COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

ELECTRONIC 2021 JOINT INTEGRATED RESOURCE PLAN OF LOUISVILLE GAS AND ELECTRIC COMPANY AND KENTUCKY UTILITIES COMPANY	))))	**CASE NO. 2021-00393**

RESPONSE OF LOUISVILLE GAS AND ELECTRIC COMPANY AND KENTUCKY UTILITIES COMPANY TO THE ATTORNEY GENERAL'S SUPPLEMENTAL DATA REQUESTS

DATED MARCH 4, 2022

FILED: MARCH 25, 2022

VERIFICATION

COMMONWEALTH OF KENTUCKY)

COUNTY OF JEFFERSON)

The undersigned, **Christopher D. Balmer**, being duly sworn, deposes and says that he is Director – Transmission Strategy and Planning for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge, and belief.

Chr D Balmer

Christopher D. Balmer

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 24th day of March 2022.

Judy Schooler

Notary Public

Notary Public ID No. 603967

My Commission Expires:

July 11, 2022

VERIFICATION

COMMONWEALTH OF KENTUCKY)
)
COUNTY OF JEFFERSON)

The undersigned, **Robert M. Conroy**, being duly sworn, deposes and says that he is Vice President, State Regulation and Rates, for Kentucky Utilities Company and Louisville Gas and Electric Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge, and belief.

Robert M. Conroy

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 22nd day of March 2022.

Notary Public

Notary Public ID No. 603967

My Commission Expires:

July 11, 2022

VERIFICATION

COMMONWEALTH OF KENTUCKY)
)
COUNTY OF JEFFERSON)

The undersigned, **Christopher M. Garrett**, being duly sworn, deposes and says that he is Controller for Kentucky Utilities Company and Louisville Gas and Electric Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge, and belief.

DocuSigned by:
Christopher M. Garrett
Christopher M. Garrett

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 22nd day of March 2022.

Notary Public

Notary Public ID No. 603967

My Commission Expires:

July 11, 2022

VERIFICATION

COMMONWEALTH OF KENTUCKY)
)
COUNTY OF JEFFERSON)

The undersigned, **Charles R. Schram**, being duly sworn, deposes and says that he is Director – Power Supply for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge, and belief.

Charles R. Schram

Charles R. Schram

Subscribed and sworn to before me, a Notary Public in and before said County and State this 22nd day of March 2022.

Judy Schooler

Notary Public

Notary Public ID No. 603967

My Commission Expires:

July 11, 2022

VERIFICATION

COMMONWEALTH OF KENTUCKY)
)
COUNTY OF JEFFERSON)

The undersigned, **David S. Sinclair**, being duly sworn, deposes and says that he is Vice President, Energy Supply and Analysis for Kentucky Utilities Company and Louisville Gas and Electric Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge, and belief.

David S. Sinclair

David S. Sinclair

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 22nd day of March 2022.

Judy Schooler

Notary Public

Notary Public ID No. 603967

My Commission Expires:

July 11, 2022

VERIFICATION

COMMONWEALTH OF KENTUCKY)
)
COUNTY OF JEFFERSON)

The undersigned, **Stuart A. Wilson**, being duly sworn, deposes and says that he is Director, Energy Planning, Analysis & Forecasting for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge, and belief.

Stuart A. Wilson

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 22nd day of March 2022.

Notary Public

Notary Public ID No. 603967

My Commission Expires:

July 11, 2022

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to Attorney General's Supplemental Request for Information
Dated March 4, 2022

Case No. 2021-00393

Question No. 1

Responding Witness: Stuart A. Wilson

Q-1. Given that the Companies expect to become winter-peaking utilities in the near future, provide a discussion regarding the impact of the following issues on the Companies' IRP process:

a. the presence, or absence of any winter-time distributed energy resources (including any behind-the-meter resources);

b. any increased adoption of EVs;

c. capacity factor ratings, and projected dispatch rates of the Companies': (i) fossil fuel plants; and (ii) renewable energy plants (including renewable energy procured via PPAs, and customers' exercising of Green Tariff Option # 3;

d. what potential, if any, there may be for enhancing summertime off-system sales into RTOs such as PJM in which most LSEs are summer-peaking;

e. what potential, if any, there may be for purchasing energy during wintertime peaks through the SEEM. Include in your response whether each SEEM member is a winter or summer peaking utility.

A-1. The combined Companies do not expect to become winter-peaking utilities in the near future. In the base load forecast, the combined Companies do not become winter peaking at any point in the IRP planning period. The combined Companies become winter peaking at the end of the IRP planning period in the low load forecast and earlier in the high load forecast because of the increased saturation of electric space heating.

a. Almost all distributed generation in the Companies' service territory, both current and forecasted, is solar generation. Solar increases the summer reserve margin without increasing the winter reserve margin. See the response to AG 1-18.

b. The base load forecast assumes EVs will account for less than 4% of new vehicle sales by 2030. Furthermore, the IRP assumes a managed charging load profile for EVs. As a result, EVs do not have a material impact on summer or winter peak demands in any forecast scenario. See Figures 5-21 and 5-22 in IRP Volume I.

c. Forecasted capacity factors for the base load, base fuel case are available in Table 8-4 in IRP Volume I. As more solar generation is added to the Companies' generation portfolio, the Companies' fossil fuel plants will dispatch at lower levels during daylight hours, particularly in the summer months when days are typically less cloudy. Any increases in winter energy requirements would primarily be served by the Companies' fossil fuel plants. Renewable capacity factors and dispatch are not impacted by load changes.

d. The Companies have not performed any analysis regarding the potential for enhanced off-system sales as part of the IRP analysis.

e. The Companies do not know the potential for purchasing economy energy from SEEM during winter peaks, but any such purchases would be considered non-firm. Non-firm purchases and sales can be cut for any or no reason. The Companies do not have information as to the winter or summer peaking nature of SEEM participants.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to Attorney General's Supplemental Request for Information
Dated March 4, 2022

Case No. 2021-00393

Question No. 2

Responding Witness: Christopher D. Balmer / Stuart A. Wilson

Q-2. Reference the 2021 IRP Vol. III, 2021 RTO Membership Analysis.

a. Explain whether the impact of the Companies becoming winter-peaking utilities in any manner affects the conclusions of the 2021 RTO Membership Analysis, and if so, how.

b. Referring in particular to pp. 5-6, explain the factors and "combination of assumptions" upon which the Companies relied for the high-favorability case as reflected in the green bars in Figures 1 and 2.

c. Referring to Table 2 on p. 7: (i) explain whether the row depicting Energy Market Benefits takes into consideration any additional benefits the Companies may realize through participating in the SEEM; and (ii) explain the degree of certainty the Companies have with the row depicting the elimination of depancaking.

d. Referring to p. 7, discuss: (i) whether the Companies anticipate that prices for financial hedge products through the planning period will increase or decrease; and (ii) whether the Companies' analysis included the potential for joint purchase / construction of generation resources with other utilities / LSEs, and if not, why not.

e. Explain whether the procurement of energy for purposes of meeting customer demand via exercises of Green Tariff Option # 3 was modelled in the RTO membership analysis; in other words, whether procuring the power to meet a Green Tariff Option # 3 demand would be more cost effective if the Companies were to become members of an RTO, and if so, how that in turn affects the overall analysis of whether RTO membership is cost-effective.

f. Referring also to the 2021 IRP Vol. III, Resource Screening Analysis, § 2.1.3 "Energy Storage," discuss whether the addition of battery storage could affect the cost-effectiveness of the decision of whether to join an RTO, and if so: (i) how; and (ii) what level of battery storage adoption begins to affect this decision.

A-2.

a. See the responses to Question No. 1 and PSC 2-5(a).

b. Sections 7 and 8 of the RTO Analysis describe the assumptions for each scenario of the cost and benefit components, respectively. Appendix A further details the inputs for each scenario (see the column labeled "High Favorability Case." The results for each component are shown in Appendix B (see the tables labeled "High Case" for both MISO on p. 47 and PJM on p. 49).

c.

(i) No, SEEM was not included in the RTO Analysis.

(ii) Table 2 on page 7 of the RTO Analysis report shows the variances in the PJM mid and high favorability cases for specific categories. The variance in the depancaking expense is based on an assumed 20% increase in MISO's driveout transmission rate, thereby increasing the Companies' depancaking obligation.

d.

(i) The Companies have no way of predicting future hedge prices.

(ii) The RTO Analysis did not consider joint resources because it was a high-level screening analysis.

e. The RTO Analysis did not evaluate the potential impact to Green Tariff Option #3 costs. Customers interested in Green Tariff Option #3 have generally expressed a preference to have additional renewables developed within Kentucky.

f. The Companies have not performed this analysis.

LOUISVILLE GAS AND ELECTRIC COMPANY
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Response to Attorney General's Supplemental Request for Information
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Case No. 2021-00393

Question No. 3

Responding Witness: Davis S. Sinclair / Stuart A. Wilson

Q-3. Provide a discussion regarding how the failure of the U.S. to secure a stable supply chain independent of China for the minerals involved in the production of EV batteries could affect the planning set forth in the current IRP regarding the penetration and adoption of EVs in the Commonwealth.

A-3. See the response to Question 1(b). Slower than forecasted growth in EVs will not have a material impact on the Companies' resource planning.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to Attorney General's Supplemental Request for Information
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Case No. 2021-00393

Question No. 4

Responding Witness: David S. Sinclair / Stuart A. Wilson

Q-4. Reference the article, "*Overwhelmed by Solar Projects, the Nation's Largest Grid Operator Seeks a Two-Year Pause on Approvals*," accessible at the link in the footnote below.[1] Provide a discussion regarding the impact that PJM's recent decision to impose a two- year delay on approving pending interconnection requests will have on the Companies' plans to procure more solar PV generation, whether through PPAs, Green Tariff Option # 3, or self-built facilities. Include in your discussion, at a minimum, the following:

a. What weight, if any, the Companies give to new solar generation projects having a PJM or MISO interconnection whether for PPAs, Green Tariff Option # 3, or self-built facilities, and how such an interconnection contributes to the project's cost-effectiveness.

b. Confirm that according to the article, PJM is cautioning that interconnection requests not yet filed may take even longer than the 2-year wait being imposed on projects that have already been filed.

c. Explain whether any delays in obtaining the requisite PJM interconnection approvals would cause the Companies to examine alternative sources.

A-4. A delay in PJM to approve interconnection requests could potentially make new resources in PJM less able to respond to an RFP from the Companies for resources needed in the near term. Because the Companies are not in PJM, PJM's interconnection delays will have no effect on the Companies' potential self-build options.

a. The Companies do not give any weight to resources with a PJM or MISO interconnection. Potential new resources are evaluated based on their

[1] https://insideclimatenews.org/news/02022022/pjm-solar-backlog-eastern-power-grid/?utm_source=Energy+News+Network+daily+email+digests&utm_campaign=61787f76f4-EMAIL_CAMPAIGN_2020_05_11_11_46_COPY_01&utm_medium=email&utm_term=0_724b1f01f5-61787f76f4-89280531 (last accessed February 2, 2022).

contribution to reliably serving load at the lowest reasonable cost. Interconnection costs are very site-specific, whether located in an RTO or not.

b. The Companies agree that is what the cited article says.

c. The Companies are open to considering resource alternatives in any location. See the responses to part (a) and Question No. 2(e).

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to Attorney General's Supplemental Request for Information
Dated March 4, 2022

Case No. 2021-00393

Question No. 5

Responding Witness: Stuart A. Wilson

Q-5. Reference the 2021 IRP Vol. III, Resource Screening Analysis, Executive Summary, p. 3.

a. Provide a foundational source for the statement that "Based on the Biden administration's energy policy and the national focus on moving to clean energy, the current environment does not support the installation of NGCC without CCS due to its CO_2 emissions."

b. If the Companies are aware of a successful, operational CCS project anywhere in the world, please provide the name, location and all available operational statistics establishing its cost viability.

c. If the Companies are unable to provide an example in response to subpart b., above, please confirm this means that tying CCS to NGCC effectively eliminates NGCC as a viable resource option.

A-5.

a. See the response to PSC 2-2(a).

b. According to Bloomberg New Energy Finance's (BNEF) CCUS Database, there are 226 operational carbon capture projects in the world, including 29 operational projects at power plants.[2] The Companies do not have cost viability information for all of these projects. Please refer to IRP Vol. III, Executive Summary, Table 1 for the NGCC with CCS cost inputs from NREL ATB.

The Companies, in partnership with the University of Kentucky, have successfully operated a 0.7 MW carbon capture system since 2014 at the E.W. Brown Generating Station in Mercer County, Kentucky. The economic and operational data can be viewed in the "Application of a Heat Integrated Post-combustion CO_2 Capture System with Hitachi Advanced Solvent into Existing

[2] Bloomberg New Energy Finance CCUS Database 1.2.
https://www.bnef.com/login?r=%2Finsights%2F25795%3Fe%3DInsight%2520Alert%3Asailthru

Coal-Fired Power Plant"[3] and "Final Technical and Economic Feasibility Study on The Application of a Heat Integrated Post-Combustion CO_2 Capture System with Hitachi Advanced Solvent into Existing Coal-Fired Power Plant."[4] Please see IRP Volume I, "Carbon Capture Research" on page 8-34 for additional information on the Companies' work in CCS.

According to BNEF's CCUS database, the world's largest operational CCS unit at a power plant is the Boundary Dam Carbon Capture and Storage project at SaskPower's Boundary Dam Power Station located in Estevan, Saskatchewan, Canada.[5] The CCS unit became operational in 2014 and has captured over 4.7 million tons of carbon dioxide according to the March 9, 2022, status update.[6] The carbon capture unit was retrofitted onto Unit 3 of the coal-fired power plant and had a total project cost of $1.35 billion CAD (~$1.22 billion USD[7]) according to the Canadian government.[8]

c. See the response to part (b).

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[3] Liu, Kunlei, Nikolic, Heather, Thompson, Jesse, Frimpong, Reynolds, Richburg, Lisa, Abad, Keemia, Bhatnagar, Saloni, Irvin, Bradley, Landon, James, Li, Wei, Matin, Naser Seyed, Pelgen, Jonathan, Placido, Andrew, Whitney, Clayton, Bhown, Abhoyjit, and Du, Yang, *Application of a Heat Integrated Post-combustion CO_2 Capture System with Hitachi Advanced Solvent into Existing Coal-Fired Power Plant (Final Technical Report)*, 2020, https://doi.org/10.2172/1635102. https://www.osti.gov/servlets/purl/1635102.

[4] Bhown, Abhoyjit, Schoff, Ron, Maxson, Andrew, Du, Yang, and Jimenez, Alex, Liu, Kunlei, Neathery, Jim, Remias, Joe, Thompson, Jesse, Richburg, Lisa, Placido, Andrew, Nikolic, Heather, Bartone, Mike, White, Jay, Eswaran, Sandhya and Wu, Song, *Final Technical and Economic Feasibility Study on The Application of a Heat Integrated Post-Combustion CO_2 Capture System with Hitachi Advanced Solvent into Existing Coal-Fired Power Plant*, 2020.

[5] SaskPower, *Boundary Dam Carbon Capture Project*, https://www.saskpower.com/Our-Power-Future/Infrastructure-Projects/Carbon-Capture-and-Storage/Boundary-Dam-Carbon-Capture-Project (accessed Mar. 14, 2022).

[6] SaskPower, *BD3 Status Update: February 2022*, https://www.saskpower.com/about-us/our-company/blog/2022/bd3-status-update-february-2022 (accessed Mar. 14, 2022)

[7] 1 USD = 1.1048 CAD average exchange rate in 2014.

[8] Government of Canada, *Boundary Dam Integrated Carbon Capture and Storage Demonstration Project*, https://www.nrcan.gc.ca/energy/publications/16235 (accessed Mar. 14, 2022).

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KENTUCKY UTILITIES COMPANY

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Question No. 6

Responding Witness: Stuart A. Wilson

Q-6. Reference the 2021 IRP Vol. III, Resource Screening Analysis, Executive Summary, p. 3. Confirm that the "battery storage" identified as a resource in Table 1 assumes the batteries would be composed of rare earth lithium-ion, and other rare earths such as nickel and cobalt.

a. Based on the article accessible at the footnote below,[9] confirm that due to demand outstripping supply, prices for lithium-ion batteries are forecasted to skyrocket.

b. Explain whether the Companies' capital cost (which apparently is based on NREL's 2021 Annual Technology Baseline) calculations took into consideration this forecast for skyrocketing lithium-ion prices.

A-6. Confirmed. The battery storage technology option in NREL's 2021 ATB is lithium-ion.

a. The linked article enumerates recent and potentially ongoing supply chain issues for lithium-ion batteries in the near-term. Specifically, the article mentions that a formerly expected price of $100/kWh by 2024 is "looking increasingly elusive." The article does not contain a forecast of battery prices. Furthermore, the earliest battery storage is included as part of a least-cost resource plan is 2029, and the article states, "Choke points in the battery supply chain should be ironed out toward the latter half of the decade as new mining projects come on line."

b. As noted, the source of the Companies' forecast of cost and operating inputs for all generation resources in the 2021 IRP including battery storage is NREL's 2021 ATB, which was published well before the linked article and shows battery storage capital costs decreasing over the long term. Any actual resource decisions will be based on actual resource costs at the time.

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[9] https://www.wsj.com/articles/rising-battery-prices-add-uncertainty-to-electric-vehicle-costs-11644062402 (last accessed Feb. 25, 2022)

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to Attorney General's Supplemental Request for Information
Dated March 4, 2022

Case No. 2021-00393

Question No. 7

Responding Witness: Stuart A. Wilson

Q-7. Reference the 2021 IRP Vol. III, 2021 RTO Membership Analysis generally. Discuss how EV penetration will or could affect the decision on whether to remain a stand- alone combined utility, or to join an RTO.

A-7. See the response to Question Nos. 1(b) and 3. EV penetration should not materially affect this decision.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to Attorney General's Supplemental Request for Information
Dated March 4, 2022

Case No. 2021-00393

Question No. 8

Responding Witness: Christopher D. Balmer

Q-8. Discuss whether the Companies believe that as more of its fossil fuel plants are retired in the near future and replaced by a growing amount of renewable resources, the Companies may have to consider utilizing grid-forming technologies. Include in your discussion: (i) any cost implications; and (ii) whether this potential need increases if the Companies remain as stand-alone utilities.

A-8.

(i) As synchronous generation is retired and removed from the system, there is less short circuit strength and lower inertia available to support grid disturbances. Inertia retards the decay of frequency, keeping it at or near 60 Hz, and short circuit strength provides ride-through capability for intermittent or sustained oscillations. Grid Forming Technologies typically refer to grid-forming inverters. Inverters are the equipment that converts DC power to AC power for intermittent generation resources such as wind, solar, and energy storage. When a generating resource has sufficient headroom, most inverters follow the grid and adapt their output to match the electric system, as long as the output remains within a set bandwidth. Outside of that bandwidth, grid-*following* inverters cease to function. Grid-*forming* inverters, on the other hand, can generate power in the absence of perfect grid conditions (i.e., voltage and frequency variations or oscillations). Grid-forming inverters provide the following benefits:

- Allow the renewable generator to stay connected to the grid during disturbances
- Mitigate unstable oscillations
- Control Frequency when used with load-following batteries

Other options which provide some short circuit strength are:

- Synchronous condensers converted from existing retired coal plants
- New synchronous condensers
- Flywheel energy storage systems

Unless additional synchronous capacity is added to the electric system as inverter-based generation continues to grow, it is likely that all inverters for renewable generation will require Grid Forming Technologies to maintain a reliable grid. Small amounts can be supported by the existing generation assets, however as these retire and are removed from the electric system, synchronous assets or grid-forming technologies will be required to maintain proper system voltage and frequency support during disturbances. Ultimately, until generation is retired and studies of powering the grid with renewables are refined with the ever-changing inverter technologies, it is unknown what the cost implications might be. Grid-forming inverters, at the utility scale, are more costly than grid-following inverters since their controls must be very robust. Synchronous condensers and flywheels should also be considered in the package of solutions identified as we reliably incorporate clean energy.

(ii) Due to the interconnected grid, if/when stability issues are present as synchronous generation is retired among all utilities, the reliability issues will be present whether the Companies are stand-alone or not.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

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Question No. 9

Responding Witness: Stuart A. Wilson

Q-9. Reference the 2021 IRP Vol. III, 2021 IRP Resource Screening Analysis, p. 4.

a. Confirm that compared with the Companies' 2018 IRP analysis, capital costs for a 2022 installation of wind and battery technologies has decreased, while capital costs for solar generation have increased; however, capital costs for all three technologies are lower by the end of the current IRP planning period than they were in the 2018 IRP.

   i. Regarding battery technology capital costs, explain the effect that heavy demand from competing sources for lithium ion and other rare earth metals (and, as discussed more fully in the article regarding rising battery prices accessible at the link in the footnote below) will have.

b. Confirm that with the exception of wind resources, fixed O&M costs have increased significantly since the 2018 IRP for all evaluated technologies. If confirmed, explain whether the Companies have any way to determine whether supply chain shortages play any role in the fixed O&M cost escalation.

A-9.

a. Confirmed.

   i. In general, higher demand results in higher prices.

b. Confirmed. The Companies do not have direct knowledge concerning the role supply chain shortages play in fixed O&M cost increases.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to Attorney General's Supplemental Request for Information
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Question No. 10

Responding Witness: Stuart A. Wilson

Q-10. Reference the 2021 IRP Vol. III, 2021 IRP Resource Screening Analysis, § 2.2.1, "Solar," p. 10. Regarding NREL's 2021 ATB projection for increased fixed O&M costs for utility-scale solar, describe the cost elements that constitute fixed O&M.

A-10. See the Companies' responses to PSC 1-42(b) and Louisville Metro 1-4. With regard to solar O&M specifically, the ATB documentation states it is "based on modeled pricing for a 100-MW_{DC}, one-axis tracking systems quoted in Q1 2019 as reported by (Feldman et al., 2021) adjusted from DC to AC." The documentation also states, "The values in the 2021 ATB are higher than those in the 2020 ATB because we include costs in this year's edition of the ATB that were not previously calculated. These include five additional line measures (land lease, property taxes, insurance, asset management, and security) that are added based on feedback collected by Lawrence Berkeley National Laboratory (LBNL) from U.S. solar industry professionals (Wiser et al., 2020)."[10]

[10] See https://atb.nrel.gov/electricity/2021/utility-scale_pv.

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Question No. 11

Responding Witness: Stuart A. Wilson

Q-11. Reference the 2021 IRP Vol. III, 2021 IRP Resource Screening Analysis, § 2.2.2, "Wind," p. 10. Confirm that both the Indiana-based, and the Kentucky-based wind options have higher LCOEs than utility-scale solar.

a. Given that the Kentucky-based wind option had a 27-31% capacity factor while the Indiana-based wind option had a capacity factor of 39-44%, explain if the reason why the Kentucky-based option has a lower LCOE than the Indiana wind option is because no transmission cost was factored into the Kentucky- based option.

b. Explain whether a Kentucky-based wind resource could be sited in a location without access to transmission which the Companies own.

A-11. Confirmed.

a. Confirmed. The only differences between Kentucky wind and Indiana wind are capacity factor and transmissions costs. Excluding transmission costs from the Indiana wind option, which has a higher capacity factor, would cause it to have a lower LCOE than the Kentucky wind option.

b. A Kentucky wind resource could be sited in a location without access to Company-owned transmission.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILTIES COMPANY

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Question No. 12

Responding Witness: Stuart A. Wilson

Q-12. Reference the 2021 IRP Vol. III, 2021 IRP Reserve Margin Analysis, Generation Planning & Analysis generally.

a. Explain and discuss whether the analysis forecasted the potential for future off-system sales. If so, explain whether off-system sales in any manner off-set potential costs with maintaining the Companies' projected reserve margin needs through the IRP planning period. Include in your discussion any potential barriers to enhancing off-system sales.

b. Confirm that under this analysis, the Companies' target reserve margin range during winter is 26% - 35%.

c. Confirm that given the intermittent availability of renewable resources during winter months, batteries would not be a cost-effective resource to meet winter peaks.

A-12.

a. No off-system sales were included.

b. Confirmed.

c. Not confirmed. Batteries are assumed to be connected to the grid and not solely to intermittent resources. As shown in Table 3 of the Long-Term Resource Planning Analysis in Vol. III of the 2021 IRP, the Companies' analysis demonstrated that batteries were part of the least-cost portfolio in the Base and High fuel price scenarios across all load scenarios.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

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Question No. 13

Responding Witness: Stuart A. Wilson

Q-13. Reference the 2021 IRP Vol. III, 2021 IRP Reserve Margin Analysis, Generation Planning & Analysis at pp. 26-27. Confirm that the Companies' careful evaluation of the moment-to-moment availability of the Rhudes Creek Solar Facility will play a key role in any further decisions regarding the Companies' generation portfolio, and winter and summer target reserve margin rates.

A-13. Confirmed.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to Attorney General's Supplemental Request for Information
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Question No. 14

Responding Witness: Stuart A. Wilson

Q-14. Reference the 2021 IRP Vol. III, 2021 IRP Long-Term Resource Planning Analysis, "Table 3: New Generation in Least-Cost Resource Plans." Confirm that:

a. for the period 2026-2030, and depending on the fuel load scenario (low, base or high), the base load scenario projects: (i) solar generation in quantities ranging from 300 MW – 1 GW; (ii) zero batteries; (iii) zero wind; (iv) two SCCTs (each having approximately 220 MW summer capacity).

b. for the period 2031-2036, and depending on the fuel load scenario (low, base or high), the base load scenario projects: (i) solar generation in quantities ranging from 0 MW – 2.4 GW; (ii) batteries in quantities ranging from zero to 1.1 GW; (iii) wind in quantities ranging from zero to 300 MW; (iv) between 0 – 5 SCCTs (each having approximately 220 MW summer capacity).

A-14.

a. Confirmed.

b. Confirmed.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to Attorney General's Supplemental Request for Information
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Question No. 15

Responding Witness: Stuart A. Wilson

Q-15. Reference the 2021 IRP Vol. III, 2021 IRP Long-Term Resource Planning Analysis generally. Provide the parameters for determining whether a fuel price is considered to fall within the low, base or high fuel scenario price. Include in your response an explanation of whether gas prices prevailing at the current time would be considered to fall within the low, base or high fuel scenario price.

A-15. The fuel price forecasts used in the 2021 IRP are intended to reflect a reasonable range of price forecasts. There are many possible outcomes for future fuel prices, with volatility expected across the forecast period including the potential for some prices to occur that are higher or lower than the forecasted range. The Companies have not defined explicit parameters for considering a price to be low, base, or high, other than the price forecasts themselves. For example, if a price occurs that is near or higher than the high price forecast, then one could consider it to be high compared to the range of forecasts the Companies presented. Natural gas futures prices, which have experienced high volatility in recent months due to global events, are currently on the high side of this range.

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Question No. 16

Responding Witness: Stuart A. Wilson

Q-16. Reference the 2021 IRP Vol. III, 2021 IRP Long-Term Resource Planning Analysis, "Table 7: Assumed Unit Retirement Dates." For each unit depicted therein, provide the amount of any projected stranded cost arising from the retirement of that unit.

A-16. The IRP does not contemplate depreciation rates for past investments as these investments are sunk costs. However, if depreciation rates are adjusted gradually over time consistent with projected retirement dates, the level of undepreciated generation assets at retirement should reflect the cost to remove the assets less salvage value. As they do currently, the Companies will continue to consider planned retirement dates when evaluating future investments to ensure the investments are prudent.

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Question No. 17

Responding Witness: David S. Sinclair

Q-17. Reference the 2021 IRP Vol. III, 2021 IRP Long-Term Resource Planning Analysis, "Table 17: New Generation in Least-Cost Resource Plans, Base Load Scenario." Confirm that under this scenario:

a. in 2028 the Companies are likely to submit CPCN applications for: (i) two SCCTs; and (ii) solar generation in quantities ranging from 300 MW to 1 GW, depending on the fuel price scenario.

b. between 2034-2036, the Companies are projected to submit CPCN applications for various types of generation in quantities ranging from 1.1 GW to as much as 3.8 GW, depending on the fuel price scenario.

c. the generation in the 2034-2036 timeframe is cumulative and in addition to the generation forecasted for 2028.

A-17.

a. The need for new generation in a future CPCN filing will be based on an updated load forecast. Furthermore, the analysis supporting a future CPCN filing will consider market-available and self-build generation alternatives- as well as new DSM programs. Given the need for regulatory approval, planning, permitting, construction, and testing, the filing of a CPCN would likely take place 4-6 years in advance of a projected commercial operation date, depending upon the type of generation requested in a CPCN.

b. See the response to part a.

c. Confirmed.

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Question No. 18

Responding Witness: Stuart A. Wilson

Q-18. Reference the 2021 IRP Vol. III, 2021 IRP Long-Term Resource Planning Analysis, "Table 18: New Generation in Least-Cost Resource Plans, High Load Scenario." Confirm that under this scenario, the total quantities of new generation the Companies forecast by 2036 ranges from 4.8 GW to as much as 9 GW, depending on the fuel price scenario.

A-18. Confirmed.

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Question No. 19

Responding Witness: Stuart A. Wilson

Q-19. Reference the 2021 IRP Vol. III, 2021 IRP Long-Term Resource Planning Analysis, "Table 19: New Generation in Least-Cost Resource Plans, Low Load Scenario." Confirm that under this scenario, the total quantities of new generation the Companies forecast by 2036 ranges from 1.1 GW to as much as 3.8 GW, depending on the fuel price scenario.

A-19. Confirmed.

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Question No. 20

Responding Witness: Stuart A. Wilson

Q-20. Explain whether the Companies agree with the following hypothetical scenario, based on the assumption that the Companies procure or build 1,000 MW of solar generation:

a. That solar generation would be available 8 hours of every day (assuming no clouds or other unavoidable curtailments);

b. This means the Companies need 16 hours of storage, equating to 16,000 MWh of battery storage;

c. 2,000 MW of generating capacity is necessary to charge the batteries every day.

d. Therefore, in order to reliably generate 1,000 MW for 24 hours each day, the total resources required would be: 3,000 MW of solar generating capacity and 16,000 MWh of storage capacity.

e. Provide cost estimates for this scenario; provide also a cost estimate for procuring this resource via dispatchable resources.

A-20.

a-e. This scenario contemplates serving a constant load with only solar and battery storage. The Companies agree that the cost of electricity in this scenario would be high, but the IRP does not contemplate a scenario like this; the Companies' load is not constant and the Companies' long-term resource planning analysis considered a much broader set of generation technologies.

The attachments being provided in Excel format contain a high-level estimate of the cost of this solar and battery storage system based on average summer and winter solar generation profiles. Note that the use of average generation profiles likely understates the cost by several orders of magnitude; in the real world, the possibility of several consecutive cloudy days in the winter increases the required amounts of solar and battery storage. Relatedly, see the

Companies' analysis, "Using solar and storage to meet 100% of the electricity requirements of a distribution circuit."[11]

[11] Available at https://lge-ku.com/sites/default/files/Using-Solar-And-Storage-Case-Study-LGE-Highland-1103-Circuit.pdf

The attachments are being provided in separate files in Excel format.

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Question No. 21

Responding Witness: Stuart A. Wilson

Q-21. Assuming the same hypothetical scenario involving the procurement of 1,000 MW of solar generation as discussed in the preceding question, discuss and explain whether the Companies agree with the following:

a. Utility planning for wind and solar generation must include planning for minimum supply;

b. Prudent planning for the meteorological conditions experienced in the Companies' service territories would dictate assumptions for at least 5 consecutive dark cloudy days.

c. Providing a fully reliable 1,000 MW for 24 hours every day during those 5 days of dark cloudy skies means that 120,000 MWh of storage is required.

d. If the Companies under this hypothetical scenario procured 16 hours of storage for evening usage, as discussed in the preceding question, this means an additional 104 hours of storage would have to be procured in order to meet the risk of cloudy days common in this region of the nation.

e. Assuming two sunny days are available to provide the charging time to yield 120,000 MWh, this would require 7,500 MW of generating capacity, which would be in addition to the 3,000 MW of generation capacity necessary to provide the 16,000 MWh of stored energy to meet reliability during the hours when sunlight is unavailable.

f. Therefore, 10,500 MW of capacity would be necessary to insure that 1,000 MW of renewable power is available around the clock.

A-21.

a. The Companies are unsure what is meant by "planning for minimum supply." The Companies have a robust process to consider the value of intermittent resources in all hours, with a focus on the expected contribution to summer and winter peaks. This process applies to the Companies' solar generation at Brown as well as hydro generation at Ohio Falls.

b. The Companies' planning process for evaluating intermittent resources relies upon historical solar irradiance and wind anemometer data, which reflects the historical occurrence of cloudy days.

c. See the responses to Question No. 20. Solar generation can be significantly diminished on a cloudy day, but it likely would not be zero. The possibility of consecutive cloudy days increases the cost of serving a round-the-clock load with a solar and battery storage system because it increases the required amounts of both solar and battery storage.

d. See the responses to Question No. 20 and part c.

e. See the responses to Question No. 20 and part c.

f. See the responses to Question No. 20.

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Question No. 22

Responding Witness: Stuart A. Wilson

Q-22. Explain whether the Companies' storage assumptions are based on operating batteries between 20% to 80%, and not on charging 100% and then draining the battery to zero. If agreed, then explain whether the Companies agree that this reduces available storage to 60% of nameplate capacity, which in turn means the "dark days" 120,000 MWh figure used in the preceding question should not actually be 200,000 MWh.

A-22. The Companies assumed states of charge ("SOC") were limited to between 5% and 95%, not 20% and 80%. Therefore, 90% of the battery's storage is usable. The Companies considered these limits in their analysis of battery storage. See the response to JI 1-57 (c) and (d).

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Question No. 23

Responding Witness: Stuart A. Wilson

Q-23. Provide cost estimates for battery resources identified in each scenario of the instant IRP docket.

A-23. See Table 3 in Section 2.1.3 in the *2021 IRP Resource Screening Analysis*.

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Question No. 24

Responding Witness: Charles R. Schram / David S. Sinclair

Q-24. Provide a discussion regarding the degree with which it will be necessary for the Companies to have stand-by sources of power online and ready to "kick-in" when renewable sources of generation, due to their inherent intermittency, become unavailable. Include in your discussion: (i) the types of resources -- technological, human, and monetary -- required to maintain reliability when a growing amount of the total fleet is based on renewable resources; and (ii) how the Companies' participation in SEEM may assist the Companies in their ability to manage the coordination necessary between renewable and dispatchable resources.

A-24.

(i) The 2021 IRP's reference case included the addition of 2,100 MW of solar, the intermittence of which is supported by the Companies' remaining fleet and the addition of 6 combustion turbines and 300 MW of batteries. Also see the response to Question No. 25.

(ii) The Companies do not anticipate that SEEM transactions will materially contribute to the ability to manage dispatch coordination requirements for the varying generation output of intermittent resources. SEEM transactions will be non-firm and offer a participant the opportunity to submit a bid or offer for energy for each 15-minute trading period. SEEM is not designed to provide resources for system balancing.

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Question No. 25

Responding Witness: Charles R. Schram / David S. Sinclair

Q-25. Provide all cost projections the Companies have prepared of the additional O&M costs that will or may be incurred at the Companies' dispatchable resource plants as additional non-dispatchable resources are brought online in the later part of the IRP planning period, resulting from the dispatchable plants having to be throttled-back in order to make greater use of the non-dispatchable resources. Include in your response any additional stranded costs projected to occur from earlier retirements of dispatchable resources as a result of the increased usage of non-dispatchable resources.

A-25. The Companies have not performed this analysis. The Companies do not anticipate any such stranded costs for existing units. The Companies' generating units routinely adjust to over 100 MW fluctuations in moment-to-moment load, even on mild weather days. Using a unit's ramping capability to change the output level, assuming the unit is already committed, is not viewed as an activity that has a cost associated with it, other than the cost associated with any change in fuel volumes. Instead, gas-fired combustion turbines generally have O&M expenses that are directly related to starts and hours of runtime. As more intermittent resources are added to the system, enough dispatchable units will need to be committed and online to ensure that adequate ramping capabilities are available to meet potential generation intermittency as well as load fluctuations.

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Question No. 26

Responding Witness: Robert M. Conroy / Christopher M. Garrett

Q-26 Reference the response to AG-DR-1-23. Explain whether shareholders, or ratepayers would pay the costs for decommissioning and/or recycling of a self-built solar facility.

a. Provide all estimates the Companies have prepared for costs of decommissioning the Brown Solar Facility, and state whether such costs are imbedded to any extent in current rates.

A-26. The Companies would seek to recover such costs through rates, as they would with any unit decommissioning or retirement costs.

a. Current depreciation rates include a 1% terminal net negative salvage value for the Brown solar facility, approximately $111,000 for KU and $71,000 for LG&E.