COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

ELECTRONIC 2021 INTEGRATED RESOURCE PLAN OF DUKE ENERGY KENTUCKY, INC.	))	CASE NO. 2021-00245

O R D E R

The Commission initiated this proceeding for Commission Staff to conduct a review of the 2021 Integrated Resource Plan (IRP) filed by Duke Energy Kentucky, Inc. (Duke Kentucky), pursuant to 807 KAR 5:058. Attached as an Appendix to this Order is the Commission Staff's Report summarizing Commission Staff's review of the IRP. This Commission Staff's Report is being entered into the record of this case pursuant to 807 KAR 5:058, Section 11(3).

IT IS THEREFORE ORDERED that the Commission Staff's Report attached as an Appendix to this Order shall be entered into the record of this matter.

PUBLIC SERVICE COMMISSION

Chairman

Vice Chairman

Commissioner

ENTERED

MAY 10 2022 rcs

KENTUCKY PUBLIC SERVICE COMMISSION

ATTEST:

Executive Director

APPENDIX

APPENDIX TO AN ORDER OF THE KENTUCKY PUBLIC SERVICE COMMISSION IN CASE NO. 2021-00245 DATED MAY 10 2022

THIRTY-THREE PAGES TO FOLLOW

Kentucky Public Service Commission

Commission Staff's Report on the

2021 Integrated Resource Plan

of Duke Energy Kentucky

Case No. 2021-00245

May 2022

SECTION 1

<u>INTRODUCTION</u>

In 1990, the Kentucky Public Service Commission (Commission) promulgated 807 KAR 5:058 to create an integrated resource planning process to provide for review of the long-range resource plans of Kentucky's jurisdictional electric generating utilities by Commission Staff. The Commission's goal was to ensure that all reasonable options for the future supply of electricity were being examined in order to provide ratepayers a reliable supply of electricity that is cost-effective.[1]

Duke Energy Kentucky, Inc. (Duke Kentucky) is an investor-owned utility supplying electricity and natural gas in northern Kentucky and is a wholly owned subsidiary of Duke Energy Ohio, Inc. (Duke Ohio), which is a wholly owned subsidiary of Duke Energy Corporation. Duke Kentucky is a member of PJM Interconnection LLC (PJM), a regional transmission organization that is also Duke Kentucky's reliability coordinator. Duke Kentucky supplies electricity to approximately 146,000 customers in Kenton, Campbell, Boone, Grant, and Pendleton counties of Northern Kentucky.[2]

Duke Kentucky filed its 2021 Integrated Resource Plan (IRP) on June 21, 2021. The IRP includes Duke Kentucky's plan for meeting its customers' electricity requirements for the 2020-2040 period.[3]

Duke Kentucky indicated that its purpose in preparing its IRP was to define a robust strategy to provide electric energy services in a reliable, efficient, and economic manner while considering the uncertainty of the current environment.[4] Its long-term objective was to employ a flexible planning process and pursue a resource strategy that considers the costs and benefits to all stakeholders (customers, shareholders, employees, suppliers, and community).[5] Duke Kentucky stated that the plan in its IRP represents the most robust and economic outcome based on various assumptions and sensitivities, which reflect the current uncertainty in regulatory, economic, environmental, and operating conditions.[6]

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[1] *See* Admin. Case No. 308, *An Inquiry into Kentucky's Present and Future Electric Needs and the Alternatives for Meeting Those Needs* (Ky. PSC Aug. 8, 1990), Order at 1–3; *see also* 807 KAR 5:058.

[2] IRP at 73.

[3] The 15-year planning period for the IRP was from 2021 through 2035. However, Duke Kentucky provided much information through 2040, so Staff used that information when available.

[4] IRP at 9.

[5] IRP at 9.

[6] IRP at 9.

The major objectives of Duke Kentucky's 2021 IRP were to:[7]

- Provide adequate, efficient and reasonable service that is economic in an uncertain environment;

- Maintain the flexibility and ability to alter the plan in the future as circumstances change;

- Choose a near-term plan that is robust over a wide variety of possible futures; and

- Minimize risks, such as wholesale market risks and reliability risks.

A procedural schedule was established after Duke Kentucky filed its 2021 IRP allowing for two rounds of requests for information to Duke Kentucky and written comments by intervenors. The Attorney General of the Commonwealth of Kentucky, by and through the Office of Rate Intervention (Attorney General), and the Sierra Club were granted intervention in this matter. Duke Kentucky responded to requests for information from the Attorney General, Sierra Club, and Commission Staff. The Attorney General and Sierra Club filed written comments regarding Duke Kentucky's IRP.

The purpose of this report is to review and evaluate Duke Kentucky's 2021 IRP in accordance with 807 KAR 5:058, Section 11(3), which requires Commission Staff to issue a report summarizing its review of each IRP filing and to make suggestions and recommendations to be considered in future IRP filings. Commission Staff recognizes that resource planning is a dynamic, ongoing process. Commission Staff's goals are to ensure that:

- All resource options are adequately and fairly evaluated;

- Critical data, assumptions, and methodologies for all aspects of the plan are adequately documented and reasonable; and

- The report includes an incremental component, noting any significant changes from Duke Kentucky's most recent IRP filed in 2018.

The remainder of this report is organized as follows:

- Section 2: Load Forecasting, reviews Duke Kentucky's projected load growth and load forecasting methodology.

- Section 3: Demand-Side Management and Energy Efficiency, summarizes Duke Kentucky's evaluation of DSM opportunities.

[7] IRP at 10.

- Section 4: Supply-Side and Demand-Side Resource Assessment and Integration focuses on supply resources available to meet Duke Kentucky's load requirements and environmental compliance planning. This section also discusses Duke Kentucky's overall assessment of supply-side and demand-side options and their integration into an overall resource plan.

SECTION 2

LOAD FORECASTING

INTRODUCTION

This section reviews Duke Kentucky's projected load changes and forecasting methodology. Calculating the energy consumption and peak demand forecast for each customer class and for the entire system is an important first step in the IRP process. It forms the basis for projecting how the generation fleet may evolve over time to meet projected customer demand, which in turn can affect long-term capital budgeting and investment decisions.

Using historical and forecasted economic and demographic data, Duke Kentucky employed Statistical End Use (SAE) Models and other regression models to forecast customer class demand. In addition to obtaining a base case forecast, Duke Kentucky ran various scenario analyses reflecting more optimistic and pessimistic outlooks to set upper and lower bounds on the base forecast.

FORECASTING METHODOLOGY AND ASSUMPTIONS

Statistically Adjusted End-Use Models

Though not discussed in any meaningful detail, SAE modeling was used in forecasting residential, commercial, and industrial energy use. Historical appliance saturation level data for all appliances were obtained from Duke Kentucky's Appliance Saturation Surveys. Historical and forecast appliance efficiency and saturation data was obtained from Itron, Inc.[8]

Data Documentation

The economic forecast data supporting the various customer class forecasts came from Moody's Analytics (Moody's). This data included national, state, and local (the Cincinnati Primary Metropolitan Statistical Area) employment; national and local population by age cohort, local income by subcategory; and inflation indices. Electricity and natural gas price data were obtained from Duke Kentucky financial reports. Marginal electricity prices by customer class were collected from customer records and rate schedules while projections were obtained from the Duke Energy Fundamentals Forecast team.[9]

For Peak Load and Energy forecasts, Moody's supplied the economic data and all local weather was obtained from the National Oceanic and Atmospheric Administration

[8] IRP, Appendix B at 81.

[9] IRP, Appendix B at 80.

(NOAA). Using daily weather data, heating degree days (HDD) and cooling degree days (CDD) were created, and an average of extreme weather conditions was used to create a normal weather day on a 30-year basis. An appliance stock variable included appliance saturations, efficiencies, and energy consumption.[10] Data in this variable was obtained from Duke Kentucky's Appliance Saturation Surveys. Itron, Inc. supplied historical appliance efficiency and saturation forecasts.[11]

A national forecast of economic and demographic variables formed the starting point for Duke Kentucky and included projections of population, employment, industrial production, inflation, wage rates, and income. The service area economy is contained within the Cincinnati Primary Metropolitan Statistical Area, which is an integral part of the regional economy.[12] Moody's also provided the service area forecasts of the same national economic and demographic variables.

Employment is comprised of non-agricultural, commercial, industrial, and government sectors. Income is comprised of wages, rents, proprietors' income, and transfer payments. Inflation was defined as changes in the Personal Consumption Index, for gasoline and other energy goods, or by the Consumer Price Index. Demographic projections included population and households for the service territory.

Residential Forecast

The Residential class sales forecast was defined as the product of forecasted residential customers in the service territory and energy use per customer. The number of residential customers was expected to show moderate growth over the forecast period at an average annual rate of 0.64 percent (from 130,434 to 147,055 by 2040).[13] Energy use per customer was defined as a function of real household income, number of households, real electricity prices, and the combined impact of weather, and saturations of air conditioners, electric space heaters, and other appliances, and appliance efficiency.[14] Over the forecast period, residential energy use was expected to grow at an average annual rate of 1.3 percent, from 1,477,914 to 1,876,353 MWh per year, after accounting for current and expected energy efficiency (EE) programs.[15] Overall, EE programs had only a small effect on the residential forecast. Comparing Residential

[10] IRP, Appendix B at 81. Appliances include electric ranges, frost free and manual defrost refrigerators, food freezers, dish washers, clothes washers and dryers, water heaters, microwaves, televisions, room air conditioners, central air conditioners, electric resistance heaters, electric heat pumps, and miscellaneous uses such as lighting.

[11] IRP, Appendix B at 80-82.

[12] IRP, Appendix B at 74.

[13] IRP, Appendix B, Figure B-1 at 96.

[14] IRP, Appendix B at 75. Though not discussed specifically, SAE modeling was employed. *See,* Appendix B at 88.

[15] IRP, Appendix B, Figure B-2a at 97.

forecasts in Figure B-2a of the IRP (before EE) with Figure B-2b of the IRP (after EE) shows that EE programs account for an estimated 1,813 MWh (0.1 percent) reduction in 2021 growing to an estimated 31,009 MWh (1.6 percent) reduction in energy consumed in 2040.[16]

Commercial Forecast

The Commercial class sales forecast was defined as the product of the forecast number of customers and energy use per commercial customer. The number of commercial customers grows very slowly at an average annual rate of 0.13 percent from 13,889 to 14,269 over the 2020-2040 forecast period.[17] Energy use per customer was defined as a function of median household income, total employment, real electricity prices, weather, and the combined impact of air conditioner, commercial heating and other appliance saturations, appliance efficiencies and commercial square footage.[18] Commercial energy use was expected to grow at an average annual rate of 0.3 percent from 1,416,427 to 1,506,320 MWh per year.[19] As with the Residential class, the energy consumption reductions due to EE programs on the Commercial class were small. Energy consumption after EE programs was reduced 1,145 MWh (0.08 percent) in 2021 growing to 26,705 MWh (1.7 percent) in 2040.[20]

Industrial Forecast

The Industrial class energy sales was defined as a function of real manufacturing gross domestic product (GDP), manufacturing employment and the impacts of real electricity prices and weather. Additional energy sales were added to the forecast due to a large industrial facility coming on line in the near future.[21] The number of industrial customers was expected to decline from 935 in 2019 to 906 in 2040.[22] Despite the slow decline in customers, industrial use was expected to grow very slowly at an average annual rate of 0.9 percent from 817,559 in 2019 to 973,054 MWh per year in 2040.[23] The

[16] IRP, Appendix B, Figures B-2a and B-2b at 97 and 98, respectively.

[17] IRP, Appendix B, Figure B-1 at 96.

[18] IRP, Appendix B at 75. Though not discussed specifically, SAE modeling was employed. *See,* Appendix B at 88.

[19] IRP, Appendix B, Figure B-2a at 97.

[20] IRP, Appendix B, Figures B-2a and B-2b at 97 and 98, respectively.

[21] IRP, Appendix B at 75.

[22] The number of industrial customers dipped from 935 in 2019 to 793 in 2020 and rebounded to 929 in 2021. IRP, Appendix B Figure B-1 at 96. Though not discussed specifically, SAE modeling was employed. *See,* Appendix B at 88.

[23] IRP, Appendix B Figure B-2a at 97. Similar to the number of industrial customers, industrial use showed a dip in 2020 and then rebound in 2021. MWh use in 2019-2021 is 817,559, 746,182, and 812,705 respectively.

reductions in energy consumption after EE programs are more pronounced than in either Residential or Commercial programs. EE programs account for energy reductions of 4,111 MWh (0.5 percent) in 2021, growing to 93,466 MWh (8.8 percent) in 2040.[24]

Street Lighting Forecast

The Street Lighting class energy sales was defined as a function of the number of residential customers and the lighting intensity end use as reported by the Energy Information Administration (EIA) long-term forecast.[25] Over the forecast period, street lighting use was expected to decline slightly from 13,827 to 13,329 MWh per year.[26]

Other - Public Authority (OPA), Company and Inter-Departmental Use Forecast

The Public Authority customer class sales forecast included energy sales from customers involved in or affiliated with federal, state, or local government, including schools, government facilities, airports, and water-pumping stations. Energy sales to these customers was defined as a function of real government output and HDD.[27] Including company and inter-departmental use, energy use was expected to grow at an average annual rate of 0.2 percent from 276,728 to 287,655 MWh per year.[28]

Total Company Net Energy Forecast

Total Electric Sales forecast was the sum of Residential, Commercial, Industrial, Street Lighting, and OPA energy forecasts. Total System Send-Out (net energy for load) equals Total Electric Sales forecast plus forecasts of total Company use and system losses.[29] Net energy for load was expected to grow over the forecast period at an average annual rate of 1.1 percent from 4,147,382 to 5,025,934 MWh.[30] The table below provides Duke Kentucky's net system energy forecast, including the effects of EE programs. EE

[24] IRP, Appendix B, Figures B-2a and B-2b at 97 and 98, respectively.

[25] IRP, Appendix B at 76.

[26] IRP, Appendix B, Figure B-2a at 97.

[27] IRP, Appendix B at 76.

[28] IRP, Appendix B, Figure B-2a at 97 and Duke Kentucky's First Response to Commission Staff's Request for Information (filed Oct. 22, 2021) (Staff's First Request), Item 31. As with the industrial usage, there is a dip in 2020 from 2019 and then a recovery in 2021. MWh use in 2019-2021 is 276,728, 188,356 and 226,890, respectively.

[29] IRP, Appendix B at 76.

[30] IRP, Appendix B, Figure B-2a at 97.

programs account for 7,882 MWh (0.2 percent) in 2021, growing to 168,982 MWh (3.5 percent) in 2040.[31]

Duke Kentucky System Service Area Energy Forecast After EE (MWh per Year)[32]

	(1)	(2)	(3)	(4)	(5)	(6)	(7) (1+2+3+4+5+6)	(8)	(9) (7+8)
Year	Rural and Residential	Commercial	Industrial	Street-Hwy Lighting	Sales for Resale *	Other **	Total Consumption	Losses and Unaccounted For ***	Net Energy for Load
2015	1,445,887	1,477,900	812,522	15,120	0	292,528	4,043,958	320,627	4,364,585
2016	1,451,682	1,494,014	810,977	15,264	0	293,918	4,065,855	322,367	4,388,222
2017	1,395,234	1,450,924	800,034	15,077	0	278,593	3,939,861	312,377	4,252,238
2018	1,563,656	1,479,511	814,989	14,317	0	285,909	4,158,382	329,698	4,488,080
2019	1,512,664	1,460,450	817,559	13,759	0	276,728	4,081,160	323,583	4,404,743
2020	1,477,914	1,416,427	746,182	13,827	0	188,356	3,842,705	304,677	4,147,382
2021	1,481,262	1,440,776	812,705	13,664	0	226,890	3,975,297	315,187	4,290,484
2022	1,477,026	1,409,837	866,225	13,617	0	267,691	4,034,396	319,874	4,354,269
2023	1,483,566	1,412,460	931,161	13,581	0	269,316	4,110,083	325,876	4,435,959
2024	1,491,406	1,420,430	928,475	13,563	0	269,470	4,123,345	326,927	4,450,273
2025	1,516,641	1,434,560	957,141	13,549	0	270,048	4,191,939	332,367	4,524,306
2026	1,525,979	1,430,349	950,316	13,534	0	270,884	4,191,062	332,297	4,523,359
2027	1,542,689	1,431,046	945,169	13,524	0	272,318	4,204,745	333,382	4,538,128
2028	1,558,264	1,433,163	943,013	13,516	0	273,964	4,221,921	334,744	4,556,666
2029	1,575,040	1,434,509	940,266	13,510	0	275,523	4,238,847	336,087	4,574,934
2030	1,599,006	1,436,910	973,099	13,438	0	277,103	4,299,556	340,901	4,640,457
2031	1,615,818	1,434,916	972,076	13,386	0	278,521	4,314,718	342,103	4,656,821
2032	1,638,609	1,439,347	971,338	13,356	0	279,814	4,342,465	344,304	4,686,768
2033	1,664,855	1,443,726	968,388	13,346	0	280,927	4,371,241	346,586	4,717,827
2034	1,686,490	1,445,171	965,092	13,339	0	281,823	4,391,916	348,225	4,740,141
2035	1,716,110	1,452,757	963,369	13,338	0	282,805	4,428,379	351,117	4,779,496
2036	1,755,426	1,470,077	964,939	13,339	0	284,013	4,487,794	355,828	4,843,623
2037	1,779,930	1,475,189	965,972	13,340	0	285,029	4,519,461	358,339	4,877,800
2038	1,812,453	1,487,979	967,982	13,342	0	285,968	4,567,724	362,167	4,929,891
2039	1,844,418	1,501,546	970,167	13,343	0	286,796	4,616,270	366,016	4,982,287
2040	1,876,353	1,506,320	973,054	13,329	0	287,655	4,656,711	369,223	5,025,934

* Sales for resale to municipals.

** Public authority, government use, Company and Inter-department use.

*** Transmission, transformer and other losses and unaccounted for energy.

[31] IRP, Appendix B, Figures B-2a and B-2b at 97 and 98, respectively. In addition, as apparent in the two Figures, the reduction in energy consumption will lead to slight reductions in lost and unaccounted for energy.

[32] IRP, Appendix B, Figures B-2a and B-2b at 97 and 98, respectively.

Peak Load Forecast

Duke Kentucky is a summer-peaking utility and is expected to remain so over the forecast period. Monthly peak-load forecasts were developed using SAE models. These models combine heating and cooling degree days and end use estimates generated by the monthly energy models and peak day weather conditions. The highest monthly energy loads were the basis for the summer and winter demand peak days.[33] Typically, the summer peak occurs in the afternoon in July and the winter peak occurs in the morning in January.[34]

Summer peak was expected to grow at an average annual rate of 0.9 percent from 809 MW to 950 MW. Similarly, winter peak was expected to grow at an average annual rate of 1.1 percent from 678 to 823 MW.[35] The table below provides Duke Kentucky's seasonal peak forecasts.

DUKE ENERGY KENTUCKY SYSTEM SEASONAL PEAK LOAD FORECAST[36]
INTERNAL DEMAND* (MEGAWATTS)
AFTER EE

	SUMMER			WINTER		
Year	LOAD	CHANGE	PERCENT CHANGE	LOAD	CHANGE	PERCENT CHANGE
2015	814			739		
2016	877	63	7.7	733	-6	-0.8
2017	841	-36	-4.1	797	64	8.7
2018	857	16	1.9	821	24	3
2019	849	-8	-0.9	742	-79	-9.6
2020	809	-40	-4.7	678	-64	-8.6
2021	815	6	0.7	733	55	8.2
2022	822	7	0.9	747	14	1.9
2023	836	14	1.7	747	0	-0.1
2024	840	4	0.5	763	16	2.1
2025	851	11	1.3	759	-4	-0.5
2026	853	1	0.1	757	-1	-0.2
2027	854	2	0.2	754	-3	-0.4
2028	857	3	0.3	755	1	0.1
2029	860	3	0.3	768	12	1.6

[33] IRP, Appendix B at 76.

[34] IRP, Appendix B at 76.

[35] IRP, Appendix B, Figure B-4b at 102. As was seen in the energy forecast, both summer and winter peak forecasts dip in 2020 from 2019 levels and then recover in 2021, though the winter peak recovers more quickly.

[36] IRP, Appendix B, Figure B-4b at 102.

2030	870	10	1.2	768	0	0
2031	874	3	0.4	769	1	0.1
2032	879	6	0.7	765	-4	-0.5
2033	885	5	0.6	764	-1	-0.1
2034	890	5	0.6	774	10	1.3
2035	898	8	0.9	792	18	2.3
2036	911	13	1.5	798	6	0.7
2037	919	8	0.8	797	-1	-0.1
2038	931	12	1.4	802	5	0.7
2039	942	11	1.1	802	-1	-0.1
2040	950	8	0.8	723	22	2.7

* Includes controllable load. The term "Internal' appears to be mislabeled, since "Internal" was defined in the IRP page 85 as a forecast before either EE or DR programs.

Sensitivity Analysis

The most likely energy and peak demand forecasts were based upon Moody's base economic forecast and assumed normal weather. Moody's divergent economic forecasts were used to generate the respective high and low forecasts for Duke Kentucky's service area. The high-growth scenario reflects strong short-term growth, and the low-growth scenario reflects a mild recession over the next three years.[37]

DUKE KENTUCKY SYSTEM RANGE OF FORECASTS[38]

	ENERGY FORECAST (GWH/YR) (NET ENERGY FOR LOAD) AFTER EE			PEAK LOAD FORECAST (MW) INTERNAL DEMAND* AFTER EE		
YEAR	LOW	MOST LIKELY	HIGH	LOW	MOST LIKELY	HIGH
2021	4,247	4,290	4,303	807	815	822
2022	4,310	4,354	4,377	797	822	847
2023	4,399	4,435	4,460	811	836	861
2024	4,421	4,450	4,474	818	840	862
2025	4,503	4,524	4,544	831	851	871
2026	4,505	4,523	4,539	833	853	872
2027	4,519	4,538	4,551	836	854	872
2028	4,537	4,556	4,569	840	857	875
2029	4,557	4,574	4,589	842	860	878
2030	4,626	4,640	4,658	853	870	888
2031	4,642	4,656	4,673	856	874	891

[37] IRP, Appendix B at 87.

[38] IRP, Appendix B, Figure B-9 at 104.

2032	4,669	4,686	4,701	861	879	898
2033	4,699	4,717	4,732	867	885	903
2034	4,722	4,740	4,756	872	890	908
2035	4,762	4,779	4,796	879	898	917
2036	4,827	4,843	4,861	892	911	931
2037	4,860	4,877	4,896	899	919	939
2038	4,912	4,929	4,948	911	931	952
2039	4,963	4,982	5,000	922	942	962
2040	5,005	5,025	5,044	929	950	971

* Includes controllable load. The term "Internal' appears to be mislabeled, since "Internal" was defined in the IRP page 85 as a forecast before either EE or DR programs.

RESPONSES TO PREVIOUS COMMISSION STAFF RECOMMENDATIONS

Commission Staff made several recommendations regarding Duke Kentucky's load forecasting in its 2018 IRP, and Duke Kentucky responded to each as indicated below.

- Duke Kentucky used a new format in its 2018 IRP that differed from its 2014 IRP in a way that Duke Kentucky felt was more readable. Commission Staff recommended maintaining the previous format and noted that at minimum, the report should contain a rigorous and detailed discussion of each forecasting model, including the final model equation and derivation of each variable used in each model equation. To address this recommendation, Duke Kentucky indicated that it returned to the format used in the 2014 IRP and added more rigorous and detailed discussions for each forecasting model.[39]

- Commission Staff indicated that the 2018 IRP included insufficient discussion of the importance and uses of weather normalization and how that has been utilized with respect to sector or total forecasts. To address this recommendation, Duke Kentucky indicated that it included a section on the use of weather normalization to Appendix B of the 2021 IRP.[40]

- Commission Staff indicated that not all figures reported or represented in the IRP were consistent throughout the 2018 IRP. To address this recommendation, Duke Kentucky indicated that it sought to review figures to ensure consistency and explain any differences.[41]

[39] IRP, Appendix F at 154-155.

[40] IRP, Appendix F at 155.

[41] IRP, Appendix F at 155-156.

- Commission Staff recommended that there should be a greater explanation of information found in tables and in any underlying assumptions driving particular results and that differences in tables purporting to show the same results should be explained. To address this recommendation, Duke Kentucky indicated that additional commentary and take-away information was added for tables and charts.[42]

- Commission Staff recommended that the IRP contain a better explanation of each forecasting model, and the specific data used for each customer class forecast, and that the explanation of each customer class and total forecast for energy usage, peak load, and the sensitivity analysis should be organized in a manner more specific to each customer class. To address this recommendation, Duke Kentucky indicated that it included greater levels of load forecasting information in the 2021 IRP.[43]

INTERVENOR COMMENTS

Intervenors made no comments specifically regarding Duke Kentucky's load forecasting.

DISCUSSION OF REASONABLENESS

Duke Kentucky's 2021 IRP is an improvement over its previous IRP. There was additional explanation of data sources and of each of the various energy and demand models. However, as discussed below, additional explanation of how independent model variables are constructed within the SAE modeling framework is warranted. In addition, Duke Kentucky attempted to improve its presentations and discussions of modeling results. However, there is still room for improvement. Duke Kentucky should continue to strive for consistent reporting of modeling results to ensure clarity and understanding.

Commission Staff is aware of and appreciates the level of effort that goes into preparing an IRP. Duke Kentucky's energy and demand forecasts are reasonable. The recommended additional explanation and analyses are intended to provide for more clarity and understanding of the underlying forecast drivers and the sensitivity to varying assumptions.

RECOMMENDATIONS FOR DUKE KENTUCKY'S NEXT IRP

- Duke Kentucky should be consistent in its use of terminology and references. For example, the term "Internal" is applied to forecasts before the application of either the

[42] IRP, Appendix F at 156.

[43] IRP, Appendix F at 156.

effects of EE or Demand Response (DR) programs.[44] However, Figures B-3b (before EE) and B-4b (after EE) both refer to Internal load. The term "Native" is applied to Internal forecasts reduced by DR but not EE.[45] However, both Figures B-3a (before EE, after DR) and B-4a (after EE, after DR) refer to Native load. In addition, these tables contain references with no accompanying explanation of the same reference applied to different Items.

- Duke Kentucky should be consistent in its presentations and calculation of forecasted results. For example, the forecasted effects of both EE and DR programs presented in IRP Figure 5.2 on page 41 do not match the effects of these programs inherent in the energy and demand forecasts in IRP Figures B-2a and B-2b on pages 97 and 98 and Figures B-3b and B-4b on pages 100 and 102, respectively. Inconsistent reporting of forecast results call into question the veracity of the results overall. Nonetheless, the program effects inherent in the Figures in Appendix B appear to be used as a starting point to design an appropriate resource portfolio.[46]

- Though not discussed in any meaningful way, SAE modeling was used to forecast Residential, Commercial, and Industrial energy use. While becoming more common in modeling Residential and Commercial use, it is not as common to see SAE methods used for industrial classes. In the next IRP, Duke Kentucky should provide detailed discussions of why SAE modeling is considered better than prior forms of modeling and how the various independent variables are derived. In addition, if SAE modeling continues to be used for the industrial class, there needs to be a discussion of the industrial appliance, equipment and process efficiencies being modeled, whether Itron tracks and forecasts these industrial factors, and the extent to which Duke Kentucky has any influence over the growth or appliance saturation levels.

- The SAE methodology was used in the peak-demand modeling. As with the energy modeling, there was little discussion of how the methodology was applied to each of the independent model variables. For the next IRP, Duke Kentucky should include greater discussion of how independent variables are constructed for both the energy and demand model.

- The sensitivity analyses were based on variations in economic activity only. While reasonable, modeling variations in weather, separately and in conjunction with economic activity, would also be reasonable. Modeling the extremes (however defined) of both economic activity and weather together to set plausible upper and lower limits to energy and demand forecasts is prudent. For the next IRP, Duke Kentucky should model more diverse sensitivity analyses, including projected variations in weather.

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[44] IRP, Appendix B at 85.

[45] IRP, Appendix B at 85.

[46] See IRP Section 7, at 65; Appendix B, Figure B-6 at 104; and Duke Kentucky's Response to Staff's First Request, Item 15b, Attachment at 3.

- For models in which two variations of the same variable are used, there needs to be additional explanation of why it is appropriate to include such closely related variables as there often does not appear to be any statistically significant collinearity between the variables. Simply improving the regression R-squared value is not a sufficient reason to include both variables. The discussion should also identify and describe the separate effects these variables have on the dependent variable.

SECTION 3

DEMAND-SIDE MANAGEMENT AND ENERGY EFFICIENCY

INTRODUCTION

This section discusses the DSM-EE aspects of Duke Kentucky's IRP. Duke Kentucky's DSM and EE portfolio was designed to make the production and delivery of energy more cost-effective with the goal of increasing the efficient use of electricity. The portfolio includes traditional conservation EE programs and DR programs whose goal is to reduce demand on Duke Kentucky's system. Through applications to the Commission by Duke Kentucky and in conjunction with its DSM/EE Collaborative, the Commission has approved expansions and revisions of Duke Kentucky's DSM/EE efforts for over two decades.

SUMMARY DISCUSSION OF DSM-EE

The current suite of programs includes the following:[47]

1. Low Income Services Program;
2. Residential Energy Assessments Program;
3. Residential Smart Saver Efficient Residences Program;
4. Residential Smart Saver Energy Efficient Products Program;
5. Smart Saver Prescriptive Program;
6. Smart Saver Custom Program;
7. Power Manager Program;
8. PowerShare;
9. Low Income Neighborhood;
10. My Home Energy Report;
11. Non-Residential Small Business Energy Saver Program;
12. Non-Residential pay for Performance; and
13. Peak Time Rebate Pilot Program

Duke Kentucky included the projected impacts of the DSM programs in this IRP filing. By 2035, DSM programs aimed at conservation were projected to reduce energy consumption by 172,500 MWh and demand coincident to the Summer Peak by 27 MW.[48] Direct Load Control Programs, such as the residential Power Manager program and the nonresidential PowerShare program, were projected to reduce peak demand by an additional 7 MW and 15 MW, respectively.[49]

[47] *See* IRP, Appendix C, at 113-138 for a complete description of all programs.

[48] IRP, Section 5 at 40-41.

[49] IRP, Section 5 at 40.

All DSM programs were screened for cost-effectiveness using the DSMore financial analysis tool.[50] Based upon the total resource test, overall, the programs included in the current suite are cost-effective.[51]

RESPONSES TO PREVIOUS COMMISSION STAFF'S RECOMMENDATIONS

Duke Kentucky's DSM programs were suspended when the 2018 IRP was being prepared due to a Commission investigation in Case No. 2017-00427[52] about whether its DSM programs were cost-effective. Hence, the 2018 IRP included scenarios with and without DSM programs.

In Case No. 2017-00427, the Commission found that most programs were cost-effective and reinstated the cost-effective programs.[53] In the report regarding the 2018 IRP, Commission Staff then recommended that the 2021 IRP include the Commission-approved DSM programs. Commission Staff also recommended that Duke Kentucky continue scrutinizing the results of each existing DSM program, measure's cost-effectiveness test and provide these results in future DSM cases, along with detailed support for future DSM program expansions and additions.[54]

Duke Kentucky has provided updated cost-effective scores in their annual DSM filings and requested amendments. Duke Kentucky stated that through the ongoing collaborative process and with a focus on developing new cost-effective program offerings, a well-established and supported process was in place.[55]

INTERVENOR COMMENTS

The Sierra Club argued that Duke Kentucky should increase its current DSM portfolio and that doing so could reduce the costs of replacing Duke Kentucky's East Bend 2 generating station with renewable energy generation.[56] Specifically, Sierra Club stated that its analysis indicated that replacing East Bend 2 with a clean energy portfolio could

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[50] IRP, Appendix C at 110.

[51] IRP, Appendix C at 112. All individual programs except for the low-income programs have cost-effective total resource cost scores.

[52] Case No. 2017-00427, *Electronic Annual Cost Recovery Filing for Demand Side Management by Duke Energy Kentucky, Inc. to Amend its Demand Side Management Programs* (Ky. PSC Feb. 14, 2018), Order.

[53] Case No. 2017-00427, *Electronic Annual Cost Recovery Filing for Demand Side Management by Duke Energy Kentucky, Inc. to Amend its Demand Side Management Programs* (Ky. PSC Sept. 13, 2018), Order.

[54] IRP, Appendix F at 157.

[55] IRP, Appendix F at 157.

[56] Sierra Club Comments, Exhibit A at 1 and 4.

save Duke Kentucky between $61 million and $239 million from 2027 through 2035 with increased DSM programs, whereas replacing East Bend 2 without any increase in DSM programs reduces the potential savings from 2027 through 2035 to $134 million.[57]

DISCUSSION OF REASONABLENESS

In the final Order of Case No. 2017-00427, the Commission recognized the importance and the need to continue certain DSM programs, especially with regard to Duke Kentucky's participation in PJM to meet its Fixed Resource Requirement (FRR) obligation.[58] The Order also noted that reducing Duke Kentucky's load requirements through DSM programs was a less costly alternative than either purchasing capacity or installing additional capacity.[59]

Duke Kentucky maintained that demand-side resources were compared to supply-side resources on a comparable basis in this IRP through an examination of performance and cost-effectiveness over a wide variety of weather and cost conditions.[60] Duke Kentucky continued to assert that through this evaluation process, risks and benefits were evaluated in the same way as traditional generation capacity additions.[61] Duke Kentucky noted that it will continue to offer a variety of DSM programs in the future as long as they are cost-effective.[62]

Duke Kentucky provided an update regarding DSM impacts to Duke Kentucky's 2020/2021 Delivery Year, noting that PJM required all FRR resources to be Capacity Performance resources. This implies that the resources must meet the Capacity Performance commitment to deliver energy whenever PJM determines the need, not just during certain time periods. Therefore, the PJM requirement no longer allowed for customers to participate in seasonal programs. Hence, Duke Kentucky only began to include DSM programs in the FRR Plan if they were available year around. As a result, fewer DSM resources have been committed.[63]

RECOMMENDATIONS

- Duke Kentucky's next IRP should include a detailed explanation of whether peak-time rebates decrease Duke Kentucky's demand and avoid costs as suggested in

[57] Sierra Club Comments, Exhibit A at 1 and 4.

[58] Case No. 2071-00427 at 15.

[59] Case No. 2017-00417 at 15.

[60] IRP, Appendix C at 110.

[61] IRP, Appendix C at 110.

[62] Duke Kentucky's Response to Staff's First Request, Item 42.

[63] Duke Kentucky's Response to Staff's First Request, Item 43.

Case No. 2019-00277, and if so, it should explain how the peak-time rebates decrease Duke Kentucky's demand and avoid costs.[64] The next IRP should also discuss other DSM rate options that Duke Kentucky has explored.

- Duke Kentucky should continue to examine all reasonable DSM programs for cost-effectiveness and possible implementation regardless of whether they are available year around.

- Duke Kentucky should continue to scrutinize the results of each existing DSM program's individual measure's cost-effectiveness test and continue to provide those results in future DSM cases, along with detailed support for future DSM program expansions and additions. Duke Kentucky should also be mindful of the increasing saturation of EE products and be watchful for the opportunity to scale back on programs offering incentives for behavior that may be dictated by factors other than the incentives.

- Commission Staff encourages Duke Kentucky to continue with the DSM Collaborative process and strive to include recommendations and inputs from the stakeholders.

- Duke Kentucky should evaluate low-income DSM programs in other jurisdictions and analyze whether such programs would be effective in Duke Kentucky's service territory.

[64] Case No. 2019-00277, *Electronic Application of Duke Kentucky, Inc. to Amend Its Demand Side Management Programs* (Ky. PSC Apr. 27, 2020).

SECTION 4

SUPPLY-SIDE AND DEMAND-SIDE RESOURCE ASSESSMENT AND INTEGRATION

INTRODUCTION

In this Section, Commission Staff reviews, summarizes, and comments on Duke Kentucky's evaluation of existing and future supply and demand-side resources. In addition, there is a discussion on Duke Kentucky's environmental compliance obligations. Finally, this section will discuss the integration process and the resulting Duke Kentucky plan.

Duke Kentucky's net installed generation capacity (ICAP) consists of a 600 MW coal-fired plant at the East Bend Generating Station (East Bend), and 462 MW's of capacity from six dual-fuel, natural gas combustion turbines (CTs) at the Woodsdale Generating Station (Woodsdale).[65] In addition, Duke Kentucky owns three solar photovoltaic (PV) stations. The solar capacity consists of two 2 MW fixed tilt arrays at the Walton Solar Facility in Kenton County, Kentucky, and a 2.8 MW fixed tilt array at the Crittenden Solar facility in Grant County, Kentucky.[66] Duke Kentucky's total 2020 unforced capacity (UCAP) of these facilities was 1023.5 MW.[67]

Because Duke Kentucky's three solar assets are connected on the distribution system, they do not count toward Duke Kentucky's PJM's UCAP requirement obligation.[68] The Woodsdale natural gas CTs have historically used propane as a back-up fuel. However, since 2019 the ability to burn oil as a backup fuel source has enabled Duke Kentucky to meet its PJM Capacity Performance requirements.[69] As of 2020, coal-fired steam supplied approximately 54.33 percent of Duke Kentucky's energy needs, natural gas supplied about 1.32 percent, solar supplied approximately 0.27 percent, and the remaining 44.08 percent was purchased from the PJM energy market.[70]

Duke Kentucky utilized Anchor Power Solutions' *EnCompass*, a production cost modeling and optimization software, for its 2020 IRP.[71] Under business-as-usual (BAU) assumptions and the optimal IRP portfolio, Duke Kentucky will have a total ICAP

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[65] IRP at 36.

[66] IRP at 36.

[67] IRP at 36.

[68] IRP at 36. Unforced generation capacity rather than installed capacity is counted toward a utility's PJM capacity annual obligation.

[69] IRP at 36 and Duke Kentucky's Response to Staff's First Request, Item 25.

[70] IRP at 37 and Duke Kentucky's Response to Staff's First Request, Item 13.

[71] IRP at 17.

generating capacity of 1499 MW by 2035.[72] Significant differences from the 2018 IRP include:

- Retirement of East Bend in 2035 versus 2041.

- Adding additional sources of renewable power (solar, wind, and storage) amounting to 35 percent of resources by 2030, growing to 52 percent by 2035.

- Replacing East Bend with a Firm Dispatchable Resource (FDR) modeled as a natural gas combined cycle (NGCC) unit as a future place holder.[73]

PJM PARTICIPATION AND RESERVE MARGIN

Duke Kentucky is a member of the PJM Interconnection, LLC (PJM) and intends to continue participating as a fixed resource requirement (FRR) entity.[74] PJM's capacity market, known as the Reliability Pricing Model (RPM) Base Residual Action, provides for long-term grid reliability by ensuring that the appropriate amount of power-supply resources is available to meet predicted energy demand. As an FRR entity, Duke Kentucky must demonstrate that its generation resource adequacy plans satisfy PJM's reliability requirements.

Among other things, PJM requires FRR entities to meet unforced capacity obligations that include a reserve margin established for each delivery year referred to as the Forecast Pool Requirement (FPR).[75] The FPR is established 3 years prior to an applicable delivery year based on the Installed Reserve Margin (IRM), the installed capacity percent above the forecasted peak load required to satisfy a loss of load expectation of, on average, 1 day every 10 years, and the pool wide average demand forced outage rate.[76] The FPR is simply the IRM expressed in terms of unforced capacity (UCAP).[77]

Beginning in 2020, PJM also required Duke Kentucky's generation resources to be Capacity Performance compliant, which means that the generation units must be

[72] IRP at 65.

[73] IRP at 4-5.

[74] IRP at 7.

[75] *See* PJM Manual 18: PJM Capacity Market, Revision 52, Section 11.2.1, 11.7.1, pgs. 231, 244-245 (dated Feb. 24, 2022) (indicating that the daily unforced capacity obligation of an FRR entity is calculated by multiplying the entity's peak load in the zone by the relevant scaling factor for the zone by the FPR); PJM Manual 20: PJM Adequacy Analysis, Revision 10, Section 1.3, 1.5, pg. 13-14 (dated August 25, 2021) (defining the FPR and showing how it is calculated).

[76] PJM Manual 20: PJM Adequacy Analysis, Revision 12, Section 1.2-1.5, pgs. 11-14.

[77] PJM Manual 20: PJM Adequacy Analysis, Revision 12, Section 1.5, pg. 14.

capable of sustained and predictable operation throughout the Delivery Year.[78] There are substantial penalties for nonperformance during periods of high load demand or system emergencies. Conversely, performance bonuses could be awarded for overperformance.[79]

Duke Kentucky explained that PJM's Capacity Performance compliance does not have a definitive set of guidelines, so its best practice was to manage risks and make appropriate investments in the reliability of its assets to reduce the likelihood non- or underperformance when called upon during a PJM-determined event.[80] The specific strategies that Duke Kentucky has undertaken, such as maintaining adequate fuel supplies and proactive maintenance for East Bend and adding oil as a backup fuel for Woodsdale, are intended to ensure that it is Capacity Performance compliant.[81]

Beginning in 2020, PJM also imposed a Minimum Internal Resource Requirement (MIRR) for Duke Kentucky's FRR load obligation.[82] MIRR dictates that a minimum percentage of resources that are committed in Duke Kentucky's FRR plan must be inside the Duke Energy Ohio Kentucky (DEOK) zone. The minimums for the current and three-forward planning years follow are as follows:[83]

Planning Year	Percentage Inside DEOK Zone
2020/2021	41.7%
2021/2022	44.7%
2022/2023	33.9%
2023/2024	32.6%

ENVIRONMENTAL COMPLIANCE

Duke Kentucky is required to comply with numerous state and federal environmental regulations, including the Acid Rain, Clean Air Interstate Rule (CAIR), Cross State Air Pollution Rule (CSAPR), sulfur dioxide National Ambient Air Quality Standards (NAAQS), Clean Water Act, Steam Electric Effluent Limitation Guidelines (ELG), and Coal Combustion Residuals (CCR).[84]

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[78] Duke Kentucky's Response to Staff's First Request for Information, Item 25.

[79] Duke Kentucky's Response to Staff's First Request for Information, Item 25.

[80] Duke Kentucky's Response to Staff's First Request for Information, Item 25.

[81] Duke Kentucky's Response to Staff's First Request for Information, Item 25.

[82] IRP at 8 and Duke Kentucky's Response to Staff's First Request for Information, Item 4.

[83] Duke Kentucky's Response to Staff's First Request for Information, Item 4.

[84] IRP at 141-142.

Duke Kentucky stated it had taken the necessary, prudent, and economic actions to attain full compliance with respect to existing, fully implemented air emission regulations.[85] Actions that Duke Kentucky has taken over the years consist of retrofitting East Bend 2 with a selective catalytic reduction (SCR), executing performance upgrades on its original flue gas desulfurization system, and the refurbishment of the electrostatic precipitator.[86] Duke Kentucky anticipates another SCR performance upgrade following a 2021 revision to CSAPR.[87] These costs were included in Duke Kentucky's modeling.[88]

Regarding water and wastewater regulation, Duke Kentucky's East Bend 2 utilizes a closed loop cooling system, which minimizes exposure to cooling water discharge and intake related regulations.[89] Duke Kentucky installed dry bottom, ash-handling systems to comply with the ELG and CCR rules and end all water and waste flows to its former bottom ash pond.[90] Former ash ponds were closed in compliance of CCR requirements.[91] Anticipated additional discharge limitations may necessitate additional waste-processing changes or equipment installations, and placeholder costs were included in the IRP analyses.[92]

TRANSMISSION AND DISTRIBUTION

Duke Kentucky indicated that there are no current or planned transmission projects affecting Duke Kentucky that are intended to provide or are associated with the provision of additional resources.[93] Changes to the transmission and distribution systems are based on meeting planning criteria and to provide reliable system performance. Projects intended solely to reduce losses are not cost-effective.[94] Duke Kentucky provided a list of transmission and distribution projects completed over the 2018-2020 period and projects planned for the 2021-2023 period.[95]

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[85] IRP at 141.

[86] IRP at 141.

[87] IRP at 141.

[88] IRP at 141.

[89] IRP at 142.

[90] IRP at 142.

[91] IRP at 142.

[92] IRP at 142.

[93] IRP, Appendix A, at 69.

[94] IRP, Appendix A, at 69.

[95] IRP, Appendix A, at 70-71.

RESOURCE OPTIONS

Duke Kentucky initially considered a wide variety of options in developing its final list of resource options to be made available to its production and cost model. Solar steam augmentation, fuel cells, supercritical CO_2 Brayton cycle, liquid air energy storage, and advanced compressed air energy storage were excluded from final consideration based on technical and commercial availability. Additional technologies were excluded based on not being feasible in Duke Kentucky's service territory, including geothermal, offshore wind, pumped storage hydropower, and traditional compressed air energy storage.[96] Technologies and resource supply options that are both available and feasible were then screened for economic viability using *EnCompass*. The table below lists the resource options ultimately considered.[97]

DESCRIPTION	SUMMER CAPACITY (MW)	TYPICAL CAPACITY FACTOR
Nuclear	2,234	90%
Small Modular Nuclear Reactor	684	95%
Ultra-Supercritical Pulverized Coal	850	70%
Combined Cycle Gas Turbine, 2x1	1,157	70%
Simple Cycle Gas Turbine	840	10%
Reciprocating Engine	201	10%
Combined Heat and Power	17	95%
Wind	20[a]	18%
Solar PV, Single-Axis Tracking	2.5[b]	24%
Battery Storage, 4-hour Lithium Ion	8[c]	15%

(a)Nameplate capacity is 150 MW, wind contribution to peak is 13% of nameplate capacity in summer.
(b)Nameplate capacity is 5 MW, solar contribution to peak is 50% of nameplate capacity in summer.
(c)Nameplate capacity is 10 MW, battery contribution to peak is 80% of capacity.

The economic optimization process selected the most economical of the resources based on the minimized Present Value Revenue Requirements (PVRR).[98] Duke Kentucky created several portfolios under a variety of plausible scenarios, including

[96] IRP at 38.

[97] IRP at 17 and Figure 4.1 at 35.

[98] IRP at 17.

futures that include CO_2 regulation and higher (or lower) than normal gas prices.[99] From that, the portfolios can be tested, and the optimal 2021 IRP plan selected.

INTEGRATION

PJM Market Prices

Duke Kentucky's BAU, or Base forecast, was for continued low natural gas prices through the early 2020s and then gradually increased thereafter.[100] The price increases were being driven in part by demand growth from continued coal unit retirements and liquefied natural gas exports.[101] A high fuel price scenario reflected constrained resource supplies and high extraction costs. A low fuel price scenario reflected high resource availability and low extraction costs. Annual U.S. coal consumption has declined over 30 percent in the last decade due to coal unit retirements, and Duke Kentucky expected coal prices to remain weak as utility demand continued to fall over the forecast horizon.[102]

Duke Kentucky modeled the generation expansion plans for the entire PJM Eastern Interconnect to obtain simulated PJM hourly energy prices under various carbon and fuel price scenarios.[103] In total, six scenarios were modeled: low gas prices, BAU (expected) gas prices, and high gas prices, each with and without carbon regulation.[104] In the carbon constrained scenario, carbon prices were assumed to begin at $5 per ton beginning in 2025 with annual price increases of $5 per ton per year.[105] Each scenario is discussed below.

- Carbon Regulation and BAU Gas Scenario

Under this scenario, the PJM Eastern Interconnect expansion plan reflected hastened retirement of coal generation due to carbon prices, which was primarily replaced with NGCC and solar resources.[106]

- Carbon Regulation and Low Gas Scenario

[99] IRP at 12-13 and 17.

[100] IRP at 18.

[101] IRP at 18.

[102] IRP at 18.

[103] IRP at 20-21.

[104] IRP at 20-21.

[105] IRP at 30; *see also* Duke Kentucky's Responses to Staff's First Request for Information, Item 8.

[106] IRP at 21-22.

The low gas prices of this scenario hasten the retirement of coal units and favor NGCC generation and solar.[107]

- Carbon Regulation and High Gas Scenario

The high gas prices in this scenario drive up power prices, which benefits coal generation in the early years and encourages the addition of renewables. Nuclear generation ultimately becomes the primary source of energy for PJM.[108]

- No Carbon Regulation and BAU Gas Scenario

Nuclear and coal units continued to operate until their useful lives were reached and then largely replaced with NGCC generation. Renewable generation expands as relative costs decline.[109]

- No Carbon Regulation and Low Gas Scenario

Persistent low gas prices and the absence of a carbon price produce the lowest energy prices of the six scenarios. Here, there was a significant increase in PJM's reliance on NGCC generation.[110]

- No Carbon Regulation and High Gas Scenario

Under this scenario, coal and nuclear generation decline slowly over the forecast horizon. The higher gas prices strengthen the adoption of renewables.[111]

Duke Kentucky Portfolio Modeling

Duke Kentucky's PJM Eastern Interconnect modeling scenarios produced widely divergent market power prices.[112] Duke Kentucky argued that this highlighted the need for its preferred generation portfolio to preserve the ability to adapt to ever-changing circumstances.[113] Using the results of the modeled PJM hourly energy prices, Duke Kentucky created six scenario-optimized portfolios, two transitional portfolios, and four East Bend 2 replacement strategy portfolios.

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[107] IRP at 25.

[108] IRP at 24.

[109] IRP at 27.

[110] IRP at 29-30.

[111] IRP at 27-28.

[112] IRP, Figure 3.8 at 31.

[113] IRP at 30-31.

Duke Kentucky included its minimum reserve margin requirement of 8.7 percent on a PJM-required UCAP basis in all portfolio analyses.[114] This reserve margin was based on Duke Kentucky's most recently established PJM UCAP reserve margin requirement. Duke Kentucky indicated that using its most recent reserve margin requirement provided a reasonable estimate, but it indicated that it understood that the requirement was subject to change.[115]

The scenario-optimized portfolios modeled carbon regulation in the presence of high, low, and base gas prices and then no carbon regulation with high, low, and base gas prices.[116] Results indicate that with high or base gas prices and no carbon regulation, there was essentially no change in Duke Kentucky's existing portfolio.[117] In the presence of low gas prices or with carbon regulation, East Bend 2 retired much earlier and renewable generation was added as early as 2025 with carbon regulation.[118] Interestingly, with carbon regulation and base gas prices, NGCC takes up much of the generation loss from East Bend 2 in 2025. With carbon regulation and low gas prices Combustion Turbines (CT) take up much of the generation loss from East Bend 2 in 2025.[119] The buildout of solar generation was accelerated only in the presence of carbon regulation and base or high gas prices. The presence of low gas prices tends to accelerate the retirement of East Bend 2, regardless of carbon regulation.[120]

Finally, the four East Bend 2 replacement portfolio scenarios were developed to better understand the trade-offs and impacts of retiring East Bend 2 in 2030.[121] Replacement strategy 1 entailed converting East Bend Unit 2 from coal fired to gas fired.[122] This resulted in a reduced capacity factor, higher variable costs and a greater reliance on market purchases through PJM.[123] Under replacement strategies 2 and 3, East Bend 2's 600 MW was replaced with 611 MW Combined Cycle (CC) and 580 MW CT respectively.[124] The tradeoff between the two options was that the CC portfolio has higher capital costs, but lower production costs, lower carbon emissions, and a reduced

[114] IRP at 9.

[115] Duke Kentucky's Response to Staff's First Request, Item 5(a).

[116] IRP at 42 and Figure 6.1 at 44 and Figure 6.2 at 46.

[117] IRP at 45 and Figure 6.2 at 46.

[118] IRP at 42, and 45 and Figure 6.2 at 46.

[119] IRP, Figure 6.1 at 44.

[120] IRP, Figure 6.1 at 44 and 6.2 at 46.

[121] IRP at 49 and Figure 6.4 at 50-51.

[122] IRP at 49.

[123] IRP at 49.

[124] IRP at 49.

reliance on market purchases. The CT portfolio has lower capital costs, but higher production costs.[125] For the last replacement strategy, East Bend 2 was replaced with a significant amount of renewable resources. The final portfolio included solar, wind, and battery resources. CT resources were also added to overcome the intermittent nature of the renewable resources. Even though 600 MW were retired, more MWs of renewable and gas resources needed to be added to compensate for the lower capacity factors and to not place too great of a reliance on market purchases.[126]

Finally, two transitional portfolios were developed (Transitional A and Transitional B) to explore different trajectories the generation fleet could take with respect to different levels of renewable addition buildouts with East Bend 2 retiring in 2034.[127] Transitional A modeled a gradual buildout of solar and Transitional B had a more aggressive buildout. The results show that with the 2035 East Bend 2 retirement, Transitional A adds 605 MW of an FDR versus only 363 MW in Transitional B.[128] Conversely, Transitional B required a larger generation fleet overall, amounting to an additional 428 MW of capacity versus Transitional A due to the lower capacity factor from the additional renewables.[129]

Duke Kentucky modeled one additional scenario based on varying the assumptions behind its BAU case. The scenario anticipates a 20 percent capital cost reduction in renewables.[130] Duke Kentucky avers that this reduction could stem from technological innovation, cost reductions in manufacturing, or tax incentives over the planning period.[131] In this scenario, assuming no carbon regulation, no renewable generation was selected, despite the lower cost, partially due to the lack of Duke Kentucky's projected resource need.[132] Alternatively, in the scenario with carbon regulation, solar was selected within two years of carbon regulation becoming effective and East Bend 2 was retired in the 2026-2027 period.[133]

2021 IRP Portfolio

Several metrics factored into Duke Kentucky's selection of the 2021 IRP optimal resource portfolio, including near-term cost competitiveness, fleet diversity, PVRR, CO_2

[125] IRP at 49 and Figure 6.4 at 50-51.

[126] IRP at 49 and Figure 6.4 at 51.

[127] IRP at 47 and Figure 6.4 at 48.

[128] IRP at 4. For modeling purposes, the Firm Dispatchable Resource was modeled with the characteristics of a natural gas combined cycle unit as a place holder.

[129] IRP at 47-48 and Figure 6.4 at 48.

[130] IRP at 52.

[131] IRP at 52.

[132] IRP at 53-54.

[133] IRP at 53-54.

emissions, and market exposure.[134] Based on its analysis, the Transitional A portfolio was selected as the best plan of action for Duke Kentucky, as it transitioned to renewable generation while maintaining the flexibility to respond to a future involving carbon regulation.[135] Duke Kentucky's 2021 IRP portfolio is shown below.

Duke Kentucky Optimal Generation Portfolio MW and Reserve Margin[136]

Resource	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
East Bend 2	600	600	600	600	600	600	600	600	600	600	600	600	600	600	0
Woodsdale CTs	564	564	564	564	564	564	564	564	564	564	564	564	564	564	564
FDR*															605
Solar	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Battery	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Wind				40	50	60	70	80	90	100	110	120	130	140	150
TOTAL	1176	1188	1200	1252	1274	1296	1318	1340	1362	1384	1406	1428	1450	1472	1499
Demand Forecast	815	822	836	840	851	853	854	857	860	870	874	879	885	890	898
Reserve Margin (ICAP)	44%	45%	44%	49%	50%	52%	54%	56%	58%	59%	61%	62%	64%	65%	67%

* Firm Dispatchable Resource

RESPONSES TO PREVIOUS COMMISSION STAFF RECOMMENDATIONS

Commission Staff made several recommendations regarding Duke Kentucky's supply-side resources and environmental compliance in its 2018 IRP, and Duke Kentucky responded to each as indicated below.

- Commission Staff recommended that Duke Kentucky continue to provide a discussion of its efforts to promote cogeneration and its consideration of various forms of renewable and distributed generation. In response to that recommendation, Duke Kentucky stated that it is committed to continually evaluating the economics of all forms

[134] IRP at 64.

[135] IRP at 54-65.

[136] IRP at 65 and Duke Kentucky's response to Commission Staff's First Request, Item 15b. For planning purposes and with current technology, the FDR was modeled with the performance and cost characteristics of a NGCC as a placeholder (IRP at 4). The wind and solar resources represent nameplate capacity (Duke Kentucky's Response to Staff's First Request, Item 24c) and the fossil generation capacity represents installed capacity (ICAP) (IRP at 4). For reliability obligations, PJM requires unforced capacity (UCAP) which is somewhat less than the capacity represented in the preferred portfolio (IRP at 36).

of distributed energy technology and will monitor the impacts caused by FERC 2222, including cogeneration, and the specific benefits that these technologies may bring to our customers. Duke Kentucky noted that its business-development personnel have sought to identify candidates for cogeneration facilities and that inquires have been made with suitable candidates, but that no customers have indicted interest at this time.[137]

- Commission Staff recommended that Duke Kentucky provide a discussion on its compliance with PJM Coincident Peak requirements and identify any noncompliance situations and the reasons for the noncompliance. In response to that recommendation, Duke Kentucky discussed its efforts to comply with PJM's capacity performance requirements. Duke Kentucky's capacity performance requirements do present some challenges to renewable resources due to their intermittent nature; therefore, Duke Kentucky will primarily rely upon renewables for their energy value and hedge value to offset market purchases.[138]

- Commission Staff recommended that Duke Kentucky provide a detailed discussion of any environmental law changes and their impacts as well as an update to its compliance with existing laws and regulations. In response to that recommendation, Duke Kentucky noted that it discussed changes to environmental laws in its 2021 IRP.[139]

- Commission Staff recommended that Duke Kentucky have a preliminary discussion on its future plans for supply-side resources as the East Bend and Woodsdale Stations are approaching the end of their service lives.[140] As noted above, Duke Kentucky focused a substantial part of its 2021 IRP on the potential retirement of those generating stations.

- Commission Staff recommended a more robust discussion on transmission and distribution similar to what Duke Kentucky had in its previous IRPs. In response to that recommendation, Duke Kentucky asserted that it returned to its original format that included more information on its transmission and distribution system.[141]

- Commission Staff recommended Duke Kentucky include a discussion on other non-utility supply sources and how the utility will meet the sustainability goals of commercial and industrial customers. In response to that recommendation, Duke Kentucky stated that it works with customers in ways that can help them meet their

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[137] IRP, Appendix F at 157-158.

[138] IRP, Appendix F at 158.

[139] IRP, Appendix F at 159.

[140] IRP, Appendix F at 159.

[141] IRP, Appendix F at 159-160.

respective sustainability goals and is working to transition its generating fleet in a way that is in the best interest of customers, helps advance customer sustainability goals and attracts new customers to the service territory.[142]

- Commission Staff recommended Duke Kentucky provide how the utility models for impacts that occur behind the meter, specifically with renewable energy sources. In response to that recommendation, Duke Kentucky stated that behind-the-meter generation is modeled as a reduction in the load forecast.[143]

INTERVENOR COMMENTS

Attorney General

The Attorney General had several observations generally regarding Duke Kentucky's optimal portfolio.[144]

- Kentucky's climate does not have adequate renewable resource capacity for large-scale, rapid adoption that is cost-effective for ratepayers.

- The intermittent nature of renewable supply-side resources carries reliability risks.

- The IRP regulations do not require utilities to factor in the additional transmission costs of wheeling power from out of state.

- Utility bills will increase with the transition to renewable energy.

- Renewable resources cannot support baseload generation and lack the ability to meet increased demand.

- There are significant transmission and grid issues with increased penetration of renewable resources.

- Kentucky has not adopted a renewable energy policy, and its statutes (KRS 278.020(1)(c)) support the burning of coal.

The Attorney General concluded that the Commission and Duke Kentucky should ensure that increased renewable adoption does not sacrifice affordability and reliability. In addition, fossil fuel plants should be operated as long as economically feasible to

[142] IRP, Appendix F at 160.

[143] IRP, Appendix F at 160.

[144] Attorney General's Comments, (filed Jan. 13, 2022) at 1-4.

minimize stranded costs arising from the retirement of plants before the end of their useful lives.[145]

Sierra Club

The Sierra Club's comments focused on the optimal portfolio's accelerated retirement of East Bend 2 from 2041 to 2035 and argued that with a clean energy portfolio, East Bend could be retired in the 2022-2024 timeframe. The Sierra Club submitted Technical Comments that contained a high level analysis of a clean energy portfolio.[146] In its comments, the Sierra Club argued that with a clean energy portfolio containing EE, DR, wind, utility scale solar, and battery storage resources, East Bend 2 could be retired as early as 2022-2024, depending on the level of DSM, which could save ratepayers between $61 million and $239 million through 2035.[147]

DISCUSSION OF REASONABLENESS

Commission Staff realizes that the IRP is simply a triennial snapshot in time and that changes in technology costs, supply disruptions and especially changing environmental requirements create risks that can greatly alter long-range plans. Commission Staff appreciates Duke Kentucky modeling developments within PJM's energy and capacity markets that will have a direct impact on its long-range plans. Further, Commission Staff is generally satisfied with Duke Kentucky's supply-side and integration analyses, but there is room for improvement. As discussed more fully within each of the recommendations below, Duke Kentucky should continue to be mindful of all material factors and take them into account in its next IRP.

RECOMMENDATIONS FOR DUKE ENERGY KENTUCKY'S NEXT IRP

- For the next IRP, Duke Kentucky should present its portfolio analyses results with a demand forecast that considers the effects of both EE and DR programs.[148] Also, presenting resource capacity values on an ICAP basis is informative; however, since PJM required reserve margins are calculated on a UCAP basis, presenting resource capacity values and reserve margins on a UCAP basis provides a different perspective. This view is important as increasing amounts of renewable generation resources are added to the generation mix. For the next IRP, Duke Kentucky should present results on both an ICAP and UCAP basis.

[145] Attorney General's Comments, (filed Jan. 13, 2022) at 3-4.

[146] *See*, Sierra Club Comments (filed Jan. 10, 2022), Exhibit A at 2. Energy savings are calculated as the net present value of coal plant costs that would be avoided by retirement less the annualized clean energy portfolio costs between 2027-2035.

[147] *See* Sierra Club Comments (filed Jan. 10, 2022) at 3 and Exhibit A at 2.

[148] See Duke Kentucky's Response to Staff's First Request Item 15(b) Attachment.

- The optimal portfolio shows the addition of wind resources starting with 40 MW's and then adding 10 MW blocks annually beginning in 2024 and 10 MW blocks of solar annually beginning in 2021. Kentucky is not typically selected for utility scale wind resources. Even though wind appears to be a cost-effective resource addition to the portfolio, a greater explanation of the practicality and underlying assumptions would lend credence to the selection. Also, even though there are many merchant-utility scale projects being proposed and possibly built in Kentucky, none are being proposed in Duke Kentucky's service territory. For the next IRP, Duke Kentucky should discuss for planning purposes whether these renewable resources will be realistically located in its service territory, in Kentucky or out of state. Also, for resources that are located outside its service territory, the estimated cost of wheeling the energy should be included in the analyses and whether Duke Kentucky is acquiring the capacity and energy through direct ownership, a partnership, or through a PPA.

- The efficiency of solar PV units varies with temperature swings, which impacts its effectiveness in meeting PJM capacity requirements and in meeting Duke Kentucky's needs. For the next IRP, Duke Kentucky should discuss how the evolving performance of solar panels varies and how those variations affect Duke Kentucky's ability to meet its energy and capacity obligations.

- As renewable resources are added to Duke Kentucky's and within PJM's service territories, operational and reliability challenges from intermittent resources could arise. For the next IRP, Duke Kentucky should discuss any issues that it or PJM is facing currently or in the near future, and if there were any issues, how they would be addressed.

- Carbon regulation can take several forms, from gradually increasing prices, set prices and market clearing prices as well as physical emission limitations and how the carbon regulations are applied to which fossil resources. Each will have different impacts on the degree to which resource portfolios/generation fleets evolve over time and the subsequent impact on customers' bills. For the next IRP, Duke Kentucky should test the sensitivity of its portfolios to various forms of carbon regulation. The analyses should include detailed explanations of the underlying assumptions. In addition, Duke Kentucky should include a discussion of the state of carbon capture and sequestration and its potential viability.

- For the next IRP, Duke Kentucky should provide an update to the latest environmental laws and any actions it has taken recently or is planning to take for compliance.

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