statewide. In addition, the Empower Kentucky Plan will result in the installation of 1,000 MW of combined heat and power capacity to reduce energy consumption and costs in the commercial and industrial sector.

The Clean Power Plan

In the Empower Kentucky Plan, Kentucky and all other states are required to meet the stipulations of the Clean Power Plan. For Kentucky generators, this means emitting no more than 64 million short tons starting in 2030 or purchasing enough emissions allowances from other states to meet any emissions overage. We assume that all states achieve the EPA's requirement for tons of CO_2 pollution reduced from their power sector, including from new sources (within the Clean Power Plan, this is referred to as meeting each state's "mass-based standard with new-source complement"). We assume that emission allowances are traded both within and across state borders among two separate groups of states: the nine states which currently trade CO_2 emissions under the Regional Greenhouse Gas Initiative and all other states modeled. In this analysis, we assume that emission allowance costs are incurred by power plants that purchase allowances—and their utility ratepayers—and that the revenue from sold allowances offset other ratepayer electric costs.

CO_2 price adder

In addition to the Clean Power Plan, the Empower Kentucky Plan also features a Kentucky-specific CO_2 price adder. This price adder is put into place at $1 per short ton in 2018 and gradually increases to $3 per short ton in 2030, continuing through 2032. (Note that this is far below the levels assumed in recent integrated resource plans from the state's utilities, as discussed above.) This price adder is applied both to in-state emitting generators, as well as to the CO_2 content of electricity imported to Kentucky. As with the revenue generated through the Clean Power Plan, we assume that most revenue from the Kentucky-specific CO_2 price adder is reinvested in the electric system in support of energy efficiency measures; however, we assume that 20 percent of all revenue raised through the CO_2 price adder is used to fund a just transition for Kentucky's coal workers and communities.

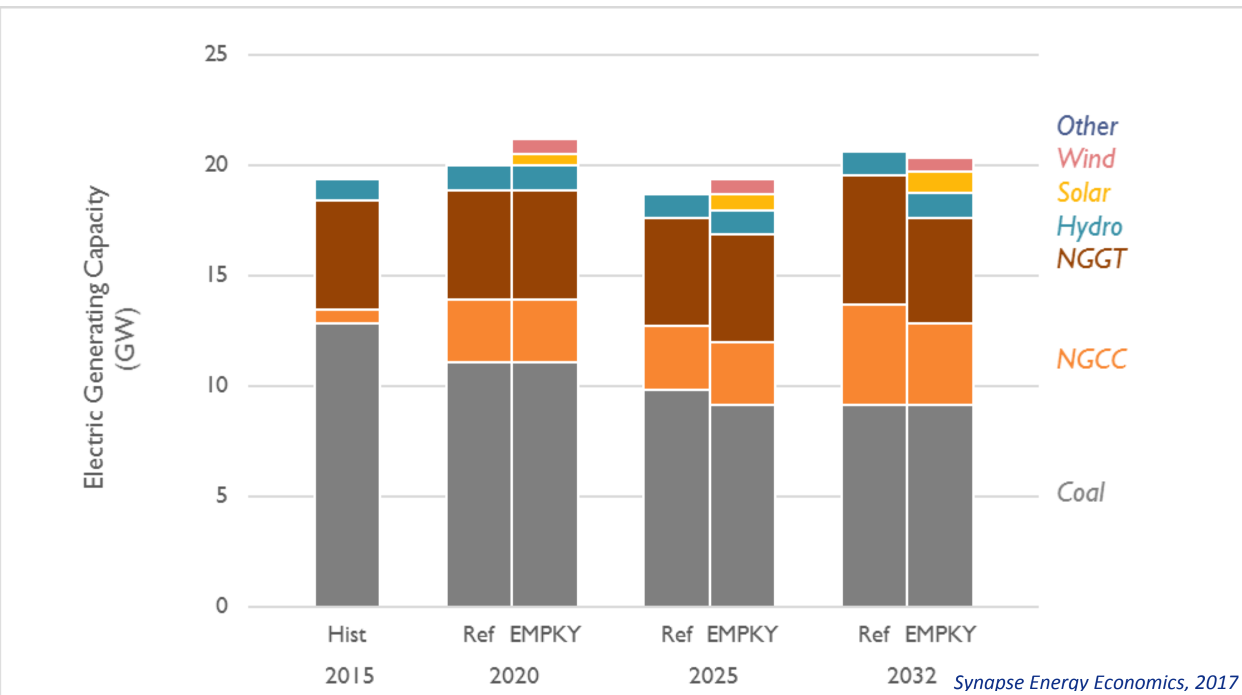
2.2. The Empower Kentucky Plan reduces CO_2 emissions by 40 percent

Kentucky's electric sector is expected to undergo significant changes in both the Reference case and the Empower Kentucky Plan. In both cases, Kentucky increasingly moves away from coal and achieves large reductions in SO_2, NO_X, and CO_2 emissions.

Changes to electric generating capacity

In both the Reference case and the Empower Kentucky Plan, 5.7 gigawatts (GW) of coal capacity is expected to retire by 2032, above and beyond what has already retired as of 2015. This includes 3.7 GW of coal capacity where owners have already announced retirement dates, as well as 2.0 GW that retires on an economic basis—as more cost-effective resources come online, these power plants are used less and less until it is more economical to retire them than to keep them running. Figure 8 shows historical electric generating capacity for Kentucky in 2015, as well as forecasted capacity in 2020, 2025, and 2032 for both the Reference case (left bars) and the Empower Kentucky Plan (right bars).

Figure 8. Projected electric generating capacity in the Reference case (Ref) and Empower Kentucky Plan (EMPKY)



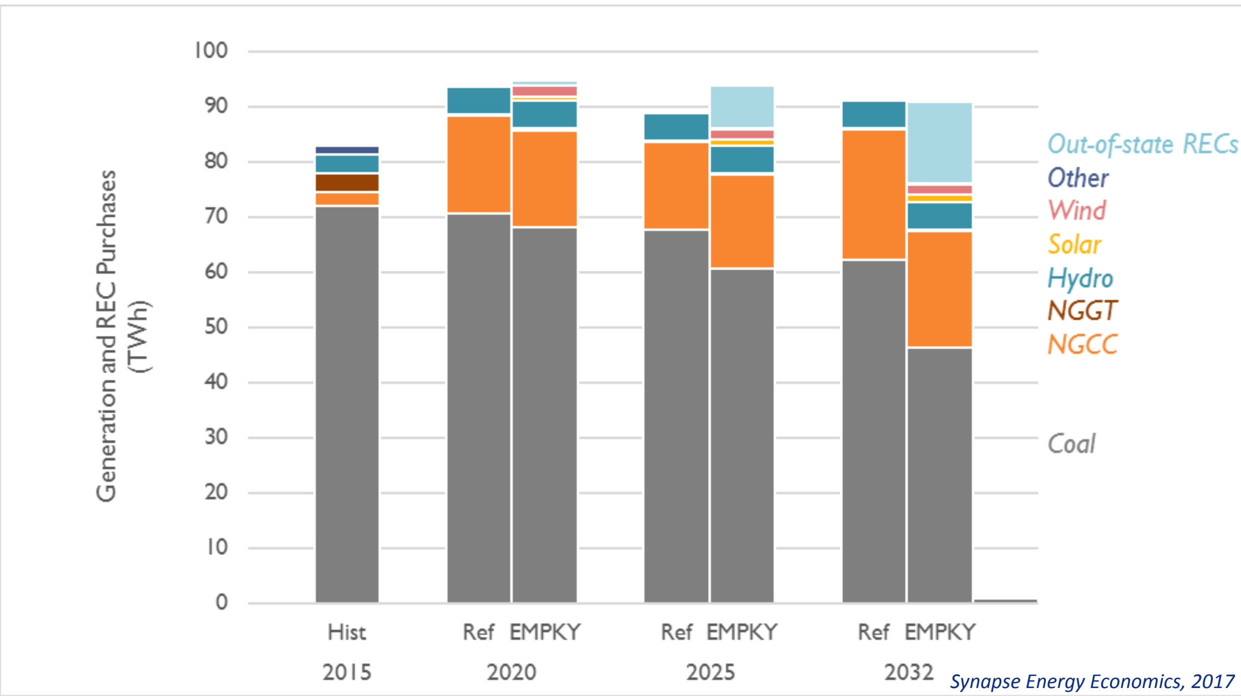
At the same time this coal capacity is retired, new resources are built. In addition to the 1.9 GW of NGCC capacity that is proposed or under construction, both cases add new NGCC units on an economic basis. Beyond the known additions, an additional 1.7 GW of new combined-cycle units are built in the

Reference case, while in the Empower Kentucky Plan 0.8 GW are built. Another major difference in the Empower Kentucky Plan is the new renewable capacity: by 2032, 1 GW of solar and 600 MW of wind are built, including distributed generation, compared to none built in the Reference case.[16]

Generation implications

As a result of the changes to Kentucky's fleet of power plants, the projected in-state generation will also change (see Figure 9). One of the most notable effects is that as new renewables and natural gas generators come online, coal generation begins to decrease. By 2032, only 68 percent of Kentucky's in-state generation comes from coal in the Reference case, compared to 87 percent in 2015. In the Empower Kentucky Plan, this number drops to 61 percent in 2032. As less coal generation is produced in Kentucky in the Reference case, utilities begin to import more electricity from neighboring states, leading to 8 percent of demand being met through imports in 2032, compared to 4 percent of all generation being exported in 2015. In the Empower Kentucky Plan, 11 percent of demand is met through imports in 2032.

Figure 9. Projected electric generation in the Reference case (Ref) and Empower Kentucky Plan (EMPKY)



[16] In the Empower Kentucky Plan, we model an RPS policy that requires Kentucky utilities to purchase renewable energy credits equivalent to 25 percent of utility sales by 2030, continuing through 2032. Roughly half of all states currently have an RPS policy. Like the policies that exist in all other states, Kentucky's policy allows utilities to purchase RECs from any state, as long as those RECs are generated in a state that is electrically connected to a Kentucky utility. Because Kentucky is one of the more interconnected states in the country, it can purchase RECs from Iowa to New Jersey and from Minnesota to Louisiana. Sixty percent of Kentucky's RECs in the Empower Kentucky Plan are bought from wind farms in Iowa, where wind generation is inexpensive, allowing for Kentucky to decrease nationwide emissions at a low cost to consumers.

While electric sales are projected to increase by 0.87 percent per year in both cases, in the Reference case Kentucky utilities only implement energy efficiency measures at the same rate as in past years (with energy savings equal to 0.38 percent of the previous years' sales); in the Empower Kentucky Plan, utilities gradually increase the level of energy efficiency measures they install in each year until they reach the level that leading states like California, Massachusetts, and Rhode Island currently attain (a gradual 0.15 percentage point increase each year until reaching 2.5 percent annual savings by 2030). Cumulative, this results in sales decreasing by 17 percent in 2032. This decrease in total electricity sales means that in 2032 Kentucky utilities avoid 13 terrawatt-hours (TWh) of electricity generation and import purchases relative to the Reference case, a decrease of 14 percent (not including REC purchases from out-of-state).

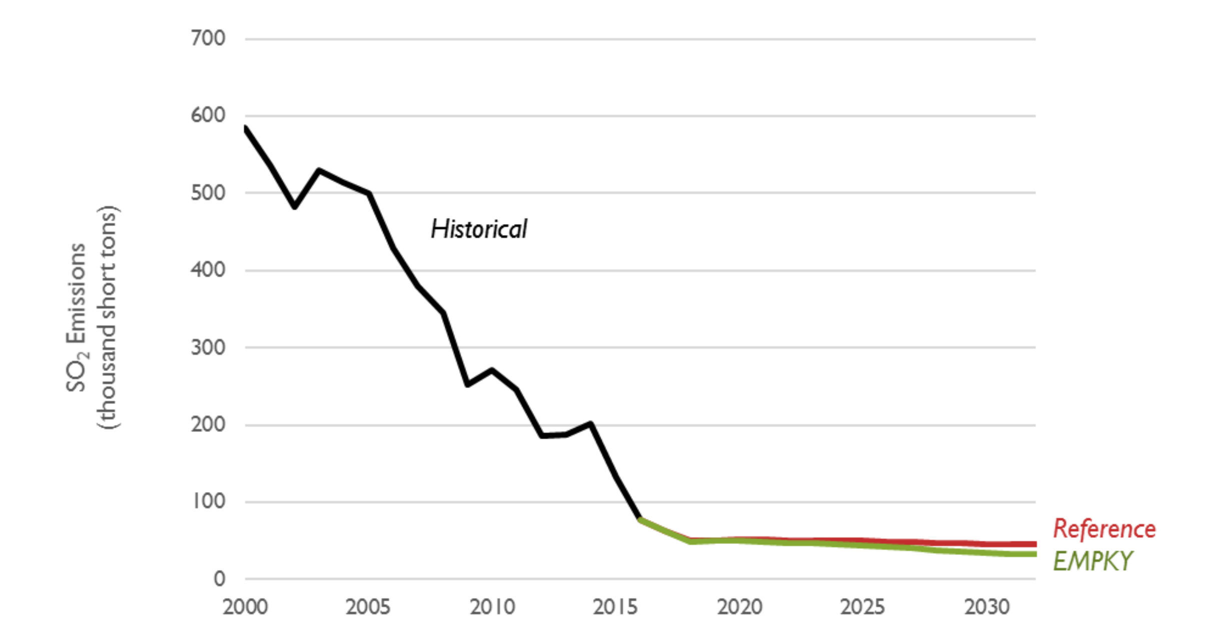
In 2018, Kentucky begins to implement a price adder for CO_2 emitted by Kentucky generators. This price adder also applies to the CO_2 pollution associated with electricity imports, which is determined by the average CO_2 emissions rate of the power sector in the originating state. This price adder increases gradually from $1 per short ton of CO_2 in 2018 to $3 in 2030, where it remains for all future years. Eighty percent of the revenue collected from this adder is assumed to be reinvested in the electric sector, causing the program to nearly be cost neutral to Kentucky ratepayers.[17] This price adder further incentivizes a switch away from CO_2-intensive generation towards cleaner, more efficient electricity.

Impacts on emissions

As a result of these changes to in-state generation, Kentucky's electric generating fleet produces far fewer emissions that harm public health. Even in the Reference case, 2032 SO_2 emissions are down 66 percent relative to 2015 while 2032 NO_X emissions are down 33 percent relative to 2015 (see Figure 10 and Figure 11). Because of the additional shift away from coal generation in the Empower Kentucky Plan, even more emission reductions are achieved: a 76 percent decrease in SO_2 by 2032 and a 53 percent decrease in NO_X by 2032 (both relative to 2015 levels).

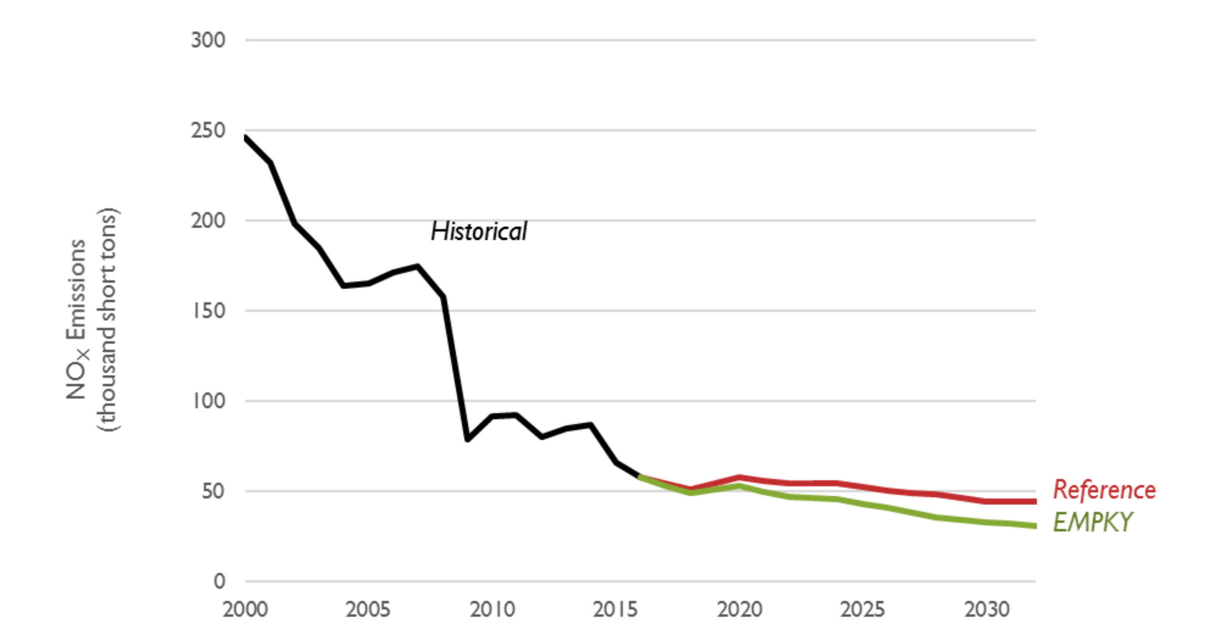
[17] See Appendix B for more discussion on this price adder.

Figure 10. Projected in-state SO_2 emissions in the Reference case and Empower Kentucky Plan (EMPKY)



Synapse Energy Economics, 2017

Figure 11. Projected in-state NO_X emissions in the Reference case and Empower Kentucky Plan (EMPKY)

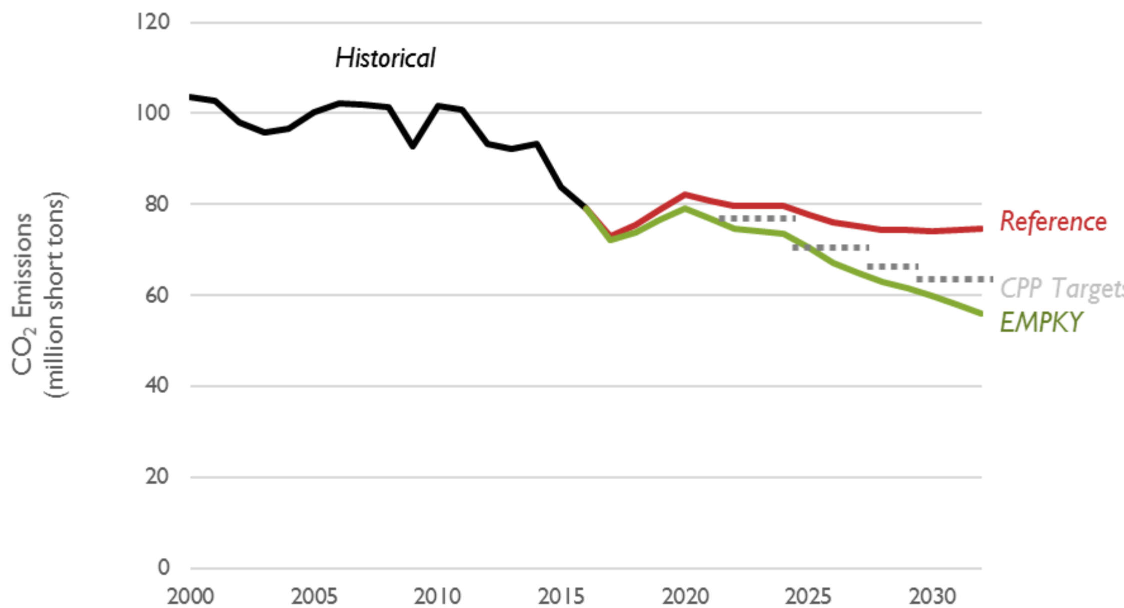


Synapse Energy Economics, 2017

Changes in the electric sector in both scenarios also lead to decreased CO_2 emissions. In the Reference case, Kentucky's CO_2 emissions are 20 percent lower in 2032 than in 2012 (see Figure 12). This represents a sizeable decrease for a scenario with no Clean Power Plan, but it falls far short of the rule's

32 percent CO_2 reduction target for Kentucky. On the other hand, because of renewables, energy efficiency, and the CO_2 price adder, CO_2 emissions in the Empower Kentucky Plan are 40 percent lower in 2032 than in 2012, exceeding the Clean Power Plan target. Under the Clean Power Plan, Kentucky utilities are required to either achieve in-state emissions of 64 million short tons in 2030 (and later years) or purchase emissions allowances from other states. In the Empower Kentucky Plan, Kentucky utilities over-comply with the Clean Power Plan and thus can sell allowances to generators in other states.[18] Between 2022 (when the Clean Power Plan goes into effect) and 2032, cumulative CO_2 emissions in the Empower Kentucky Plan are 14 percent lower than in the Reference case.

Figure 12. Projected in-state CO_2 emissions in the Reference case and Empower Kentucky Plan (EMPKY)



Synapse Energy Economics, 2017

The above numbers are framed in terms of a generation-based emissions inventory—i.e., the framework of the Clean Power Plan, where states are eligible to count emissions reductions as long as they happen within their state borders. However, under Kentucky's RPS policies in the Empower Kentucky Plan, a majority of the required renewables are built in other states, producing 15 TWh of electricity that is then delivered to the Kentucky electric system. If Kentucky utilities were to count emission reductions caused by these out-of-state renewable generators, 2032 CO_2 emissions in the Empower Kentucky Plan would drop from 25 percent lower than the Reference case to 33 percent lower than the Reference case.[19]

[18] Note that nationwide compliance with the Clean Power Plan is achieved relatively easily—allowances are not priced until 2026, when they reach a price of $2 per short ton. Prices then grow to just under $6 per short ton by 2030, before dropping to under $5 per short ton in 2032.

[19] This calculation assumes that these renewables displace emissions from existing natural gas-fired combined cycle generators.

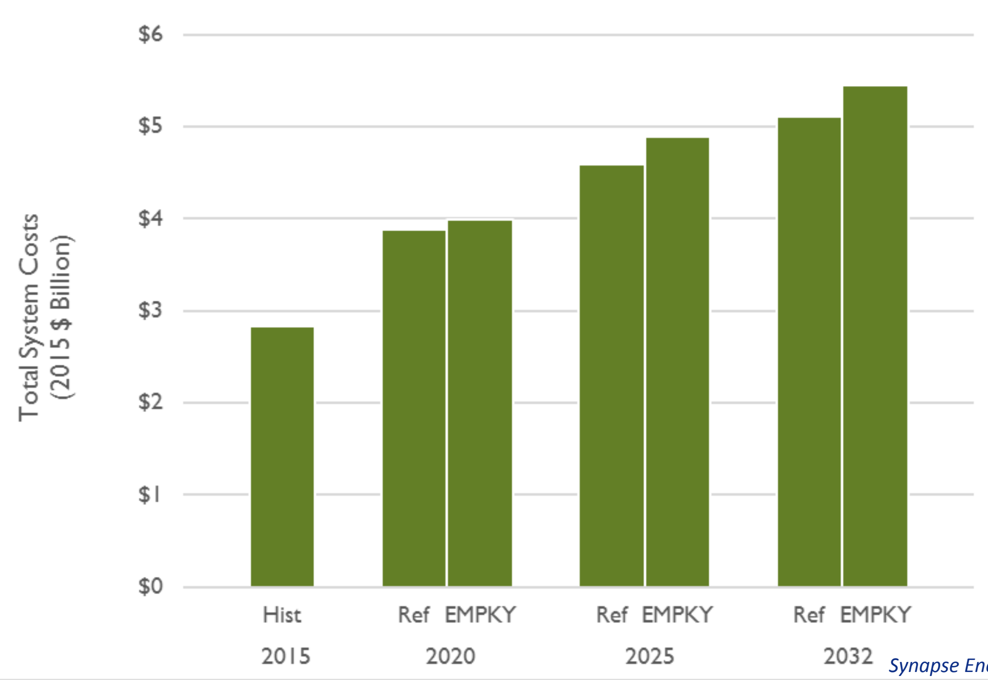
2.3. Kentucky's new electrical system does not increase costs

These changes to system capacity, electric generation, and emissions all have implications for what Kentucky ratepayers pay for electricity. We find that the Empower Kentucky Plan is not any more expensive than the Reference case. On the contrary, it actually leads to monthly electric bill savings for Kentucky consumers.

System costs

On a system cost-basis (i.e., the dollar amount required to reliably provide electric service to Kentucky customers, including costs relating to capital expenditures, operating and maintenance, energy efficiency, environmental retrofits, transmission construction, and purchased imported electricity, among others), we estimate that 2032 costs in the Reference case increase to $5.1 billion (see Figure 13). In the Empower Kentucky Plan, system costs are just 7 percent higher, in part because of investment in cost-effective energy efficiency.

Figure 13. Kentucky electric system costs in the Reference case (Ref) and Empower Kentucky Plan (EMPKY)

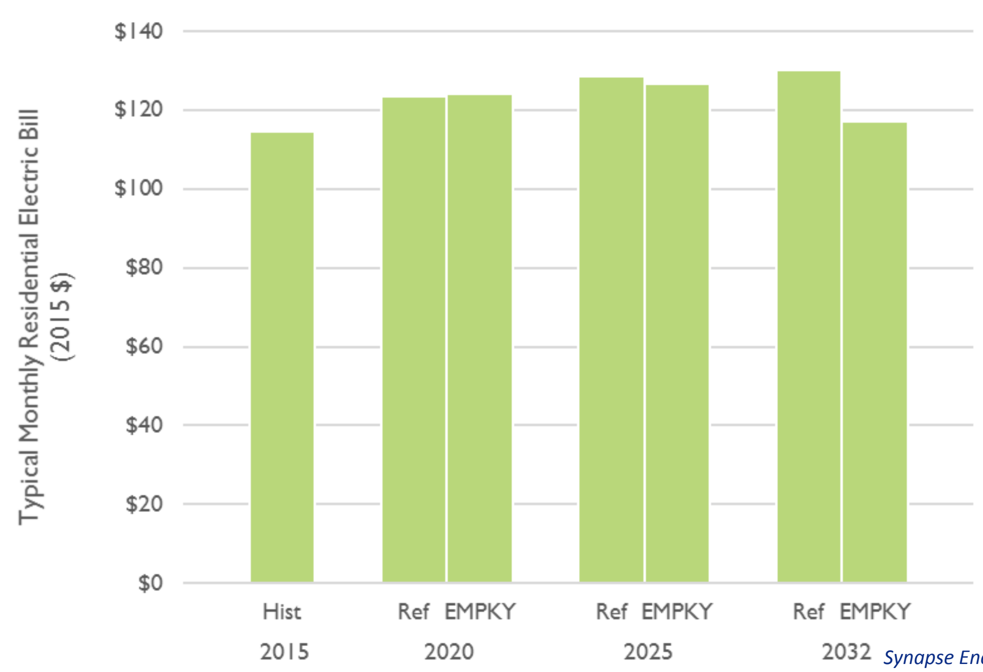


Synapse Energy Economics, 2017

Monthly electric bills

Despite 2032 system costs being slightly increased in the Empower Kentucky Plan, monthly bills are lower because of energy efficiency savings. While residential ratepayers might be paying more for electricity on a dollar-per-kWh basis, they more than make up for this rate increase by avoiding unnecessary use of electricity. In 2032, monthly residential electric bills are estimated to be $117 per month, just $3 per month higher than average bills were in 2015 and $13 per month lower than bills would be in a case where the Empower Kentucky Plan is not implemented.

Figure 14. Typical monthly residential bills in the Reference case (Ref) and Empower Kentucky Plan (EMPKY)



Synapse Energy Economics, 2017

2.4. The Empower Kentucky Plan produces more jobs for Kentuckians than a Reference case

The Empower Kentucky Plan leads to a diversified generating fleet, reduces emissions that harm public health and the global climate, and delivers net savings to Kentucky ratepayers' wallets. Importantly, we also find that the Empower Kentucky Plan is a pathway towards more jobs for Kentuckians.

From 2018 to 2032, the Empower Kentucky Plan creates a total of 46,300 net additional job-years, an average of 3,100 net additional jobs in each year, relative to the Reference case.[20] Many of these jobs are created through increased energy efficiency investment, which relies on local workers who live in Kentucky and continue to contribute to the local economy. We find that in 2032 the Empower Kentucky Plan creates an annual average of 600 more jobs, relative to the Reference case (see Figure 15).

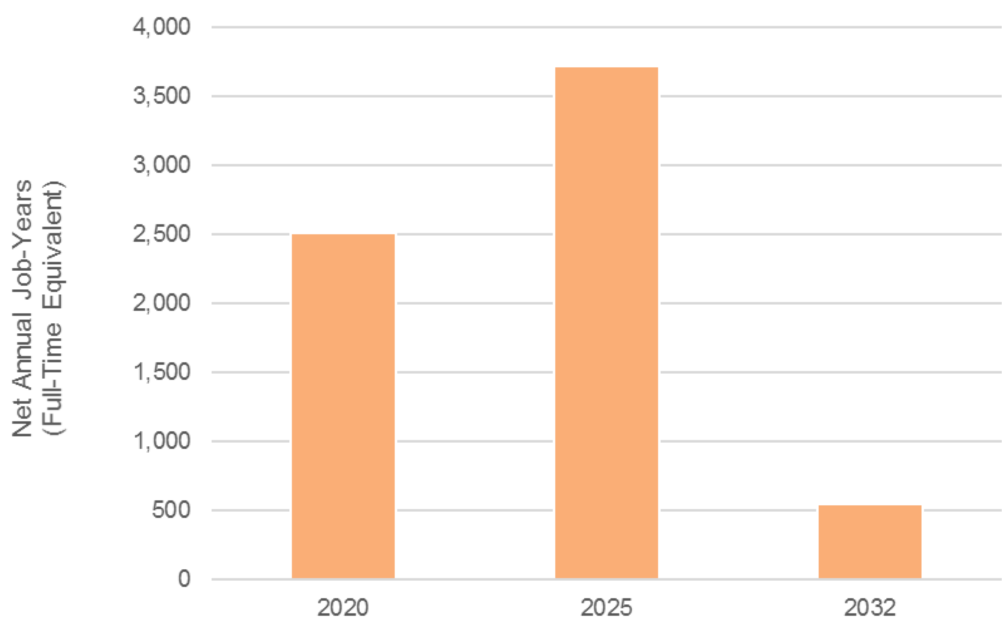
In addition, we assume that 20 percent of all revenue generated by the Empower Kentucky's CO_2 price adder is used to fund a just transition for Kentucky workers. This revenue funds job training and education; financial support for affected workers and communities; local infrastructure and job creation initiatives; and support for local innovation and entrepreneurship.[21] From 2018 to 2032, the Empower

[20] These numbers are in "job-years," equivalent to one full-time job lasting a single year.

[21] To learn more about KFTC's plan for a just transition for the state's coal workers, and economy as a whole, see: https://www.kftc.org/sites/default/files/docs/resources/kftcs_just_transition_framework.pdf

Kentucky Plan creates $387 million to use in a just transition for Kentucky's coal workers and communities.

Figure 15. Net annual job-years created in the Empower Kentucky Plan, relative to the Reference case



Synapse Energy Economics, 2017

3. SUMMARY OF FINDINGS

In this analysis we find that an Empower Kentucky Plan not only results in reduced emissions—it also achieves a just transition for Kentuckians by reducing monthly electric bills and creating thousands of new jobs.

An Empower Kentucky Plan creates 46,300 more job-years for Kentuckians than a business-as-usual future over 15 years.

From 2018 to 2032, 46,300 more total job-years are created under the Empower Kentucky Plan, equivalent to an average of 3,100 new jobs in each year, relative to the Reference case. Many of these jobs are created through expanding energy efficiency programs in Kentucky.

The Empower Kentucky Plan exceeds the Clean Power Plan's requirement by cutting carbon dioxide emissions by 37 million tons from 2012 to 2032, a 40 percent reduction.

Under the Empower Kentucky Plan, Kentucky's electric power sector produces 56 million short tons of carbon dioxide (CO_2) emissions in 2032, or 40 percent less than were emitted in 2012. From 2022 to 2032, the Empower Kentucky Plan produces 6 percent fewer emissions than is required for Kentucky to comply with the federal Clean Power Plan. CO_2 emissions under the Empower Kentucky Plan are 14 percent lower than under the Reference case. CO_2 pollution declines under the Reference case, but not by enough to meet Clean Power Plan targets.

The Empower Kentucky Plan reduces harmful pollutants that threaten the health of Kentuckians.

Compared to a business-as-usual future, the Empower Kentucky Plan reduces pollutants in 2032 by 13 thousand short tons of sulfur dioxide (SO_2) and 13 thousand short tons of nitrogen oxides (NO_X). Over the 15-year-period of 2018 to 2032, this results in a cumulative reduction of 93 thousand short tons of SO_2 and 132 thousand short tons of NO_X. SO_2 and NO_X are major precursors to acid rain and smog, and both can cause or worsen asthma, emphysema, bronchitis, and heart disease.

The Empower Kentucky Plan saves customers money, reducing average residential bills by 10 percent compared to the business-as-usual case in 2032.

Implementing energy efficiency, renewables, and carbon pricing reduces residential electric bills by $13 per month in 2032 relative to the business-as-usual future. These net cost savings are due to reduced purchases of fossil fuels, implementing energy efficiency measures, and avoided costly environmental retrofits. The Empower Kentucky Plan leads to average residential electric bills 10 percent lower than the reference case in 2032.

The Empower Kentucky Plan invests $387 million in a just transition for Kentucky's coal workers and communities.

A key objective of the Empower Kentucky Plan is to ensure a just transition for workers and communities most affected by the shift to a clean energy economy. Under this plan, 20 percent of all carbon pricing revenue—$387 million—is re-invested in job training and education; financial support for affected workers and communities; local infrastructure and job creation initiatives; and support for local innovation and entrepreneurship.[22]

Over the 15-year period, the low price on CO_2 emissions from instate and imported electricity generation imposed under this plan will generate almost $1.9 billion in total revenue. Of that, 20 percent is dedicated to support just transition efforts. The remaining $1.5 billion will be re-invested in efforts to accelerate energy efficiency across the economy and state. It can be expected that a share of those energy sector investments will also benefit affected workers and communities, in addition to the $387 million directed towards just transition strategies.

The Empower Kentucky Plan invests $11 billion in energy efficiency across the economy and prioritizes savings for low-income customers.

In the Empower Kentucky Plan, utilities will invest $11 billion in energy efficiency programs between 2018 and 2032 and achieve cumulative energy savings 17 percent lower than the business-as-usual case.

Fifty-five percent of all energy savings come from Kentucky's commercial and industrial sector, and 45 percent from residential customers. Within those overall efficiency goals, the Empower Kentucky Plan calls for 18 percent of all energy savings to come from projects and programs benefitting low-income customers and communities. That low-income standard is higher than some leading states are achieving today, a reflection of Kentucky's higher average household electricity consumption and lower median household incomes.

The Empower Plan also builds 1,000 MW of new combined heat and power capacity by 2032 as a cost effective approach to achieve energy savings in commercial and industrial sectors. Combined heat and power systems allow facilities to generate heat or hot water and electricity from the same energy source, often located on-site, and produce significant, low-cost energy savings.

The Empower Kentucky Plan results in a cleaner and more diverse energy system in Kentucky by 2032, while system costs are just 7 percent higher and average residential bills are lower.

Under the Empower Kentucky Plan, the share of Kentucky's electricity generated from coal falls to 61 percent in 2032, compared to 87 percent in 2015 and 68 percent in the Reference case. The same number of coal plant retirements are expected over the next 15 years under both scenarios. In the Empower Kentucky Plan, Kentucky will build 0.8 GW less natural gas than in the Reference case, while installing 1 GW more solar (including more than 600 MW of distributed solar), building 600 MW more

[22] To learn more about KFTC's plan for a just transition for the state's coal workers, and economy as a whole, see: https://www.kftc.org/sites/default/files/docs/resources/kftcs_just_transition_framework.pdf and www.empowerkentucky.org.

wind, and increasing imports by just 3 percentage points. Overall system costs for the Empower Kentucky Plan are just 7 percent higher than the reference case, while average bills are lower due to greater energy efficiency.

Conclusion

If Kentucky embarks on a clean energy future as envisioned in the Empower Kentucky Plan, its citizens will benefit from lower electric bills, cleaner air and water, more jobs, and more support for workers and communities affected by our energy transition, all while exceeding the state's obligation to reduce harmful climate emissions.

Appendix A: Electric System and Jobs Impact Models

Synapse relied on two models to conduct its analysis of the Reference case and the Empower Kentucky Plan: Synapse's adapted version of the National Renewable Energy Laboratory's (NREL) Regional Energy Deployment System (ReEDS) model, and IMPLAN, a job impact model developed by IMPLAN Group PLC and modified by Synapse.[23]

Electric-Sector ReEDS Model

ReEDS is a long-term capacity expansion and dispatch model of the electric power system in the lower 48 states. Synapse has adapted its in-house version of the ReEDS model to allow for more detailed outputs by state and sector and to permit differentiation of energy efficiency expectations by state.

Compliance with the Clean Power Plan is modeled as achieving the state-level mass-based targets that include estimated emissions from new sources (the "new source complement") on a biennial basis. We assume that emission allowances are traded both within and across state borders among two separate groups of states: the nine states which currently trade carbon dioxide (CO_2) emissions under the Regional Greenhouse Gas Initiative (RGGI) and all other states modeled. The price of CO_2 allowances is set endogenously within the model as a shadow price.

IMPLAN Job Impacts Model

We estimated the job impacts using IMPLAN, which captures the in-state job impacts from energy spending in Kentucky only.[24] The assumed spending comes from following activities:

- Construction of generating resources, transmission, and energy efficiency installations
- Operations of energy resources
- Consumer and business re-spending of electricity

For the electric sector, we developed customized inputs for the IMPLAN model relying in part on NREL's JEDI model.[25] For each resource, we estimated the portion of the investment spent on materials versus

[23] ReEDS version used is ReEDS_v2015.2(r25). More information is available at: http://www.nrel.gov/analysis/reeds. IMPLAN is a commercial model developed by IMPLAN Group PLC. Information on IMPLAN is available at: http://implan.com/

[24] This modeling does not incorporate the job impacts in Kentucky of changes to the electric system that occur outside of Kentucky's borders.

[25] NREL. *Jobs and Economic Development Impact (JEDI) Models.* Last accessed February 2017. Available at: http://www.nrel.gov/analysis/jedi/about_jedi.html.

labor. Impacts from household spending and gas stations were more straightforward since these industries directly correspond to IMPLAN sectors. The analysis results in impacts of the following types:

- **Direct impacts** include jobs for contractors, construction workers, plant operators, and automobile manufacturers. We developed these estimates using the amount of investment, the share of that investment spent on labor for each resource, and industry-specific wages.

- **Indirect impacts** include jobs that support the direct activities. For instance, an investment in a new wind farm not only creates jobs at the wind farm, but also down the supply chain, increasing jobs for turbine and other component manufacturers. We adjusted the IMPLAN model's base resource spending allocation assumptions for the entire electric industry based on NREL data on requirements for each individual resource.

- **Induced impacts** result from employees in newly created direct and indirect jobs spending their paychecks locally on restaurants, car repairs, and countless other consumer goods and services. Induced impacts also come from customer savings on energy spending, which are spent on the same broad range of goods and services.

Temporal Scope

The time period of our modeling is 2016-2032. ReEDS modeling is performed at two-year intervals starting in 2014. Historical data has been included in our post-processing to serve as a point of comparison for future emissions.

Geographic Scope

In the ReEDS model, all states in the continental United States are represented. ReEDS divides the United States into 134 power control areas that are consistent with state boundaries and can be aggregated to model state impacts. Each power control area is modeled as having a single aggregated "unit" of each resource type, the size of which is equal to the sum of the capacities of the actual units in that territory. For this analysis, Synapse modeled the country as a whole to capture interactions between states.

APPENDIX B: MODELED SCENARIOS

To investigate the costs and benefits of pursuing a clean energy future for Kentuckians, Synapse modeled two scenarios through 2032:

- **Reference case:** This is a future in which Kentucky continues on a business-as-usual trajectory. Energy efficiency and renewables are added at minimal levels. Natural gas plays a much larger role than it has historically in Kentucky, and coal continues to be a dominant part of the state's energy. In this scenario, we assume the Clean Power Plan is not implemented for Kentucky or any other state.

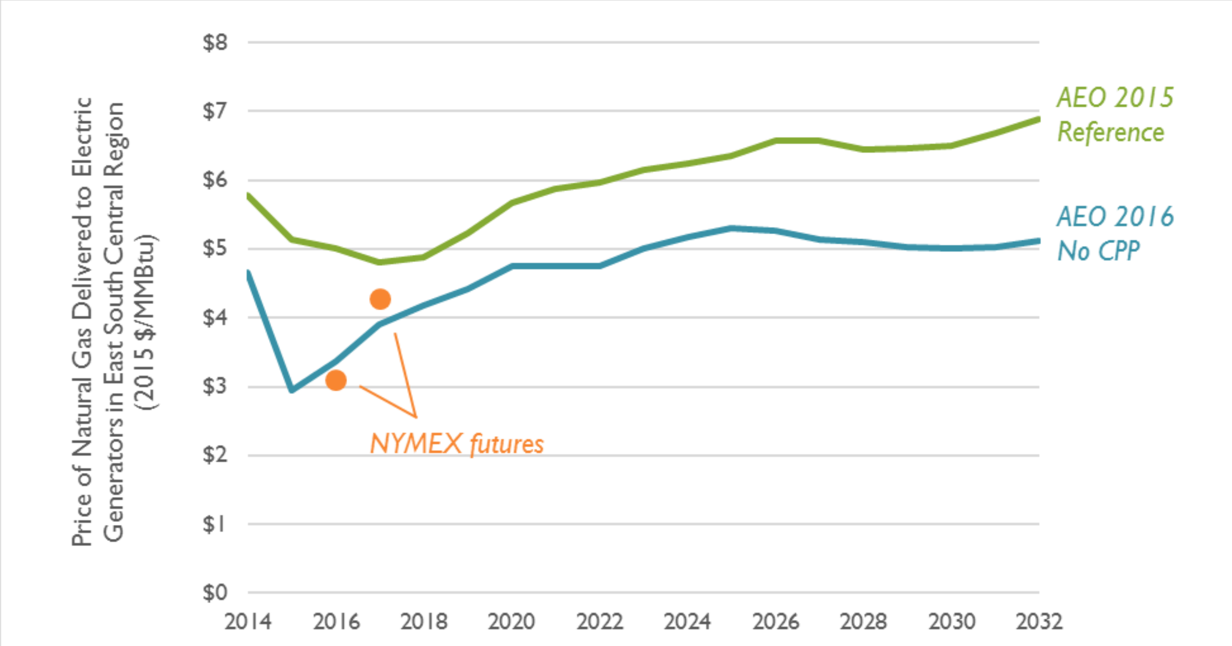
- **Empower Kentucky Plan:** In this case, Kentucky pursues a three-fold strategy: it invests in cost-effective energy efficiency and combined heat and power, establishes an aggressive renewable portfolio standard of 25 percent by 2030, and creates a carbon dioxide price that rises from $1 in 2018 to $3 in 2030. In this case, we assume that Kentucky and all other states meet the carbon reductions mandated under the Clean Power Plan. While coal and natural gas continue to play significant roles in this scenario, generation from those sources declines, relative to the Reference case.

This section details the input assumptions used in both scenarios, as well as the input assumptions that are unique to the Reference case and the Empower Kentucky Plan. Note that all assumptions in this analysis were carefully developed in a process involving stakeholders from Kentuckians for the Commonwealth.

Electric sector natural gas prices

Sustained low natural gas prices have already had an important effect on the share of electricity produced by coal units. For 17 out of the 21 months from April 2015 to December 2016, more U.S. electricity was produced from natural gas than from coal—a remarkable first. Utilities are beginning to take advantage of low natural gas prices and expectations that these prices will remain low for the foreseeable future (see Figure 16 for natural gas price forecasts from NYMEX and the Energy Information Administration's (EIA) Annual Energy Outlook (AEO)). Currently, over 800 megawatts (MW) of new natural gas combined-cycle capacity has been constructed, while an additional 1,900 MW is proposed or under construction in Kentucky. In both the Reference case and the Empower Kentucky Plan, we use the same natural gas price forecast: we rely on the "AEO 2016 No CPP" natural gas price. This series is most in line with current near-term prices for natural gas.

Figure 16. Natural gas prices delivered to electric power generators in the Kentucky region



Synapse Energy Economics, 2017

Sources: AEO 2015, AEO 2016, NYMEX data as of July 2016
Notes: Since this analysis was conducted, the EIA has released an AEO 2017, which forecasts average 2017-2030 natural gas prices delivered to electric power generators in the East South Central census region (of which Kentucky is member) to be 7 percent lower than the same estimates from AEO 2016.

Sales forecasts and energy efficiency

Recently, sales of electricity in Kentucky have plummeted relative to historical levels. At the same time, forecasts of future sales remain low compared to past growth. Between 2010 and 2015, Kentucky's electric sales fell at an average annual rate of -4.34 percent.[26] Kentucky's Energy Cabinet estimates that sales will remain essentially flat for the foreseeable future, while both the AEO 2016 Reference case and an aggregation of Kentucky utility integrated resource plans forecast that electric sales will grow by about 0.87 percent per year (see Table 5). In both the Reference case and the Empower Kentucky Plan, we assume that electric sales (absent any energy efficiency, combined heat and power projects, or distributed renewable generation) will grow by the "KY IRPs" value of 0.87 percent per year.

[26] Note that this rate of change is a substantial departure from previous years. This decrease is tied to reductions in residential sales (which dropped by 6 percent during this period) but is also largely tied to industrial sales reductions, which decreased by 28 percent during this time period, in part as a result of the closure of the Paducah uranium enrichment plant and other energy-intensive facilities.

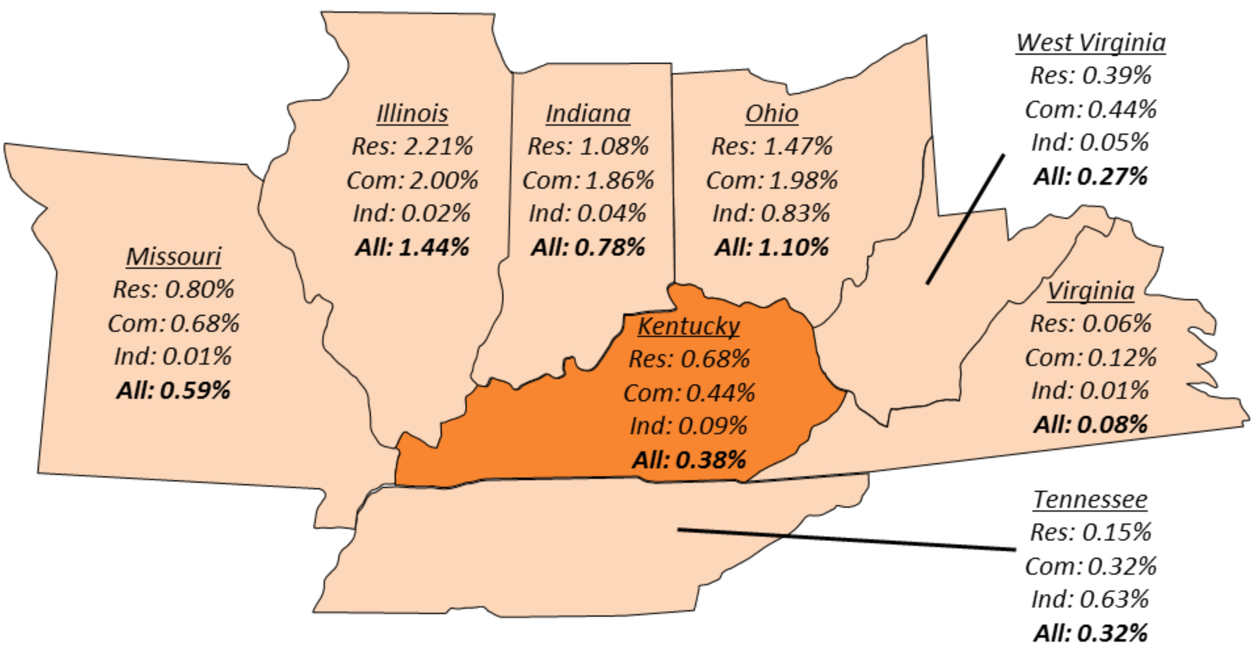
Table 5. Potential sales forecasts to implement in this modeling analysis

	Cumulative Annual Growth Rate
Historical average: 2010 to 2015	-4.34%
AEO 2015 Reference case	0.99%
AEO 2016 Reference case	0.87%
KY IRPs	0.87%
KY Energy Cabinet	-0.06%

Note: The Historical CAGR is calculated for the period between 2010 and 2015. CAGRs for all other series are calculated for the period between 2016 and 2032.

In 2014, Kentucky utilities achieved annual incremental energy efficiency savings of 0.38 percent of the previous year sales, relatively low compared to many of its neighbors (see Figure 17).

Figure 17. Utility program energy efficiency savings in Kentucky and neighboring states, 2014



Note: Sector-specific percentages refer to savings as a percent of those sector's sales (for example the residential sector in Kentucky achieved 0.68 percent savings as a percent of residential sales). 2015 data was not available at the time input assumptions were developed—2015 savings as a percent of previous year sales were 0.42 percent.
Source: EIA 861 2014

Table 6 compares Kentucky's energy savings achieved from utility programs to both the United States average. Kentucky's total energy efficiency savings are about half of the incremental savings achieved nationwide. While Kentucky is on average under-investing in energy efficiency compared to the nation as a whole, it is even more dramatically under-investing in industrial energy efficiency, with savings in this sector just one-third that of the U.S. average. Table 6 also shows 2014 energy efficiency savings for Massachusetts, the top-ranking state for energy efficiency according to American Council for an Energy-

Efficient Economy (ACEEE).[27] As a result of strong state policies partnered with on-the-ground utility experience, Massachusetts has attained incremental energy savings more than six-and-half-times greater than Kentucky. Massachusetts utilities have also filed plans to increase these savings to 2.94 percent each year for 2016 to 2018.[28] Massachusetts' plan puts special emphasis on low-income and commercial and industrial savings, with annual savings goals of 1.83 percent and 2.59 percent, respectively.

Table 6. Incremental energy efficiency savings as a percent of sales in utility programs, 2014

	Kentucky	U.S. Average	Massachusetts
Residential	0.68%	0.81%	2.92%
Commercial	0.44%	0.88%	2.53%
Industrial	0.09%	0.31%	1.56%
All Sectors	**0.38%**	**0.70%**	**2.52%**

Note: Sector-specific percentages refer to savings as a percent of those sector's sales (for example the residential sector in Kentucky achieved 0.68 percent savings as a percent of residential sales). 2015 data was not available at the time input assumptions were developed—2015 savings as a percent of previous year sales were 0.42 percent.
Source: EIA 861 2014

General energy efficiency potential and costs

In terms of energy efficiency potential, a 2015 report by Applied Energy Group performed on behalf of Kentucky Power found that even at moderate levels of penetration, statewide energy efficiency programs could reach levels of 0.65 percent by 2018 in Kentucky. A second scenario found that by achieving Kentucky Power's "economic potential" (in which all cost-effective measures are adopted by consumers), all sectors could achieve levels of 1.34 percent by 2018.[29] For comparison, in the agency's Clean Power Plan analysis the U.S. Environmental Protection Agency assumes that all utilities can increase energy efficiency savings by 0.2 percentage points per year (over current-year savings) starting in 2020 with Kentucky reaching annual incremental energy efficiency savings of 1 percent by 2024.[30] EPA assumes that this level of savings can be sustained through 2040. Other potential studies, such as ACEEE's 2012 report *Energy Efficiency Cost-Effective Resource Assessment for Kentucky* written for the U.S. Department of Energy, found that levels of 1 percent could be achieved.

In Synapse's February 2016 preliminary analysis for KFTC, we found that energy efficiency levels of 3 percent per year by 2030 could cause Kentucky to achieve Clean Power Plan compliance, when renewable levels were relatively low (13 percent of sales by 2030). Separately, we found that when

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[27] ACEEE Scorecards are available at http://aceee.org/state-policy/scorecard

[28] Massachusetts three-year plans for 2016-2018 available at http://ma-eeac.org/plans-updates/

[29] Note that Synapse's December 2015 report for Mountain Associates for Community Economic Development, *Employment After Coal*, uses an Applied Energy Group study based on this market potential study and uses an energy efficiency trajectory similar to the "economic potential" estimate.

[30] Available at https://www.epa.gov/sites/production/files/2015-11/df-cpp-demand-side-ee-at3.xlsx

combined with high levels of renewables (13 percent per year by 2030), renewable levels of 1 percent per year by 2020 were sufficient to meet Clean Power Plan compliance.

This analysis of the Empower Kentucky Plan assumes an all-in levelized cost of saved energy associated with energy efficiency programs of $0.070 per kilowatt hour (kWh), or a first-year cost of about $0.596 per kWh.[31] We assume that utility and participant costs of energy efficiency are split 50/50.[32] This results in utility-side costs of $0.035 per kWh (levelized) and $0.298 per kWh (first-year).

The next sections discuss possible levels of energy efficiency to model both by sector and for electric cooperatives, which encompass more than 40 percent of Kentucky's electric system sales. Note that savings percentages below are given in reference to sector-specific sales.

Residential programs

Kentucky's residential efficiency programs are its most robust, achieving annual incremental savings of 0.68 percent in 2014 (compared to total residential sales). However, nearby states, including Illinois, Ohio, Indiana, and Missouri, are achieving still higher savings at levels between 0.80 and 2.21 percent per year. Applied Energy Group's 2015 study on Kentucky found that levels of 0.72 percent could be achieved in a mid case and that 1.63 percent could be achieved in an "economic potential" scenario. ACEEE's 2012 study on Kentucky found that the residential sector could achieve annual incremental savings levels of 1.1 percent per year.

Commercial programs

Kentucky's commercial efficiency programs also lag behind its neighbors, including Illinois, Ohio, Indiana, and Missouri, all of which achieve savings of at least 0.68 percent per year in this sector (versus Kentucky's 0.44 percent). Applied Energy Group's 2015 study found that levels of 0.46 percent could be achieved in the commercial sector in a mid case and that 0.96 percent could be achieved in an "economic potential" scenario. ACEEE's 2012 study found that the commercial sector could achieve annual incremental savings levels of 1.4 percent per year.

Industrial programs

Kentucky's industrial efficiency programs have historically been its weakest, although they are in line with many neighboring states. Only Ohio achieves significantly more energy efficiency savings—at levels of 0.83 percent (compared to industrial sales), it is over nine times greater than Kentucky's savings level. Applied Energy Group's 2015 study found that levels of 0.69 percent could be achieved in the industrial sector in a mid case and that 1.29 percent could be achieved in an "economic potential" scenario.

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[31] This value is calculated based on Synapse analysis of EIA 861 data.

[32] This is the same assumption used by EPA in its Clean Power Plan technical support documentation at https://www.epa.gov/sites/production/files/2015-11/df-cpp-demand-side-ee-at3.xlsx

ACEEE's 2012 study found that the industrial sector could achieve annual incremental savings levels of at least 0.7 percent per year.

Combined heat and power

Combined heat and power (CHP) projects are among the most cost-effective ways to achieve electricity savings. Instead of separately procuring on-site heat or hot water and electricity, an industrial or commercial facility can use a single CHP system to produce both. CHP systems can significantly reduce the energy expenditures of large industrial facilities and commercial buildings, which may help offset rising energy costs associated with other changes to Kentucky's electric system.

A March 2016 study of Kentucky by the DOE found more than 2.7 gigawatts (GW) of CHP potential distributed across over 4,000 sites, with over half of this potential concentrated in fewer than 100 large sites.[33] Sites for installing CHP projects include industrial facilities specializing in primary metals, stone/clay/glass manufacturing, and petroleum refining, as well as commercial sites such as colleges and universities, office buildings, and hospitals.

Because CHP projects can be installed at many different types and sizes of facilities, their costs vary significantly. On average, total costs of installing CHP systems can range from about $900 per kW to $1,600 per kW.[34] Many states currently provide incentives for implementing CHP projects. Massachusetts, for example, provides two incentives: one for capacity at $800 per kW and one for energy produced at $75-115 per megawatt hour (MWh).[35] Other utilities, such as Baltimore Gas & Electric in Maryland and ComEd and Ameren in Illinois, provide slightly different incentives. These include capacity incentives of $250-350 per kWh and production incentives of $60-80 per MWh, but only for a short period of time, with a cap on total incentive dollars spent of $2.0-2.5 million per project.[36] Collectively, these programs average first-year costs of about $250 per MWh, or about $15 per MWh when levelized over 20 years (the price assumptions used in this analysis).

These same states have achieved different levels of realized CHP projects. While Kentucky has only had four new CHP projects installed in the ten-year period from 2006 to 2015, Maryland and Illinois both installed 16, while Massachusetts installed 102 (see Table 7). The average size of these projects varied widely in size from 1 MW per project in Massachusetts to 5.5 MW per project in Illinois. While some

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[33] Available at http://www.energy.gov/sites/prod/files/2016/04/f30/CHP%20Technical%20Potential%20Study%203-31-2016%20Final.pdf

[34] More information available at http://www.c2es.org/technology/factsheet/CogenerationCHP

[35] More information available at http://www.masssave.com/~/media/Files/Business/Applications-and-Rebate-Forms/A-Guide-to-Submitting-CHP-Applications-for-Incentives-in-Massachusetts.pdf

[36] More information available at http://www.bgesmartenergy.com/business/chp and http://programs.dsireusa.org/system/program/detail/5506

specific projects are smaller than even 50 kW, many are much larger projects totaling 24 to 78 MW at hospitals, universities, and industrial facilities.

Table 7. CHP projects installed, 2006 to 2015

	Total Projects	Total Capacity (MW)	Average Capacity per Project (MW)
Kentucky	4	18.7	4.7
Massachusetts	102	105.4	1.0
Maryland	16	35.5	2.2
Illinois	16	87.9	5.5

Source: https://doe.icfwebservices.com/chpdb/

In the Reference case, we assumed no incremental combined heat and power projects. In the Empower Kentucky Plan, Synapse assumed a trajectory for combined heat and power as depicted in Table 8. This results in cumulative energy savings from CHP projects totaling 0.5 percent by 2030.

Table 8. Total CHP capacity to be added in Empower Kentucky Plan

	2017	2018	2019	2020	2021 and each year thereafter
Total New CHP Capacity (MW)	5	25	50	75	100

Low-income programs

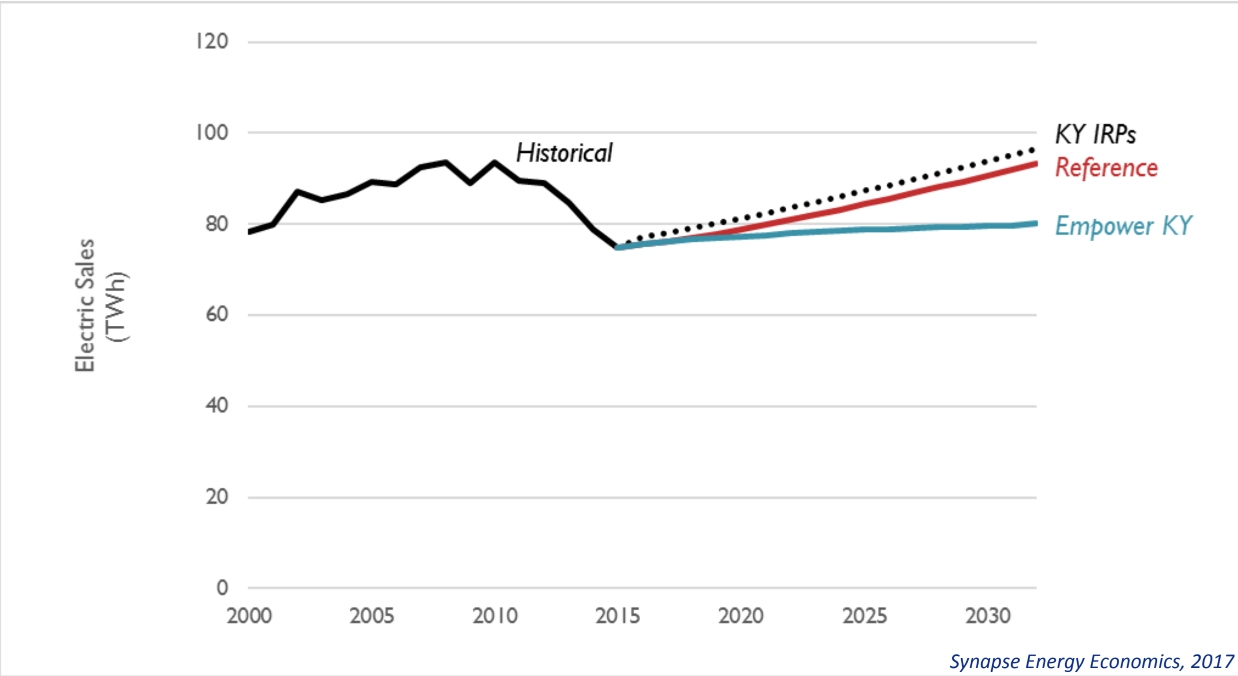
Providing assistance for low-income customers through energy efficiency programs is a key feature of the Empower Kentucky Plan. While over 19 percent of Kentucky residents are living below the federal poverty level according to the U.S. Census Bureau, just 0.14 percent of energy efficiency program expenditures were spent on targeted low-income programs in recent years according to ACEEE data. Some Kentucky utilities, such as Duke, LG&E/KU, and Kentucky Power, are currently implementing low-income energy efficiency programs, although at relatively low levels of about 0.01 percent of incremental annual savings as a percent of total utility sales.[37] Meanwhile, utilities such as Duquesne Light and PECO Energy in Pennsylvania achieved low-income energy efficiency at levels seven to nine times higher than Kentucky utilities. Some states require low-income energy efficiency programs to be maintained at some level relative to overall savings: Massachusetts, for example, requires that at least 10 percent of all annual energy efficiency budgets be spent on low-income programs. One utility—Eversource Energy—recently achieved low-income savings levels 12 times higher than Kentucky utilities. In the Empower Kentucky Plan, we assume that 18 percent of all energy efficiency savings are directed at low-income customers and communities.

[37] Low-income programs are sometimes reported as their own sector and sometimes rolled into residential programs. Because of this discrepancy in reporting, we have provided low-income savings levels as a percent of total sales.

In the Reference case, we assume that Kentucky utilities continue to implement energy efficiency measures at the same rate as in past years (with energy savings equal to 0.38 percent of the previous years' sales). In the Empower Kentucky Plan, utilities gradually increase the level of energy efficiency measures they install in each year until they reach the level currently achieved by leading states like California, Massachusetts, and Rhode Island (a gradual 0.15 percentage point increase each year until reaching 2.5 percent annual savings by 2030, then sustained through the rest of the study period).

Figure 18 displays the level of electricity sales estimated in a future with no energy efficiency, as well as the electricity sales modeled in the Reference case and Empower Kentucky Plan, inclusive of energy efficiency, combined heat and power, and distributed solar.[38]

Figure 18. Electric sales in a case with no energy efficiency (KY IRPs), the Reference case, and the Empower Kentucky Plan



Electric generating units in Kentucky

In both scenarios we make the same assumptions for prescribed electric generating unit additions and retirements. Depending on modeled system dynamics, including the impacts of fuel prices, electricity sales, and carbon prices, other units may be added or retired. Table 9 lists all units that are currently operating as of the end of 2016. Table 10 lists electric generating units that retired in the recent past, while Table 11 lists the units that are under construction or announced to come online within the next few years.

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[38] In the Empower Kentucky Plan, we assume that the Kentucky renewable portfolio standard requires 25 percent of Kentucky sales to be met through renewables by 2030, including a 1 percent carve-out for distributed solar.

Table 9. Currently-existing electric generating units

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	American Mun Power-Ohio, Inc	Cannelton Hydroelectric Plant	57399	CG1	Hydro	Hydro	Hancock	2016		29	125	48%
Operating	American Mun Power-Ohio, Inc	Cannelton Hydroelectric Plant	57399	CG2	Hydro	Hydro	Hancock	2016		29	125	48%
Operating	American Mun Power-Ohio, Inc	Cannelton Hydroelectric Plant	57399	CG3	Hydro	Hydro	Hancock	2016		29	125	48%
Operating	Big Rivers	D B Wilson	6823	1	Coal	Steam	Ohio	1984		509	3,115	70%
Operating	Big Rivers	HMP&L Station Two Henderson	1382	1	Coal	Steam	Henderson	1973		200	781	44%
Operating	Big Rivers	HMP&L Station Two Henderson	1382	2	Coal	Steam	Henderson	1974		205	997	55%
Out of Service	Big Rivers	Kenneth C Coleman	1381	1	Coal	Steam	Hancock	1969		205	-	-
Out of Service	Big Rivers	Kenneth C Coleman	1381	2	Coal	Steam	Hancock	1970		205	-	-
Out of Service	Big Rivers	Kenneth C Coleman	1381	3	Coal	Steam	Hancock	1971		192	-	-
Operating	Big Rivers	R D Green	6639	1	Coal	Steam	Webster	1979		293	1,351	52%
Operating	Big Rivers	R D Green	6639	2	Coal	Steam	Webster	1981		293	1,386	54%

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	Big Rivers	Robert A Reid	1383	1	Other	Steam	Webster	1966		96	-	-
Standby	Big Rivers	Robert A Reid	1383	GEN2	Natural Gas	Gas Turbine	Webster	1976		99	-	-
Operating	City of Hamilton - (OH)	Meldahl Hydroelectric Project	56872	1	Hydro	Hydro	Bracken	2016		35	126	41%
Operating	City of Hamilton - (OH)	Meldahl Hydroelectric Project	56872	2	Hydro	Hydro	Bracken	2016		35	126	41%
Operating	City of Hamilton - (OH)	Meldahl Hydroelectric Project	56872	3	Hydro	Hydro	Bracken	2016		35	126	41%
Operating	City of Owensboro	Elmer Smith	1374	1	Coal	Steam	Daviess	1964	2019	163	698	49%
Operating	City of Owensboro	Elmer Smith	1374	2	Coal	Steam	Daviess	1974	2023	282	1,257	51%
Operating	City of Paris - (KY)	Paris (KY)	1376	1	Other	Int. Com-bustion	Bourbon	1952		1	-	-
Operating	City of Paris - (KY)	Paris (KY)	1376	2	Other	Int. Com-bustion	Bourbon	1954		1	-	-
Operating	City of Paris - (KY)	Paris (KY)	1376	3	Other	Int. Com-bustion	Bourbon	1934		1	-	-
Operating	City of Paris - (KY)	Paris (KY)	1376	4	Other	Int. Com-bustion	Bourbon	1947		1	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	City of Paris - (KY)	Paris (KY)	1376	5	Other	Int. Com-bustion	Bourbon	1949		1	-	-
Operating	City of Paris - (KY)	Paris (KY)	1376	6	Other	Int. Com-bustion	Bourbon	1974		3	-	-
Operating	City of Paris - (KY)	Paris (KY)	1376	7	Other	Int. Com-bustion	Bourbon	1974		3	-	-
Operating	Cox Interior Inc	Cox Waste to Energy	54850	01	Other	Steam	Taylor	1995		4	-	-
Operating	Cox Interior Inc	Cox Waste to Energy	54850	02	Other	Steam	Taylor	2002		1	-	-
Operating	Domtar Paper Company LLC	Kentucky Mills	55429	01	Other	Steam	Hancock	2001		88	377	49%
Operating	DTE Calvert City LLC	Calvert City	55308	GEN1	Natural Gas	Gas Turbine	Marshall	2000		27	-	-
Operating	Duke	East Bend	6018	2	Coal	Steam	Boone	1981		772	3,667	54%
Operating	EKPC	Bavarian LFGTE	56277	1	Other	Int. Com-bustion	Boone	2003		1	-	-
Operating	EKPC	Bavarian LFGTE	56277	2	Other	Int. Com-bustion	Boone	2003		1	-	-
Operating	EKPC	Bavarian LFGTE	56277	3	Other	Int. Com-bustion	Boone	2003		1	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	EKPC	Bavarian LFGTE	56277	4	Other	Int. Com-bustion	Boone	2003		1	-	-
Operating	EKPC	Bluegrass Generating Station	55164	CT1	Natural Gas	Gas Turbine	Oldham	2002		208	17	1%
Operating	EKPC	Bluegrass Generating Station	55164	CT2	Natural Gas	Gas Turbine	Oldham	2002		208	17	1%
Operating	EKPC	Bluegrass Generating Station	55164	CT3	Natural Gas	Gas Turbine	Oldham	2002		208	17	1%
Operating	EKPC	Cooper	1384	1	Coal	Steam	Pulaski	1965		114	239	24%
Operating	EKPC	Cooper	1384	2	Coal	Steam	Pulaski	1969		230	406	20%
Operating	EKPC	Glasgow LFGTE	60137	1	Other	Int. Com-bustion	Barren	2015		1	-	-
Operating	EKPC	Green Valley LFGTE	56278	1	Other	Int. Com-bustion	Greenup	2003		1	-	-
Operating	EKPC	Green Valley LFGTE	56278	2	Other	Int. Com-bustion	Greenup	2003		1	-	-
Operating	EKPC	Green Valley LFGTE	56278	3	Other	Int. Com-bustion	Greenup	2003		1	-	-
Operating	EKPC	H L Spurlock	6041	1	Coal	Steam	Mason	1977		358	1,870	60%

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	EKPC	H L Spurlock	6041	2	Coal	Steam	Mason	1981		592	3,085	59%
Operating	EKPC	H L Spurlock	6041	3	Coal	Steam	Mason	2005		329	1,744	60%
Operating	EKPC	H L Spurlock	6041	4	Coal	Steam	Mason	2009		329	1,863	64%
Operating	EKPC	Hardin County LFGTE	56280	1	Other	Int. Com-bustion	Hardin	2006		1	-	-
Operating	EKPC	Hardin County LFGTE	56280	2	Other	Int. Com-bustion	Hardin	2006		1	-	-
Operating	EKPC	Hardin County LFGTE	56280	3	Other	Int. Com-bustion	Hardin	2006		1	-	-
Operating	EKPC	J K Smith	54	GT1	Natural Gas	Gas Turbine	Clark	1999		149	32	2%
Operating	EKPC	J K Smith	54	GT10	Natural Gas	Gas Turbine	Clark	2010		98	21	2%
Operating	EKPC	J K Smith	54	GT2	Natural Gas	Gas Turbine	Clark	1999		149	32	2%
Operating	EKPC	J K Smith	54	GT3	Natural Gas	Gas Turbine	Clark	1999		149	32	2%
Operating	EKPC	J K Smith	54	GT4	Natural Gas	Gas Turbine	Clark	2001		108	23	2%

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	EKPC	J K Smith	54	GT5	Natural Gas	Gas Turbine	Clark	2001		108	23	2%
Operating	EKPC	J K Smith	54	GT6	Natural Gas	Gas Turbine	Clark	2005		98	21	2%
Operating	EKPC	J K Smith	54	GT7	Natural Gas	Gas Turbine	Clark	2005		98	21	2%
Operating	EKPC	J K Smith	54	GT9	Natural Gas	Gas Turbine	Clark	2010		98	21	2%
Operating	EKPC	Laurel Ridge LFGTE	56279	1	Other	Int. Com-bustion	Laurel	2003		1	-	-
Operating	EKPC	Laurel Ridge LFGTE	56279	2	Other	Int. Com-bustion	Laurel	2003		1	-	-
Operating	EKPC	Laurel Ridge LFGTE	56279	3	Other	Int. Com-bustion	Laurel	2003		1	-	-
Operating	EKPC	Laurel Ridge LFGTE	56279	4	Other	Int. Com-bustion	Laurel	2003		1	-	-
Operating	EKPC	Laurel Ridge LFGTE	56279	5	Other	Int. Com-bustion	Laurel	2006		1	-	-
Operating	EKPC	Pendleton County LFGTE	56327	1	Other	Int. Com-bustion	Pendleton	2007		1	-	-
Operating	EKPC	Pendleton County LFGTE	56327	2	Other	Int. Com-bustion	Pendleton	2007		1	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	EKPC	Pendleton County LFGTE	56327	3	Other	Int. Com-bustion	Pendleton	2007		1	-	-
Operating	EKPC	Pendleton County LFGTE	56327	4	Other	Int. Com-bustion	Pendleton	2007		1	-	-
Operating	Green City Recovery, LLC	Green City Recovery, LLC	60703	1	Other	Int. Com-bustion	Scott	2016		1	-	-
Operating	Kentucky Power Co	Big Sandy	1353	1	Natural Gas	Steam	Lawrence	1963		281	530	22%
Operating	LG&E/KU	Cane Run	1363	11	Natural Gas	Gas Turbine	Jefferson	1968		16	0	0%
Operating	LG&E/KU	Cane Run	1363	7A	Natural Gas	Com-bined Cycle	Jefferson	2015		260	1,565	69%
Operating	LG&E/KU	Cane Run	1363	7B	Natural Gas	Com-bined Cycle	Jefferson	2015		260	1,608	70%
Operating	LG&E/KU	Cane Run	1363	7S	Natural Gas	Com-bined Cycle	Jefferson	2015		287	1,709	68%
Operating	LG&E/KU	Dix Dam	1354	1	Hydro	Hydro	Mercer	1925		9	-	-
Operating	LG&E/KU	Dix Dam	1354	2	Hydro	Hydro	Mercer	1925		9	-	-
Operating	LG&E/KU	Dix Dam	1354	3	Hydro	Hydro	Mercer	1925		9	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	LG&E/KU	E W Brown	1355	1	Coal	Steam	Mercer	1957		114	219	22%
Operating	LG&E/KU	E W Brown	1355	2	Coal	Steam	Mercer	1963		180	410	26%
Operating	LG&E/KU	E W Brown	1355	3	Coal	Steam	Mercer	1971		464	1,105	27%
Operating	LG&E/KU	E W Brown	1355	5	Natural Gas	Gas Turbine	Mercer	2001		123	65	6%
Operating	LG&E/KU	E W Brown	1355	6	Natural Gas	Gas Turbine	Mercer	1999		177	94	6%
Operating	LG&E/KU	E W Brown	1355	7	Natural Gas	Gas Turbine	Mercer	1999		177	94	6%
Operating	LG&E/KU	E W Brown	1355	8	Natural Gas	Gas Turbine	Mercer	1995		126	67	6%
Operating	LG&E/KU	E W Brown	1355	9	Natural Gas	Gas Turbine	Mercer	1994		126	67	6%
Operating	LG&E/KU	E W Brown	1355	10	Natural Gas	Gas Turbine	Mercer	1995		126	67	6%
Operating	LG&E/KU	E W Brown	1355	11	Natural Gas	Gas Turbine	Mercer	1996		126	67	6%
Operating	LG&E/KU	E W Brown	1355	SOLAR	Solar	Photo-voltaic	Mercer	2016		10	12	13%
Operating	LG&E/KU	Ghent	1356	1	Coal	Steam	Carroll	1974		557	3,050	62%

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	LG&E/KU	Ghent	1356	2	Coal	Steam	Carroll	1977		556	2,971	61%
Operating	LG&E/KU	Ghent	1356	3	Coal	Steam	Carroll	1981		557	2,683	55%
Operating	LG&E/KU	Ghent	1356	4	Coal	Steam	Carroll	1984		556	3,074	63%
Operating	LG&E/KU	Haefling	1358	1	Natural Gas	Gas Turbine	Fayette	1970		21	-	-
Operating	LG&E/KU	Haefling	1358	2	Natural Gas	Gas Turbine	Fayette	1970		21	-	-
Operating	LG&E/KU	Mill Creek (KY)	1364	1	Coal	Steam	Jefferson	1972		356	1,802	58%
Operating	LG&E/KU	Mill Creek (KY)	1364	2	Coal	Steam	Jefferson	1974		356	1,652	53%
Operating	LG&E/KU	Mill Creek (KY)	1364	3	Coal	Steam	Jefferson	1978		463	2,007	49%
Operating	LG&E/KU	Mill Creek (KY)	1364	4	Coal	Steam	Jefferson	1982		544	2,469	52%
Operating	LG&E/KU	Ohio Falls	1365	1	Hydro	Hydro	Jefferson	1928		10	-	-
Operating	LG&E/KU	Ohio Falls	1365	2	Hydro	Hydro	Jefferson	1928		10	-	-
Operating	LG&E/KU	Ohio Falls	1365	3	Hydro	Hydro	Jefferson	1928		10	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	LG&E/KU	Ohio Falls	1365	4	Hydro	Hydro	Jefferson	1928		10	-	-
Operating	LG&E/KU	Ohio Falls	1365	5	Hydro	Hydro	Jefferson	1928		10	-	-
Operating	LG&E/KU	Ohio Falls	1365	6	Hydro	Hydro	Jefferson	1928		13	-	-
Operating	LG&E/KU	Ohio Falls	1365	7	Hydro	Hydro	Jefferson	1928		13	-	-
Operating	LG&E/KU	Ohio Falls	1365	8	Hydro	Hydro	Jefferson	1928		10	-	-
Operating	LG&E/KU	Paddys Run	1366	11	Natural Gas	Gas Turbine	Jefferson	1968		16	7	5%
Operating	LG&E/KU	Paddys Run	1366	12	Natural Gas	Gas Turbine	Jefferson	1968		33	14	5%
Operating	LG&E/KU	Paddys Run	1366	13	Natural Gas	Gas Turbine	Jefferson	2001		178	78	5%
Operating	LG&E/KU	Trimble County	6071	1	Coal	Steam	Trimble	1990		566	3,565	72%
Operating	LG&E/KU	Trimble County	6071	2	Coal	Steam	Trimble	2011		834	4,135	56%
Operating	LG&E/KU	Trimble County	6071	5	Natural Gas	Gas Turbine	Trimble	2002		199	143	8%
Operating	LG&E/KU	Trimble County	6071	6	Natural Gas	Gas Turbine	Trimble	2002		199	143	8%

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	LG&E/KU	Trimble County	6071	7	Natural Gas	Gas Turbine	Trimble	2004		199	143	8%
Operating	LG&E/KU	Trimble County	6071	8	Natural Gas	Gas Turbine	Trimble	2004		199	143	8%
Operating	LG&E/KU	Trimble County	6071	9	Natural Gas	Gas Turbine	Trimble	2004		199	143	8%
Operating	LG&E/KU	Trimble County	6071	10	Natural Gas	Gas Turbine	Trimble	2004		199	143	8%
Operating	LG&E/KU	Zorn	1368	1	Natural Gas	Gas Turbine	Jefferson	1969		18	-	-
Operating	Lock 7 Hydro Partners LLC	Mother Ann Lee	1359	1	Hydro	Hydro	Mercer	2008		1	-	-
Operating	Lock 7 Hydro Partners LLC	Mother Ann Lee	1359	2	Hydro	Hydro	Mercer	2007		1	-	-
Operating	Lock 7 Hydro Partners LLC	Mother Ann Lee	1359	3	Hydro	Hydro	Mercer	2007		1	-	-
Operating	North American Biofuels, LLC	Blue Ridge Generating	59392	GEN1	Other	Int. Com-bustion	Estill	2013		2	-	-
Operating	Paducah Power System	PPS Power Plant No 1	56556	1	Natural Gas	Gas Turbine	McCracken	2010		60	-	-
Operating	Paducah Power System	PPS Power Plant No 1	56556	2	Natural Gas	Gas Turbine	McCracken	2010		60	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	Riverside Generating Co LLC	Riverside Generating LLC	55198	GTG1	Natural Gas	Gas Turbine	Lawrence	2001		230	105	5%
Operating	Riverside Generating Co LLC	Riverside Generating LLC	55198	GTG2	Natural Gas	Gas Turbine	Lawrence	2001		230	105	5%
Operating	Riverside Generating Co LLC	Riverside Generating LLC	55198	GTG3	Natural Gas	Gas Turbine	Lawrence	2001		230	105	5%
Operating	Riverside Generating Co LLC	Riverside Generating LLC	55198	GTG4	Natural Gas	Gas Turbine	Lawrence	2002		230	105	5%
Operating	Riverside Generating Co LLC	Riverside Generating LLC	55198	GTG5	Natural Gas	Gas Turbine	Lawrence	2002		230	105	5%
Operating	TVA	Kentucky Dam	1377	1	Hydro	Hydro	Marshall	1945		45	189	48%
Operating	TVA	Kentucky Dam	1377	2	Hydro	Hydro	Marshall	1944		42	179	48%
Operating	TVA	Kentucky Dam	1377	3	Hydro	Hydro	Marshall	1944		42	179	48%
Operating	TVA	Kentucky Dam	1377	4	Hydro	Hydro	Marshall	1945		45	189	48%
Operating	TVA	Kentucky Dam	1377	5	Hydro	Hydro	Marshall	1948		45	189	48%
Operating	TVA	Marshall Energy Facility	55232	CT1	Natural Gas	Gas Turbine	Marshall	2002		86	25	3%

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	TVA	Marshall Energy Facility	55232	CT2	Natural Gas	Gas Turbine	Marshall	2002		86	25	3%
Operating	TVA	Marshall Energy Facility	55232	CT3	Natural Gas	Gas Turbine	Marshall	2002		86	25	3%
Standby	TVA	Marshall Energy Facility	55232	CT4	Natural Gas	Gas Turbine	Marshall	2002		86	25	3%
Standby	TVA	Marshall Energy Facility	55232	CT5	Natural Gas	Gas Turbine	Marshall	2002		86	25	3%
Standby	TVA	Marshall Energy Facility	55232	CT6	Natural Gas	Gas Turbine	Marshall	2002		86	25	3%
Standby	TVA	Marshall Energy Facility	55232	CT7	Natural Gas	Gas Turbine	Marshall	2002		86	25	3%
Standby	TVA	Marshall Energy Facility	55232	CT8	Natural Gas	Gas Turbine	Marshall	2002		86	25	3%
Operating	TVA	Paradise	1378	1	Coal	Steam	Muhlenberg	1963	2017	704	2,565	41%
Operating	TVA	Paradise	1378	2	Coal	Steam	Muhlenberg	1963	2017	704	2,422	39%
Operating	TVA	Paradise	1378	3	Coal	Steam	Muhlenberg	1970		1,150	4,949	49%
Operating	TVA	Shawnee	1379	1	Coal	Steam	McCracken	1953		175	621	40%
Operating	TVA	Shawnee	1379	2	Coal	Steam	McCracken	1953		175	833	54%

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	TVA	Shawnee	1379	3	Coal	Steam	McCracken	1953		175	856	56%
Operating	TVA	Shawnee	1379	4	Coal	Steam	McCracken	1954		175	693	45%
Operating	TVA	Shawnee	1379	5	Coal	Steam	McCracken	1954		175	828	54%
Operating	TVA	Shawnee	1379	6	Coal	Steam	McCracken	1954		175	811	53%
Operating	TVA	Shawnee	1379	7	Coal	Steam	McCracken	1954		175	596	39%
Operating	TVA	Shawnee	1379	8	Coal	Steam	McCracken	1955		175	691	45%
Operating	TVA	Shawnee	1379	9	Coal	Steam	McCracken	1955		175	690	45%
Operating	US Army Corps of Engineers	Barkley	1371	1	Hydro	Hydro	Lyon	1966		33	122	43%
Operating	US Army Corps of Engineers	Barkley	1371	2	Hydro	Hydro	Lyon	1966		33	122	43%
Operating	US Army Corps of Engineers	Barkley	1371	3	Hydro	Hydro	Lyon	1966		33	122	43%
Operating	US Army Corps of Engineers	Barkley	1371	4	Hydro	Hydro	Lyon	1966		33	122	43%
Operating	US Army Corps of Engineers	Laurel Dam	6171	1	Hydro	Hydro	Laurel	1977		70	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Operating	US Army Corps of Engineers	Wolf Creek	1380	1	Hydro	Hydro	Russell	1952		45	141	36%
Operating	US Army Corps of Engineers	Wolf Creek	1380	2	Hydro	Hydro	Russell	1952		45	141	36%
Operating	US Army Corps of Engineers	Wolf Creek	1380	3	Hydro	Hydro	Russell	1952		45	141	36%
Operating	US Army Corps of Engineers	Wolf Creek	1380	4	Hydro	Hydro	Russell	1951		45	141	36%
Operating	US Army Corps of Engineers	Wolf Creek	1380	5	Hydro	Hydro	Russell	1951		45	141	36%
Operating	US Army Corps of Engineers	Wolf Creek	1380	6	Hydro	Hydro	Russell	1951		45	141	36%

Table 10. Recently-retired units in Kentucky

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Retired	DTE Silver Grove LLC	Silver Grove	57955	1	Natural Gas	Gas Turbine	Campbell	2001	2013	5	-	-
Retired	EKPC	Dale	1385	1	Coal	Steam	Clark	1954	2015	27	-	-
Retired	EKPC	Dale	1385	2	Coal	Steam	Clark	1954	2015	27	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Retired	EKPC	Dale	1385	3	Coal	Steam	Clark	1957	2016	81	-	-
Retired	EKPC	Dale	1385	4	Coal	Steam	Clark	1960	2016	81	-	-
Retired	EKPC	Mason County LFGTE	56977	1	Landfill Gas	Int. Com-bustion	Mason	2009	2015	2	-	-
Retired	Kentucky Power Co	Big Sandy	1353	2	Coal	Steam	Lawrence	1969	2015	816	-	-
Retired	LG&E/KU	Cane Run	1363	4	Coal	Steam	Jefferson	1962	2015	163	-	-
Retired	LG&E/KU	Cane Run	1363	5	Coal	Steam	Jefferson	1966	2015	209	-	-
Retired	LG&E/KU	Cane Run	1363	6	Coal	Steam	Jefferson	1969	2015	272	-	-
Retired	LG&E/KU	Green River	1357	1	Coal	Steam	Muhlenberg	1950	2003	37.5	-	-
Retired	LG&E/KU	Green River	1357	2	Coal	Steam	Muhlenberg	1950	2003	37.5	-	-
Retired	LG&E/KU	Green River	1357	3	Coal	Steam	Muhlenberg	1954	2015	75	-	-
Retired	LG&E/KU	Green River	1357	4	Coal	Steam	Muhlenberg	1959	2015	114	-	-
Retired	LG&E/KU	Haefling	1358	3	Natural Gas	Gas Turbine	Fayette	1970	2013	21	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Retired	LG&E/KU	Pineville	1360	3	Coal	Steam	Bell	1951	2002	37.5	-	-
Retired	LG&E/KU	Tyrone	1361	1	Other	Steam	Woodford	1948	2007	31.2	-	-
Retired	LG&E/KU	Tyrone	1361	2	Other	Steam	Woodford	1964	2007	31.2	-	-
Retired	LG&E/KU	Tyrone	1361	3	Coal	Steam	Woodford	1953	2013	75	-	-
Retired	LG&E/KU	Waterside GT	1367	7	Natural Gas	Gas Turbine	Jefferson	1964	2006	20	-	-
Retired	LG&E/KU	Waterside GT	1367	8	Natural Gas	Gas Turbine	Jefferson	1964	2006	25	-	-
Retired	TVA	Shawnee	1379	3	Coal	Steam	McCracken	1956	2014	175	-	-

Table 11. Under construction or proposed units in Kentucky

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Under Construction	American Mun Power-Ohio, Inc	Smithland Hydroelectric Plant	57400	SG1	Water	Hydro	Livingston	2017		25	-	-
Under Construction	American Mun Power-Ohio, Inc	Smithland Hydroelectric Plant	57400	SG2	Water	Hydro	Livingston	2017		25	-	-

Dec 2016 Operational Status	Owner	Plant	ORSPL	Unit	Fuel Type	Unit Type	County	Online Year	Retire-ment Year	Nameplate Capacity (MW)	2016 Generation (GWh)	2016 Capacity Factor (%)
Under Construction	American Mun Power-Ohio, Inc	Smithland Hydroelectric Plant	57400	SG3	Water	Hydro	Livingston	2017		25	-	-
Proposed	Cash Creek Generating LLC	Cash Creek	56107	-	Natural Gas	Com-bined Cycle	Henderson	2019		320	-	-
Proposed	Cash Creek Generating LLC	Cash Creek	56107	-	Natural Gas	Com-bined Cycle	Henderson	2019		320	-	-
Proposed	Cash Creek Generating LLC	Cash Creek	56107	-	Natural Gas	Com-bined Cycle	Henderson	2019		187	-	-
Proposed	EKPC	Cooperative Solar One	60863	PV1	Solar	Photo-voltaic	Unknown	2017		9	-	-
Proposed	SunCoke Energy, Inc.	SunCoke Energy South Shore Facility	60373	SSST6	Coal	Steam	Greenup	2018		90	-	-
Under Construction	TVA	Paradise	1378	CTG1	Natural Gas	Com-bined Cycle	Muhlenberg	2017		231	-	-
Under Construction	TVA	Paradise	1378	CTG2	Natural Gas	Com-bined Cycle	Muhlenberg	2017		231	-	-
Under Construction	TVA	Paradise	1378	CTG3	Natural Gas	Com-bined Cycle	Muhlenberg	2017		231	-	-
Under Construction	TVA	Paradise	1378	STG1	Natural Gas	Com-bined Cycle	Muhlenberg	2017		467	-	-

Environmental control retrofits

As a result of EPA regulations unrelated to the Clean Power Plan, it is expected that many coal plants will be required to install environmental control equipment over the next few years. This equipment controls air emissions of nitrogen oxides, sulfur dioxide, mercury, and particulates; controls water withdrawals and overall consumption; and regulates the disposal of coal ash and polluted effluent. These needed environmental controls are often costly in terms of both capital expenditures and ongoing maintenance and operation, and as a result, retrofitted coal plants are often dispatched less frequently or outright retired to avoid expensive upgrades. In futures like the Empower Kentucky Plan where more renewables and energy efficiency replace coal generation, overall cost savings can be significant when compared to a Reference case in which installation and operation of these expensive retrofits moves forward. Table 12 displays the assumptions about what types of upcoming retrofits will be required at coal units. Table 13 shows how these assumptions get applied to each of Kentucky's existing coal units—if plants already have adequate controls, they are not assumed to need new retrofits. Units retiring or undergoing a fuel conversion are not expected to require new environmental controls.

Table 12. Default environmental retrofit assumptions

Retrofit	Controlled Pollutant	Year of Installation	Control Stringency
Dry FGD	Sulfur dioxide (SO_2)	2020	-
SCR	Nitrogen oxides (NO_X)	2021	-
ACI	Mercury	2016	-
Baghouse	Particulate matter, mercury, SO_2, NO_X	2025	-
Recirculating cooling	Water withdrawals and consumption	2019	Units withdrawing >125 million gallons per day require control
Coal combustion residuals	Coal ash	2019	Subtitle D (non-hazardous)
Effluent controls	Effluent	2019	FGD wastewater and dry fly ash handling

Table 13. Environmental retrofits assumed for each Kentucky coal unit. Units are given an "existing" designation if the specified control currently exists at the coal unit and is not projected to be added in the future. Units are given a "required" designation if the unit does not currently control for the specified pollutant or does not control for the pollutant to an adequate level.

Owner	Plant	ORSPL	Unit	Dry FGD	SCR	ACI	Baghouse	Cooling	CCR	Effluent
Big Rivers Electric Corp	D B Wilson	6823	1	Existing	Existing	Required	Required	Existing	Required	Required
Big Rivers Electric Corp	HMP&L Station Two Henderson	1382	1	Existing	Existing	Required	Required	Existing	Required	Required
Big Rivers Electric Corp	HMP&L Station Two Henderson	1382	2	Existing	Existing	Required	Required	Existing	Required	Required
Big Rivers Electric Corp	Kenneth C Coleman	1381	1	Existing	Required	Existing	Required	Required	Required	Required
Big Rivers Electric Corp	Kenneth C Coleman	1381	2	Existing	Required	Existing	Required	Required	Required	Required
Big Rivers Electric Corp	Kenneth C Coleman	1381	3	Existing	Required	Existing	Required	Required	Required	Required
Big Rivers Electric Corp	R D Green	6639	1	Existing	Required	Existing	Required	Existing	Required	Required
Big Rivers Electric Corp	R D Green	6639	2	Existing	Required	Existing	Required	Existing	Required	Required
City of Owensboro	Elmer Smith	1374	1	Existing	Existing	Retiring in 2019	Retiring in 2019	Retiring in 2019	Retiring in 2019	Retiring in 2019
City of Owensboro	Elmer Smith	1374	2	Existing	Existing	Existing	Required	Required	Required	Required
Duke	East Bend	6018	2	Existing	Existing	Required	Required	Existing	Required	Required
EKPC	Cooper	1384	1	Required	Required	Required	Required	Required	Required	Required
EKPC	Cooper	1384	2	Existing	Existing	Required	Existing	Existing	Required	Required
EKPC	H L Spurlock	6041	1	Existing	Existing	Required	Required	Existing	Required	Required
EKPC	H L Spurlock	6041	2	Existing	Existing	Required	Required	Existing	Required	Required

Owner	Plant	ORSPL	Unit	Dry FGD	SCR	ACI	Baghouse	Cooling	CCR	Effluent
EKPC	H L Spurlock	6041	3	Existing	Existing	Required	Existing	Existing	Required	Required
EKPC	H L Spurlock	6041	4	Existing	Existing	Required	Existing	Existing	Required	Required
LG&E/KU	E W Brown	1355	1	Existing	Required	Required	Required	Existing	Required	Required
LG&E/KU	E W Brown	1355	2	Existing	Required	Required	Required	Existing	Required	Required
LG&E/KU	E W Brown	1355	3	Existing	Existing	Required	Required	Existing	Required	Required
LG&E/KU	Ghent	1356	1	Existing	Existing	Required	Required	Existing	Required	Required
LG&E/KU	Ghent	1356	2	Existing	Required	Required	Required	Existing	Required	Required
LG&E/KU	Ghent	1356	3	Existing	Existing	Required	Existing	Existing	Required	Required
LG&E/KU	Ghent	1356	4	Existing	Existing	Required	Existing	Existing	Required	Required
LG&E/KU	Mill Creek (KY)	1364	1	Existing	Required	Required	Required	Required	Required	Required
LG&E/KU	Mill Creek (KY)	1364	2	Existing	Required	Required	Required	Existing	Required	Required
LG&E/KU	Mill Creek (KY)	1364	3	Existing	Existing	Required	Required	Existing	Required	Required
LG&E/KU	Mill Creek (KY)	1364	4	Existing	Existing	Required	Existing	Existing	Required	Required
LG&E/KU	Trimble County	6071	1	Existing	Existing	Required	Existing	Existing	Required	Required
LG&E/KU	Trimble County	6071	2	Existing	Existing	Required	Existing	Existing	Required	Required
TVA	Paradise	1378	3	Existing	Existing	Required	Required	Existing	Required	Required
TVA	Shawnee	1379	1	Required	Required	Required	Existing	Required	Required	Required

Owner	Plant	ORSPL	Unit	Dry FGD	SCR	ACI	Baghouse	Cooling	CCR	Effluent
TVA	Shawnee	1379	2	Required	Required	Required	Existing	Required	Required	Required
TVA	Shawnee	1379	3	Required	Required	Required	Existing	Required	Required	Required
TVA	Shawnee	1379	4	Required	Required	Required	Existing	Required	Required	Required
TVA	Shawnee	1379	5	Required	Required	Required	Existing	Required	Required	Required
TVA	Shawnee	1379	6	Required	Required	Required	Existing	Required	Required	Required
TVA	Shawnee	1379	7	Required	Required	Required	Existing	Required	Required	Required
TVA	Shawnee	1379	8	Required	Required	Required	Existing	Required	Required	Required
TVA	Shawnee	1379	9	Required	Required	Required	Existing	Required	Required	Required

Renewable portfolio standard

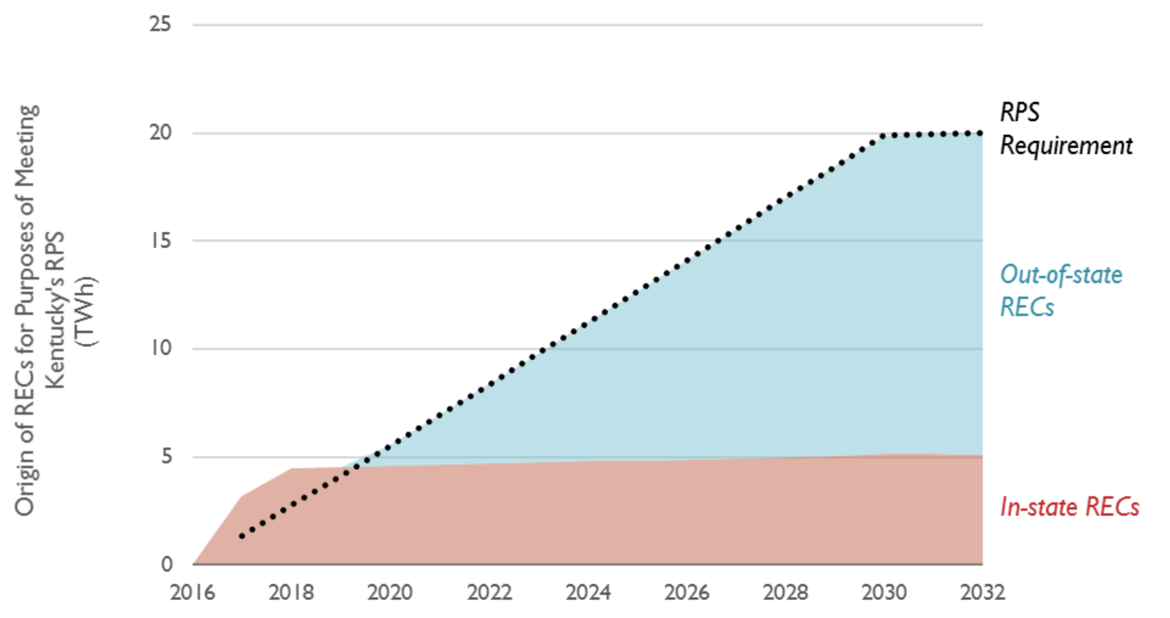
In both scenarios, the ReEDS model will build renewables like wind and utility-scale solar in Kentucky or in other states if it is economic to do so. In the Empower Kentucky, all utilities are required to comply with a renewable portfolio standard. We model this standard as coming into effect in 2017 and increasing by about 1.8 percent per year until a level of 25 percent is achieved by 2030, where it is sustained into the future (see Figure 19). Qualifying resources include new wind, solar, or hydroelectric generators.[39] This standard includes an assumption that 1 percent of sales will come from distributed solar resources by the year 2030.

Like the renewable portfolio standard policies in place in states around the country, utilities are eligible to purchase renewable energy credits (RECs) from renewable generators that are either situated in Kentucky or capable of delivering electricity to Kentucky utilities via a larger balancing authority, as long as no other utility has already purchased that REC. Because Kentucky is one of the more interconnected states in the country, it can purchase RECs from Iowa to New Jersey and from Minnesota to Louisiana. According to this analysis, sixty percent of Kentucky's RECs in the Empower Kentucky Plan are bought from wind farms in Iowa, where wind generation is inexpensive, allowing for Kentucky to decrease nationwide emissions at a low cost to consumers.

In our analysis, we find that by 2030, nearly 2 terawatt hours (TWh) of wind are added in Kentucky as a result of the renewable portfolio standard policy (equivalent to about 600 MW). At the same time, 1.4 TWh of solar are added, compared to less than 0.1 TWh in the Reference case. This includes 0.8 TWh of distributed solar (about 600 MW) and 0.6 TWh of utility-scale solar (about 400 MW).

[39] In the Empower Kentucky Plan, biomass is not a qualifying resource for the purpose of complying with the RPS; in addition, biomass is not permitted as a low-carbon or carbon neutral resource.

Figure 19. In-state and out-of-state REC purchases under Kentucky's RPS in the Empower Kentucky Plan



Clean Power Plan

In the Reference case, we assume that the Clean Power Plan is not in effect. In the Empower Kentucky Plan, Kentucky and all other states are required to comply with the Clean Power Plan. Compliance with the Clean Power Plan means that by 2030 states must not emit more CO_2 emissions than a level of 32 percent below 2005 CO_2 emissions.[40] For Kentucky, this means not exceeding 64 million short tons. Analogous to renewable portfolio standards, Kentucky utilities may either achieve these emission reductions by reducing output at emitting Kentucky power plants (i.e., purchasing electricity from cleaner generators) or by purchasing CO_2 emissions allowances from other states (i.e., effectively paying for the "right to pollute" a single ton of CO_2). The Clean Power Plan comes into effect in 2022 and continues throughout the study period. The Clean Power Plan is split up into four compliance periods in which the total number of allowed CO_2 emissions is ratcheted down.

Compliance with the Clean Power Plan is modeled as achievement of the state-level mass-based targets including estimated emissions from new sources (the "new source complement"). We assume that emission allowances are traded both within and across state borders among two separate groups of states: (1) the nine states that currently trade CO_2 emissions under the Regional Greenhouse Gas Initiative (RGGI) and (2) all other states modeled. The price of CO_2 allowances under the Clean Power Plan is set endogenously within the model as a shadow price.

[40] 2005 is the year by which the goal is theoretically set, but progress is actually benchmarked against a "starting year" of 2012.

Allowance allocation

Under the Clean Power Plan, states are given a set number of allowances that they may distribute to in-state generators. For Kentucky, allowances equal a level of 77 million short tons in 2022 and decrease to 64 million short tons starting in in 2030. States may choose to distribute these allowances through a number of options, including "free" allocation (in which the allowances may be distributed, for free, to all generators based on their output in previous years) or auctioned allocation (in which generators pay into a pool to purchase allowances from the state). If generators wish to emit more than they are allotted under their distributed allowances, they will need to purchase allowances from other generators, either in-state or from other states.

In existing carbon trading systems, such as RGGI, proceeds from allowance auctions are recirculated to the electric system. Each state deals with this recirculation differently: some states place an emphasis on funding energy efficiency or renewables, while other states provide a rebate to customers, with a focus on low-income ratepayers. Another option (not in place in RGGI) would be to refund auction proceeds to the generators themselves. For any approach, if auction proceeds are wholly refunded to the electric system the program will appear, from a ratepayer perspective, to have the same cost as participating in free allocation.[41] In this analysis, we do not make an explicit determination on which approach—free allocation or auctions with 100 percent cost recirculation—is used; we do, however, assume that costs are incurred by power plants that purchase allowances—and their utility ratepayers—and that the revenue from sold allowances help to offset other ratepayer electric costs.

Clean Energy Incentive Program

As part of the Clean Power Plan, all states may participate in the Clean Energy Incentive Program (CEIP). The CEIP rewards early implementation of energy efficiency measures in low-income households or businesses and early implementation of solar and wind projects. Under the CEIP, these two types of projects are awarded emission allowances (which program administrators and developers can then resell to generate revenue) from two separate pools:

1. **State pool:** Each state may award allowances to early-acting low-income energy efficiency and renewable energy projects, up to the limit of the number of allowances each state is awarded under the Clean Power Plan in the first compliance period of 2022-2024. For Kentucky, this means that there are, in theory, 231 million emission allowances available.

2. **Federal pool:** EPA will match each emissions allowance distributed by the state up to a set level. For Kentucky, there are 15 million allowances available for distribution from EPA. These 15 million allowances are subdivided into two equal pools—one for low-income energy efficiency programs and one for renewable energy projects.

[41] Ratepayers may, however, see increased or decreased costs associated with switching to lower-carbon electricity resources.

Under the CEIP, low-income programs receive twice as much credit as renewable energy projects.

Despite these incentives, and despite the incentives put in place under the Empower Kentucky Plan, only a fraction of the allowances available under the CEIP are distributed to Kentucky.[42] For low-income programs, a total of 2 million allowances are distributed: 1 million each under the state and federal pools. For renewable energy projects, a total of 0.2 million allowances are distributed, also split equally between the state and federal pools. Collectively, this means that just 8 percent of the total available allowances in Kentucky's federal pool are distributed and that just 0.5 percent of the total available allowances in Kentucky's state pool are distributed. Because of these low levels and the relative ease of compliance nationwide (with respect to the Reference case) in the first compliance period, it is unlikely these allowances will be worth a substantial value individually. As such, they likely will not significantly impact the overall implementation costs of low-income energy efficiency programs or renewable energy projects.

CO_2 price adder

In addition to the Clean Power Plan, a key part of the Empower Kentucky Plan is the enactment of an in-state carbon price. This carbon adder is a cost paid by Kentucky utilities above and beyond any costs they incur from purchasing allowances to meet compliance under the Clean Power Plan. In this scenario, we assume that a $1 per short ton adder comes into effect in 2018 and increases gradually until it reaches $3 per short ton in 2030, where it is sustained into the future.[43] We assume that this price is applied to both in-state emitting power plants and to electricity imports into Kentucky (where imports are priced according to the CO_2 emissions rate of their originating state). We also exclude biomass from consideration as a low-carbon or carbon neutral resource.

Unlike the Clean Power Plan, this policy is not a cap on emissions that results in a CO_2 price. Instead, it is an explicit price on CO_2 emissions that makes emitting plants more costly to operate and drives down total emissions.

As with the cost impacts associated the Clean Power Plan, we assume that costs associated with the Kentucky-specific CO_2 price adder are recirculated to electric ratepayers. However, we assume that 20 percent of the costs generated from the CO_2 price adder are removed from the electric sector and used to fund a just transition for Kentucky workers. Initiatives would include job training and education; financial support for affected workers and communities; local infrastructure and job creation initiatives;

[42] We assume low-income programs in Kentucky to make up 18 percent of all energy efficiency savings in a given year.

[43] During this analysis, we found that increasing energy efficiency and implementing an RPS policy alone were not enough to reduce Kentucky's CO_2 emissions to meet its target under the Clean Power Plan. Instead, Kentucky utilities achieve compliance through a combination of in-state reductions and allowance purchases. Furthermore, this early iteration did not generate revenue to support just transition efforts. We therefore examined an array of CO_2 price scenarios and selected the level that achieved KFTC goals for pollution reductions while not accelerating the build out of a new natural gas infrastructure.

and support for local innovation and entrepreneurship.[44] From 2018 to 2032, the Empower Kentucky Plan creates $387 million to support a just transition for Kentucky's coal workers and communities.

[44] To learn more about KFTC's plan for a just transition for the state's coal workers, and economy as a whole, see: https://www.kftc.org/sites/default/files/docs/resources/kftcs_just_transition_framework.pdf