Efficiency Study Report

Developed by

Kentucky Energy and Environment Cabinet

Department for Energy Development Independence

In Partnership with

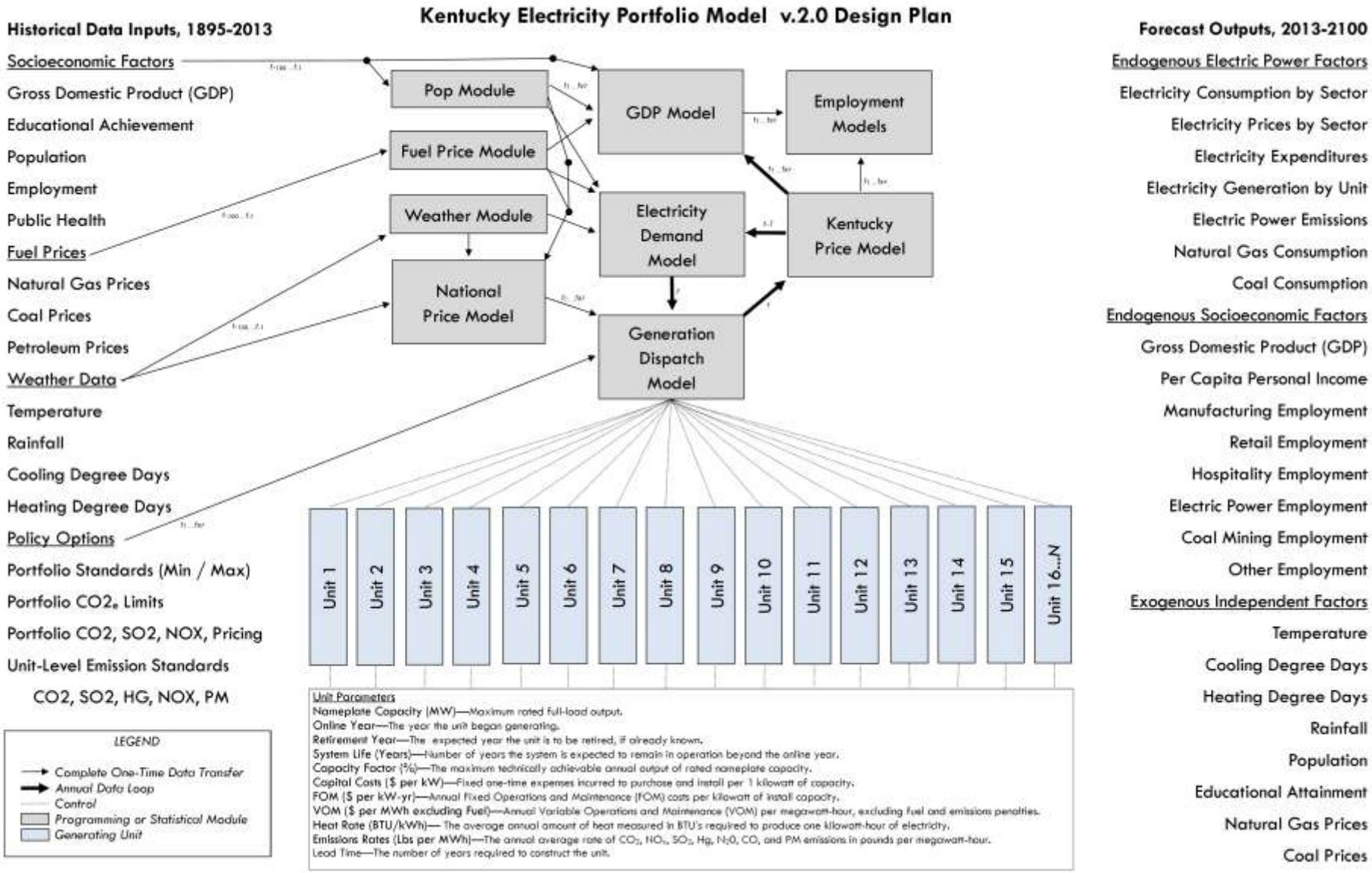
University of Kentucky Department of Statistics

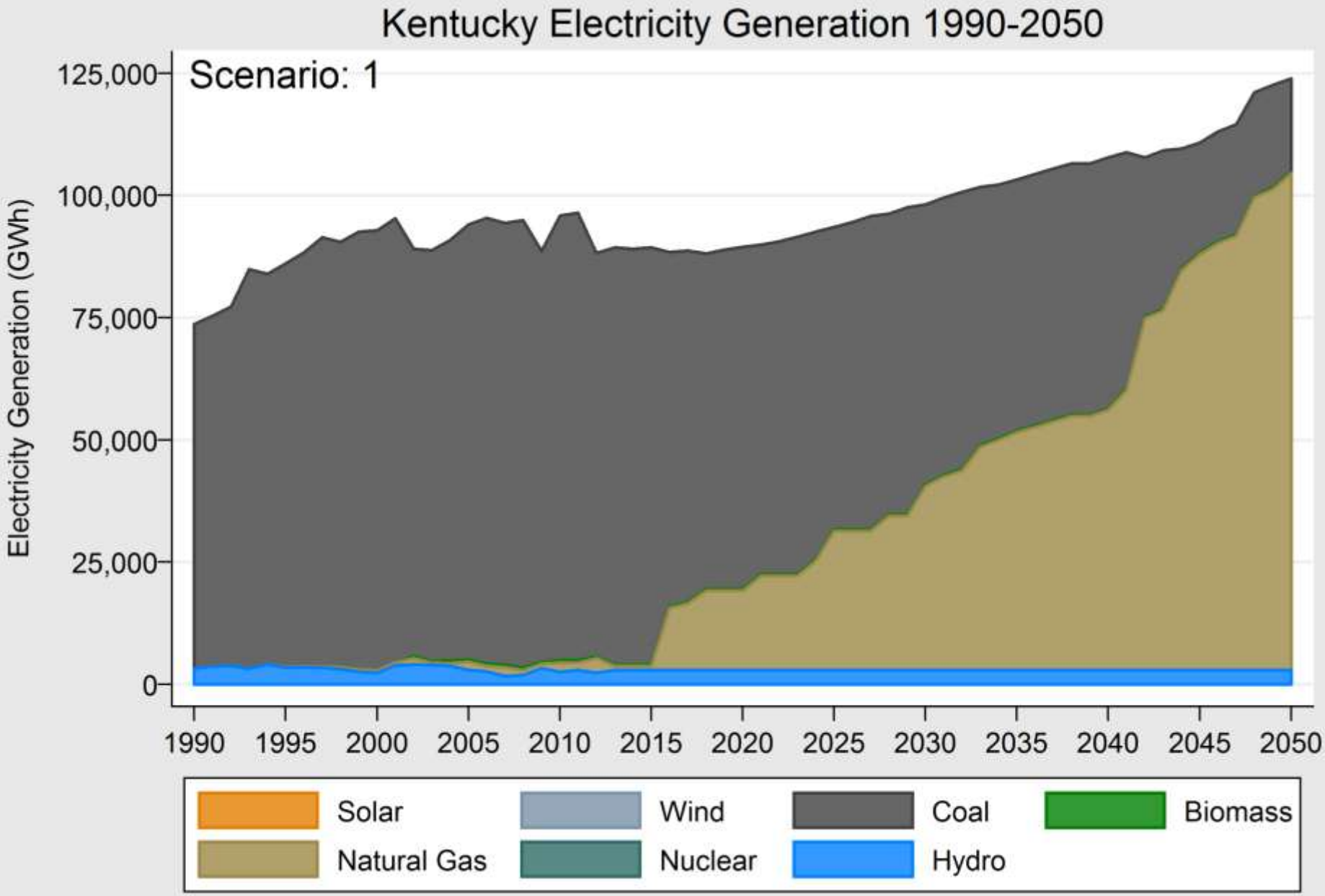
University of Kentucky Center for Applied Energy Research

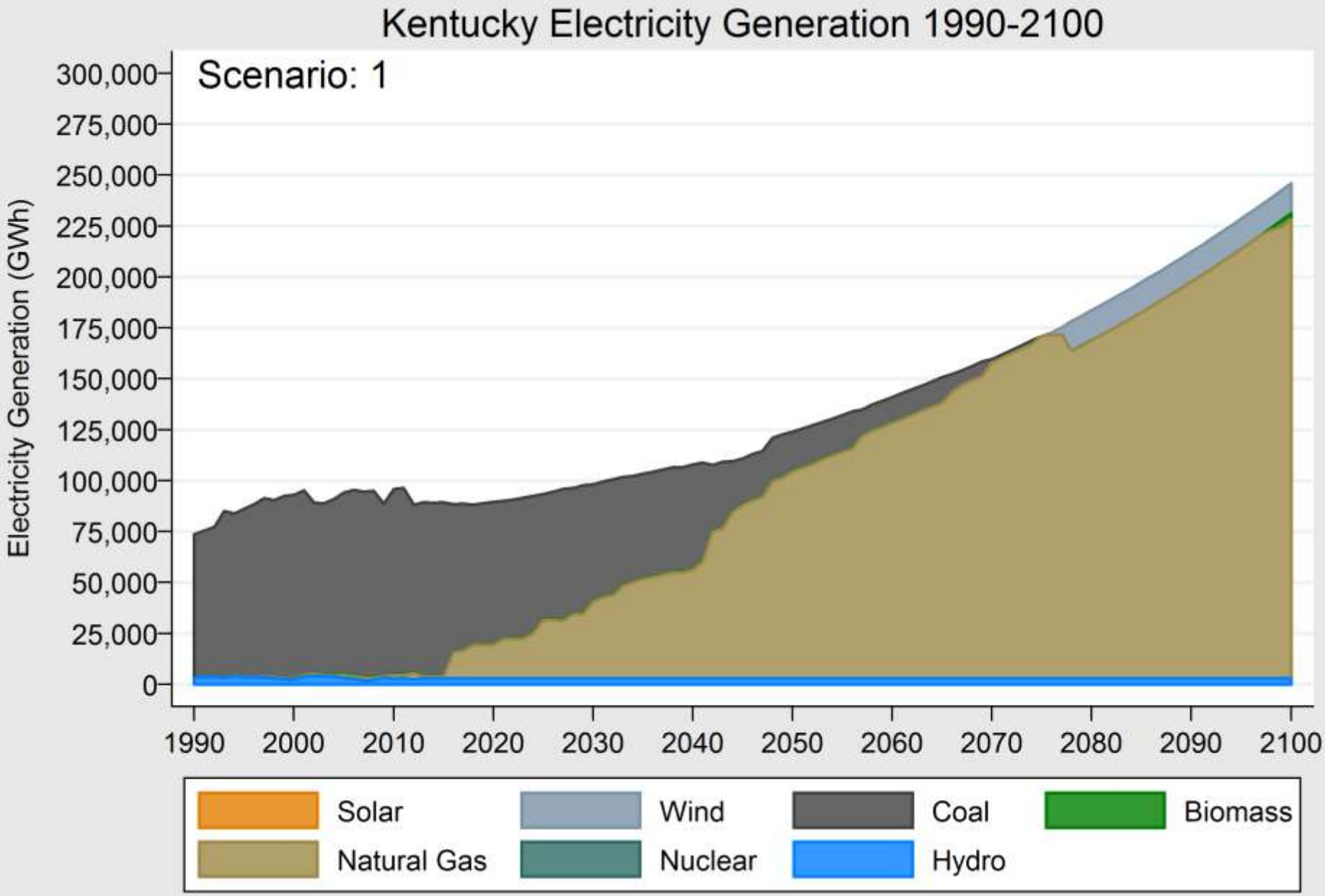
Pacific Northwest National Laboratory

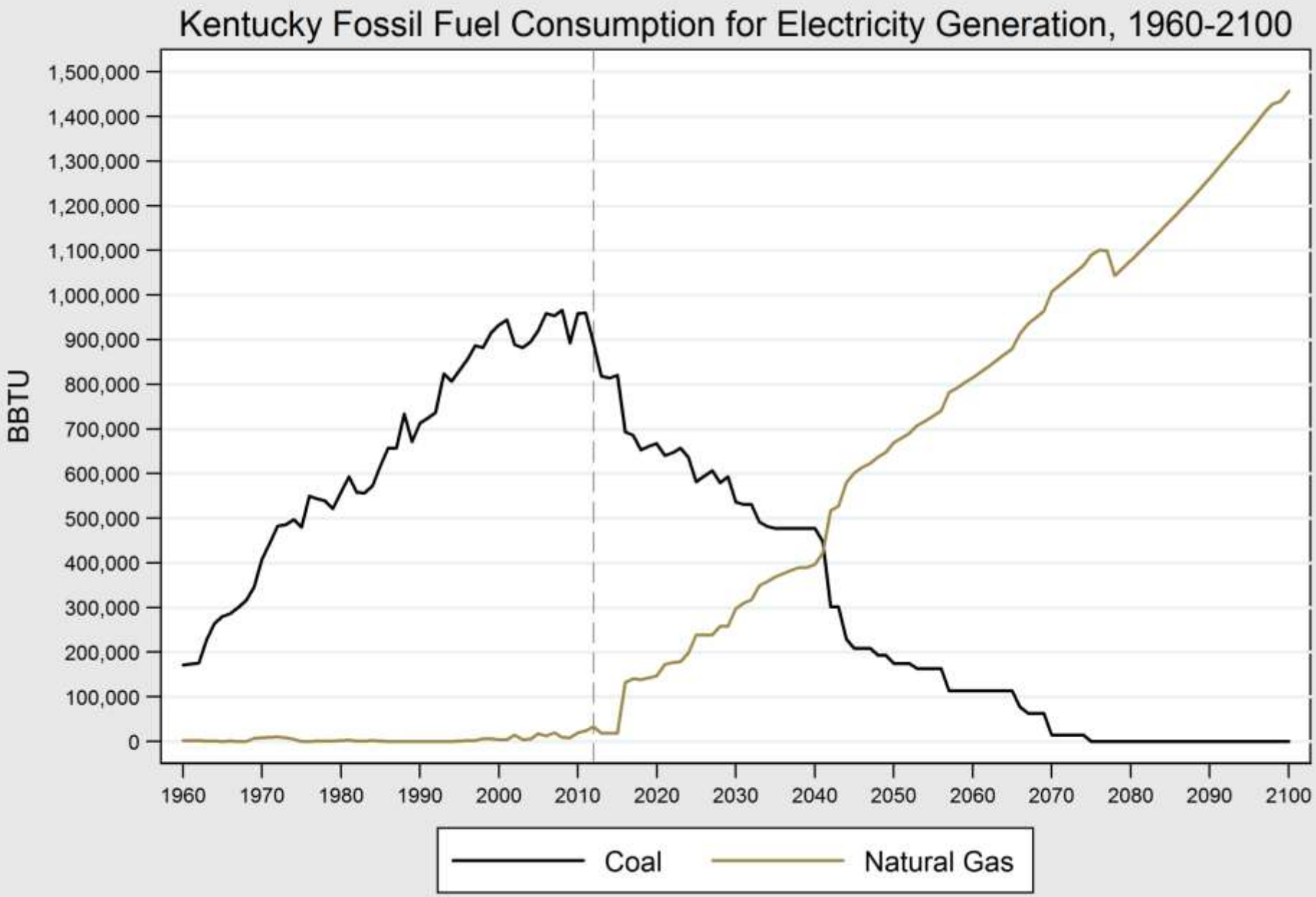
January 27th, 2014

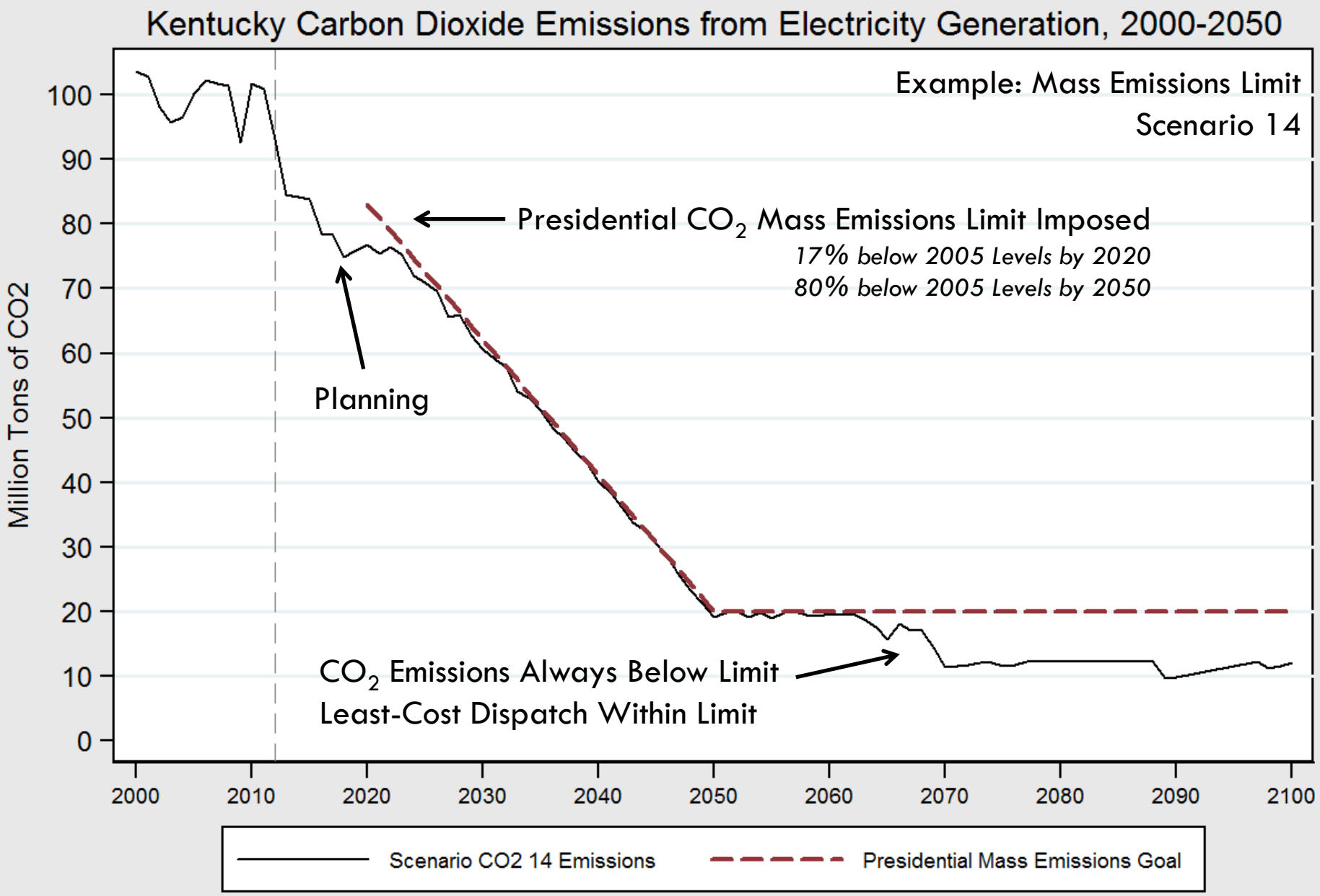
Kentucky Electricity Portfolio Model v.2.0 Design Plan

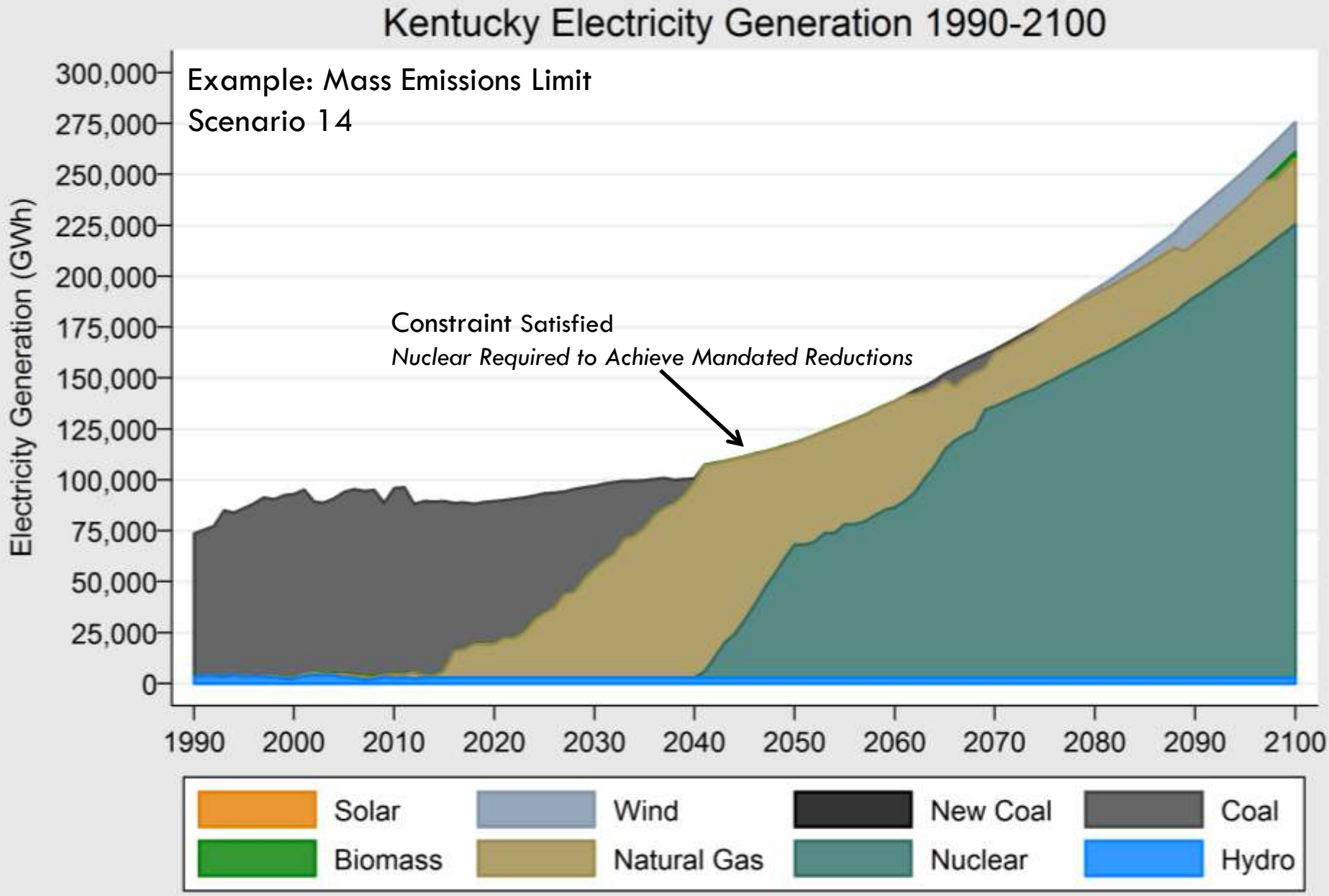



Kentucky Electricity Generation 1990-2050
Scenario: 1
Electricity Generation (GWh)
125,000
100,000
75,000
50,000
25,000
0
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Solar
Wind
Coal
Biomass
Natural Gas
Nuclear
Hydro
Kentucky Electricity Portfolio Model, EEC-DEDI, 1 Nov 2013 Scenario:1


Kentucky Electricity Generation 1990-2100
Scenario: 1
Electricity Generation (GWh)
300,000
275,000
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
0
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Solar
Wind
Coal
Biomass
Natural Gas
Nuclear
Hydro
Kentucky Electricity Portfolio Model, EEC-DEDI, 1 Nov 2013 Scenario:1


Kentucky Fossil Fuel Consumption for Electricity Generation, 1960-2100
BBTU
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Coal
Natural Gas
Kentucky Electricity Portfolio Model, EEC-DEDI, 1 Nov 2013 Scenario: 1


Kentucky Carbon Dioxide Emissions from Electricity Generation, 2000-2050
Example: Mass Emissions Limit
Scenario 14
Presidential CO_2 Mass Emissions Limit Imposed
17% below 2005 Levels by 2020
80% below 2005 Levels by 2050
Planning
CO_2 Emissions Always Below Limit
Least-Cost Dispatch Within Limit
Million Tons of CO2
0
10
20
30
40
50
60
70
80
90
100
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Scenario CO2 14 Emissions
Presidential Mass Emissions Goal
Kentucky Electricity Portfolio Model, EEC-DEDI, 26 Nov 2013 Scenario: 14


Kentucky Electricity Generation 1990-2100
Example: Mass Emissions Limit
Scenario 14
Constraint Satisfied
Nuclear Required to Achieve Mandated Reductions
Electricity Generation (GWh)
300,000
275,000
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
0
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Solar
Wind
New Coal
Coal
Biomass
Natural Gas
Nuclear
Hydro
Kentucky Electricity Portfolio Model, EEC-DEDI, 17 Nov 2013 Scenario:14

CO_2 Results Matrix

Kentucky CO_2 Emissions, 2035 (Million Tons of CO_2)				
Federal Policy Options	Response			
	1: Nuclear Banned	2: Nuclear Allowed	3: Balanced Portfolio	4: Coal Portfolio
1: Reference Case	69.98	70.00	70.02	70.72
2: Carbon Price: $10 - $20	64.48	64.56	64.59	68.07
3: Carbon Price: $20 - $40	45.79	45.85	54.17	65.41
4: Carbon Price: $40 -$60	35.10	35.12	12.96	63.91
5: CO2 Rate Limit	59.99	64.66	64.15	65.40
6: CO2 Rate Limit 5-Year Stay	59.99	64.66	64.15	65.40
7: Mass Emissions Reduction	51.03	51.19	49.29	48.85

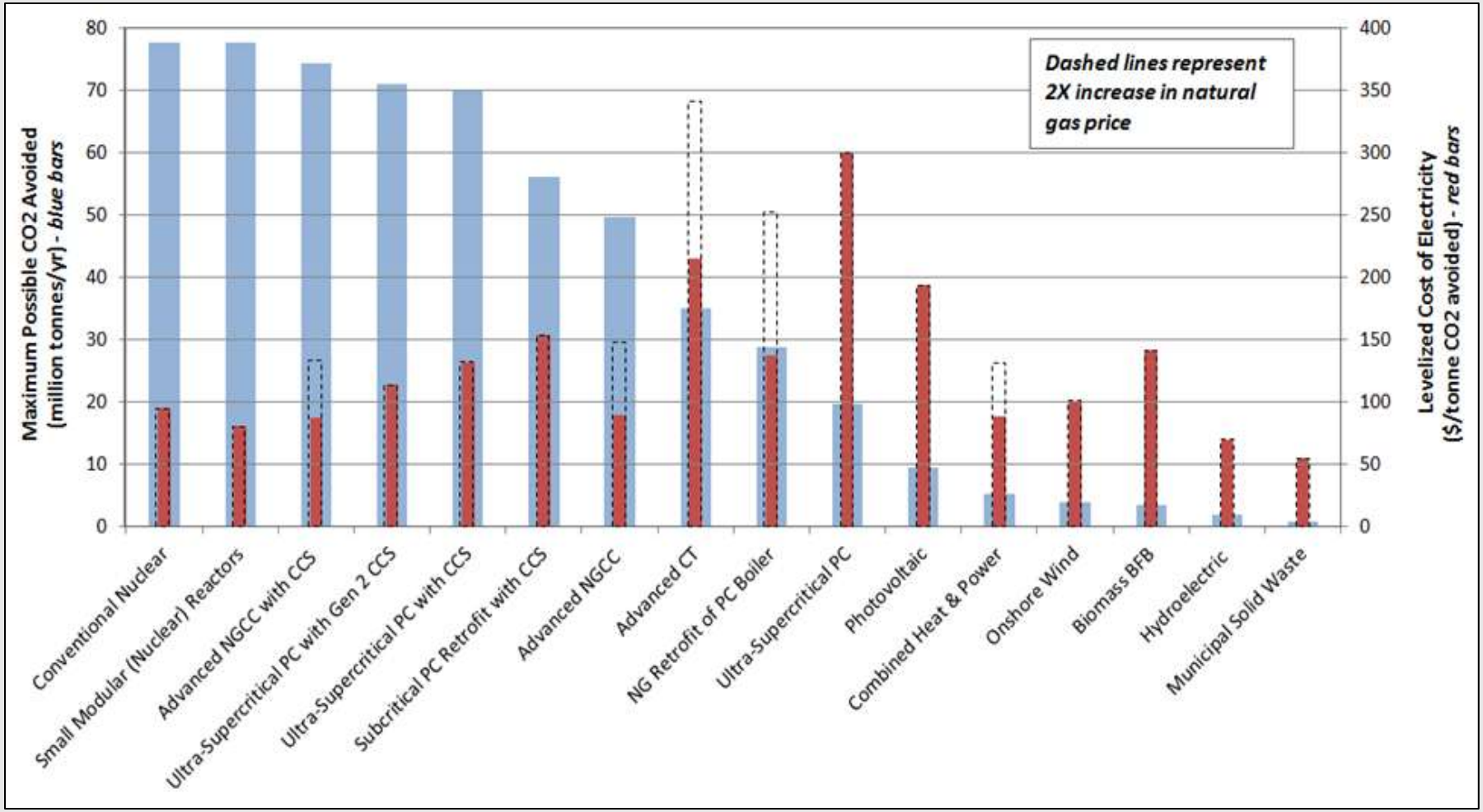
Electricity Price Results Matrix

Kentucky Total Electricity Price, 2035 (2010 Cents per kWh)				
Federal Policy Options	Response			
	1: Nuclear Banned	2: Nuclear Allowed	3: Balanced Portfolio	4: Coal Portfolio
1: Reference Case	10.00	10.01	10.00	9.60
2: Carbon Price: $10 - $20	11.71	11.73	11.71	11.23
3: Carbon Price: $20 - $40	12.99	13.01	13.13	12.86
4: Carbon Price: $40 -$60	13.37	13.38	13.62	14.21
5: CO2 Rate Limit	11.74	10.16	10.16	9.73
6: CO2 Rate Limit 5-Year Stay	11.74	10.16	10.16	9.73
7: Mass Emissions Reduction	11.84	10.87	11.22	10.40

Employment Results Matrix

Kentucky Total Employment, 2035 (Full-Time Jobs)				
Federal Policy Options	Response			
	1: Nuclear Banned	2: Nuclear Allowed	3: Balanced Portfolio	4: Coal Portfolio
1: Reference Case	2,848,177	2,847,528	2,848,169	2,846,696
2: Carbon Price: $10 - $20	2,776,057	2,775,591	2,776,081	2,779,789
3: Carbon Price: $20 - $40	2,729,966	2,729,488	2,725,305	2,724,407
4: Carbon Price: $40 -$60	2,717,401	2,716,961	2,709,253	2,703,511
5: CO2 Rate Limit	2,775,189	2,840,552	2,840,681	2,847,005
6: CO2 Rate Limit 5-Year Stay	2,775,189	2,840,552	2,840,681	2,847,005
7: Mass Emissions Reduction	2,771,049	2,809,794	2,795,586	2,818,670

Cost vs. CO_2 Reduction Potential



Key Findings

After running 28 separate scenarios and analysis, several key results stand out.

1. **The trend toward greater use of natural gas and away from coal for electricity generation already underway will accelerate with CO_2 regulations because**
   a. Natural gas is cheap, plentiful and expected to stay that way.
   b. EPA regulations are the law and utilities are doing what is necessary to comply.
   c. Neither building new coal units nor retro-fitting existing coal units with improved generation or CCS control technology is cost effective when compared to other generation technologies.
2. **CO_2 regulations, in whatever form, will cause further electricity price increases, state GDP and state employment decreases.** But, between a carbon price, a rate standard or a mass emission standard, the latter is the least harmful to Kentucky.
3. **Relaxing Kentucky prohibitions of nuclear power in KRS 279.605(1) and "least cost" provisions in KRS 278.020 will provide the opportunity for generation fleet diversity and, potentially, prolong the use of coal.**
4. Although Kentucky has very limited renewable energy resource potential, **increased renewable electricity generation should be considered** as part of a broader strategy to protect Kentucky from future federal greenhouse gas emissions regulations and natural gas price volatility.

Recommendations

1. **Continue to advocate for a Mass Emission reduction standard with the EPA.**
2. **Relax the nuclear prohibition in KRS 278.605(1).** Nuclear energy is the only carbon neutral resource capable of meeting significant portions of Kentucky's generating requirements.
3. **Relax the least cost provision in KRS 278.020 to promote the potential for renewable energy technologies** to help insulate the Kentucky economy from future federal greenhouse gas regulations and natural gas price volatility.