Renewable Energy, Coal, and the Significance of Electricity to Kentucky

Presentation to the

University of Kentucky Law School

LAW 908 - Energy Law

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Website: **energy.ky.gov**

Overview

- **Kentucky Renewable Energy Potential:** *Limited*
- **Kentucky Coal Production & Employment:** *Declining*
- **Kentucky's Electricity Portfolio Today:** *Coal*
- **Kentucky's Future Electricity Portfolio:** *Natural Gas*
- **The Significance of Electricity to Kentucky:** *Manufacturing*
- **The Mathematics behind the Models**: $Y_{it} = \beta_0 + \sum_{j=1}^{k-1} \beta_j X_{jit} + \beta_{1i} X_{1it} + \alpha_i + \varepsilon_{it}$ **!**

Kentucky Renewable Energy Potential

Wind Resources

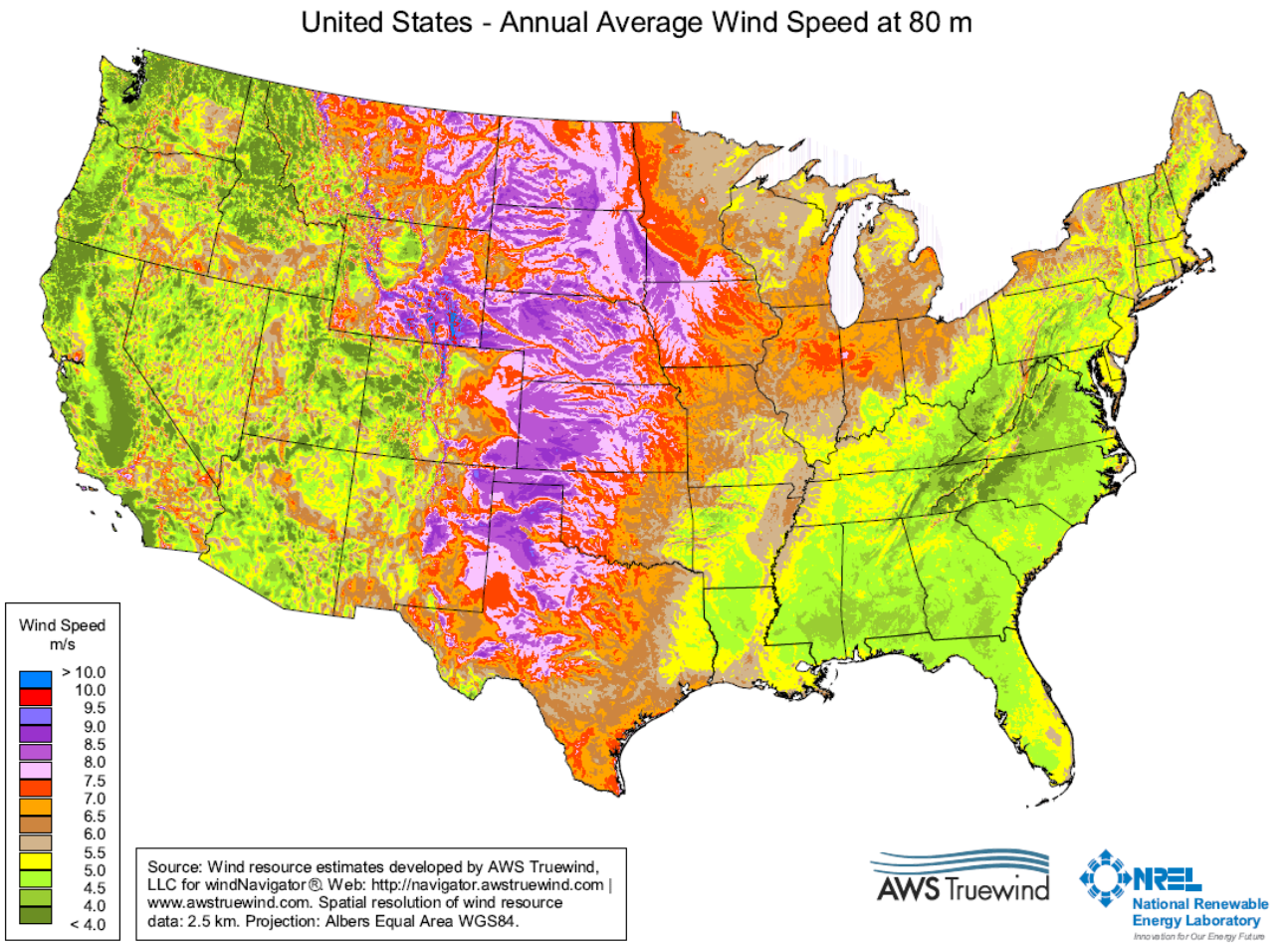
Photo: Kentucky Energy and Environment Cabinet Staff, Buffalo Mountain Wind Farm, Tennessee, 2010.

Wind Resources

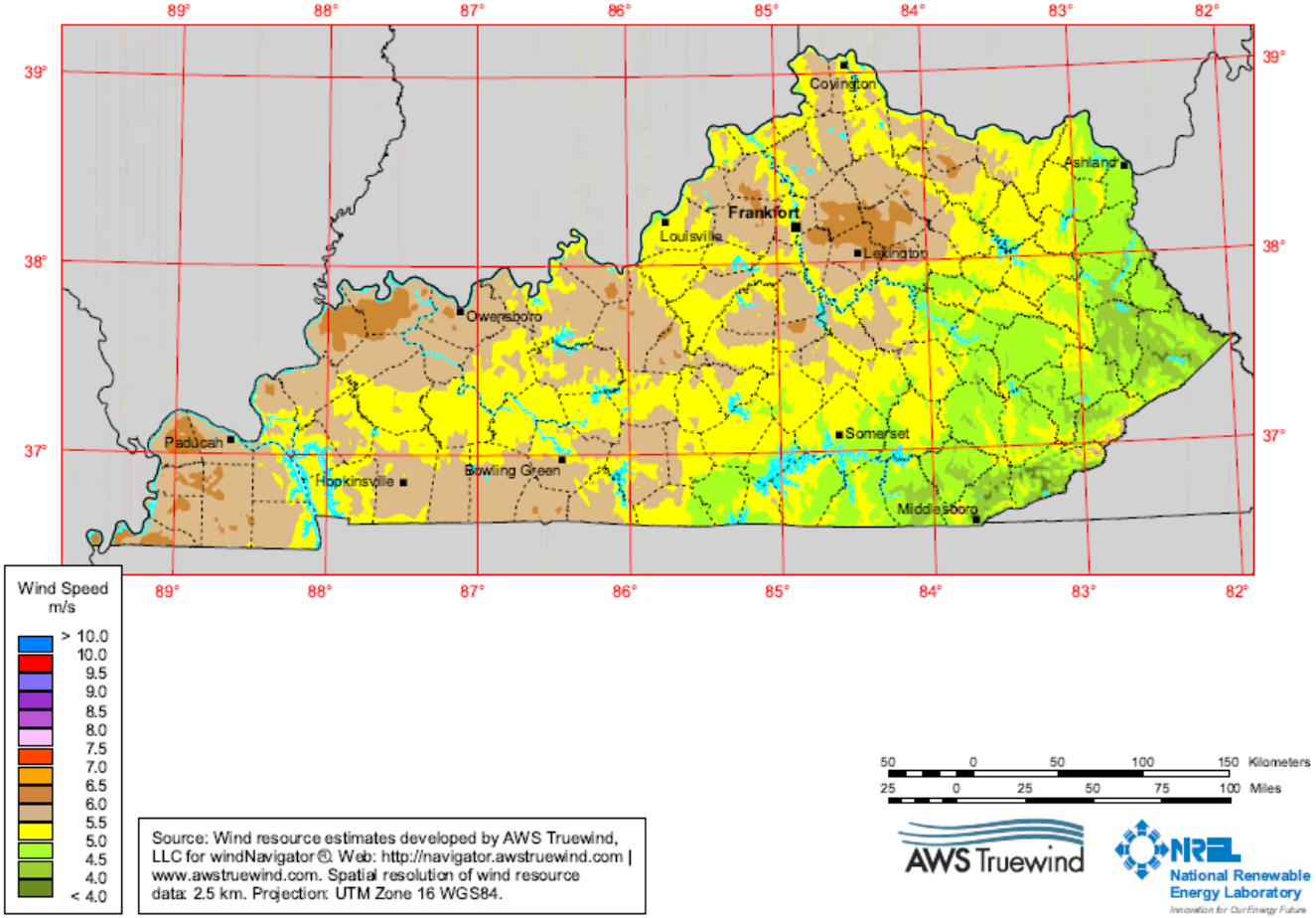
EEC Staff Video of Buffalo Mountain Wind farm in Tennessee

Photo: Kentucky Energy and Environment Cabinet Staff, Buffalo Mountain Wind Farm, Tennessee, 2010.

Wind Resources



Wind Resources

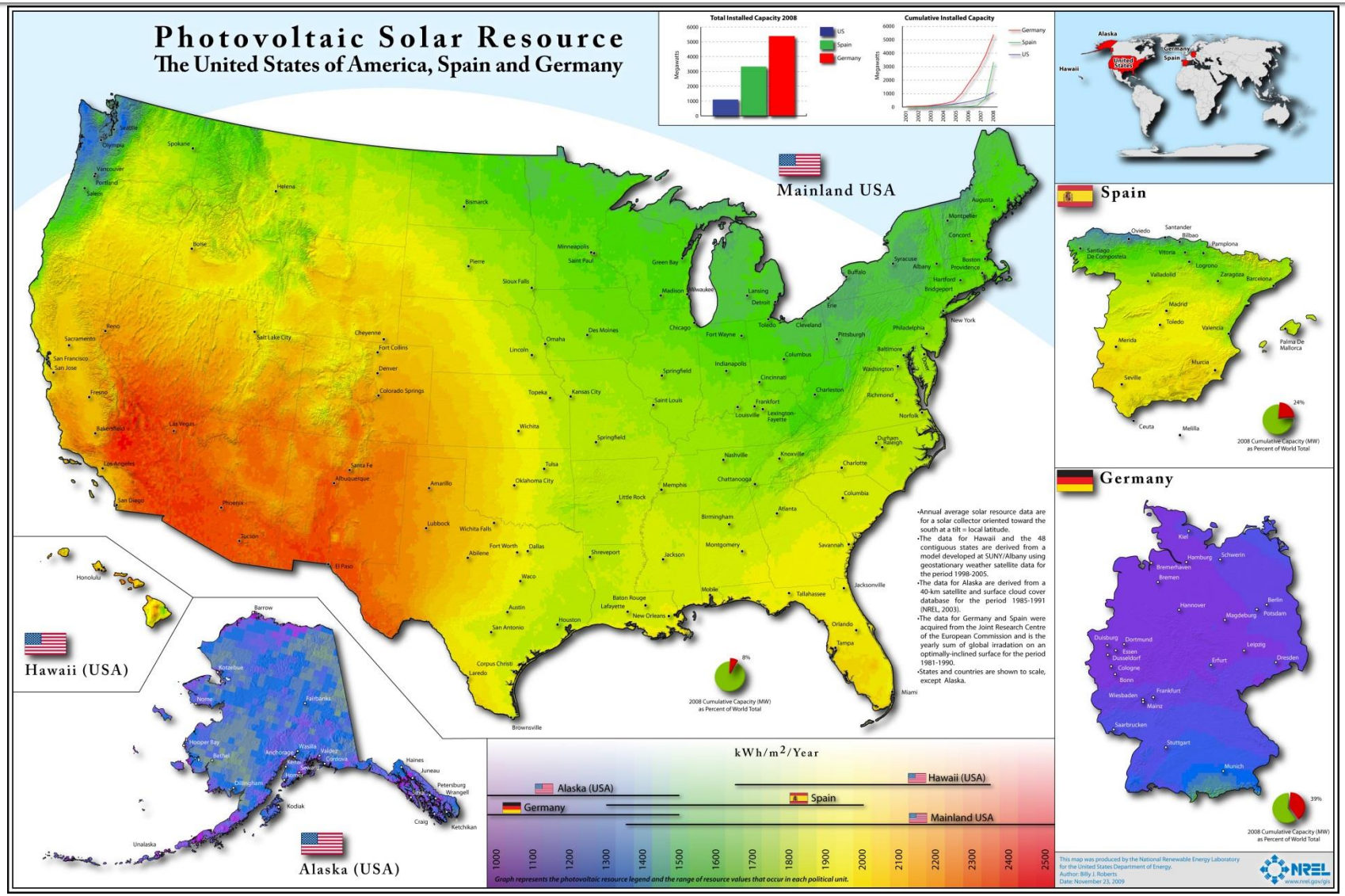


EEC Staff Video of Buffalo Mountain Wind farm in Tennessee

Solar Resources

Photo: University of Kentucky S·KY Blue Solar House at the Solar Decathlon in Washington D.C., 2009

Solar Resources



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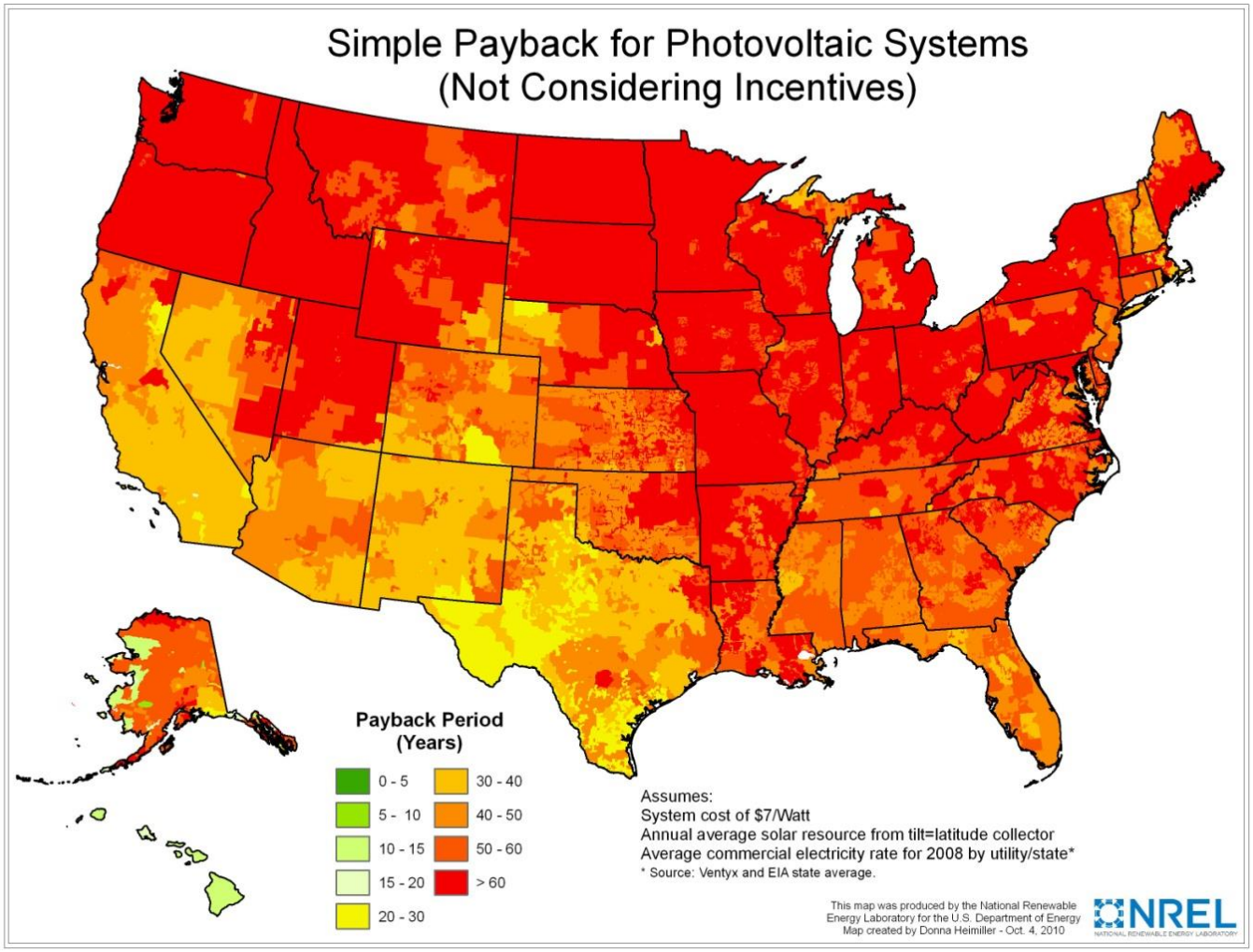
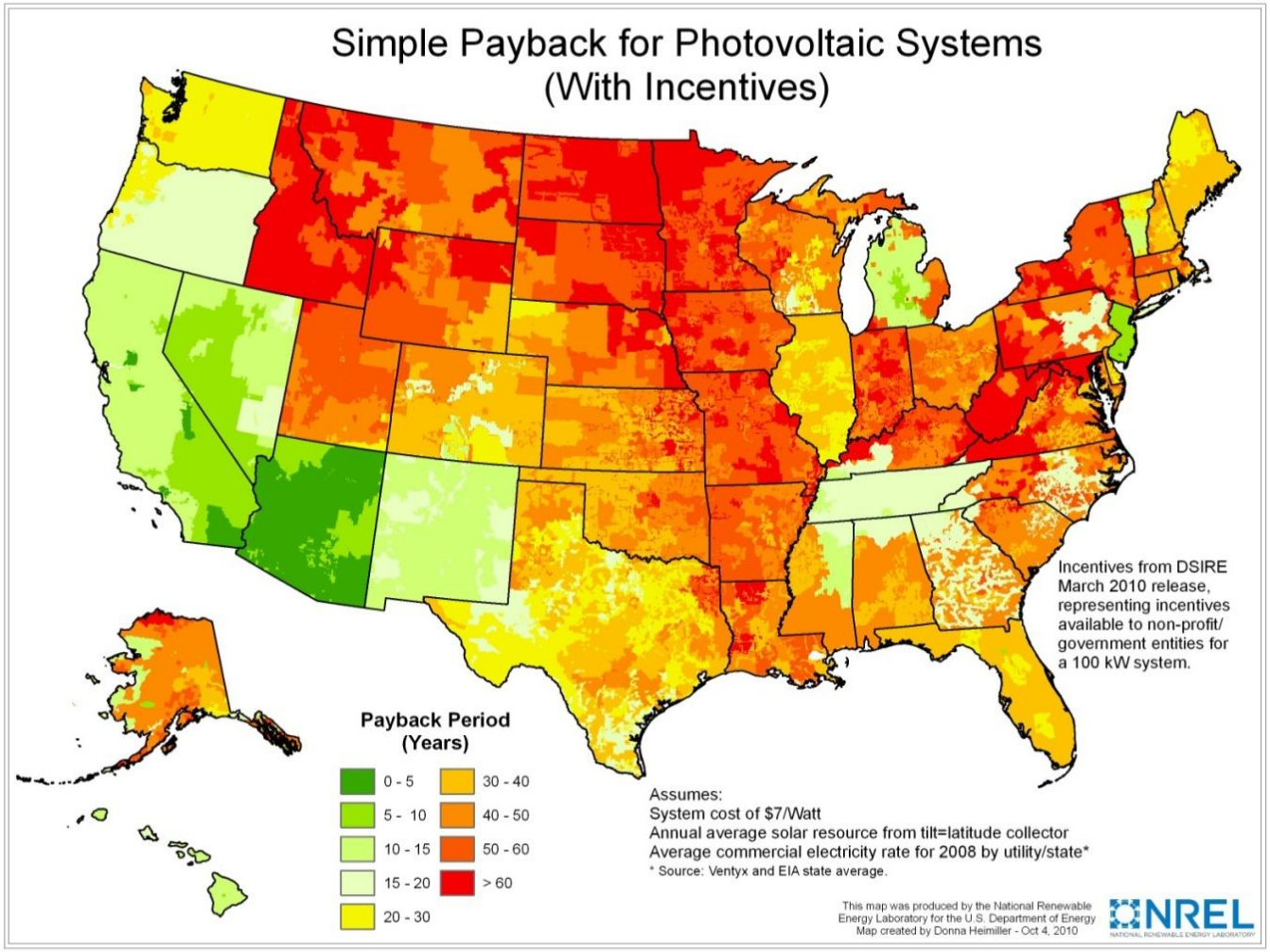
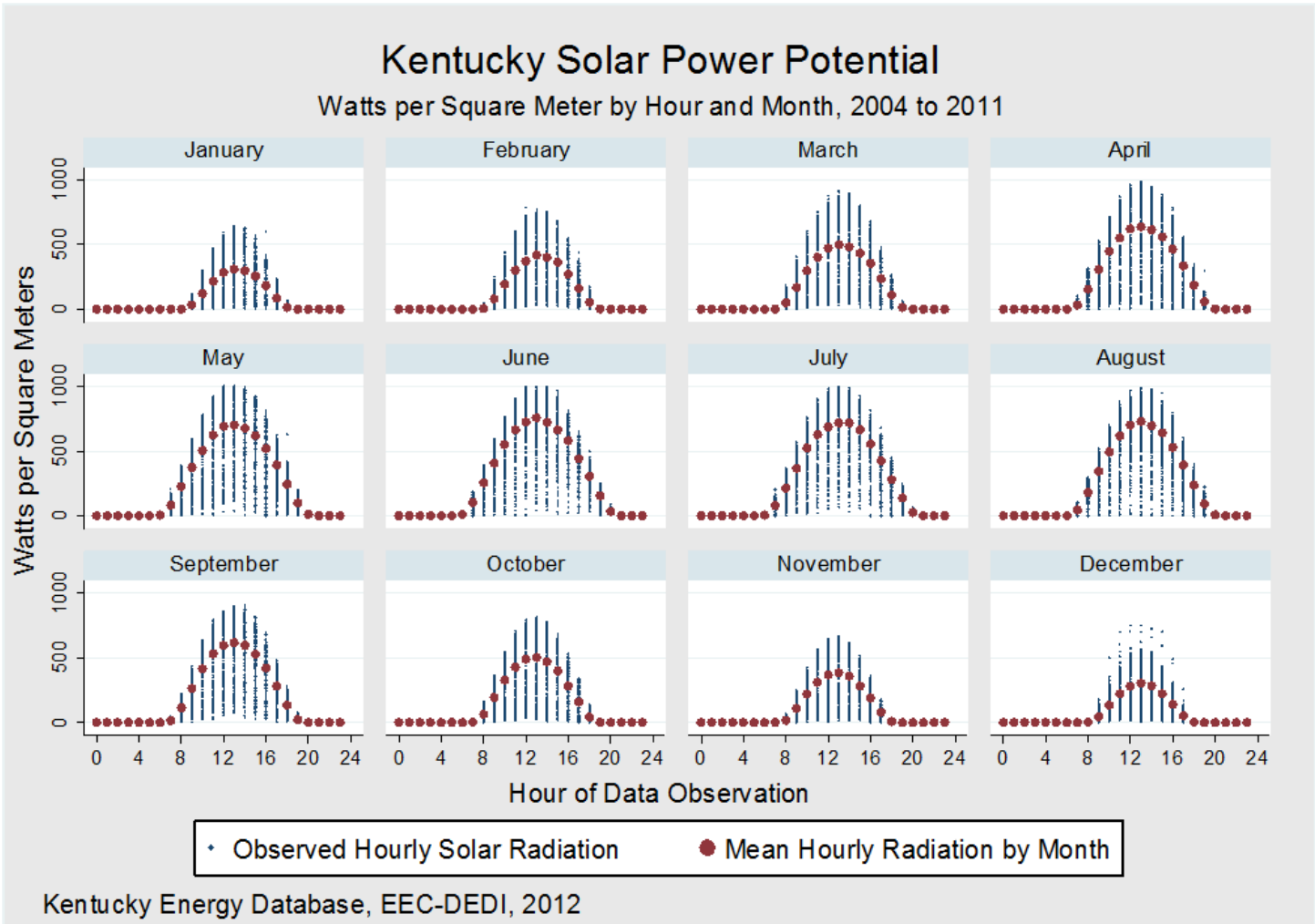


Solar Resources



Solar Resources



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Solar Resources

Kentucky Average Maximum Achievable Solar Capacity Factors, 2004-2011													
Hour	Annual		January	February	March	April	May	June	July	August	September	October	November	December
24/7	14.85%		6.60%	9.60%	12.87%	18.20%	21.10%	23.34%	22.09%	20.91%	16.56%	12.27%	8.47%	6.14%
5:00	0.000%		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
6:00	0.196%		0.000%	0.000%	0.000%	0.012%	0.673%	1.192%	0.525%	0.024%	0.000%	0.000%	0.000%	0.000%
7:00	2.997%		0.000%	0.000%	0.115%	3.261%	8.242%	10.378%	7.927%	4.402%	1.355%	0.259%	0.000%	0.000%
8:00	10.651%		0.210%	0.656%	4.967%	15.233%	22.615%	25.471%	21.379%	17.934%	11.319%	6.276%	1.541%	0.080%
9:00	22.358%		3.412%	7.930%	16.790%	30.558%	37.324%	40.458%	36.529%	34.413%	26.143%	19.309%	10.667%	4.435%
10:00	35.151%		12.071%	19.269%	29.657%	44.536%	50.266%	54.952%	52.302%	49.250%	41.347%	32.614%	21.920%	13.331%
11:00	45.633%		21.521%	30.015%	40.180%	54.893%	62.083%	66.078%	62.548%	61.545%	52.872%	42.529%	30.914%	22.198%
12:00	52.219%		28.232%	37.108%	46.994%	62.072%	68.977%	72.146%	68.565%	69.879%	59.308%	48.674%	36.653%	27.839%
13:00	54.647%		30.928%	41.754%	49.742%	63.652%	69.912%	75.576%	71.583%	72.809%	61.501%	50.065%	38.182%	29.999%
14:00	52.430%		29.661%	40.038%	48.129%	61.288%	67.462%	71.968%	71.549%	69.383%	59.444%	46.759%	35.593%	28.040%
15:00	46.760%		25.494%	36.249%	43.110%	55.708%	61.769%	66.218%	66.383%	63.844%	52.556%	39.604%	28.153%	21.972%
16:00	37.260%		18.213%	26.923%	36.366%	46.214%	51.793%	57.906%	55.296%	52.742%	41.795%	28.159%	18.733%	13.908%
17:00	25.275%		8.653%	16.055%	23.433%	33.288%	39.210%	44.043%	42.394%	39.128%	28.148%	15.850%	7.701%	5.212%
18:00	13.378%		1.339%	5.230%	10.832%	18.635%	24.233%	33.032%	27.881%	23.669%	13.263%	4.091%	0.588%	0.209%
19:00	4.833%		0.000%	0.150%	1.492%	5.810%	9.846%	15.339%	13.753%	9.173%	2.097%	0.055%	0.000%	0.000%
20:00	0.669%		0.000%	0.000%	0.000%	0.095%	1.144%	3.249%	2.722%	0.765%	0.002%	0.000%	0.000%	0.000%
21:00	0.001%		0.000%	0.000%	0.000%	0.000%	0.000%	0.005%	0.003%	0.000%	0.000%	0.000%	0.000%	0.000%
22:00	0.000%		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

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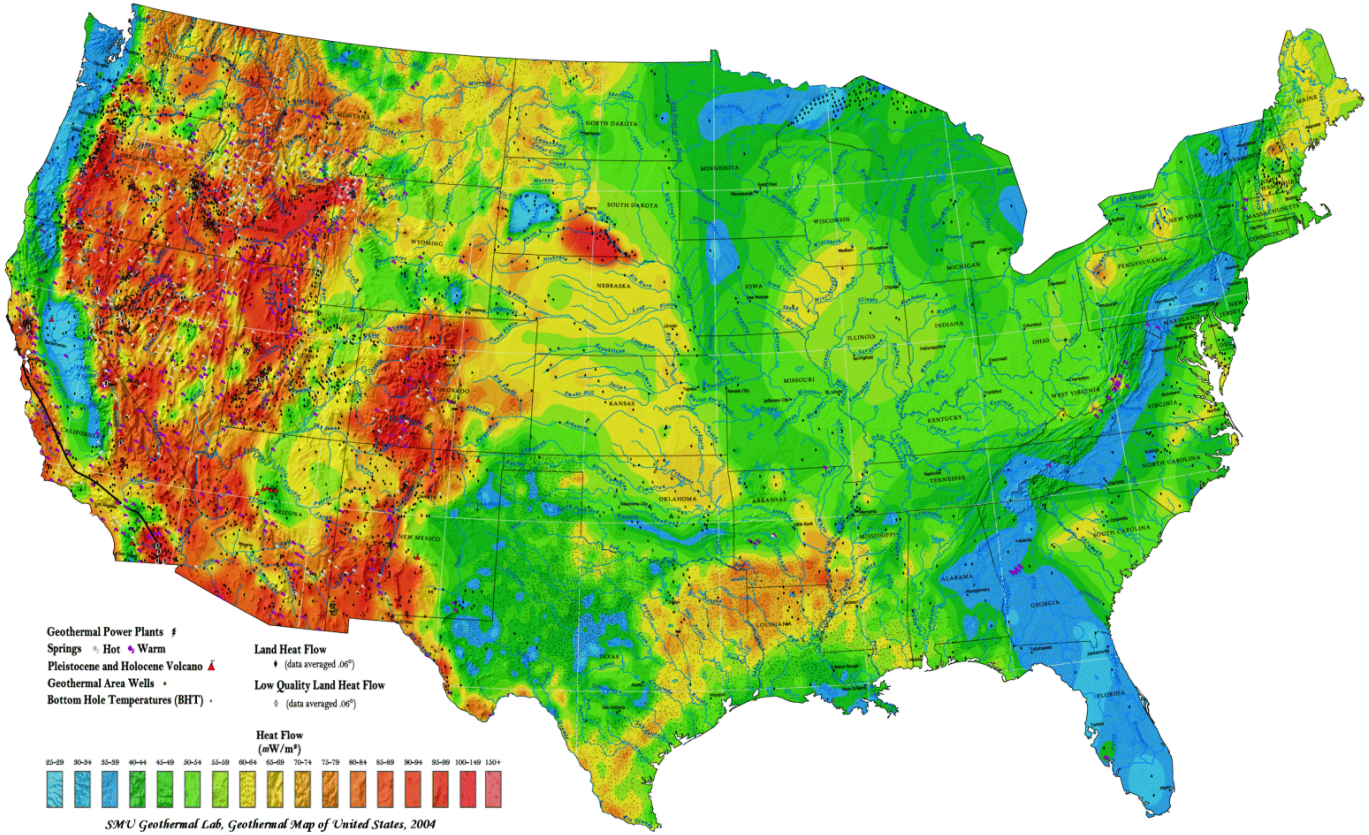
Geothermal Resources

Photo: Nesjavellir Geothermal Power Station in Iceland. Wikimedia Commons.

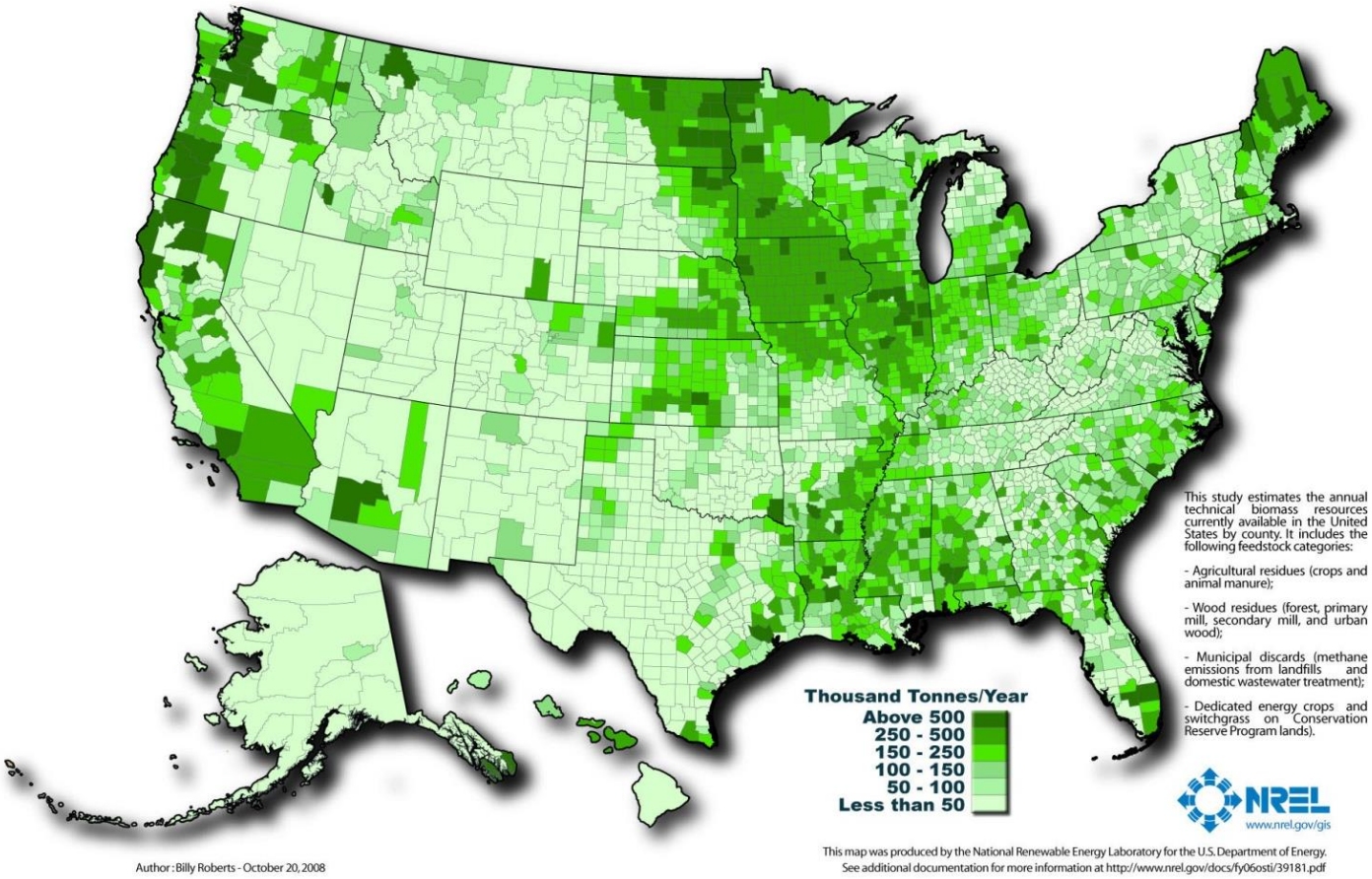
Geothermal Resources



Biomass Resources

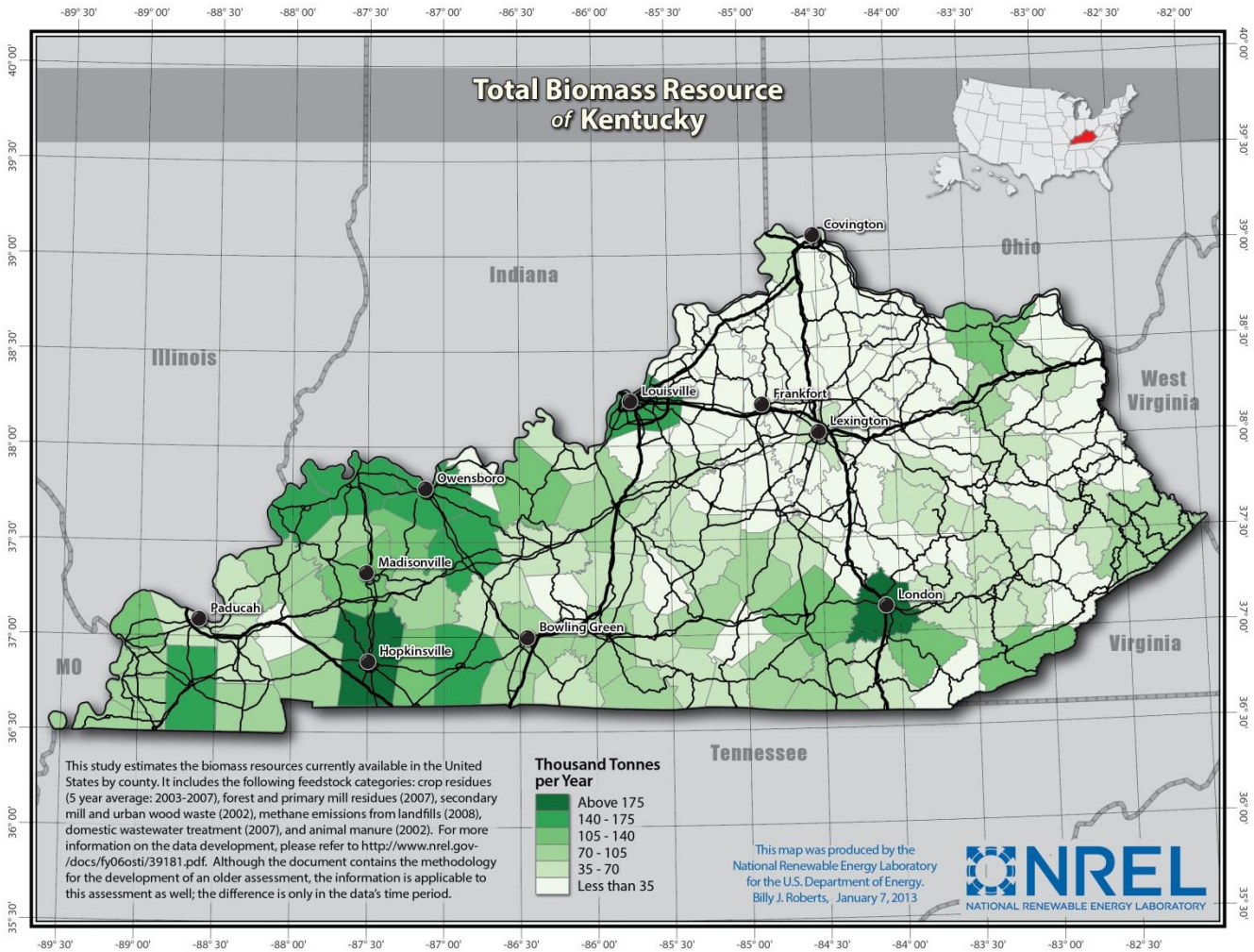
Photo: Kentucky Energy and Environment Cabinet Staff, Recast Energy, Louisville, Kentucky, 2012.

Biomass Resources



Full Report: http://www.nrel.gov/docs/fy06osti/39181.pdf

Biomass Resources



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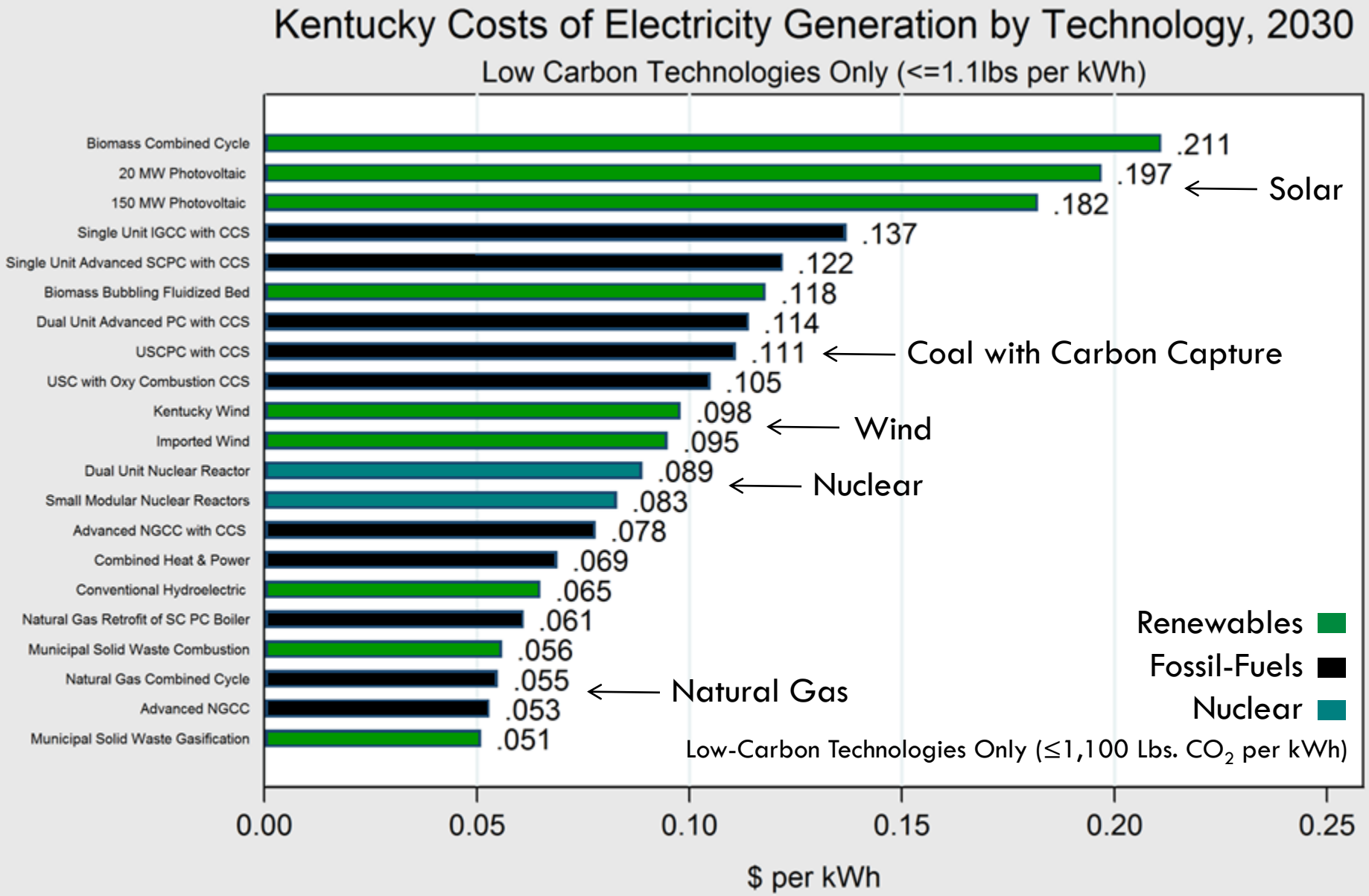


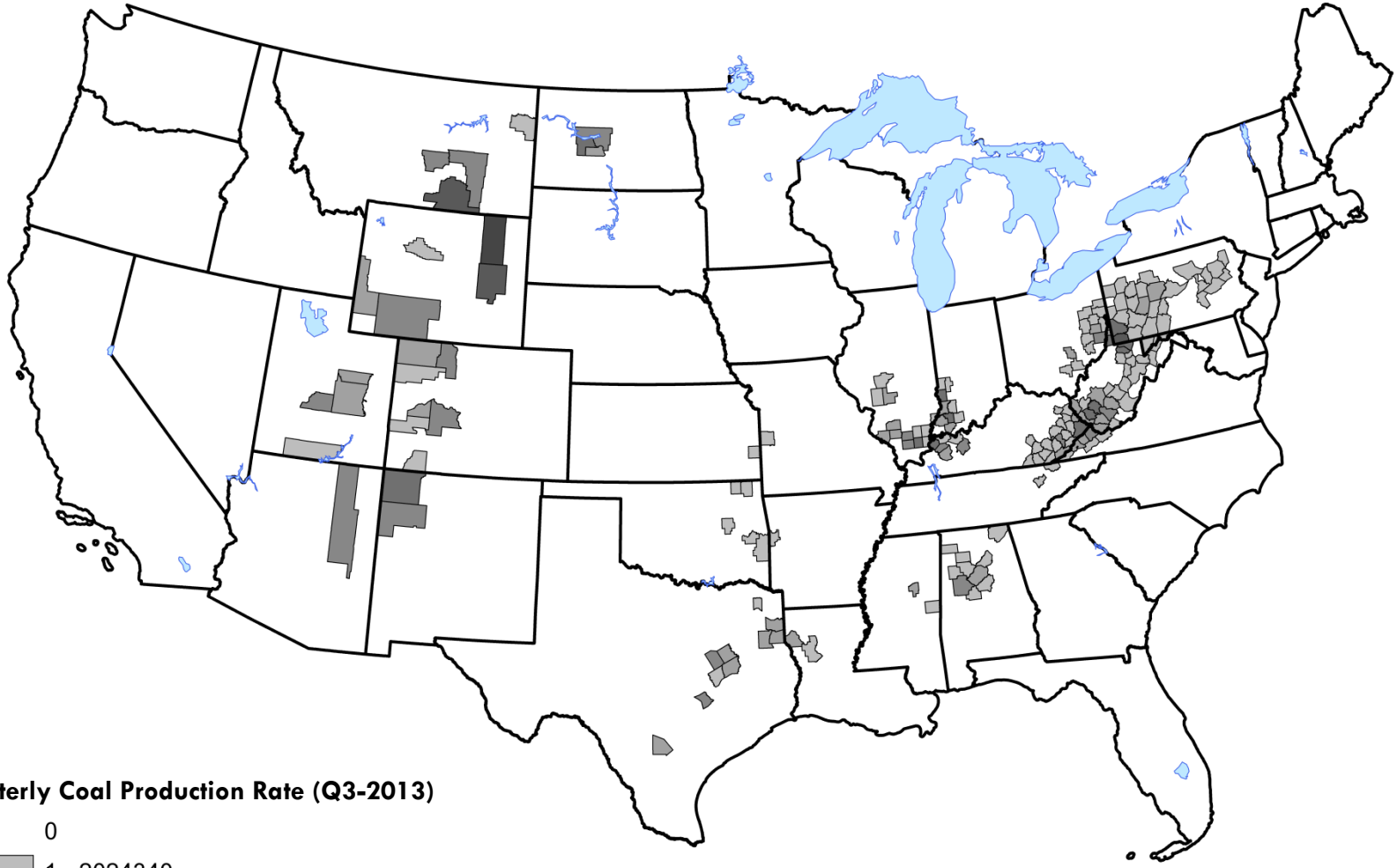
Kentucky Energy Database, EEC-DEDI, 2013

Kentucky Electricity Portfolio Model

Detailed Cost Data Available on Pages C.89 and C.90 of Complete Report

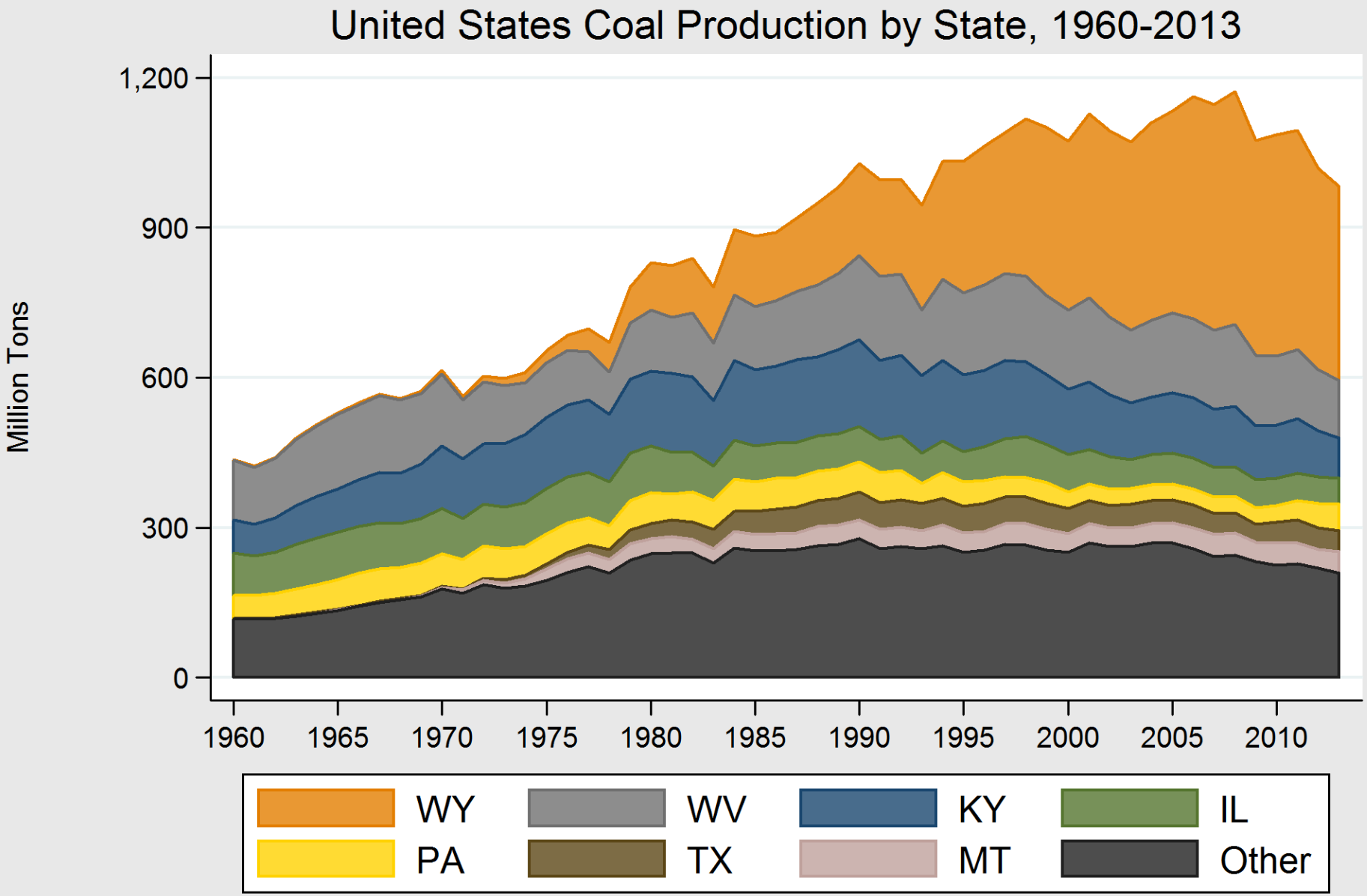
Kentucky Coal Production & Employment

United States Coal Production, Q3-2013



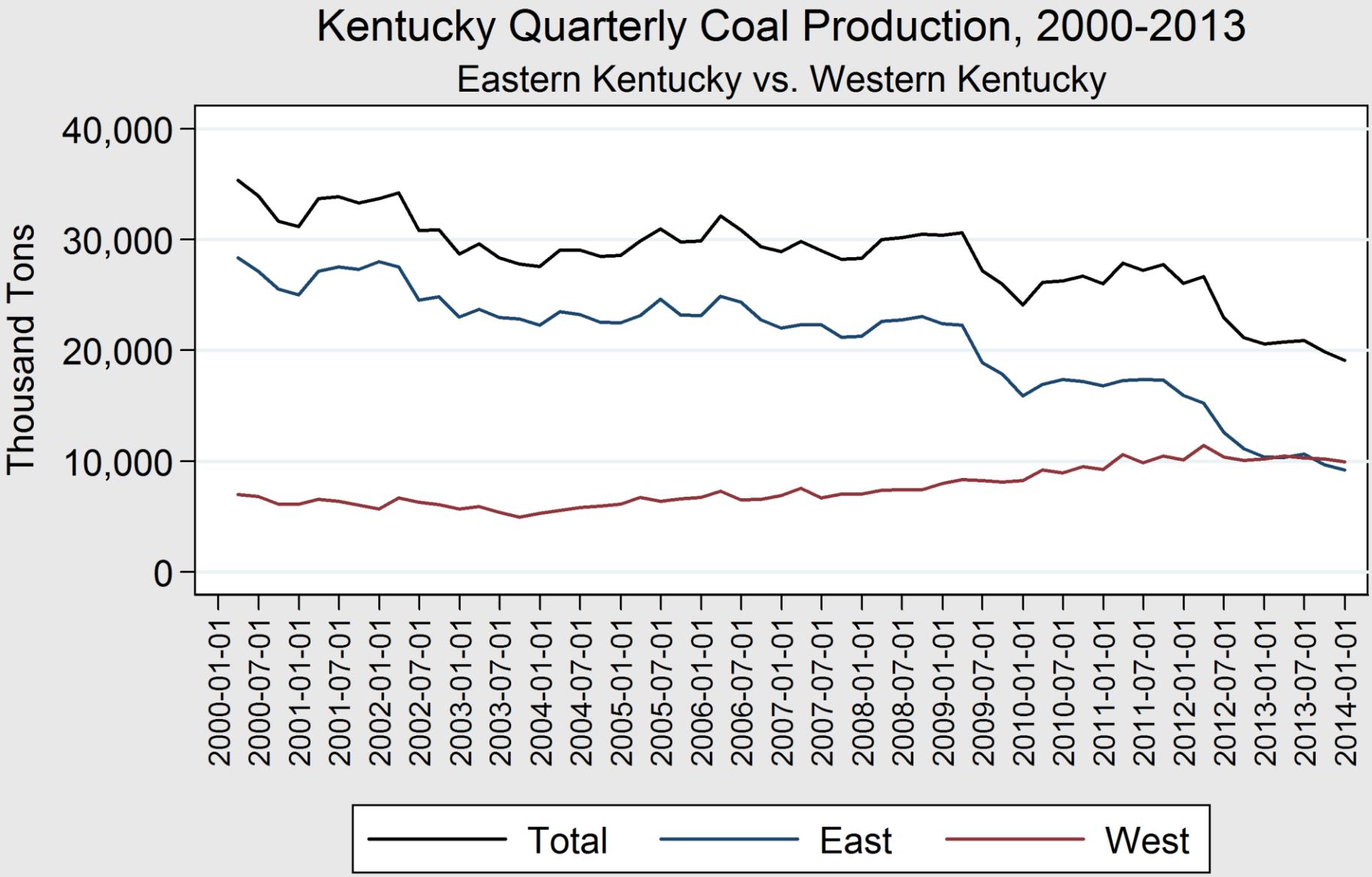
Quarterly Coal Production Rate (Q3-2013)

- 0
- 1 - 2024340
- 2024341 - 4357840
- 4357841 - 6951370
- 6951371 - 11800000
- 11800001 - 23400000
- 23400001 - 259000000



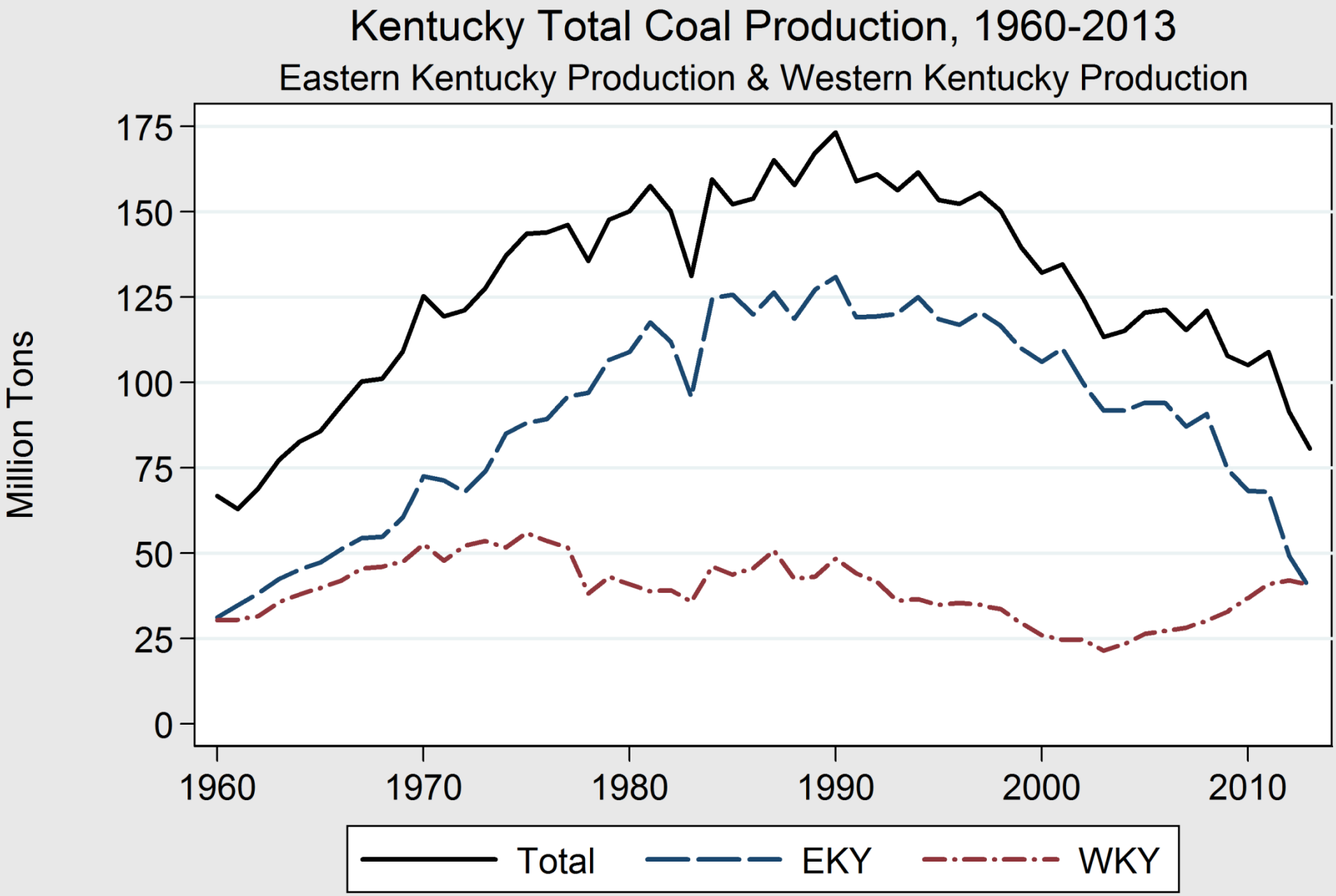
Kentucky Energy Database, EEC-DEDI, 2014

Data Source: United States Mine Safety and Health Administration (MSHA) & EIA State Energy Data System

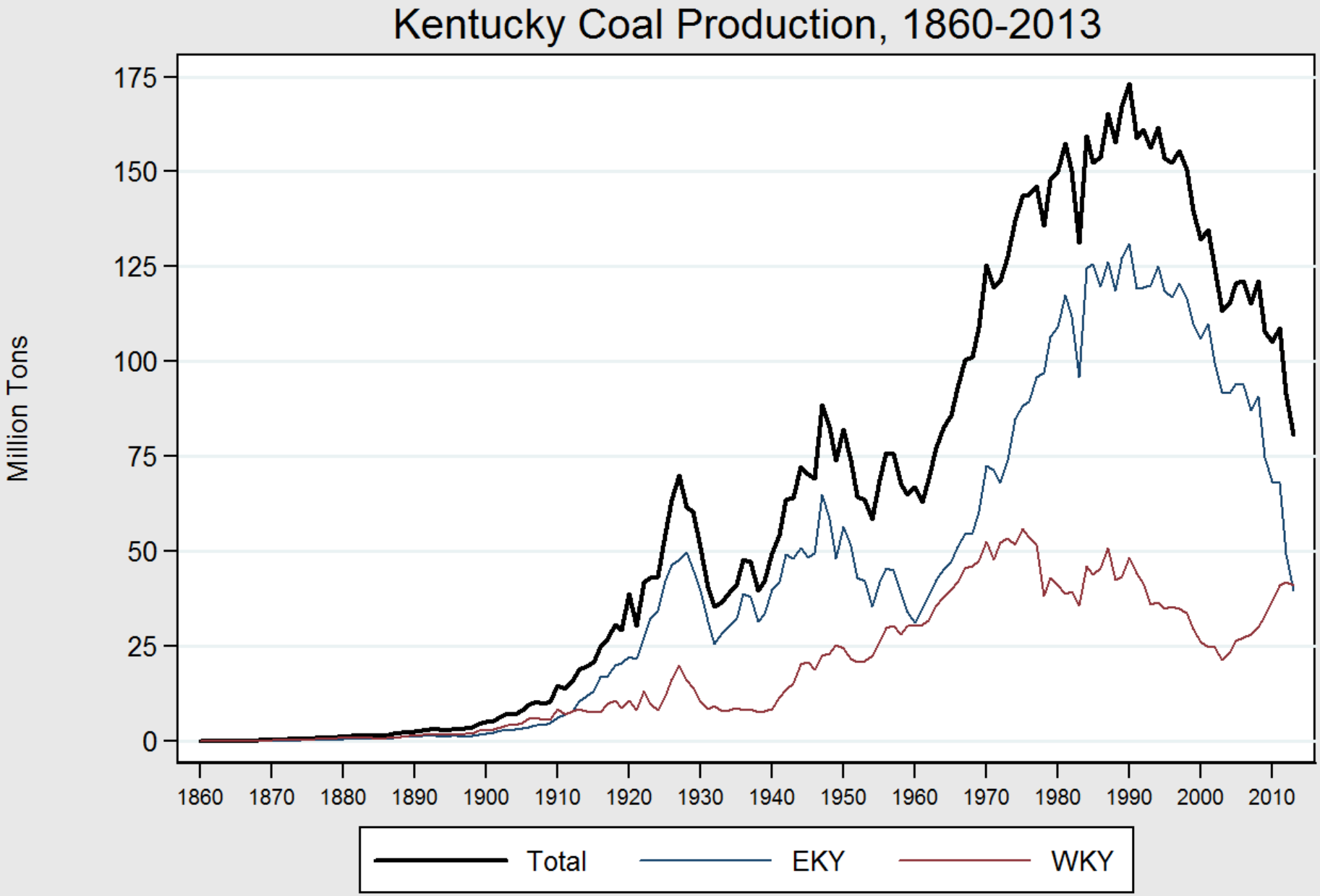


Kentucky Energy Database, EEC-DEDI, 2014

Microdata Source: MSHA-MDRS Queried on: 5 Feb 2014



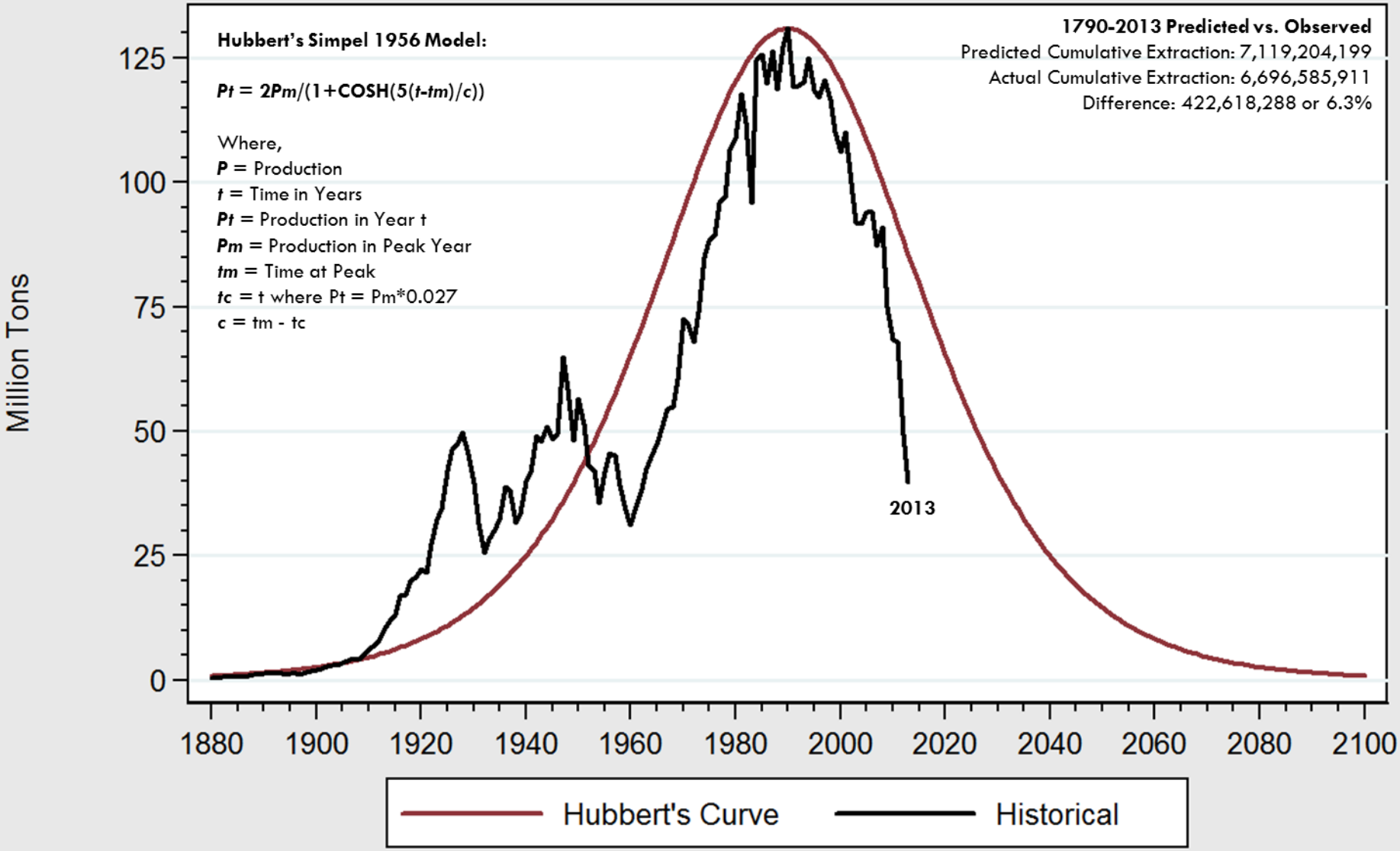
Kentucky Energy Database, EEC-DEDI, 2014



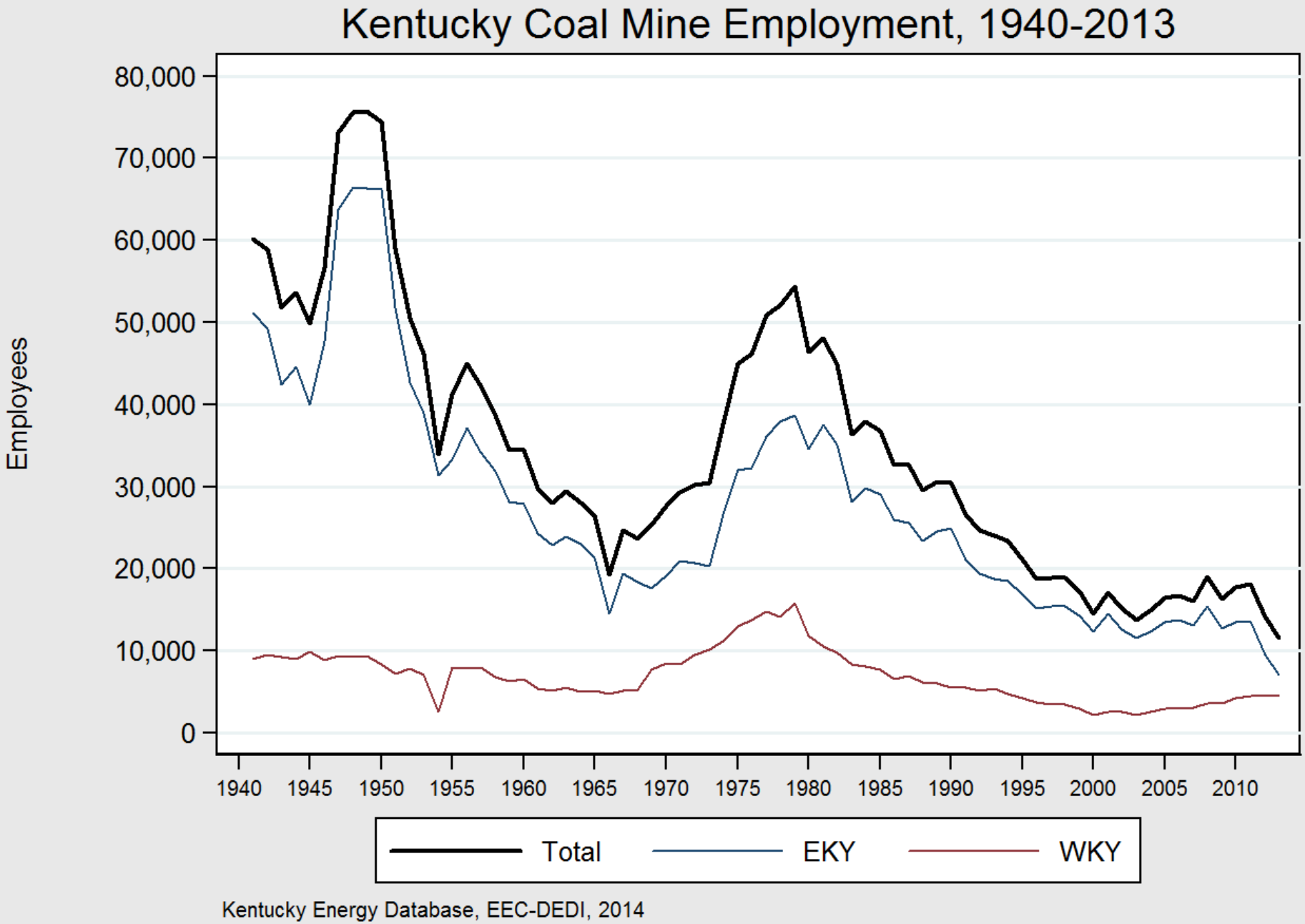
Kentucky Energy Database, EEC-DEDI, 2014

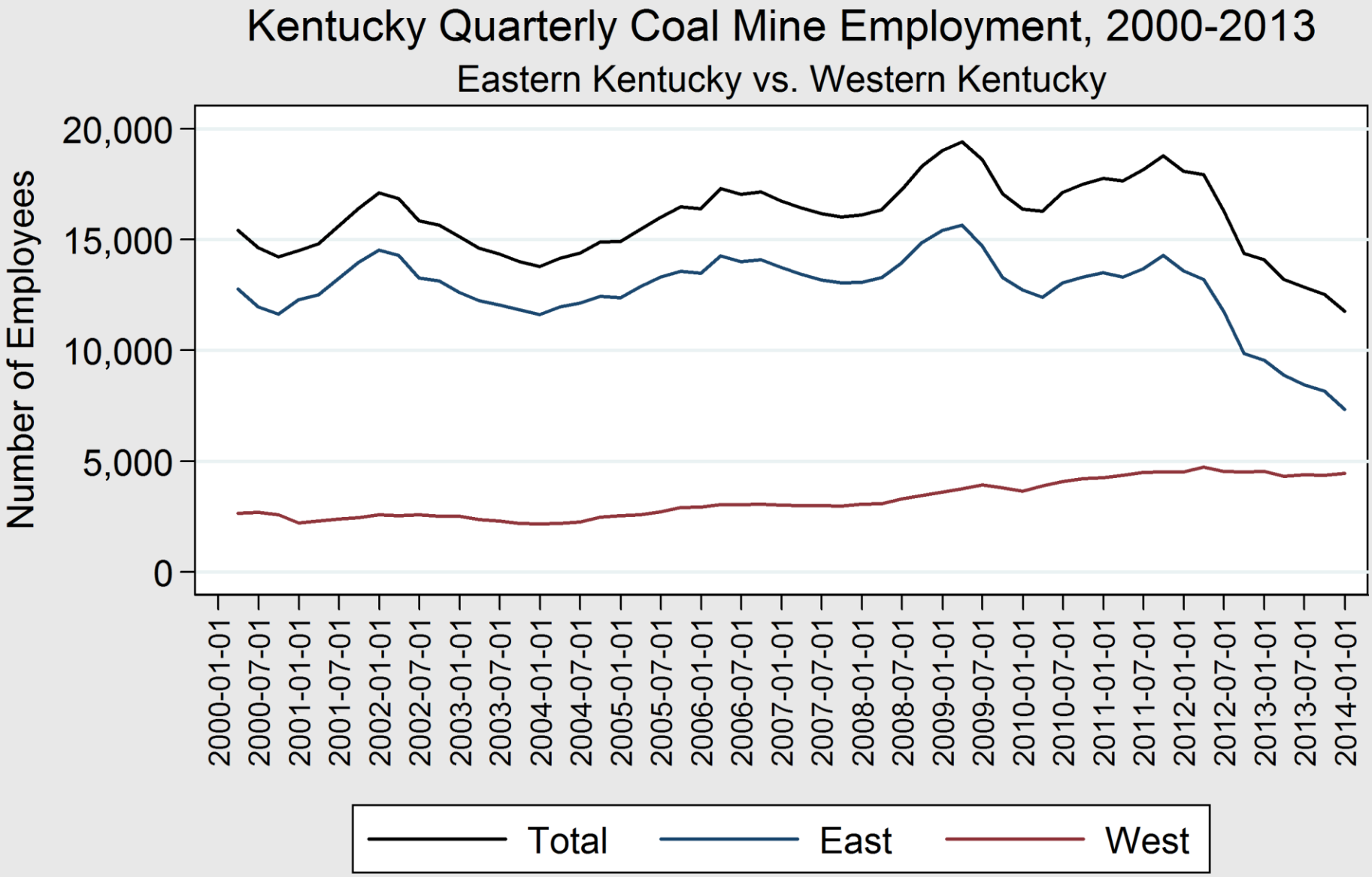
Eastern Kentucky Coal Production, 1880-2100

Hubbert's Curve Applied to Eastern Kentucky Coal Production



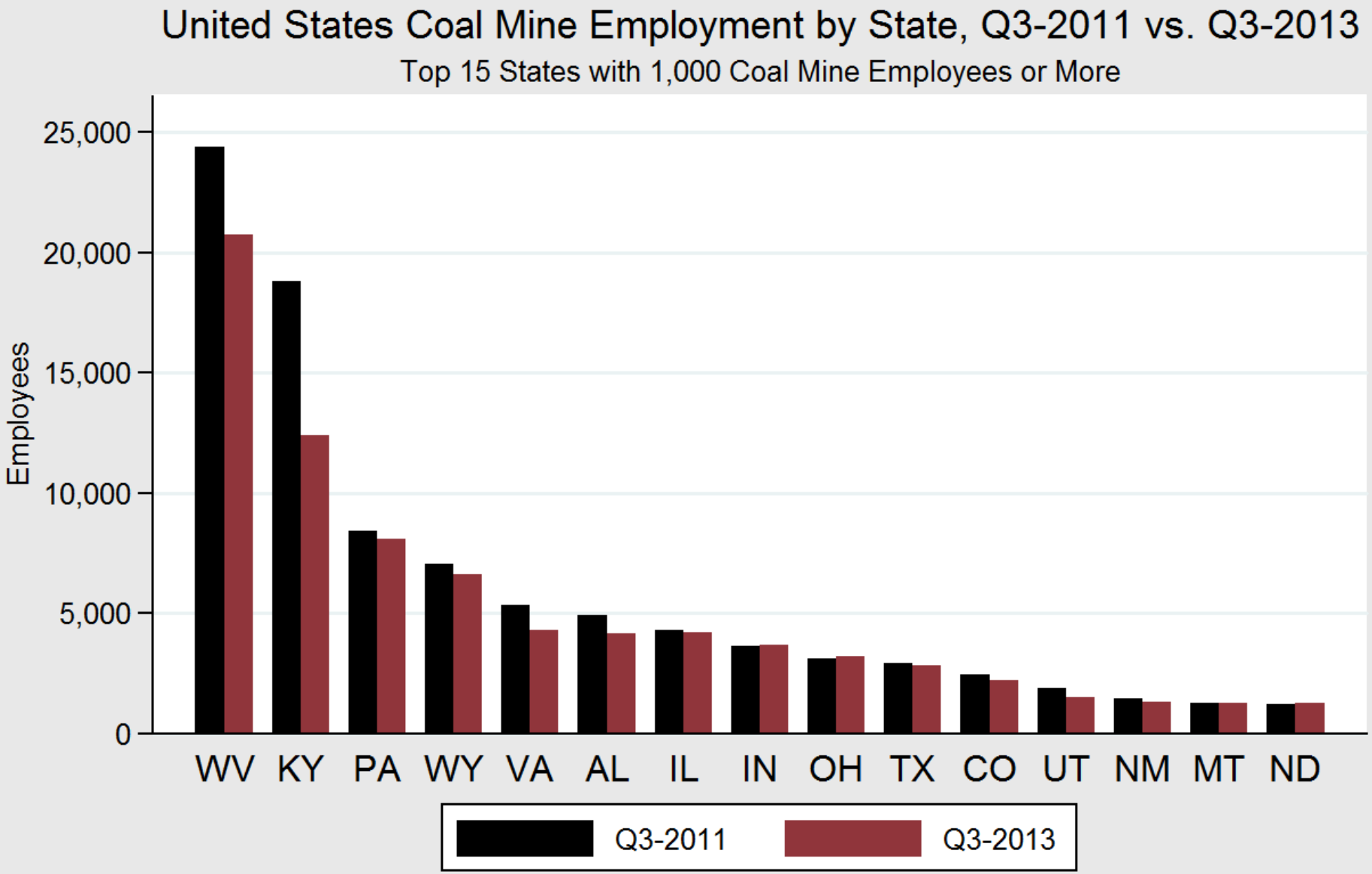
Kentucky Energy Database, EEC-DEDI, 2014


Kentucky Coal Mine Employment, 1940-2013
Employees
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Total
EKY
WKY
Kentucky Energy Database, EEC-DEDI, 2014



Kentucky Energy Database, EEC-DEDI, 2014

Microdata Source: MSHA-MDRS Queried on: 28 Feb 2014

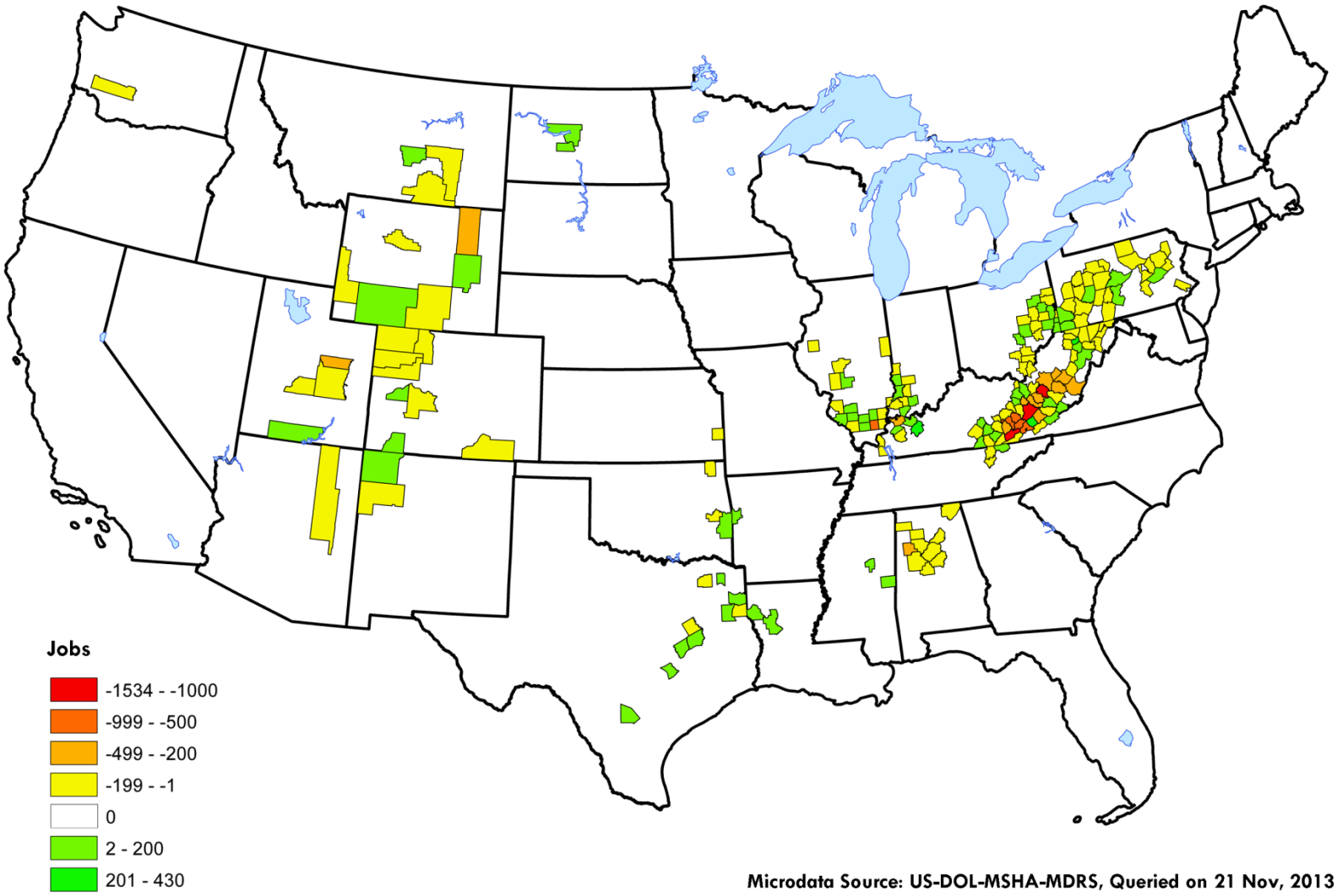


Kentucky Energy Database, EEC-DEDI, 2013

Microdata Source: MSHA-MDRS, Queried on: 21 Nov 2013

Change in Coal Mine Employment

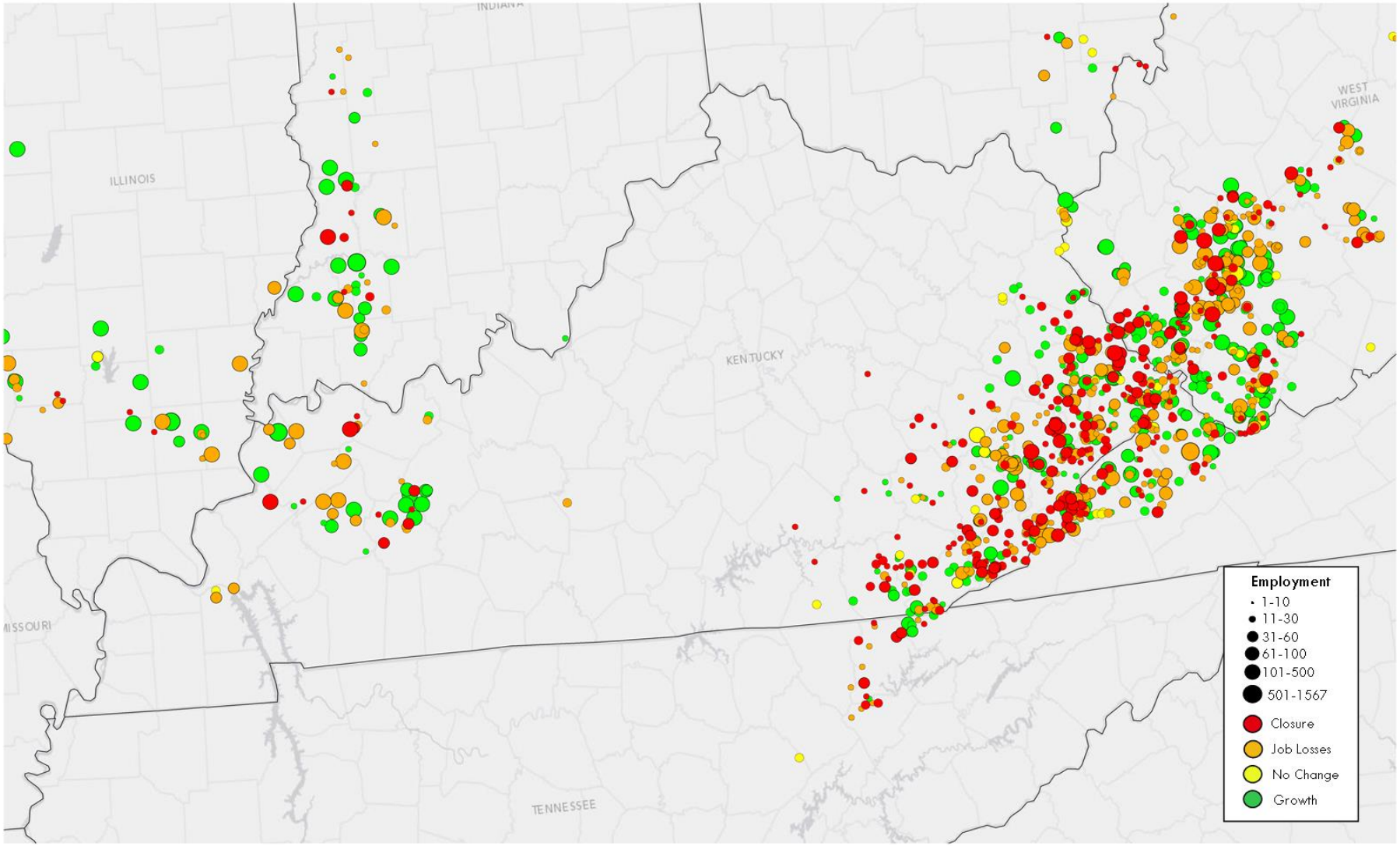
Q3-2011 — Q3-2013



Microdata Source: US-DOL-MSHA-MDRS, Queried on 21 Nov, 2013

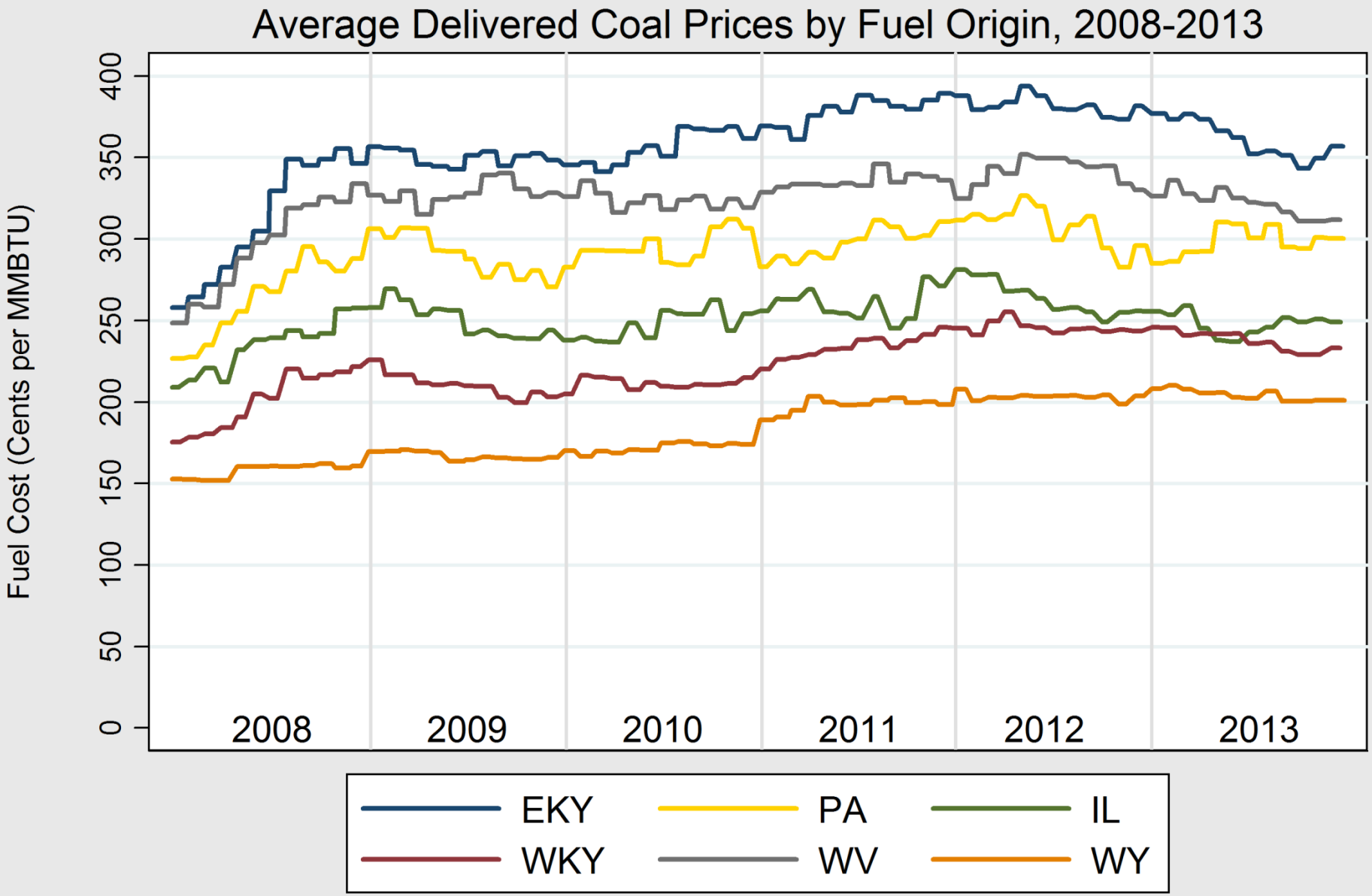
Map by the Kentucky Energy and Environment Cabinet, 2013

Change in Coal Production Employment by Mine, Q3-2011 to Q3-2013



Note: Some coal mines are not visible because of their physical proximity to one-another.

Kentucky Energy Database, EEC-DEDI, 2013
Microdata Source: MSHA-MDRS, Queried 11/15/2013

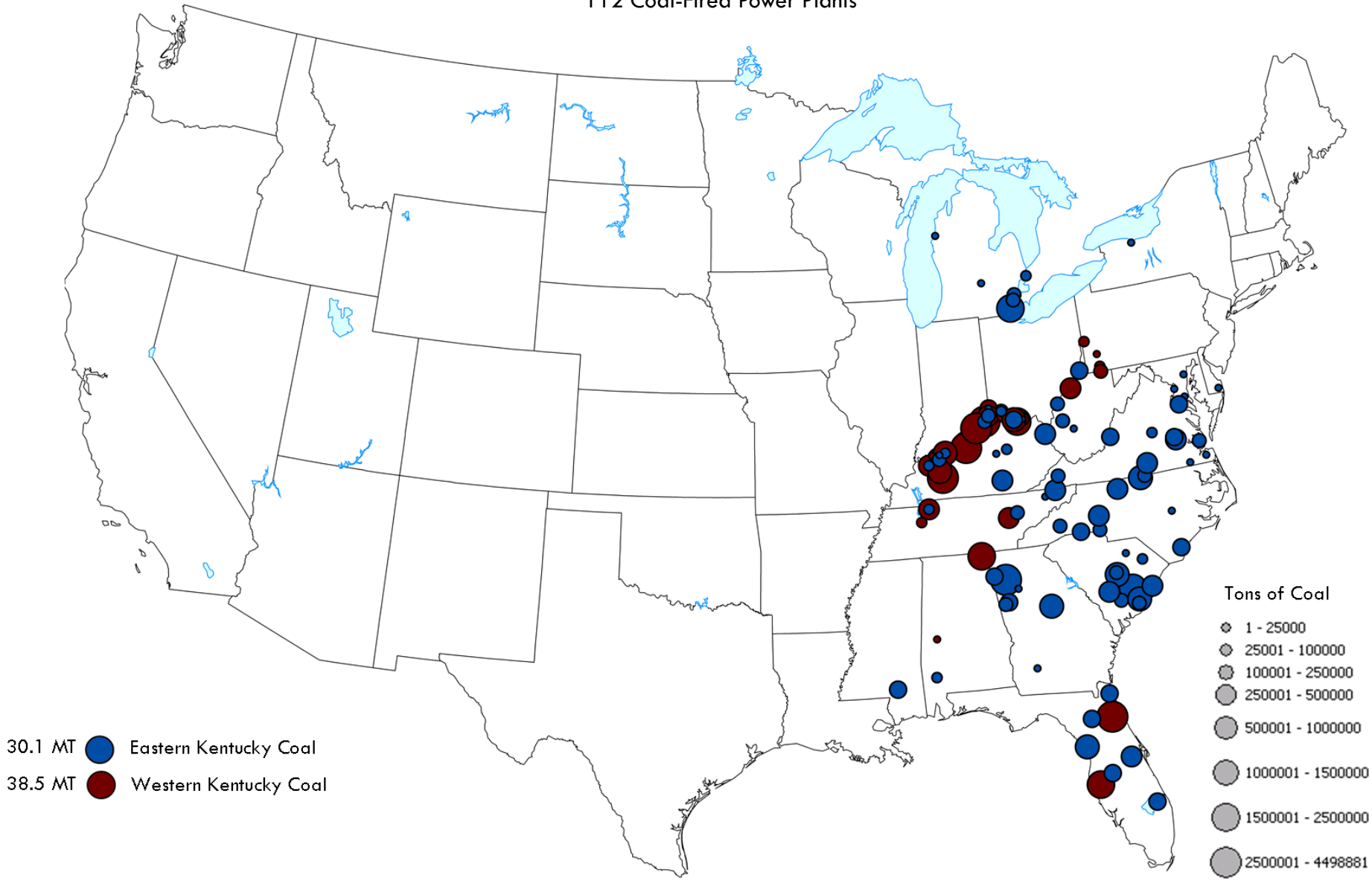


Kentucky Energy Database, EEC-DEDI, 2014

Top Five Coal Producing States in 2013. Microdata Source: Form EIA-923. EKY=Eastern Kentucky. WKY=Western Kentucky

Kentucky Coal Deliveries, 2012

112 Coal-Fired Power Plants



Kentucky Energy Database, EEC-DEDI, 2013

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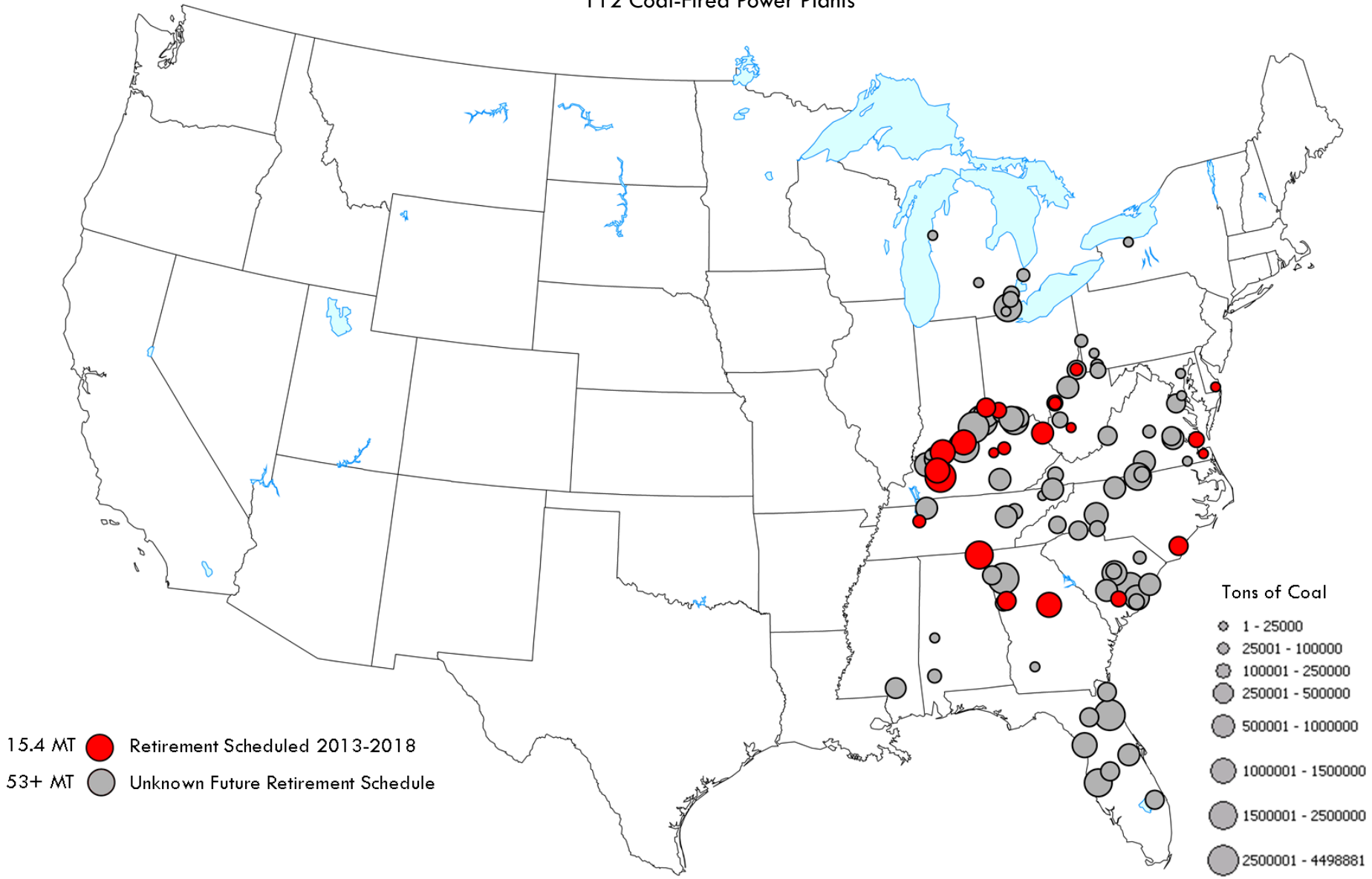

Kentucky Energy Database, EEC-DEDI, 2013

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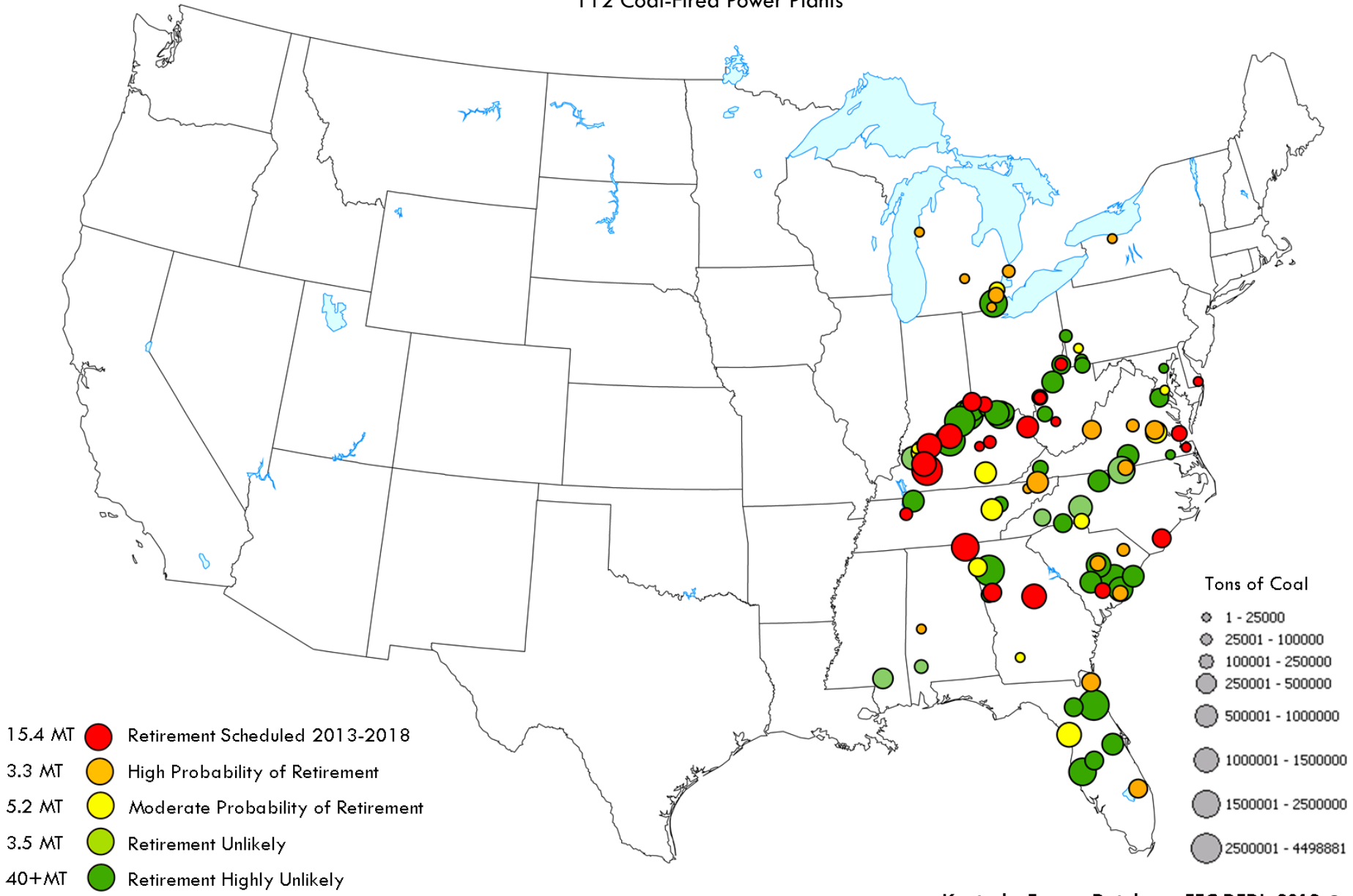
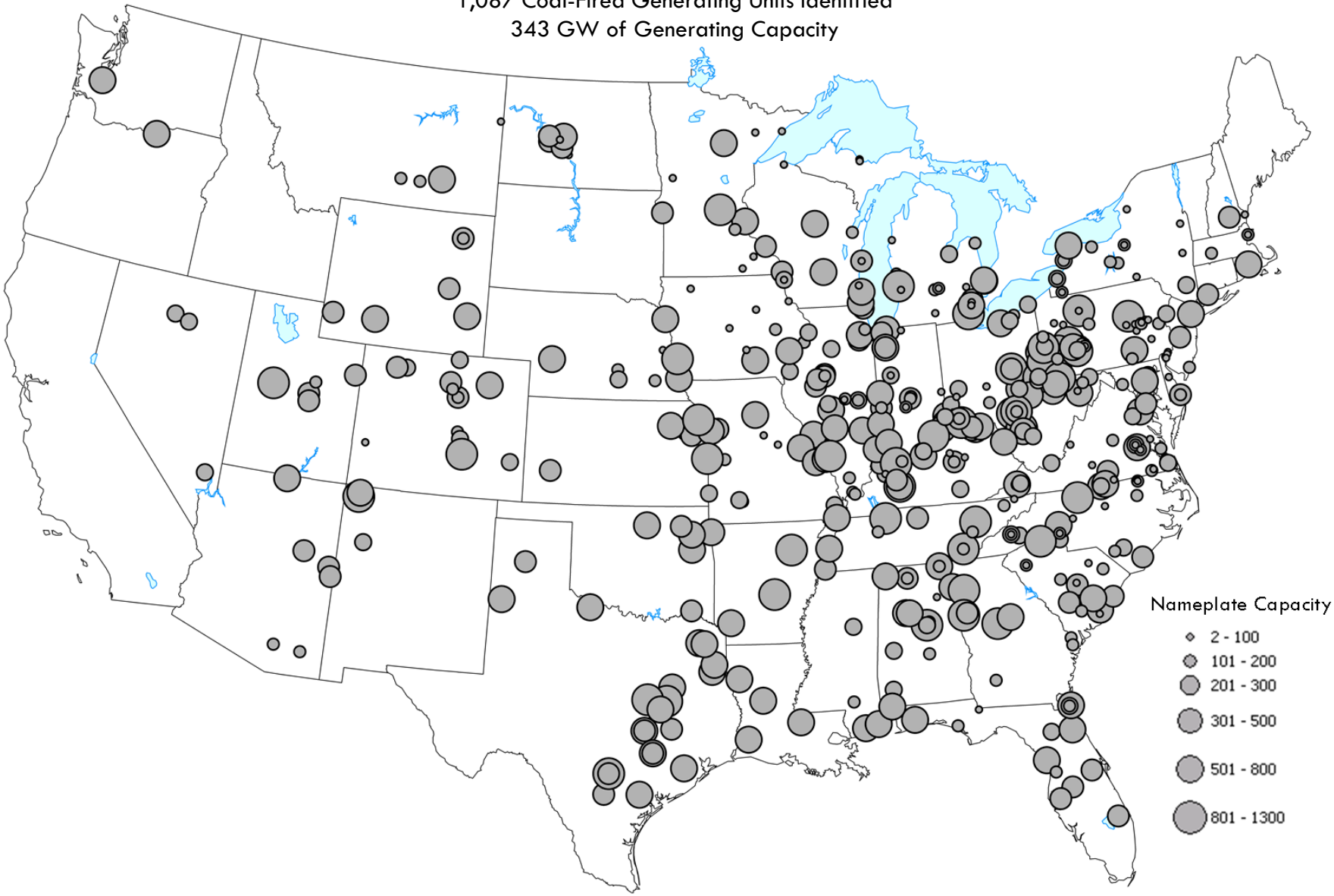


Kentucky Energy Database, EEC-DEDI, 2013

United States Coal-Fired Electricity Generating Units, 2013

1,087 Coal-Fired Generating Units Identified
343 GW of Generating Capacity



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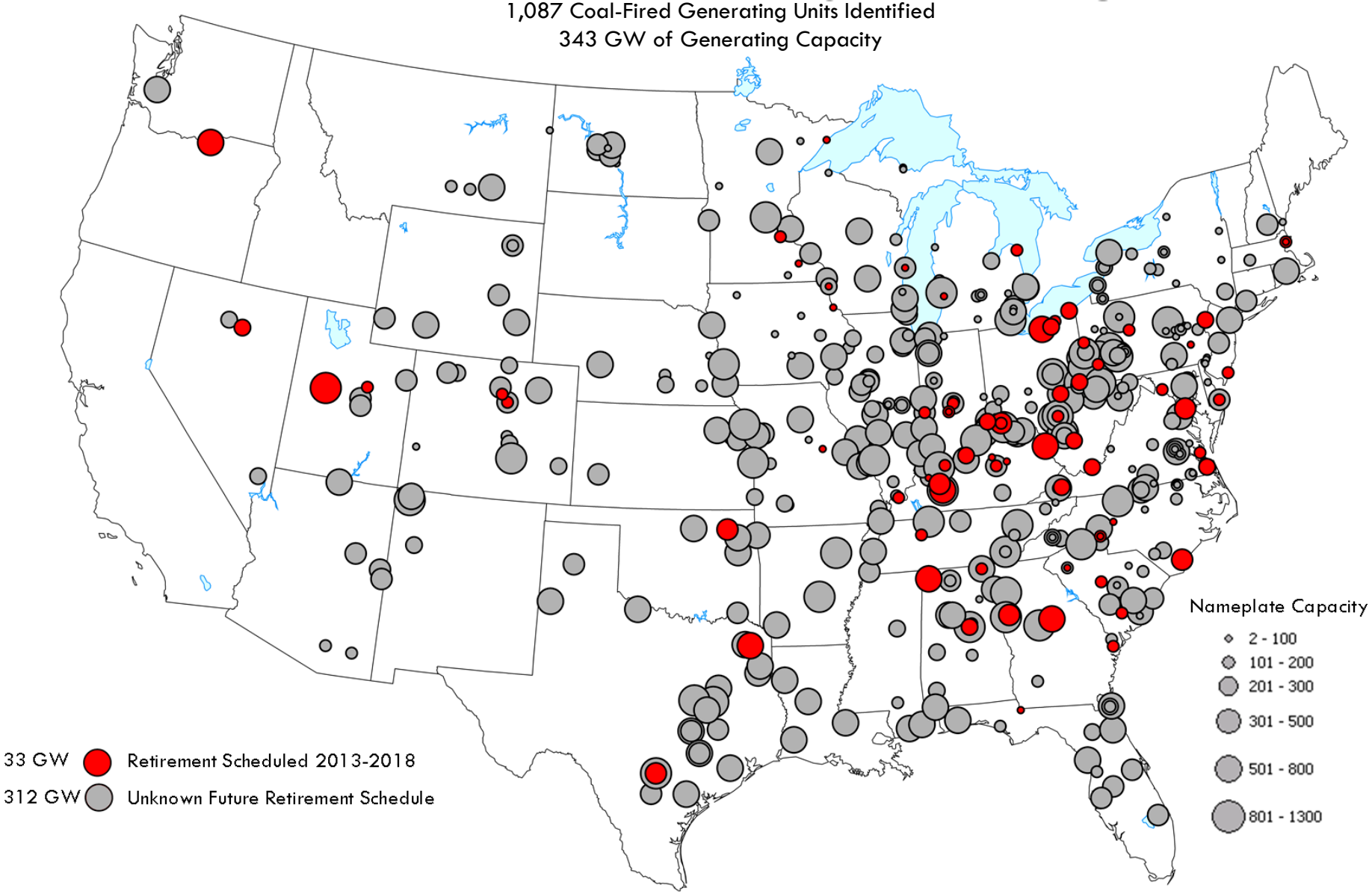

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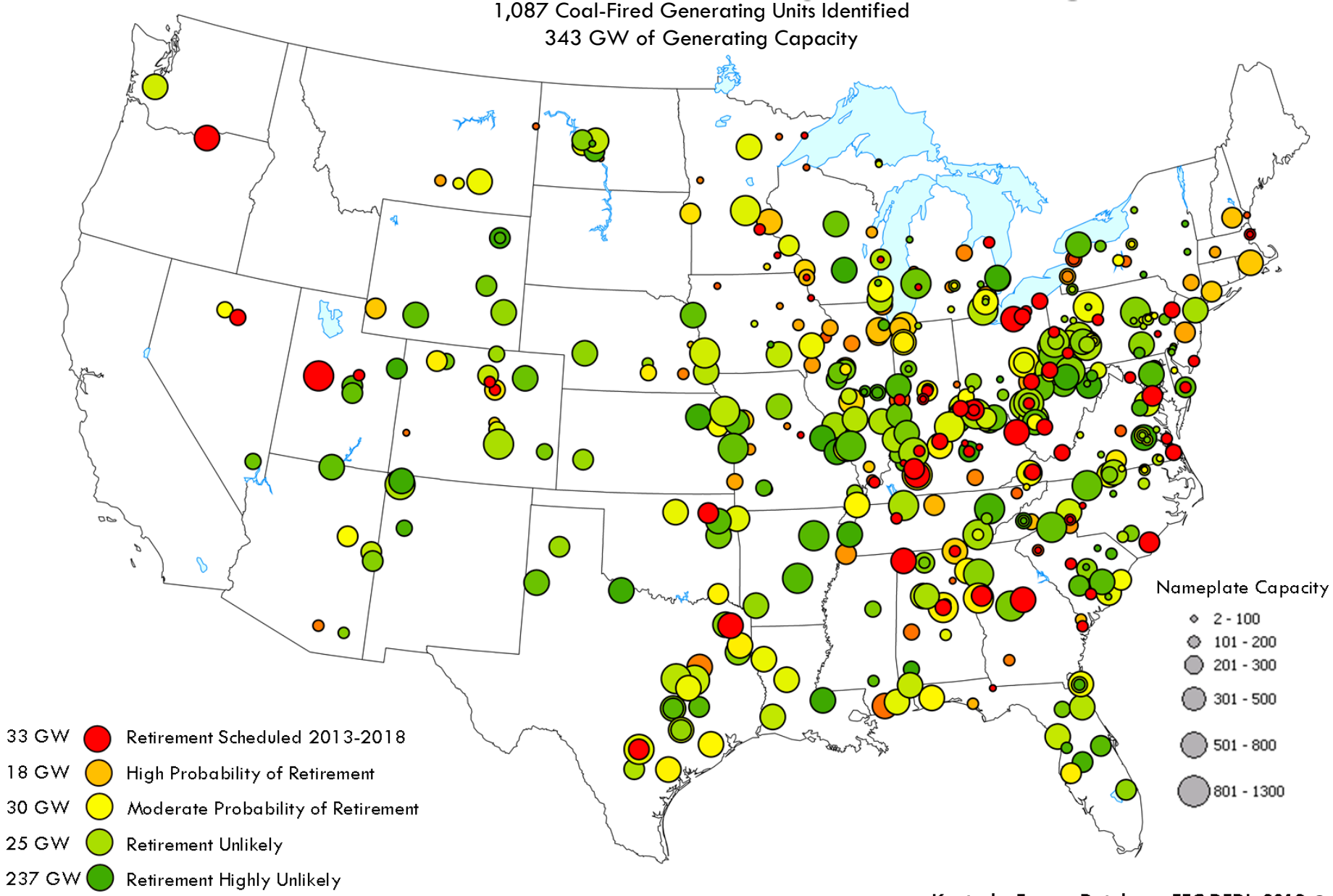


Kentucky Energy Database, EEC-DEDI, 2013

More on Coal…

Kentucky remains the third-largest coal-producing state, with 2 distinct coal-producing regions.

In western Kentucky, high sulfur coal production remains relatively stable. Despite numerous power plant closures, western Kentucky has regained markets lost to lower-sulfur coal in eastern Kentucky as utilities install desulfurization systems.

Eastern Kentucky coal fields have been hit especially hard by a combination of regulatory and market factors. Long-term low and declining productivity in eastern Kentucky mining operations has increased production costs, which has decreased price competitiveness versus coal from other regions and alternative sources of energy, namely currently low-priced natural gas. Recent environmental regulations affecting both coal production and combustion, are further increasing the costs and decreasing cost-competitiveness. Other market forces, such as moderate electricity demand growth, are also decreasing national demand for energy.

Coal-fired capacity retirements are concentrated in the Southeast and the Midwest. These regions account for 65% of the coal capacity in the United States. And, these two regions account for most of eastern Kentucky's coal shipments out of state.

Mining employment losses in eastern Kentucky account for 47 percent of the total reduction in national mining employment in the last year.

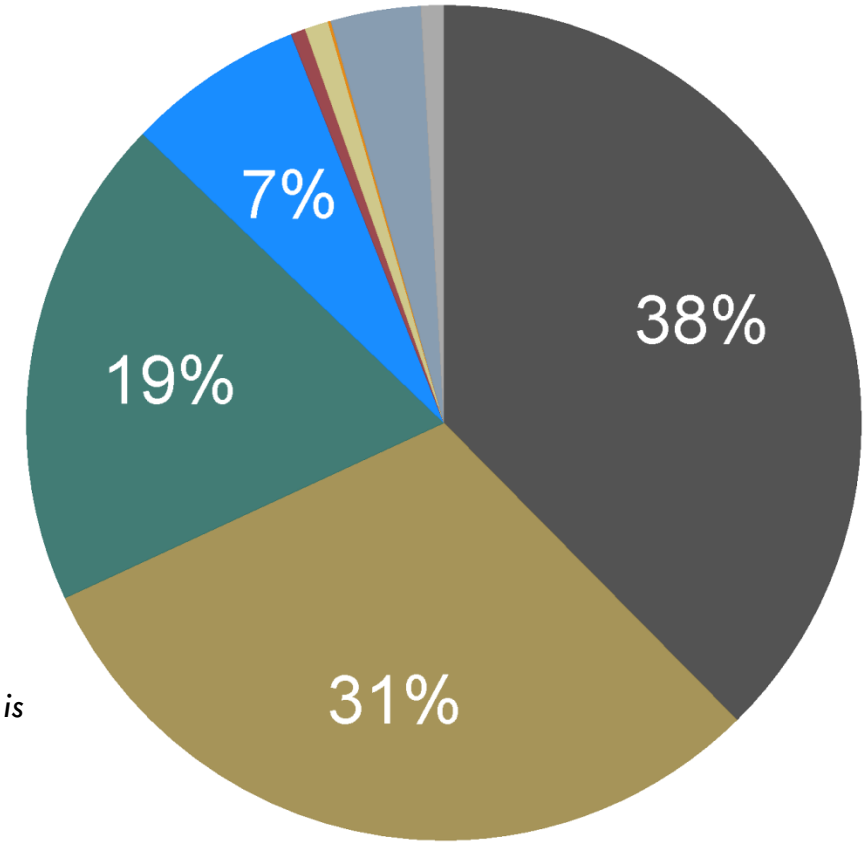
Kentucky Coal Facts and Kentucky Quarterly Coal Report
http://energy.ky.gov/Pages/CoalFacts.aspx

A Quick Introduction to

Kentucky's Electricity Portfolio

United States Electricity Generation, 2012

Electricity Generation by Fuel Type (%)



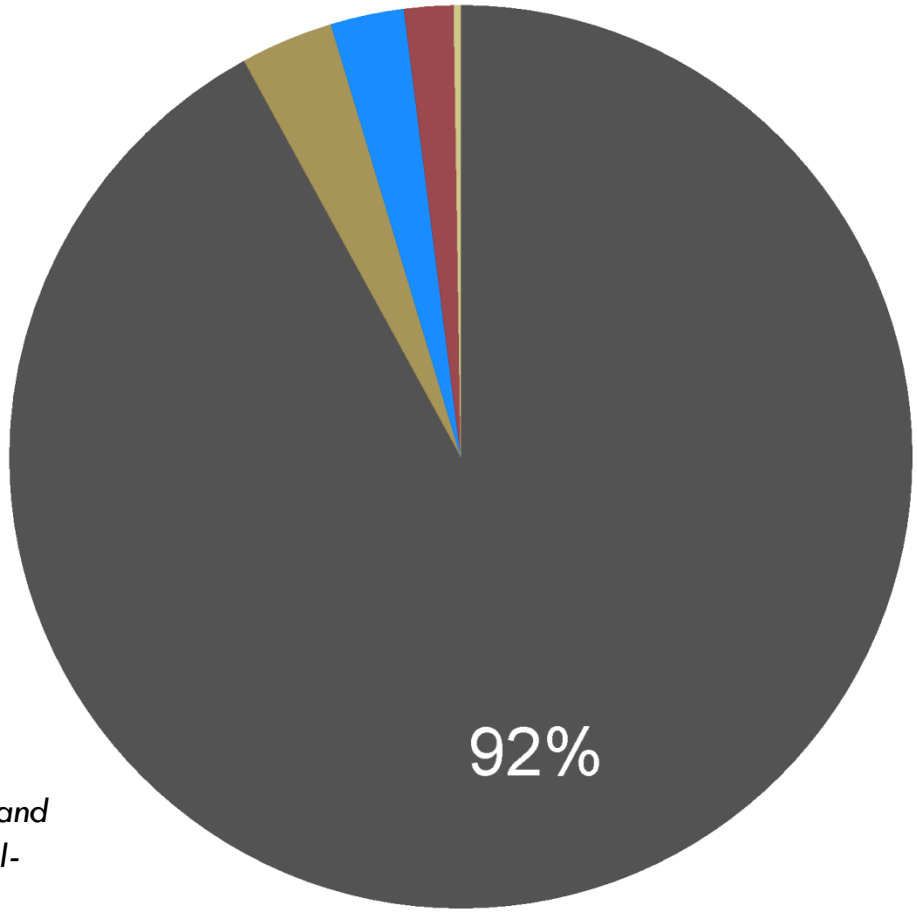
Electricity consumption nationally is relatively balanced between coal, natural gas, nuclear power, hydroelectric, and wind.

Coal	Natural Gas	Nuclear
Hydro	Petroleum	Wood
Solar	Wind	All Other

Kentucky Energy Database, EEC-DEDI, 2013

Kentucky Electricity Generation, 2012

Electricity Generation by Fuel Type (%)



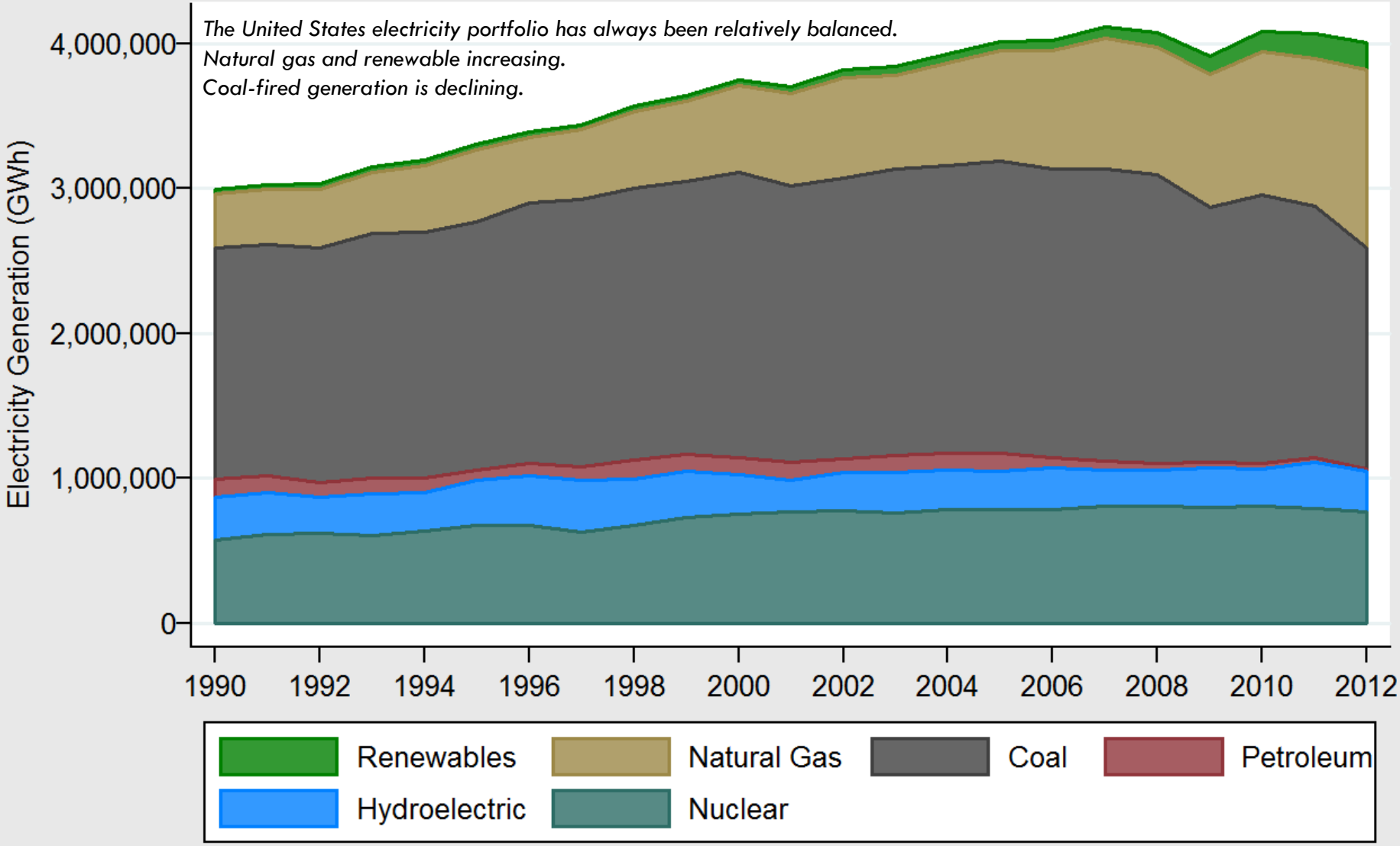
Over 92% of the electricity generated in Kentucky in 2012 and 2013 came from Kentucky's coal-fired power plants.

Coal | Natural Gas | Hydro
Petroleum | Wood

Kentucky Energy Database, EEC-DEDI, 2013

United States Electricity Generation, 1990-2012

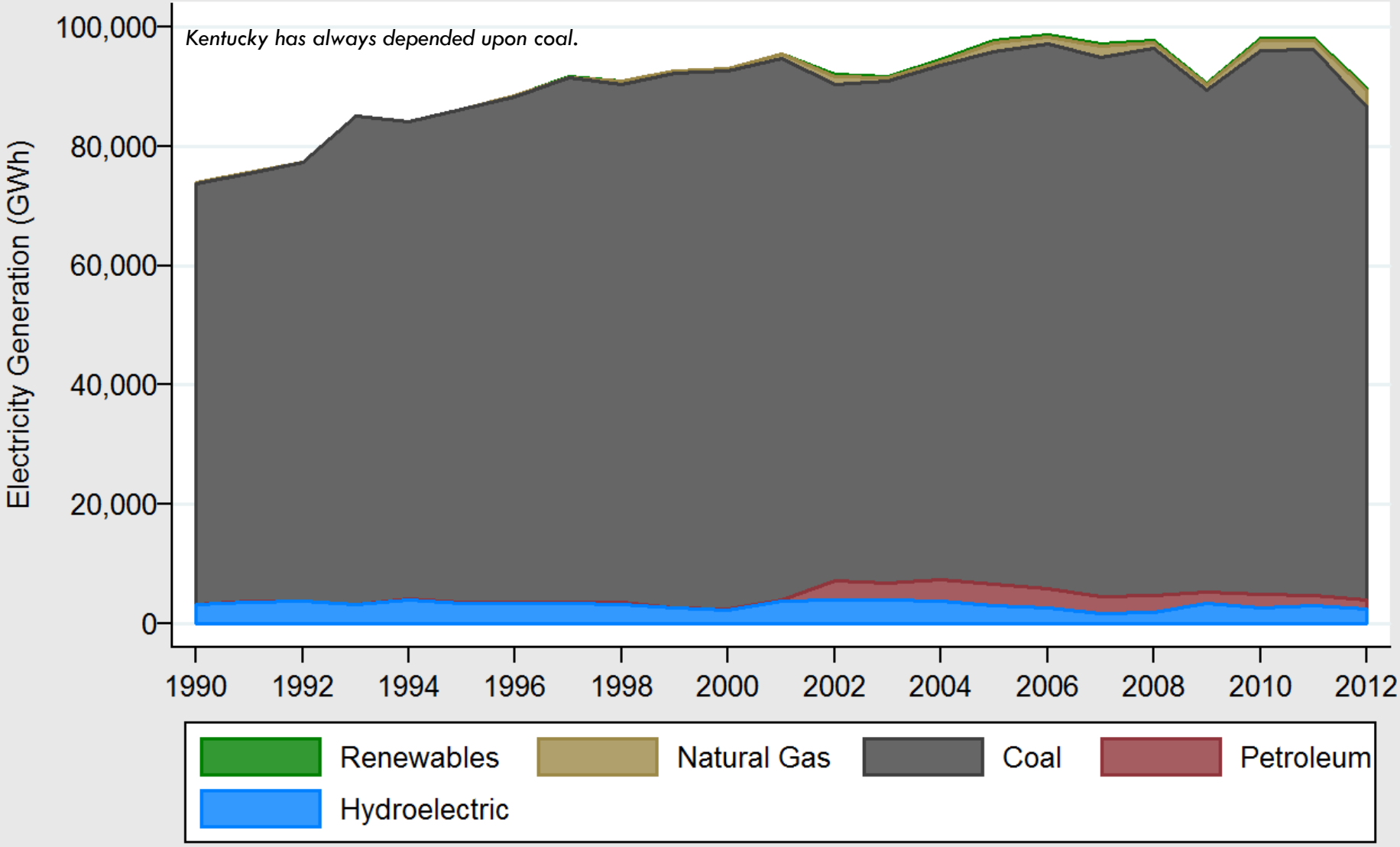
Generation by Fuel Type (Gigawatt Hours)



Kentucky Energy Database, EEC-DEDI, 2013

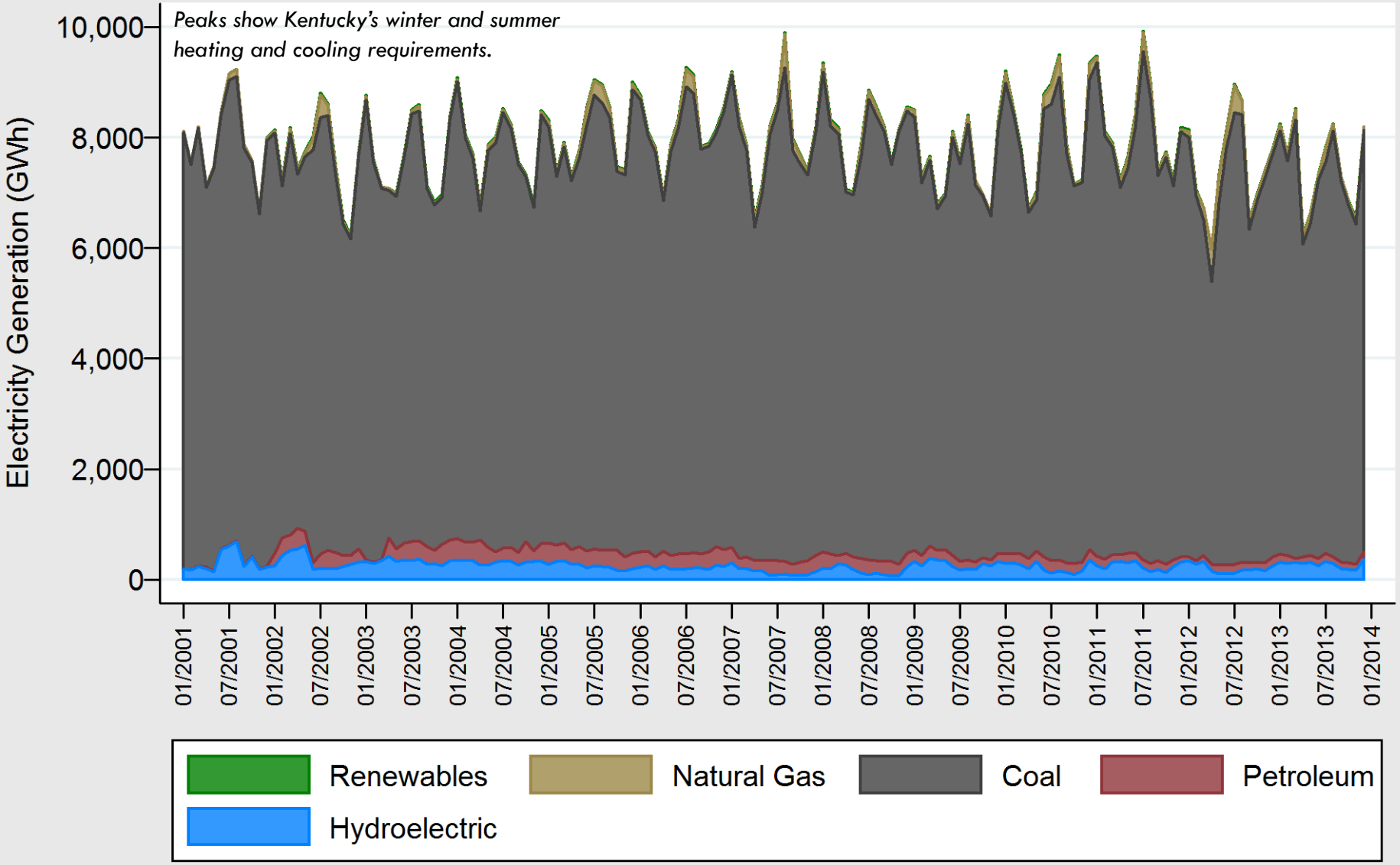
Kentucky Electricity Generation, 1990-2012

Generation by Fuel Type (Gigawatt Hours)



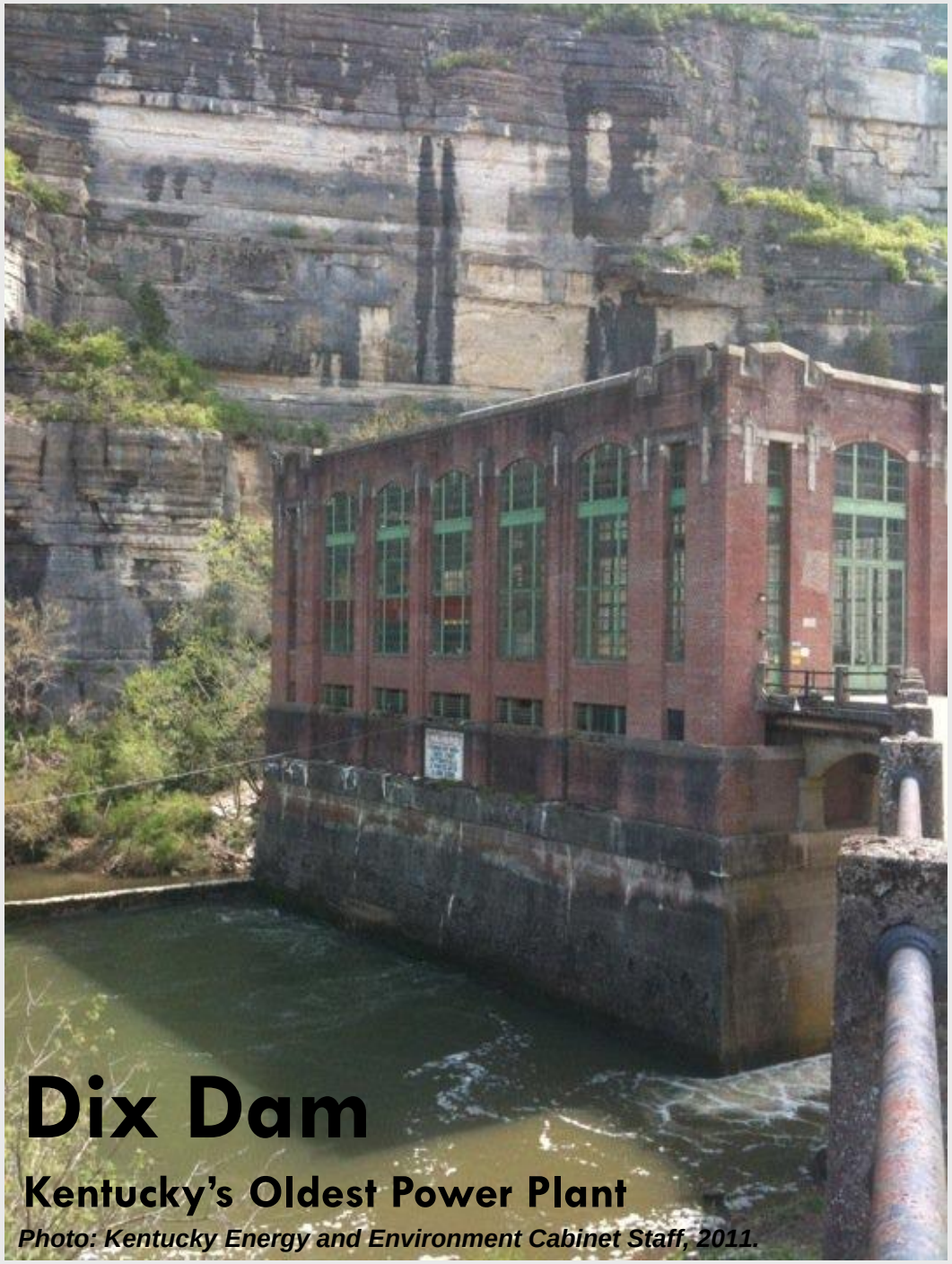
Kentucky Energy Database, EEC-DEDI, 2013

Kentucky Electricity Generation by Fuel Type, 2001-2013



Kentucky Energy Database, EEC-DEDI, February 2014

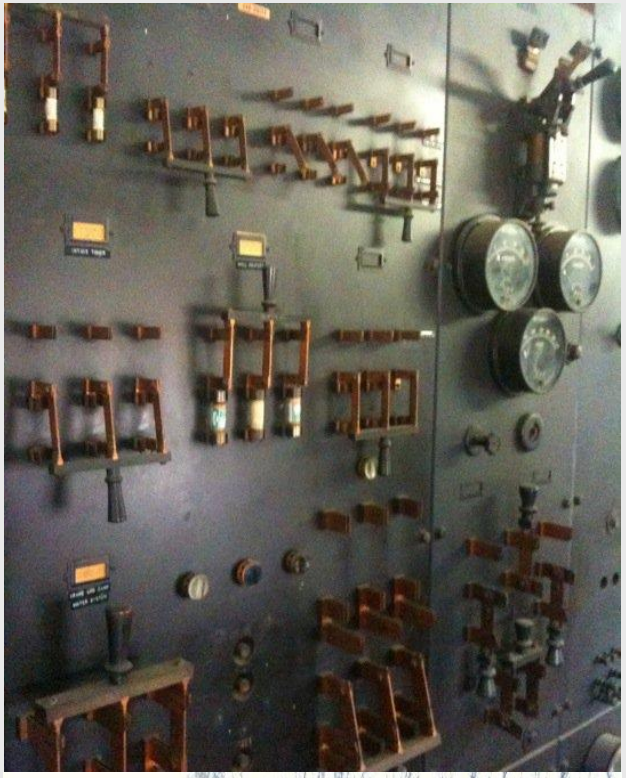
Data Source: EIA Electric Power Monthly, February 2014

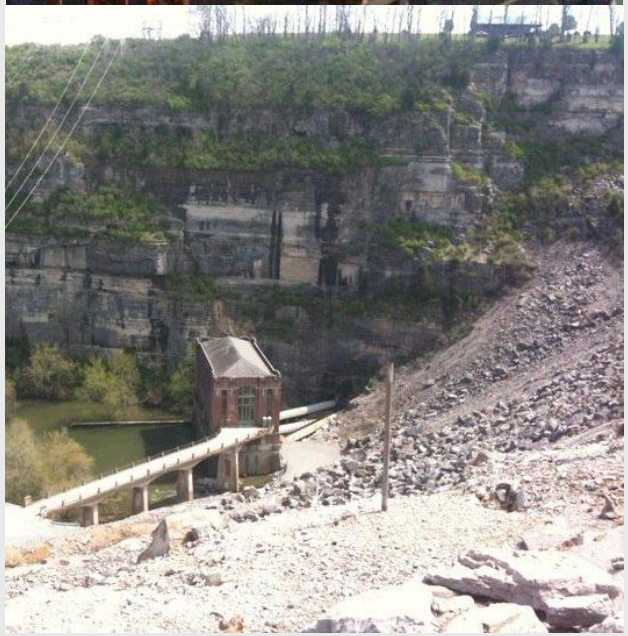


Dix Dam

Kentucky's Oldest Power Plant

Photo: Kentucky Energy and Environment Cabinet Staff, 2011.





Trimble County

Kentucky's Newest Coal Plant

Photo: LG&E-KU, 2014

A Quick Introduction to

Kentucky's Future Electricity Portfolio

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"Economic Challenges Facing Kentucky's Electricity Generation Under Greenhouse Gas Constraints"

Changes in Federal Regulation

More numerous and more stringent federal environmental regulations affecting coal-fired generation in ways that differ from the past.

Mercury Air Toxics Standards (MATS)

MATS has accounted for a large portion of recent coal plant retirements.

National Ambient Air Quality Standard (NAAQS)

Much more stringent Ozone (O3) standards likely to be proposed.

Cross State Air Pollution Rule (CSAPR)

Supreme Court decision expected in June 2014.

Water intake & and Effluent Limitations

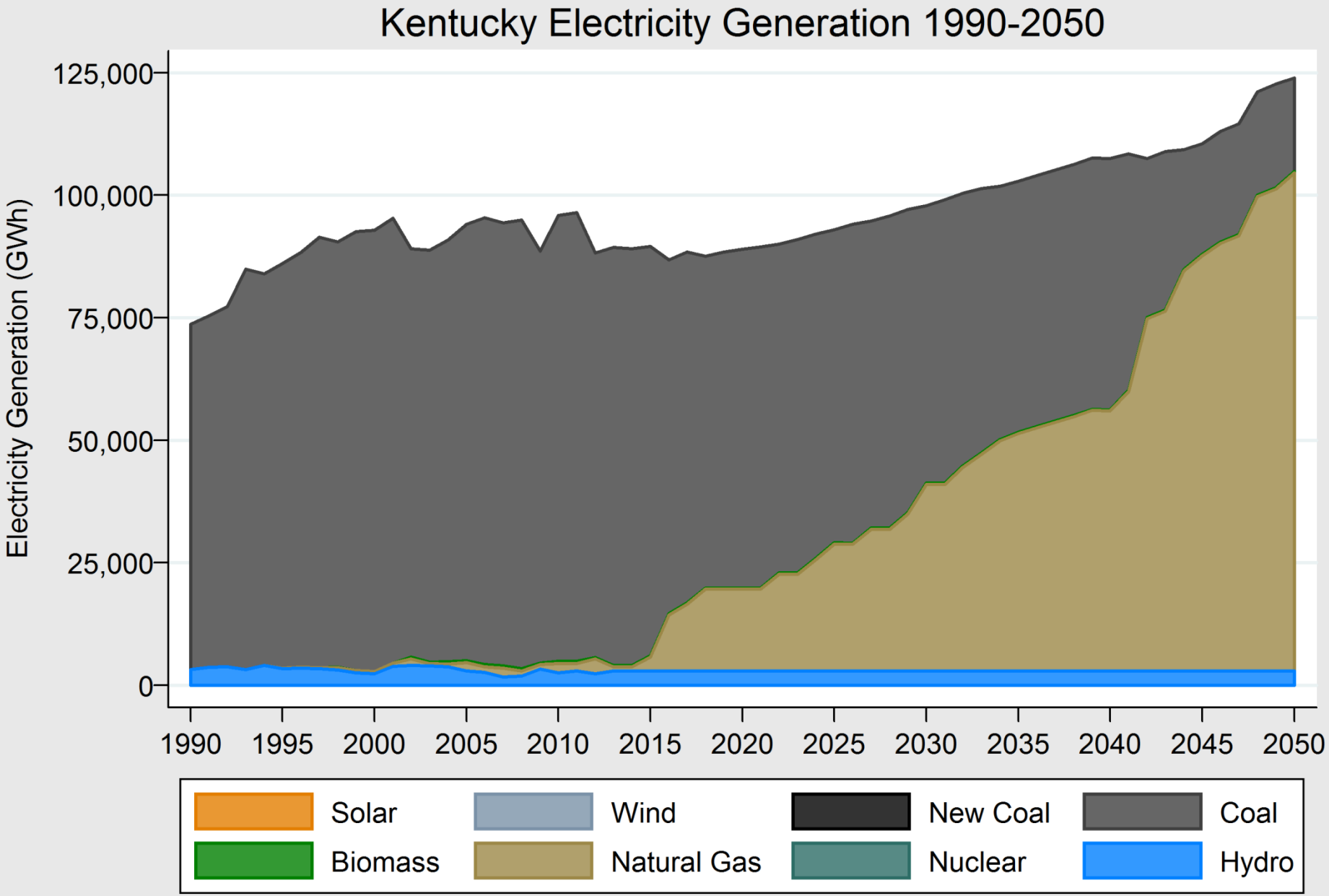
EPA is past deadline to propose rules for water intake structures.

Coal Combustion Residuals (coal ash)

EPA under pressure to act, especially in light of recent spills; depending on approach EPA takes, could require costly compliance for utilities.

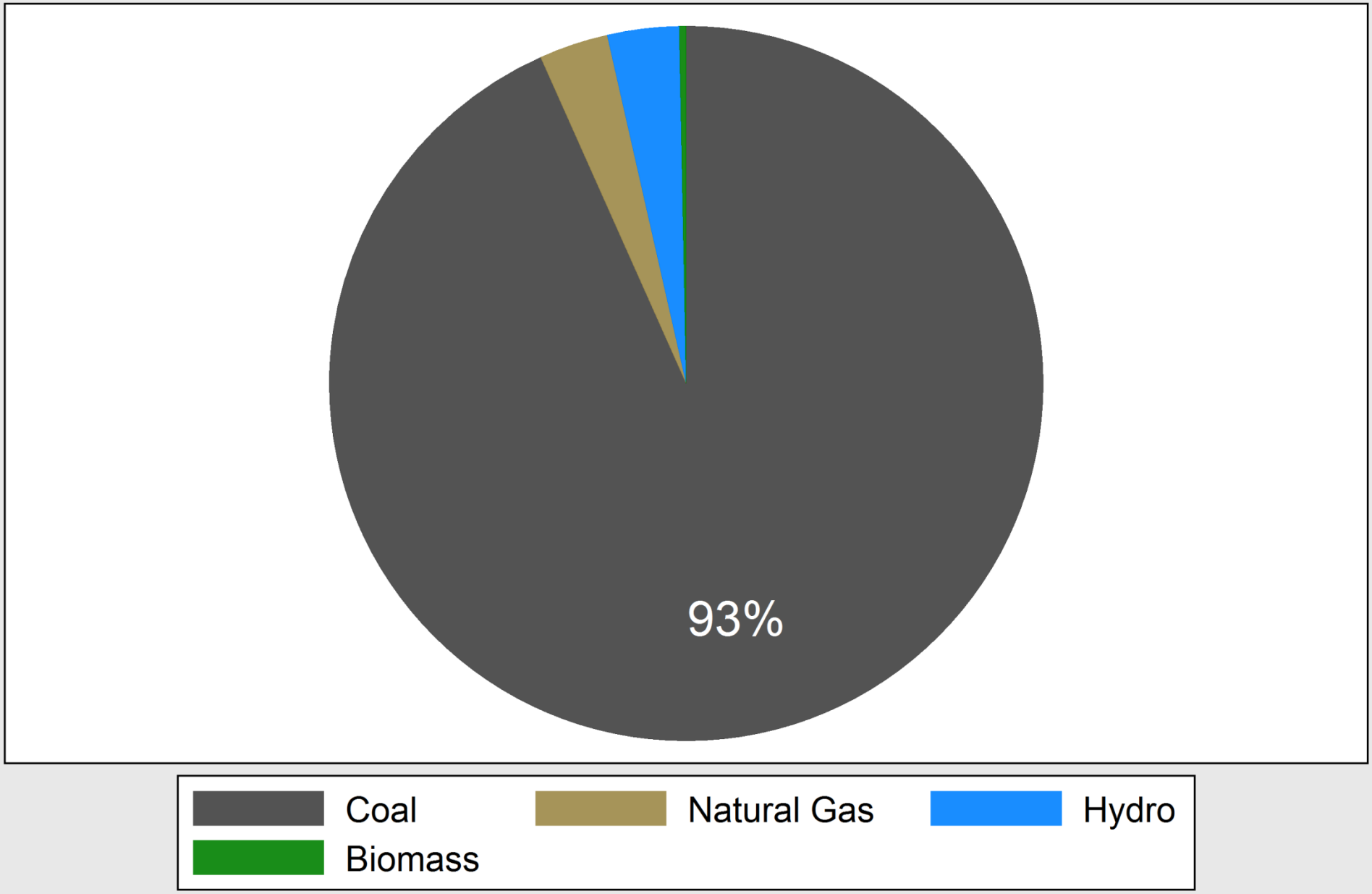
President's Climate Agenda

EPA using Clean Air Act 111(b) to set an unachievable 1,100 lbs. o f CO_2 per MWh limit for new coal power plants.
EPA is considering using Clean Air Act 111(d) to establish CO_2 emission standards for existing coal power plants.



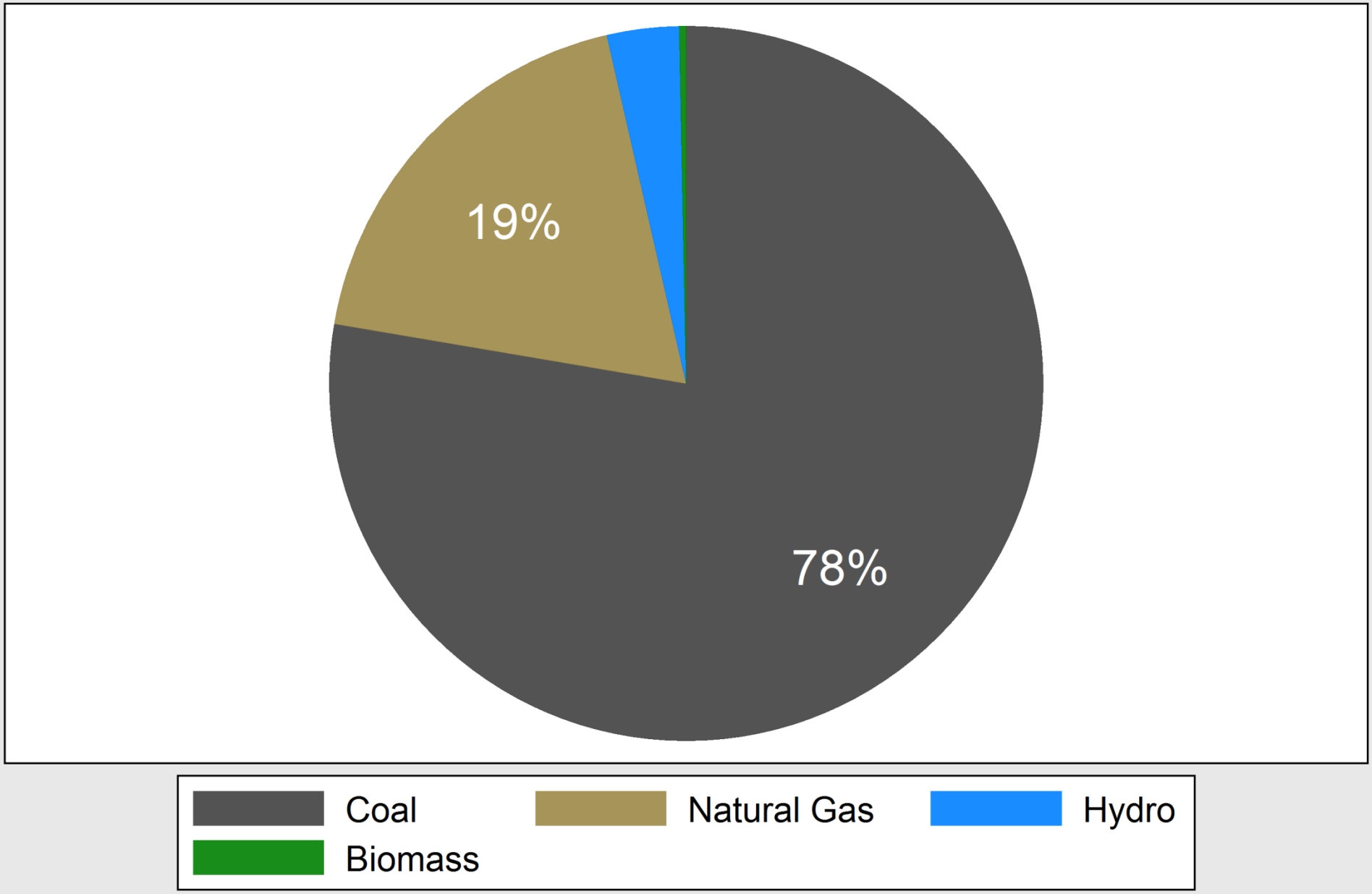
Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario:1

Kentucky Electricity Generation, 2015



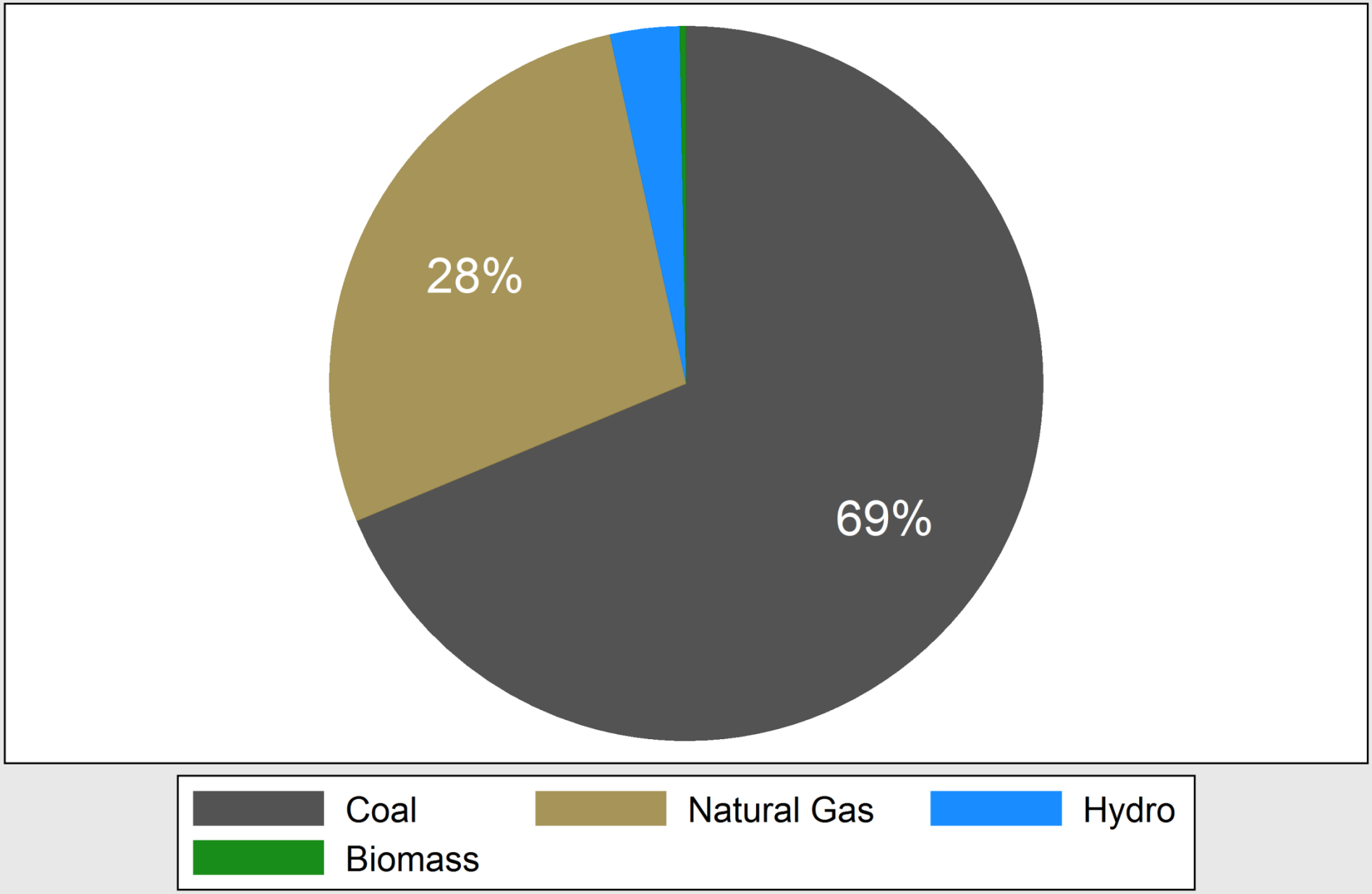
Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario:1

Kentucky Electricity Generation, 2020



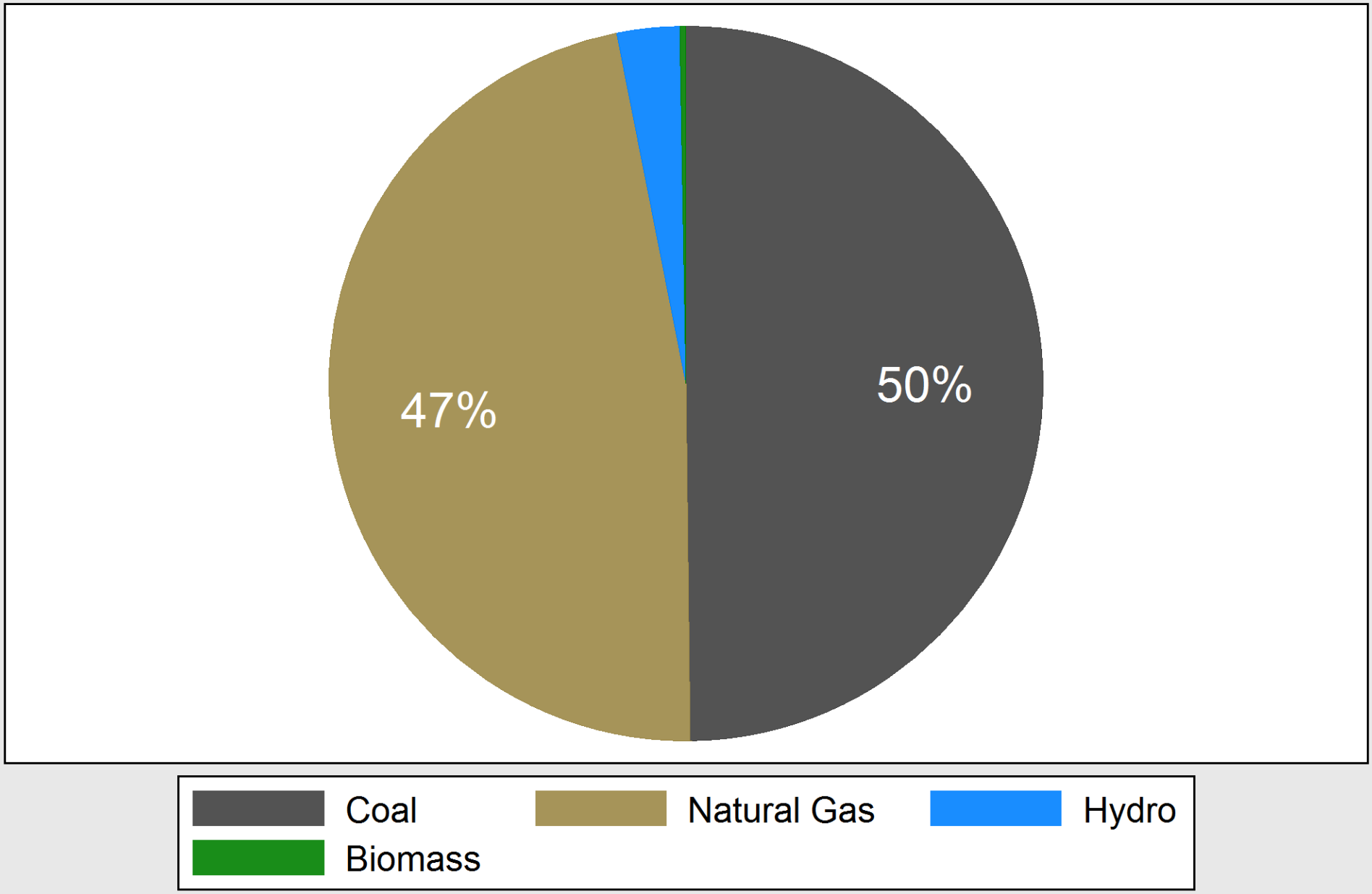
Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario:1

Kentucky Electricity Generation, 2025



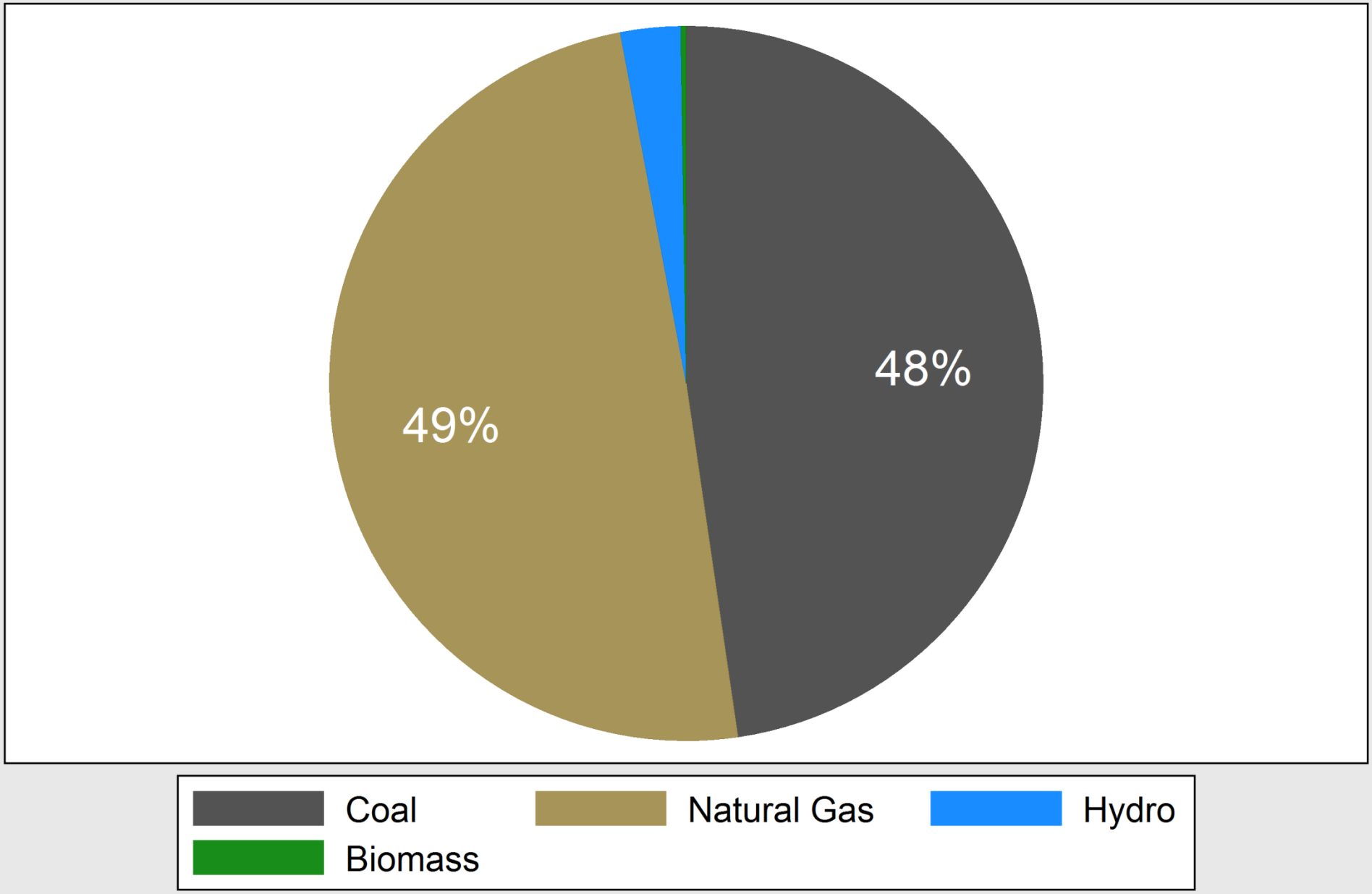
Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario:1

Kentucky Electricity Generation, 2035



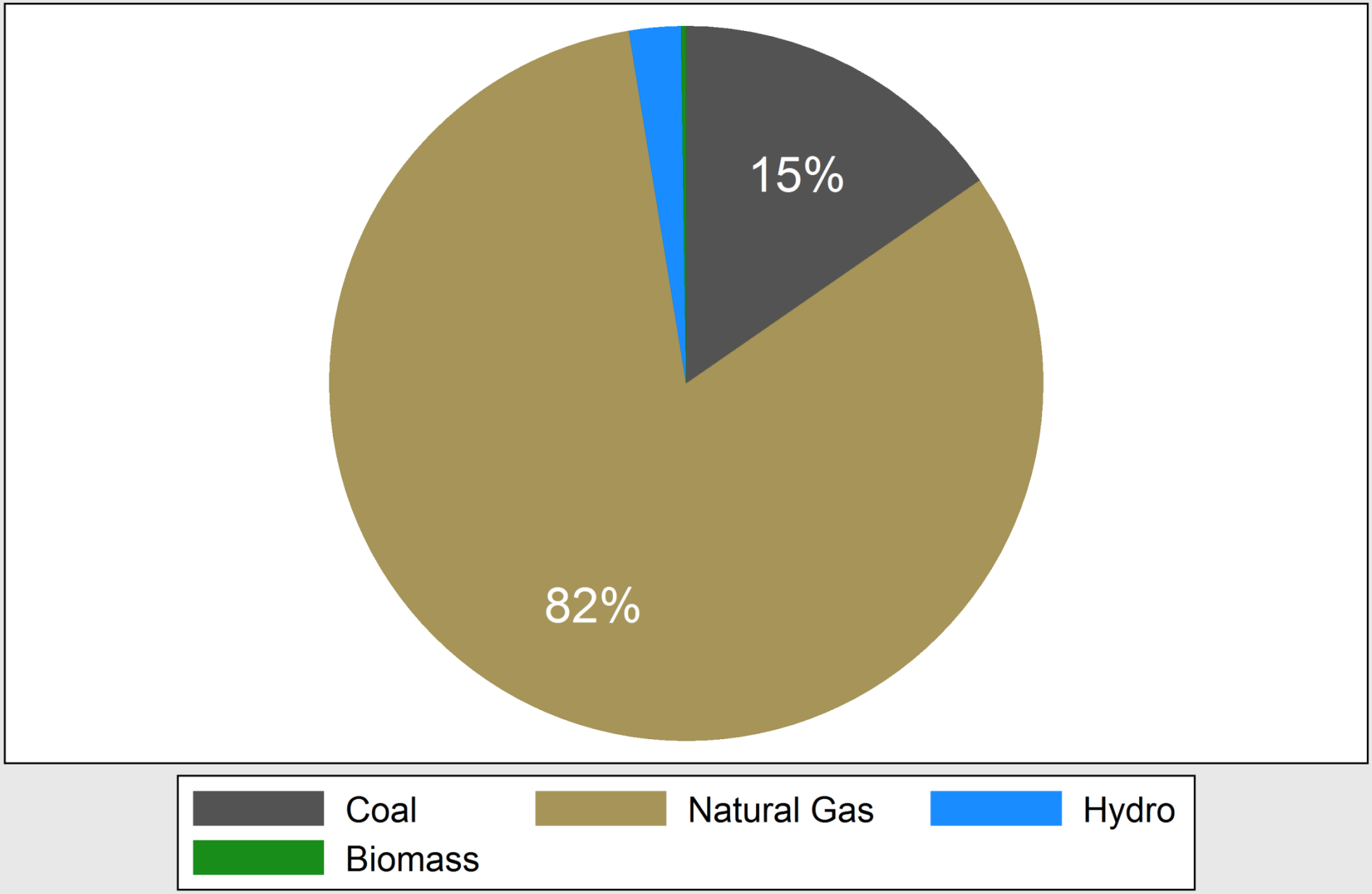
Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario:1

Kentucky Electricity Generation, 2040

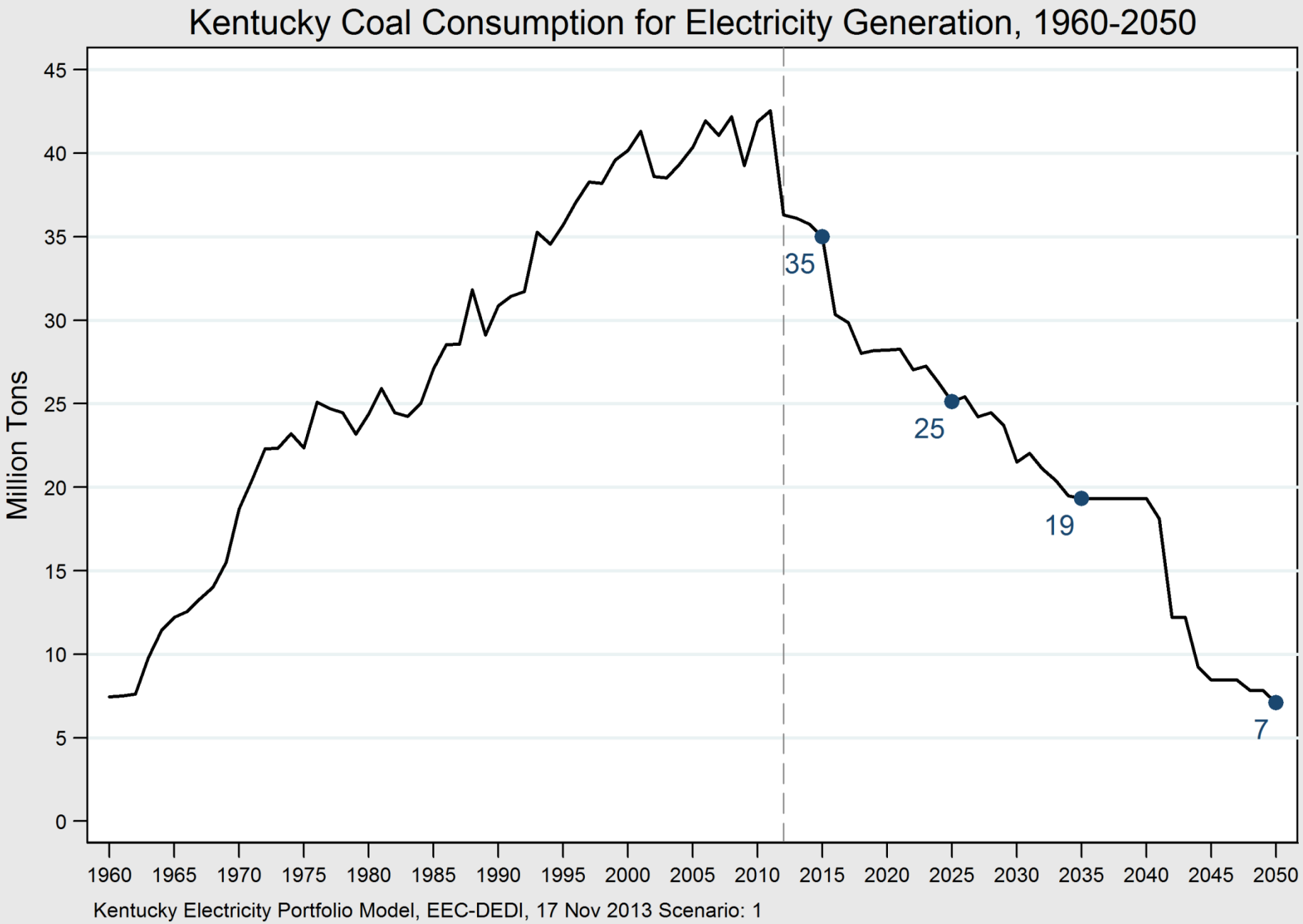


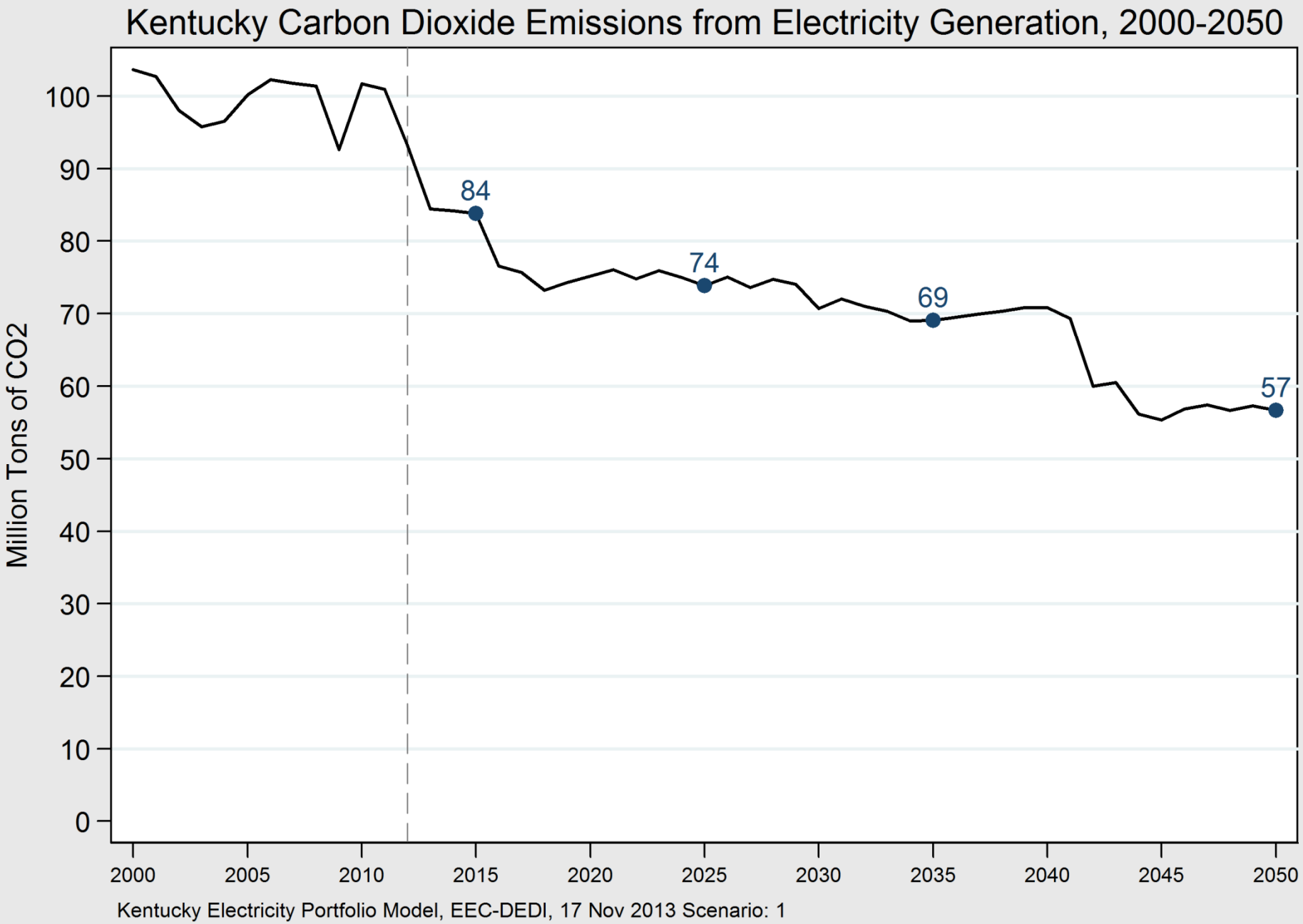
Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario:1

Kentucky Electricity Generation, 2050



Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario:1


Kentucky Coal Consumption for Electricity Generation, 1960-2050
Million Tons
45
40
35
30
25
20
15
10
5
0
35
25
19
7
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario: 1


Kentucky Carbon Dioxide Emissions from Electricity Generation, 2000-2050
Million Tons of CO2
100
90
80
70
60
50
40
30
20
10
0
84
74
69
57
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario: 1

Significance of Electricity to Kentucky

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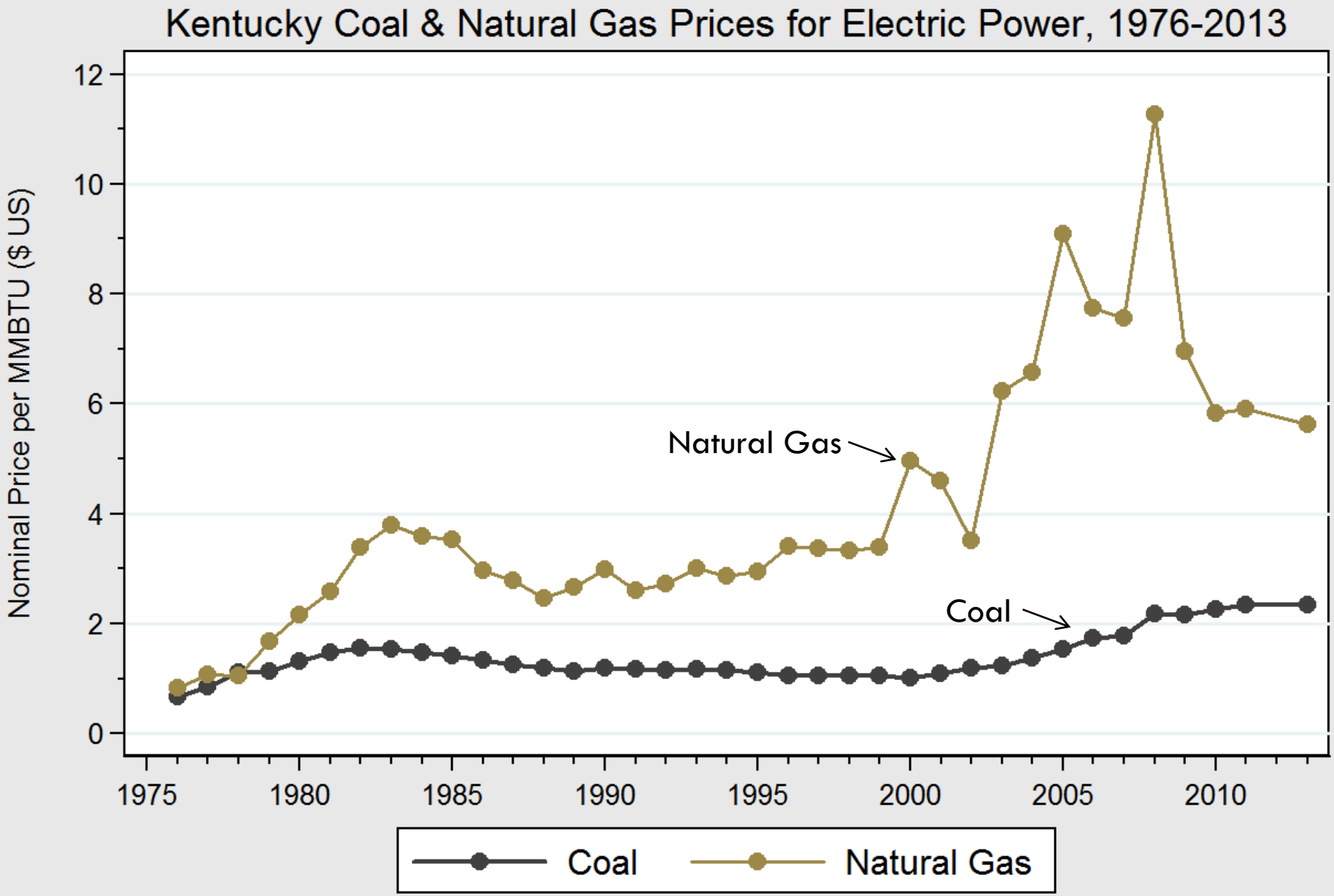
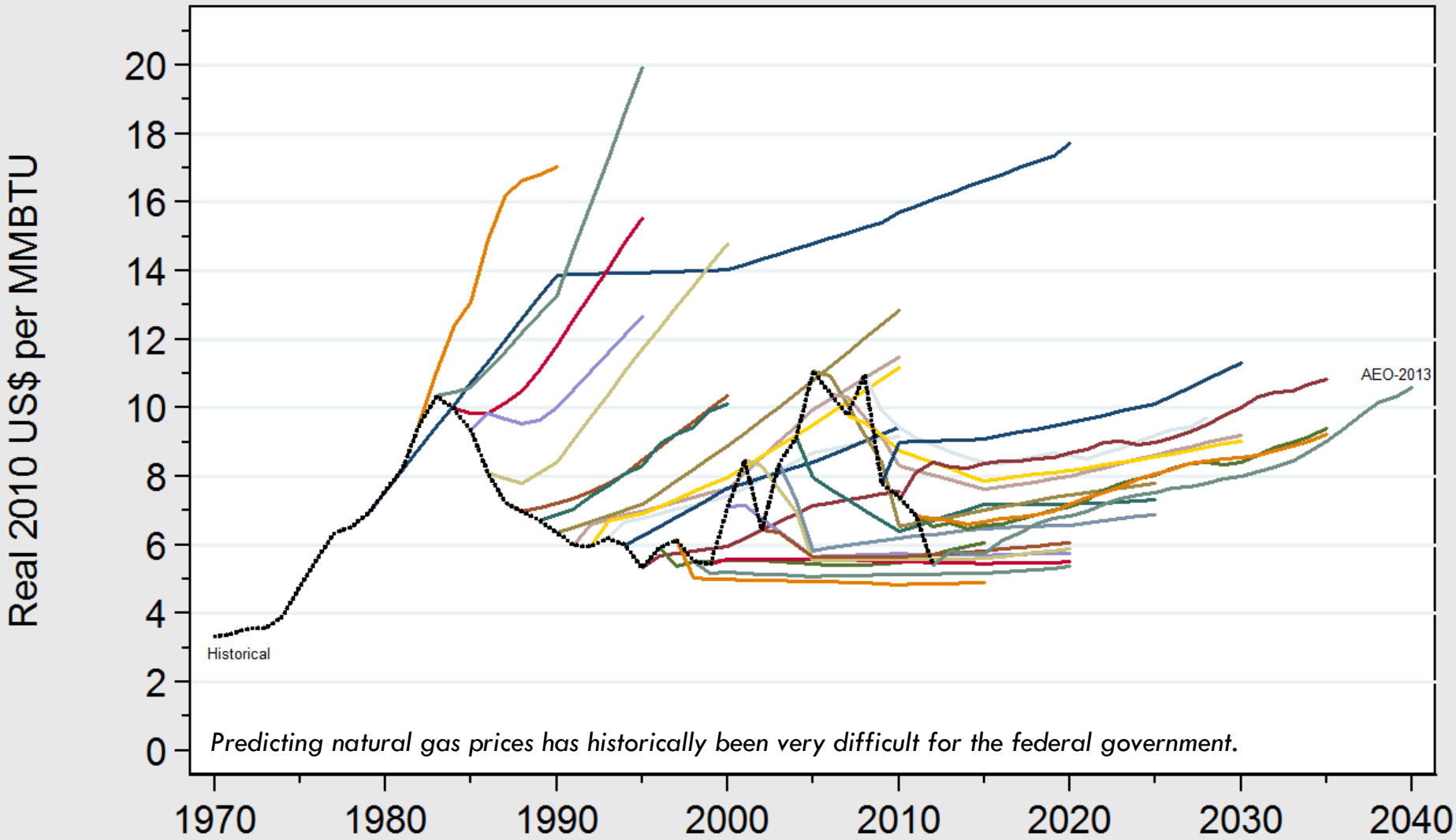


Kentucky Energy Database, EEC-DEDI, 2014

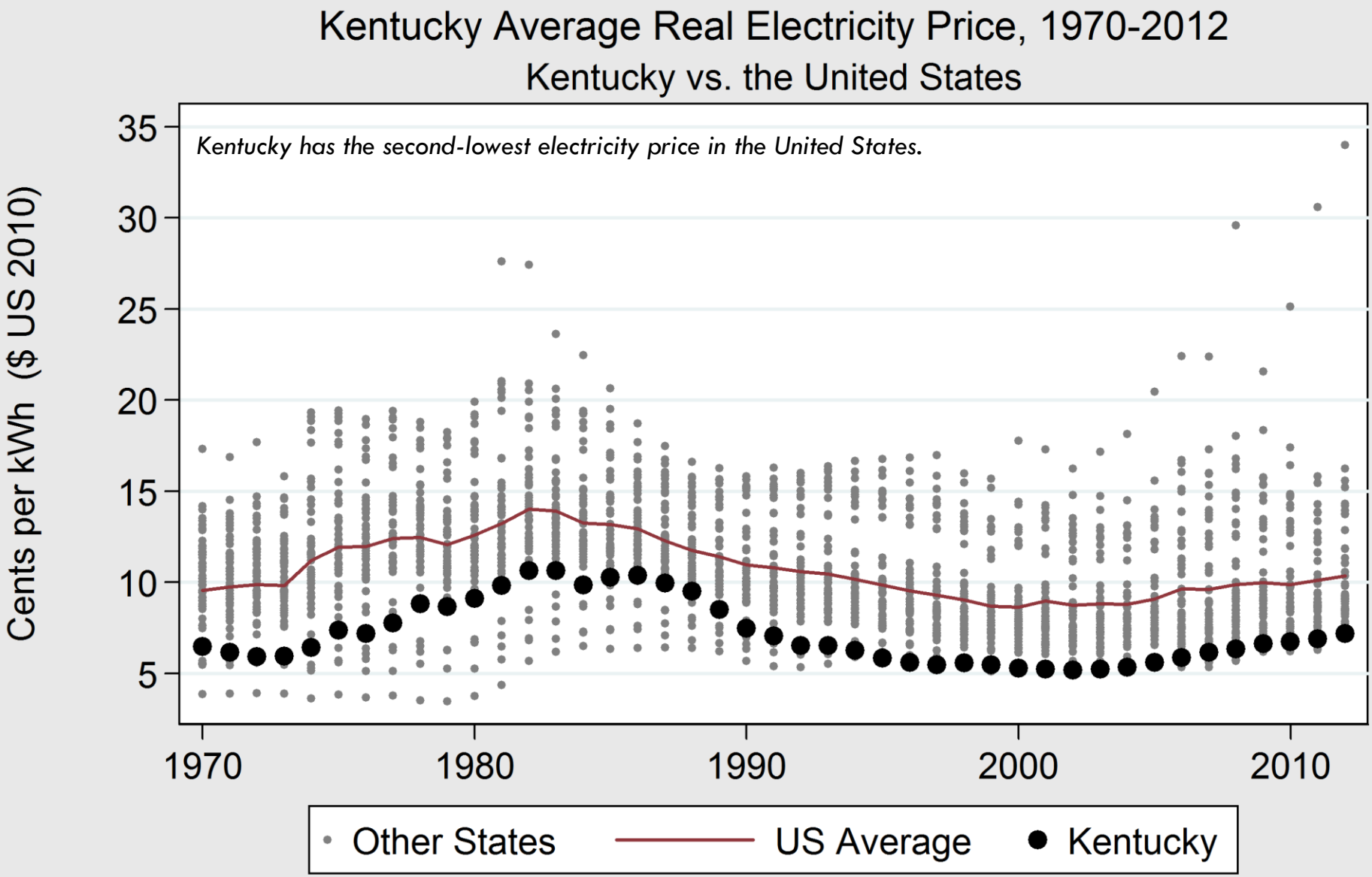
EIA Natural Gas Price Forecasts, 1979-2013

Energy Information Administration Annual Energy Outlook Forecasts vs. Actual



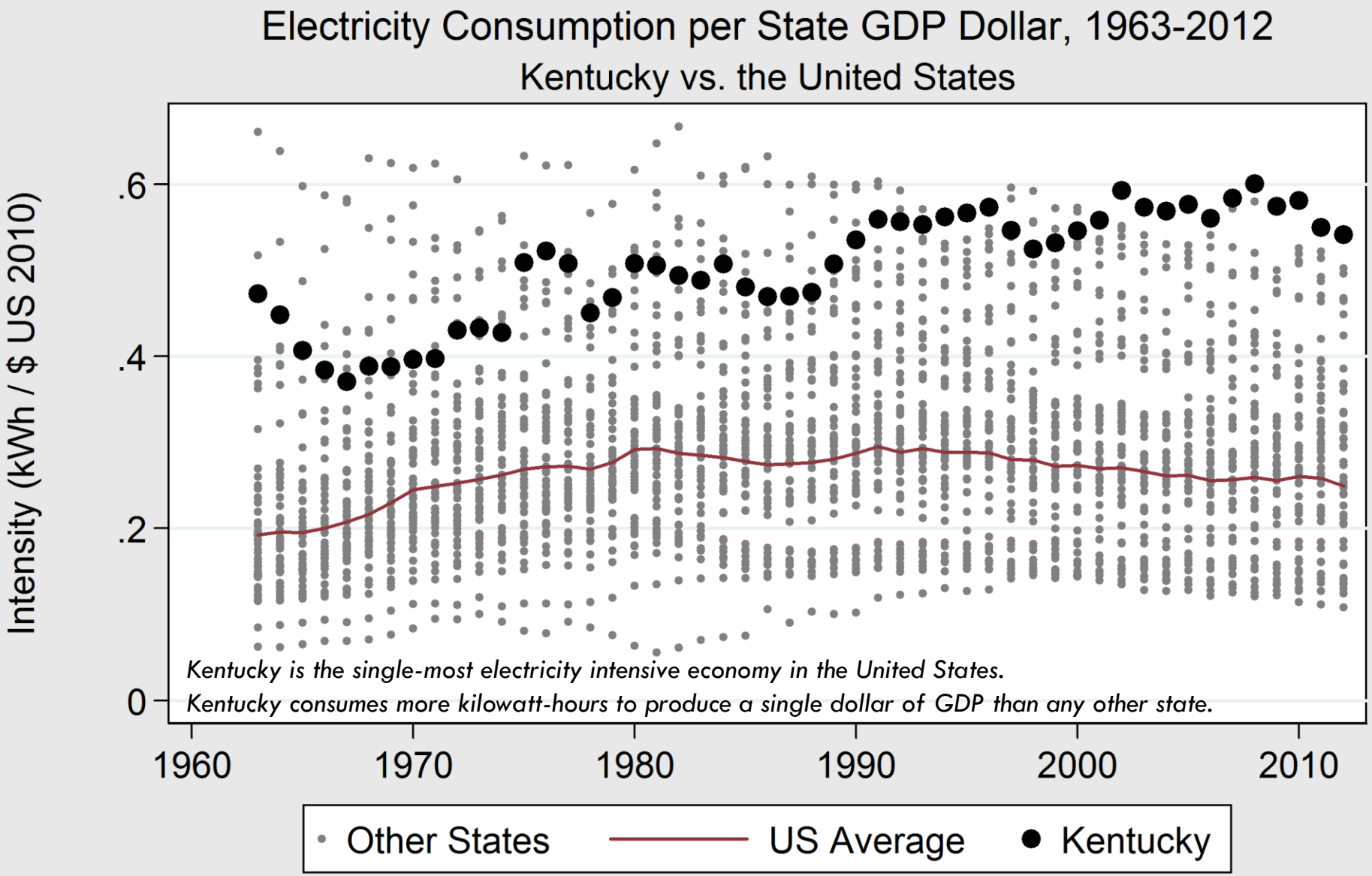
Kentucky Energy Database, EEC-DEDI, 2013

Data Sources: EIA-AEO 1979-2013 - Reference Case Delivered Price - All Sectors & BLS-CPI, 2013



Kentucky Energy Database, EEC-DEDI, 2013

Data Source: EIA Form 861 & 826 & BLS-CPI

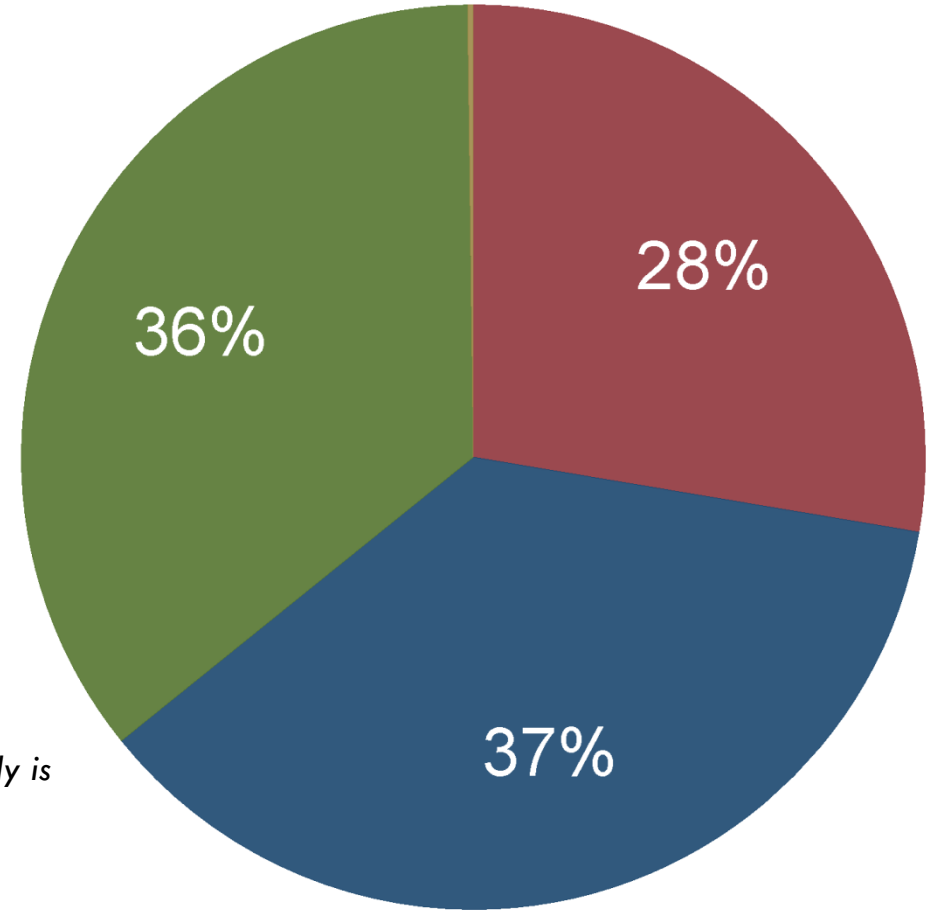


Kentucky Energy Database, EEC-DEDI, 2013

Data Source: EIA Forms 861 & 826 & BEA GDP by State

United States Electricity Consumption, 2012

Consumption by Sector (%)



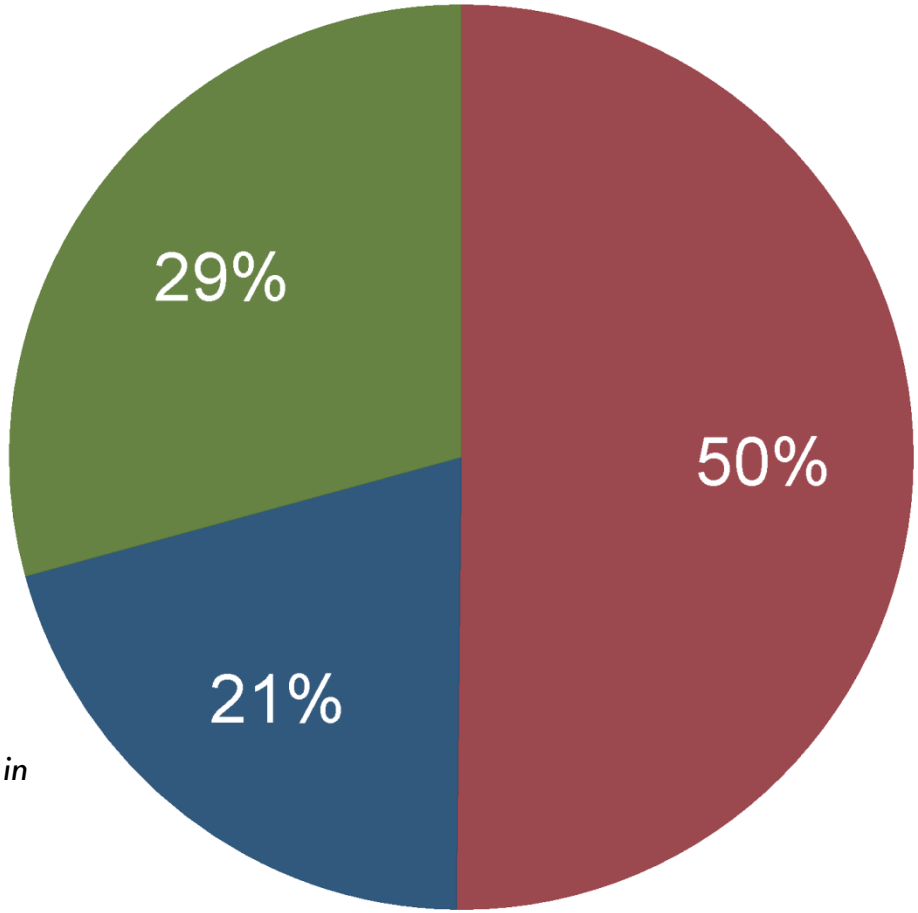
Electricity consumption nationally is split fairly equally between commercial, industrial, and residential consumers.

Industrial
Commercial
Residential
Transportation

Kentucky Energy Database, EEC-DEDI, 2013

Kentucky Electricity Consumption, 2012

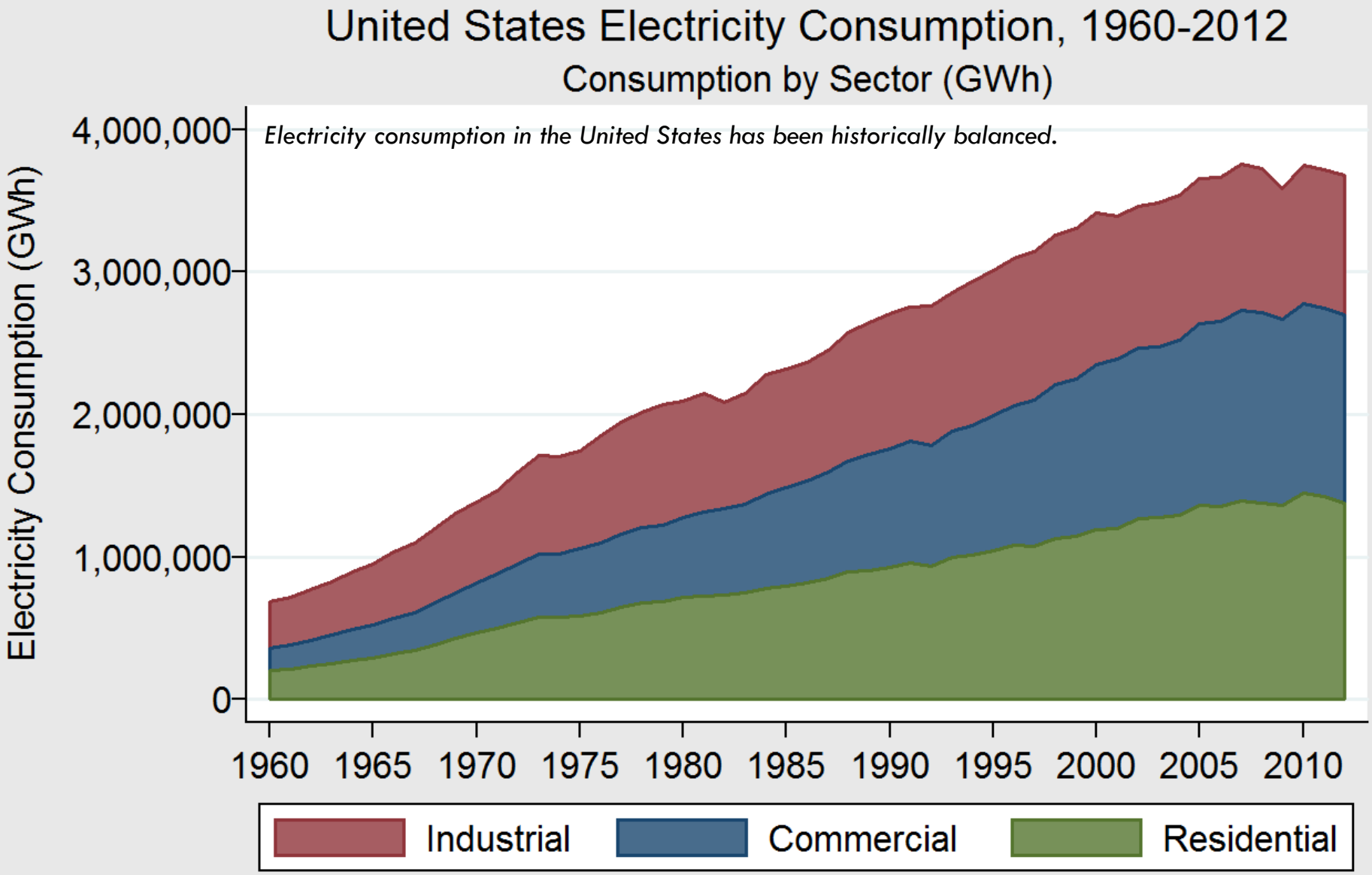
Consumption by Sector (%)



Half of the electricity consumed in Kentucky every year goes to industrial and manufacturing processes.

Industrial
Commercial
Residential

Kentucky Energy Database, EEC-DEDI, 2013

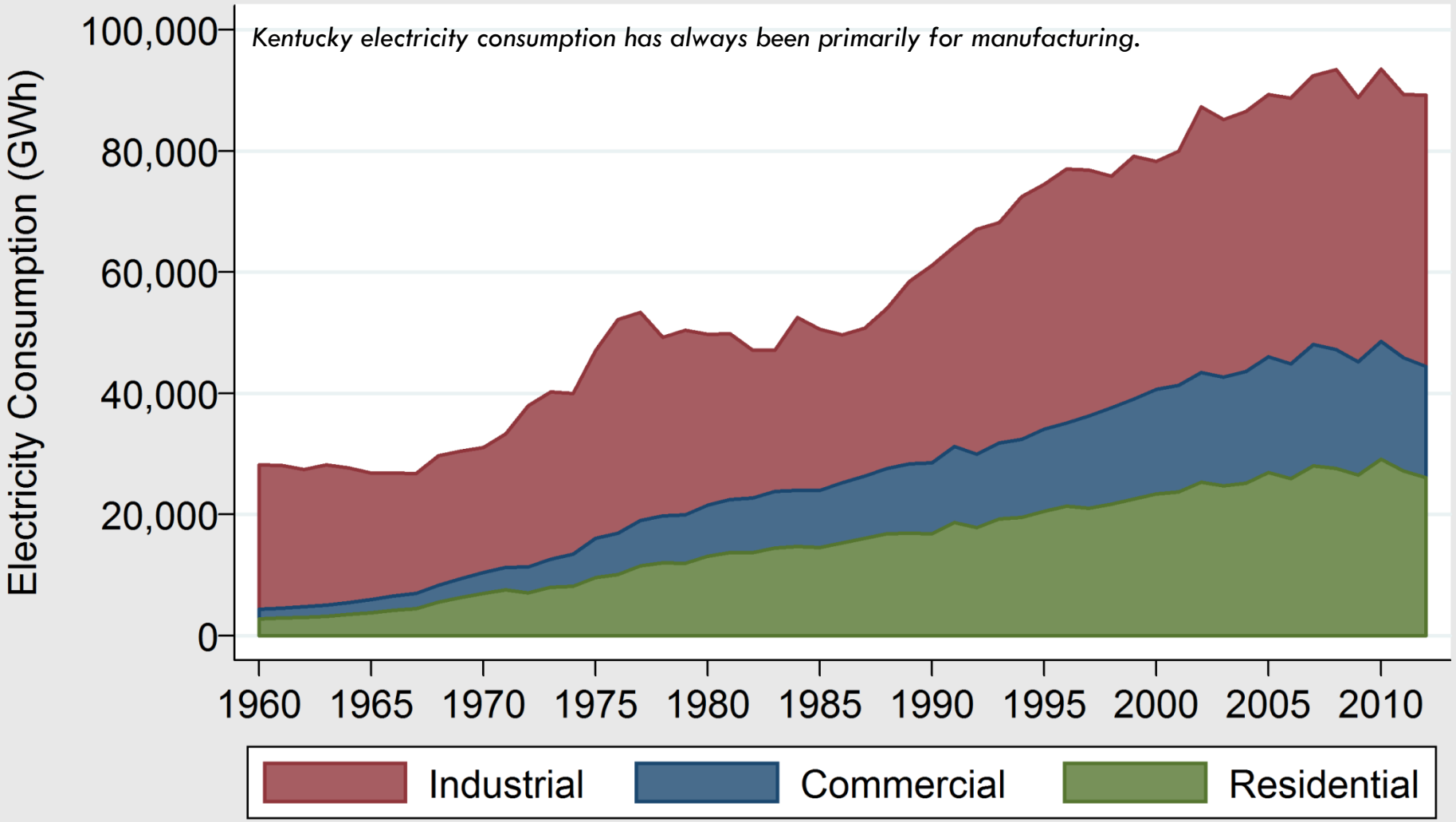


Kentucky Energy Database, EEC-DEDI, 2013

Data Source: EIA Form 861 & 826

Kentucky Electricity Consumption, 1960-2012

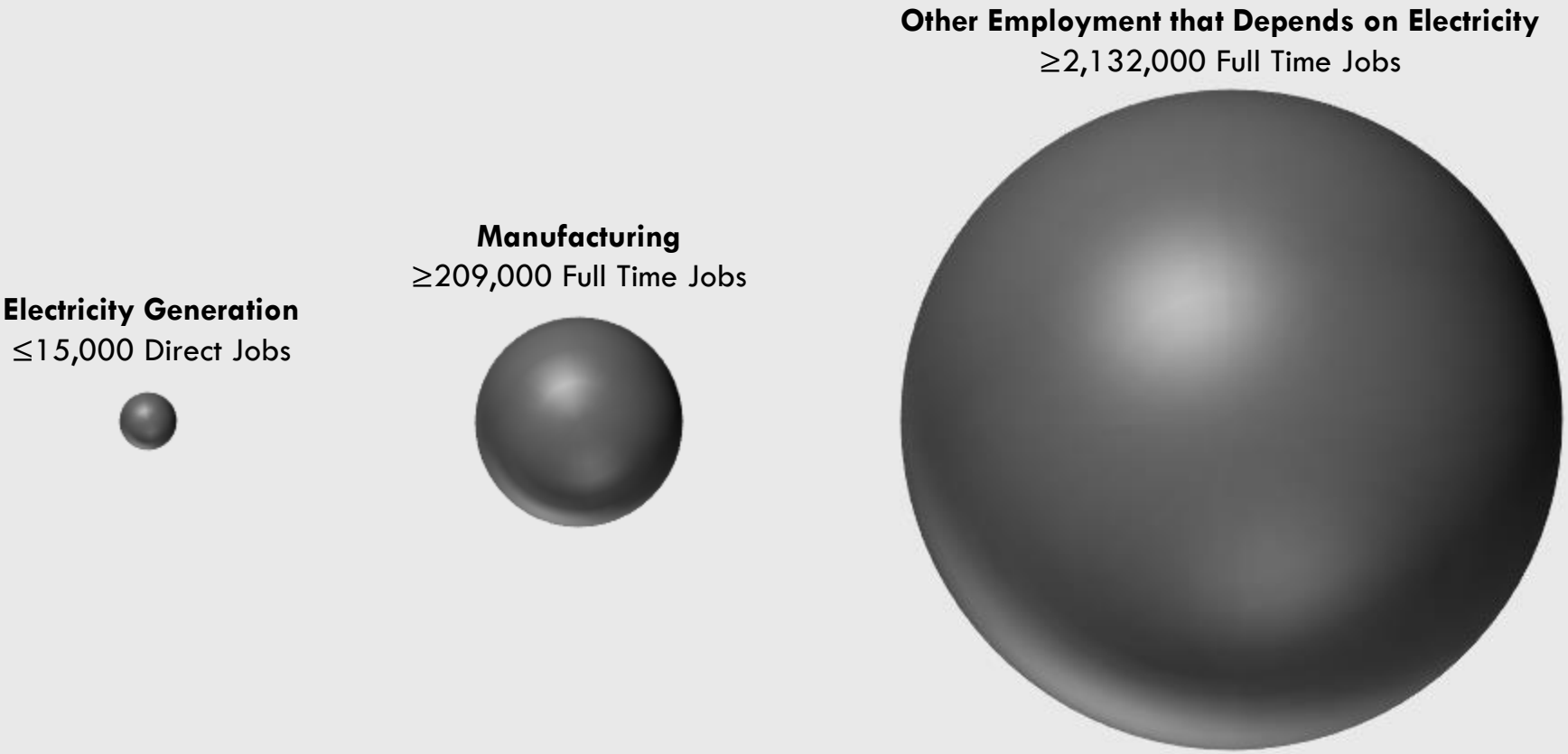
Consumption by Sector (GWh)



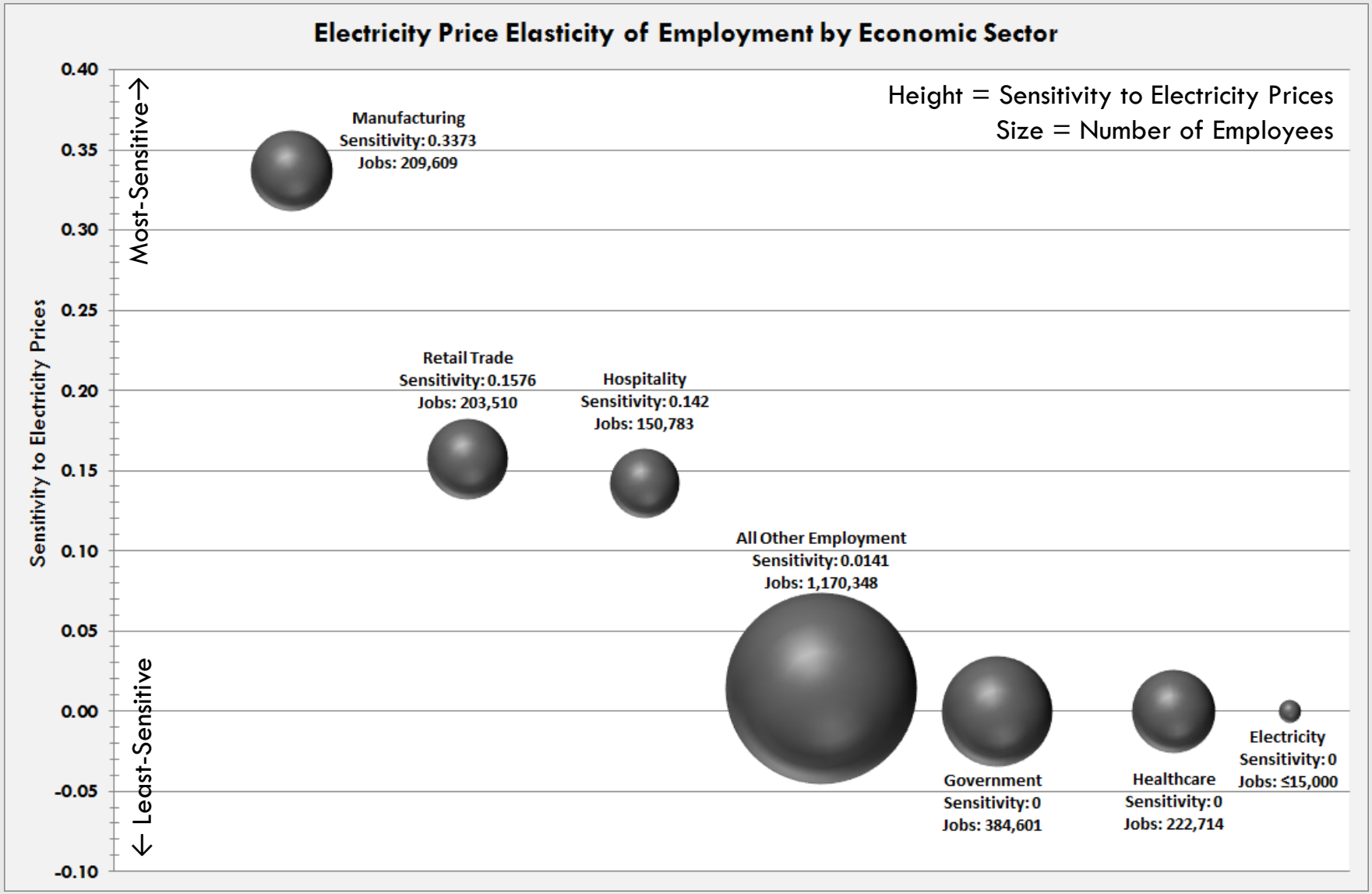
Kentucky Energy Database, EEC-DEDI, 2013

Data Source: EIA Form 861 & 826

Kentucky Electricity Portfolio & Employment



Employment Depends Upon Electricity – Direct employment for electricity generation, such as power plant operators and coal miners, is a relatively smaller portion of total employment in Kentucky compared to the millions of jobs that depend upon the reliable and inexpensive electricity they produce. Electricity-dependent jobs can be modeled with electricity price elasticity of employment coefficients.



Sensitivity to Electricity Prices Differs by Industry – This study developed price elasticity of employment coefficients for the top five employment sectors in Kentucky by modeling the historical responsiveness of employment nationally. Manufacturers were the most-responsive. Retail stores, restaurants, and hotels were less than half as responsive. Government and healthcare showed no responsiveness whatsoever.

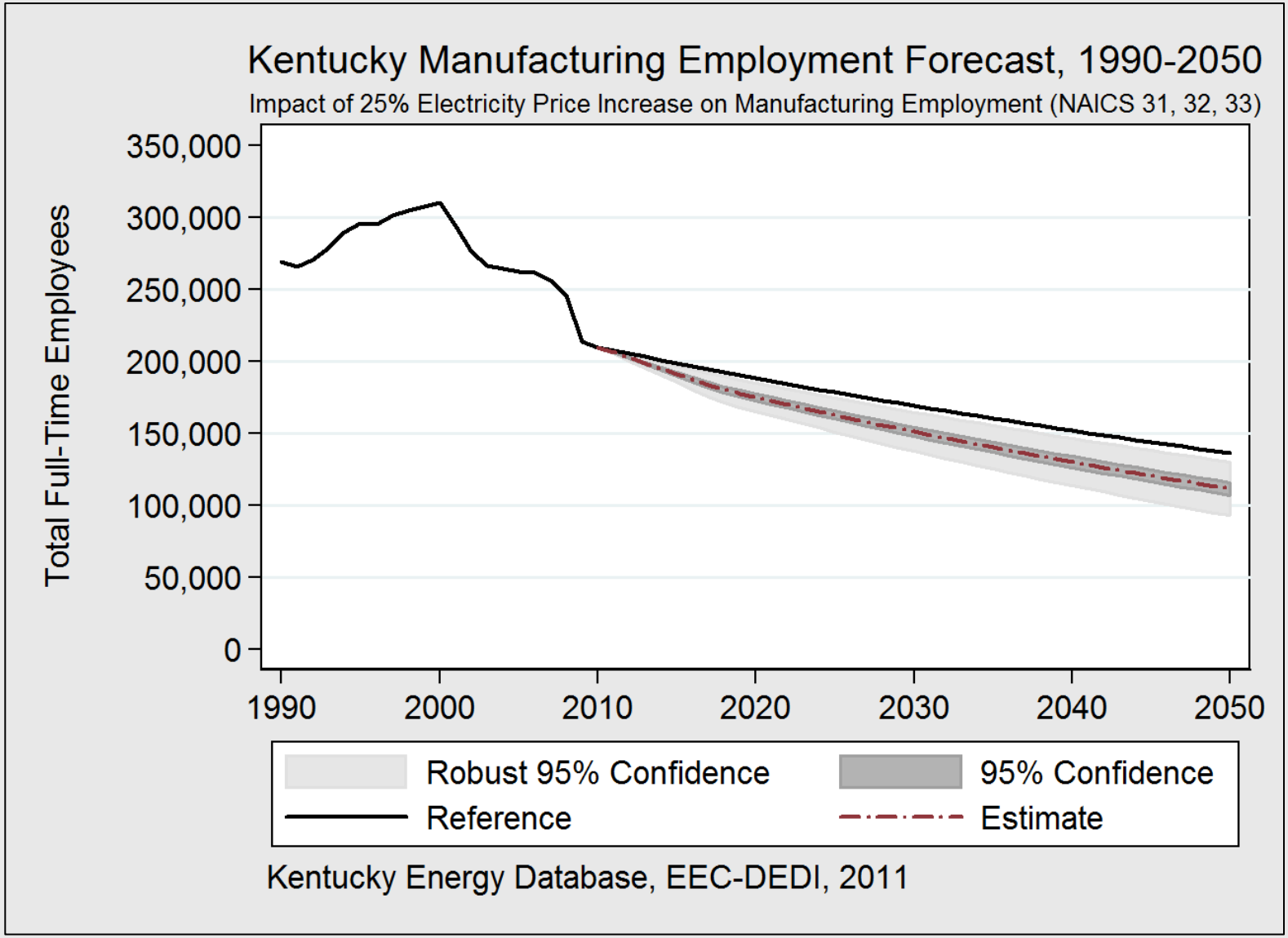
Kentucky Electricity Portfolio & Employment

Intensity Rank	Manufacturing Sector	Kilowatt-hours per $ of Product	Kentucky Electricity Cost per $ of Product	Percentage of Production Costs	Kentucky Workers
1	**Aluminum Smelting**	4.37313	$0.236	23.6%	3,482
2	**Iron & Steel Mills**	1.5764	$0.085	8.5%	2,954
4	**Basic Chemical**	0.71269	$0.039	3.9%	3,043
5	**Glass Manufacturing**	0.60508	$0.033	3.3%	2,015
24	**Motor Vehicle Parts**	0.14747	$0.008	0.8%	16,660
52	**Motor Vehicle Assembly**	0.03654	$0.002	0.2%	11,384

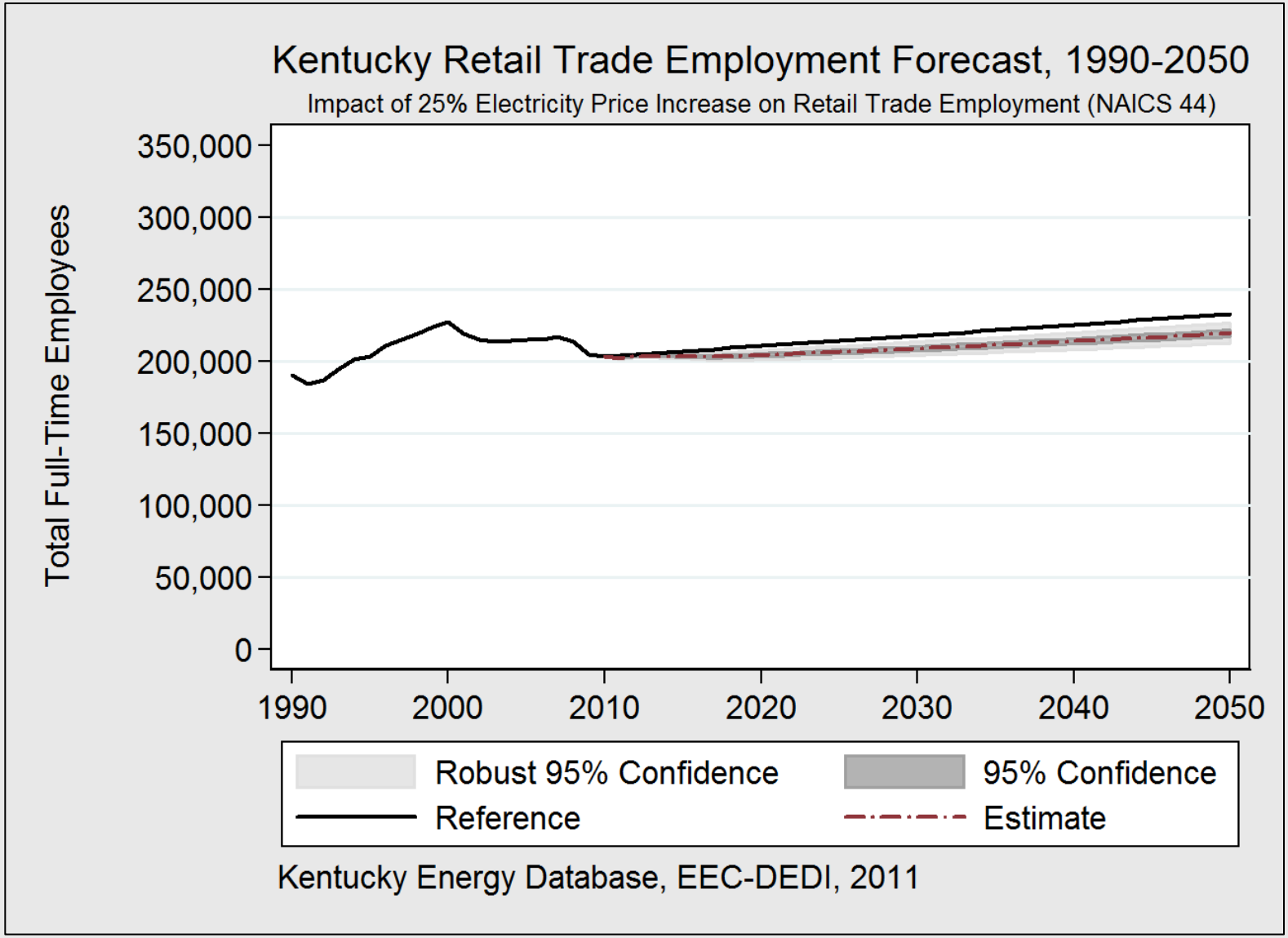
The production of aluminum, iron, steel, chemicals, and glass are some of the most-electricity intensive manufacturing processes, where up to a quarter of total production costs go to electricity expenses.

Other large manufacturing sectors, like motor vehicle assembly, which may be less electricity-intensive, depend upon primary material inputs from more electricity-intensive sectors.

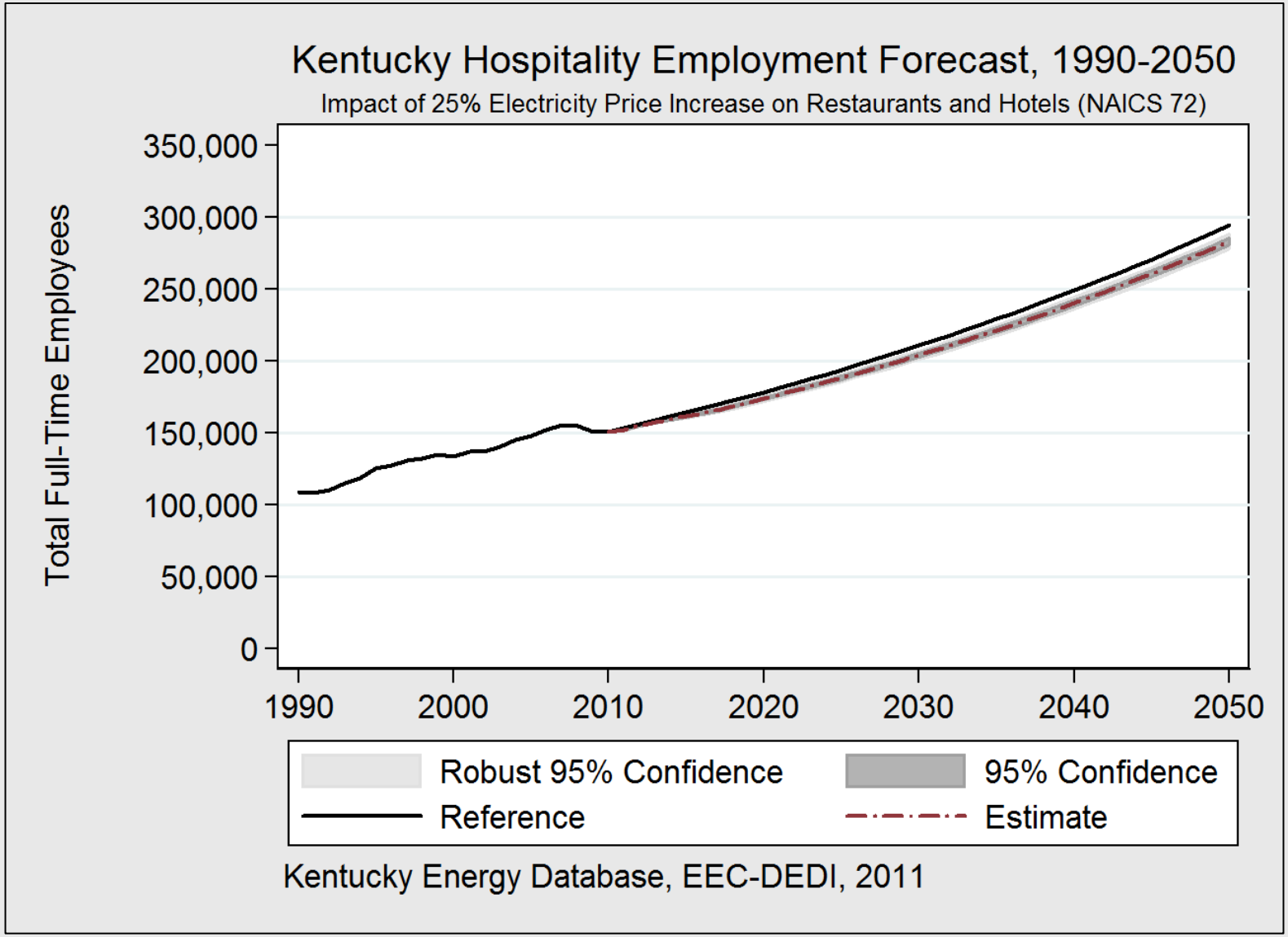
The complete List of all manufacturing sectors is available on page of 4 of the associated white paper:
http://energy.ky.gov/Programs/Documents/Vulnerability%20of%20Kentucky's%20Manufacturing%20Economy.pdf



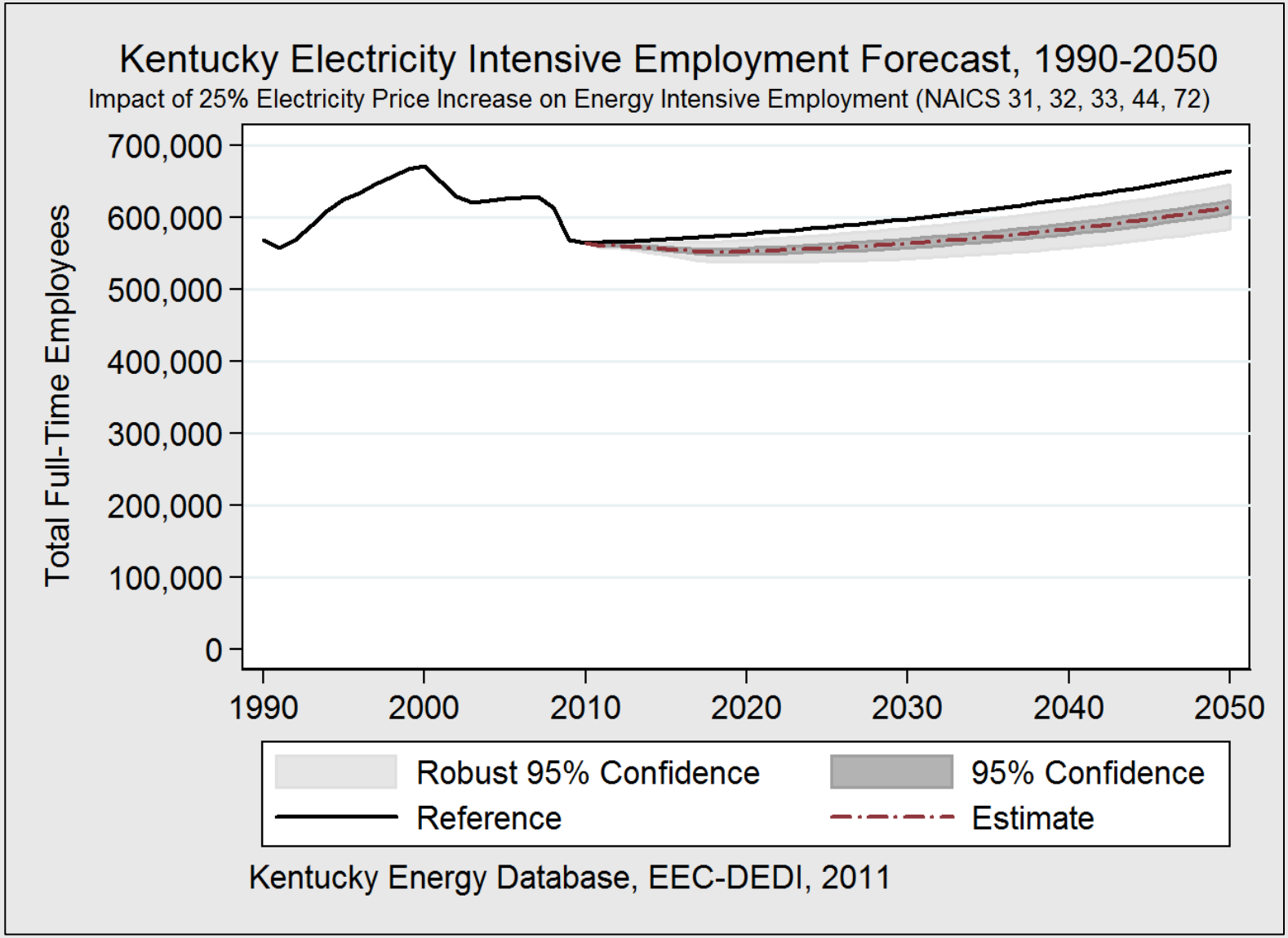
Manufacturers are the Most-Responsive to Electricity Prices - Given a 25% increase in real electricity prices by 2025, manufacturing establishments in Kentucky would be expected to permanently shed an additional **17,660** full-time jobs long-run as a direct result of price increases, and with 95% confidence using robust standard errors between **5,764** and **31,022** full-time jobs, *ceteris paribus*.



Retail Stores are Much Less Responsive - Given a 25% increase in real electricity prices by 2025, retail establishments in Kentucky would be expected to fail to create **7,225** full-time jobs long-run, and with 95% confidence using robust standard errors, between **3,916** and **12,160** full-time jobs, *ceteris paribus*.



Restaurants and Hotels are Even Less Responsive - Given a 25% increase in real electricity prices by 2025, restaurants and hotels in Kentucky would be expected to shed **5,352** full-time jobs long-run, and with 95% confidence using robust standard errors, between **2,940** and **7,765** full-time jobs, *ceteris paribus*.



Combined Impact of Electricity-Intensive Sectors - Given a 25% increase in real electricity prices by 2025, Kentucky's most electricity-intensive economic sectors, (manufacturing, retail trade, restaurants, and hotels) could be expected to shed a combined total of **30,237** full-time jobs and with 95% confidence and robust standard errors between **12,620** and **50,947**.

Significance of Electricity to Kentucky

- **Low and stable electricity prices have fostered the single-most electricity intensive manufacturing economy in the United States.**
- **Half of the electricity consumed in Kentucky goes to manufacturing.**
- **Manufacturing is Kentucky's largest source of GDP and leading source of employment.**
- **Kentucky's economy is vulnerable to electricity price increases.**
- **Price elasticity of employment should be taken into consideration, when trying to understand such impacts.**

Download the Full Report

"The Vulnerability of Kentucky's Manufacturing Economy to Increasing Electricity Prices"

A Quick Peek at Some of the

The Mathematics behind the Forecasts

Model of Electricity Prices & Employment by Sector

A multiple regression of panel data model using fixed effects was estimated for each of the top five employment opportunities in Kentucky, both with and without robust standard errors, for a total of ten models. Fixed effects were used to control for the numerous factors inherently affecting sector-specific employment as well as electricity prices from state to state that have not been accounted for in the independent variables included in this study. The result is a conservative estimate of the isolated national effect of the variable of interest, real electricity prices on employment by industry.

The multiple regression of panel data model with fixed effects can be generally given by,

$$Y_{it} = \beta_0 + \sum_{j=1}^{k-1} \beta_j X_{jit} + \alpha_i + \varepsilon_{it}$$

Where i and t index states and years, such that y_{it} is the dependent variable of interest, employment by industry, in state i in year t, β_0 is the constant y intercept across all states, X is a k by 1 vector of explanatory variables, $\beta_j X_{jit}$ is the product of the observation for each independent variable j through k for state i in year t and the coefficient of X, k is the total number of included independent variables, α_i is the time-invariant fixed effect for state i, and ε_{it} are the residuals, and where $\varepsilon_{it} \sim N(0, \sigma^2)$, or are approximately normally distributed with a mean of zero.

Read the Complete Report on this Model

Model of Electricity Prices & Employment by Sector

A multiple regression of panel data model using fixed effects was estimated for each of the top five employment opportunities in Kentucky, both with and without robust standard errors, for a total of ten models. Fixed effects were used to control for the numerous factors inherently affecting sector-specific employment as well as electricity prices from state to state that have not been accounted for in the independent variables included in this study. The result is a conservative estimate of the isolated national effect of the variable of interest, real electricity prices on employment by industry.

The multiple regression of panel data model with fixed effects can be generally given by,

Predicted Employment by Industry in State (i) and Time (t)

Stochastic Error Term (~ $N(0, \sigma^2)$)

$$Y_{it} = \beta_0 + \boxed{\sum_{j=1}^{k-1} \beta_j X_{jit}} + \alpha_i + \varepsilon_{it}$$

Constant Intercept Across States

Fixed Effect for State (i)

Sum of the product of the observation for each independent variable *j* through *k* for state *i* in year *t* and the coefficient of *Xj*

Where *i* and *t* index states and years, such that y_{it} is the dependent variable of interest, employment by industry, in state *i* in year *t*, β_0 is the constant *y* intercept across all states, *X* is a *k* by 1 vector of explanatory variables, $\beta_j X_{jit}$ is the product of the observation for each independent variable *j* through *k* for state *i* in year *t* and the coefficient of *X*, *k* is the total number of included independent variables, α_i is the time-invariant fixed effect for state *i*, and ε_{it} are the residuals, and where $\varepsilon_{it} \sim N(0, \sigma^2)$, or are approximately normally distributed with a mean of zero.

Read the Complete Report on this Model

Model of Electricity Prices & Employment by Sector

Logged Variables	Manufacturing Employment	Retail Employment	Hospitality Employment	Healthcare Employment	Government Employment
Price of Electricity	**-0.337** ***	**-0.158** ***	**-0.142** ***	**-0.0426** **	**0.00084**
(Real 2010 US$)	(-0.0307)	(-0.0136)	(-0.0152)	(-0.0158)	(-0.0101)
	0.0249	-0.108	-0.0679	-0.536 ***	-0.14 **
Educational Attainment	(-0.146)	(-0.065)	(-0.0728)	(-0.0758)	(-0.0482)
State GDP	0.744 ***	0.509 ***	0.318 ***	0.17 ***	0.253 ***
(Real 2010 US$)	(-0.0514)	(-0.0228)	(-0.0255)	(-0.0265)	(-0.0169)
Population	0.166 **	0.26 ***	0.129 ***	0.37 ***	0.258 ***
	(-0.0532)	(-0.0236)	(-0.0264)	(-0.0275)	(-0.0175)
Year	-76.05 ***	-11.31 ***	21.11 ***	55.21 ***	3.801 *
	(-5.536)	(-2.457)	(-2.752)	(-2.861)	(-1.819)
Constant	579.4 **	88.85 ***	-153.9 ***	-413.5 ***	-22.72
	(-41.38)	(-18.36)	(-20.57)	(-21.39)	(-13.6)
R-Squared	0.7776	0.956	0.9219	0.8885	0.9344
Observations (*N x t*)	1069	1071	1069	1071	1071
Number of States (*N*)	51	51	51	51	51

Standard Errors in Parentheses

Asterisk Denotes Statistical Significance at the Following Levels: * p<0.05, ** p<0.01, *** p<0.001

All variables were transformed to their natural logarithms, such that their coefficients may be interpreted as elasticities.

Model of Electricity Prices & Employment by Sector

Logged Variables	Manufacturing Employment	Retail Employment	Hospitality Employment	Healthcare Employment	Government Employment
Index of Coefficients β_j					
Price of Electricity	β_1 → **-0.337** ***	**-0.158** ***	**-0.142** ***	**-0.0426** **	**0.00084**
(Real 2010 US$)	(-0.0307)	(-0.0136)	(-0.0152)	(-0.0158)	(-0.0101)
Educational Attainment	β_2 → 0.0249	-0.108	-0.0679	-0.536 ***	-0.14 **
	(-0.146)	(-0.065)	(-0.0728)	(-0.0758)	(-0.0482)
State GDP	β_3 → 0.744 ***	0.509 ***	0.318 ***	0.17 ***	0.253 ***
(Real 2010 US$)	(-0.0514)	(-0.0228)	(-0.0255)	(-0.0265)	(-0.0169)
Population	β_4 → 0.166 **	0.26 ***	0.129 ***	0.37 ***	0.258 ***
	(-0.0532)	(-0.0236)	(-0.0264)	(-0.0275)	(-0.0175)
Year	β_5 → -76.05 ***	-11.31 ***	21.11 ***	55.21 ***	3.801 *
	(-5.536)	(-2.457)	(-2.752)	(-2.861)	(-1.819)
Constant	β_0 → 579.4 **	88.85 ***	-153.9 ***	-413.5 ***	-22.72
	(-41.38)	(-18.36)	(-20.57)	(-21.39)	(-13.6)
R-Squared	0.7776	0.956	0.9219	0.8885	0.9344
Observations (*N x t*)	1069	1071	1069	1071	1071
Number of States (*N*)	51	51	51	51	51

Sign of Coefficients = Direction

Standard Errors in Parentheses

Asterisk Denotes Statistical Significance at the Following Levels: * p<0.05, ** p<0.01, *** p<0.001

Stars = Significance Levels

All variables were transformed to their natural logarithms, such that their coefficients may be interpreted as elasticities.

Contact Information

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Website: **energy.ky.gov**