COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

ELECTRONIC APPLICATION OF KENTUCKY POWER COMPANY FOR (1) A GENERAL ADJUSTMENT OF ITS RATES FOR ELECTRIC SERVICE; (2) APPROVAL OF TARIFFS AND RIDERS; (3) APPROVAL OF ACCOUNTING PRACTICES TO ESTABLISH REGULATORY ASSETS AND LIABILITIES; (4) A SECURITIZATION FINANCING ORDER; AND (5) ALL OTHER REQUIRED APPROVALS AND RELIEF	)))))))	**CASE NO. 2023-00159**

TESTIMONY OF JOSHUA BILLS

ON BEHALF OF JOINT INTERVENORS MOUNTAIN ASSOCIATION, APPALACHIAN CITIZENS' LAW CENTER, KENTUCKIANS FOR THE COMMONWEALTH, AND KENTUCKY SOLAR ENERGY SOCIETY

October 2, 2023

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I. INTRODUCTIONS & QUALIFICATIONS

Q. Please state for the record your name and business address.

A. My name is Joshua Bills. My business address is 433 Chestnut Street, Berea, Kentucky, 40403.

Q. On whose behalf are you testifying in this proceeding?

A. I am testifying on behalf of Mountain Association, Appalachian Citizens' Law Center, Kentuckians for the Commonwealth, and Kentucky Solar Energy Society (collectively, "Joint Intervenors").

Q. By whom are you employed and in what position?

A. I am employed by Mountain Association as a Senior Energy Analyst.

Q. Please describe your current position.

A. Mountain Association for Community Economic Development, DBA Mountain Association is a Community Development Financial Institution ("CDFI") working with people in eastern Kentucky and Central Appalachia to create economic opportunity, strengthen democracy, and support the sustainable use of natural resources. Our energy programs work to strengthen the region's residents, small businesses, local governments, communities, and non-profits by helping to reduce energy costs and consumption, increase energy security, and build resilience in the face of climate change. Mountain Association has worked with hundreds of small commercial and nonprofit Kentucky Power Company ("Kentucky Power" or "the Company") customers over the last 15 years providing technical assistance and/or financing to access investments in energy efficiency and renewable energy, resulting in reduced customer operating expenses. We have also

assisted contractors with technical trainings and equipment financing to grow their businesses.

I've been employed in energy-related work at Mountain Association since 2008. As a Senior Energy Analyst, I serve as Mountain Association's subject matter expert on commercial energy efficiency and renewable energy. Specific responsibilities include promoting and delivering energy analyses, technical assistance, and energy consulting services to enterprises and local governments in eastern Kentucky for implementing efficiency and renewable energy projects. Such assistance includes utility billing reviews to identify energy cost saving opportunities, supporting clients with project implementation, applying for grants and utility rebates (when available), and evaluating return on investment. Another function of my position is to actively engage in regulatory or legislative changes that could impact our energy sector work.

Q. Please describe your professional background.

A. In regards to my background, I have been involved in energy efficiency and renewable energy work in Kentucky for over 25 years. Prior to Mountain Association, I was a North American Board of Certified Energy Practitioners (NABCEP) Photovoltaic (PV) Installation Board Certified solar installer with over 100 renewable energy installations. My resume is attached to my testimony as Attachment JB-1.

My role upon starting at Mountain Association shifted focus to include commercial energy efficiency, as described earlier. I have been a Certified Energy Manager since 2011. My time is spent supporting enterprises with billing reviews, technical assistance, energy assessments, application assistance for clean energy grants, and educating and advocating for policy supporting opportunities for enterprises to save energy costs. I've

worked with municipal, cooperative, and investor-owned utilities on net metering, community solar, and energy efficiency projects and policies, including the Berea solar farm, two net metering tariffs, and How$martKY™, an inclusive financing program based on the Pay As You Save, or PAYS®,[1] model.

Q. Please describe your educational background.

A. As for education, I obtained a Bachelor of Science in Mechanical Engineering from Washington University in St. Louis, and a Bachelor of Arts in Mathematics from Berea College.

Q. Have you previously filed expert witness testimony in other proceedings before this Commission or before other regulatory commissions?

A. Yes, I have previously filed testimony before this Commission in Kentucky Power's prior rate case, Case No. 2020-00174. In Case No. 2013-00287, I submitted testimony that the Commission construed as a public comment.

Q. What is the purpose of your testimony?

A. The purposes of my testimony are two-fold: (1) to propose a PAYS®[2] program and discuss the importance of accelerating investment in a cost-effective portfolio of DSM/EE Program, especially as customers face a significant rate increase; and (2) to raise certain issues that we have seen impacting the small commercial customers we work with in Kentucky Power Service Territory. These issues include the availability of federal

[1] PAYS® is registered to Energy Efficiency Institute, Inc. *See* Energy Efficiency Inst., Inc., *Pays® Essential Elements & Minimum Program Requirements* (updated July 20, 2021), https://www.eeivt.com/pays-essential-elements-minimum-program-requirements-2/.
[2] *See also Inclusive Utility Investment*, ENERGY STAR (last updated May 2023), https://www.energystar.gov/products/inclusive_utility_investment.

incentives for energy efficiency investments, and barriers to access those for customers taking service under NMS-II and COGEN/SPP I and II tariffs; issues regarding billing transparency for customers subject to a demand charge; and inequitable application of a demand charge to the smallest commercial customers.

II. SUMMARY OF RECOMMENDATIONS

Q. Please summarize Kentucky Power's requests in this proceeding that are relevant to your testimony.

A. Kentucky Power has proposed raising electric rates in order to increase annual revenues by nearly $94 million, which equates to a total increase across all classes of 13.54%.[3] Yet the Company has correctly recognized the "unique economic and financial challenge that [its] customers are facing,"[4] which include paying electric bills even at current base rates. The proposed base rate increases will clearly affect all rate classes. However, my testimony will highlight challenges for residential and small commercial customers in Kentucky Power territory.

Q. What challenges do you see residential and small commercial customers facing?

The resulting increase in average or typical electric bills, due to Kentucky Power's request, would have the largest impact felt first by Residential Service customers, and second by smaller enterprises receiving General Service. These classes would see

[3] Direct Testimony of Cynthia G. Wiseman, *Electronic Application of Kentucky Power Company For (1) A General Adjustment of Its Rates for Electric Service; (2) Approval of Tariffs and Riders; (3) Approval of Accounting Practices to Establish Regulatory Assets and Liabilities; (4) A Securitization Financing Order; and (5) All Other Required Approvals and Relief,* Case No. 2023-00159, at 18: 3–6 (June 29, 2023) ("Wiseman Direct").
[4] *Id.* at 21:7–8.

increases of 18.3% and 12.8%, respectively.[5] The percentage increase by class is summarized in Table JB-1, below.

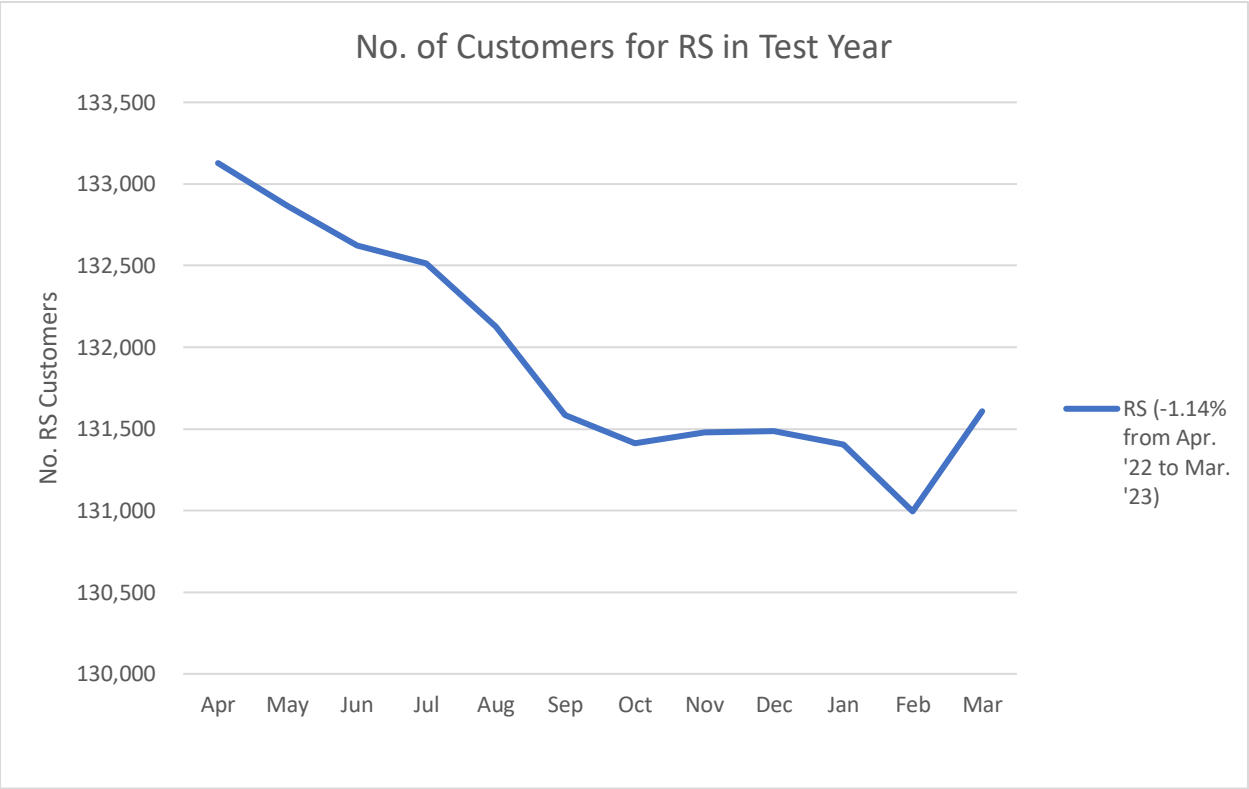
Table JB-1: Kentucky Power Proposed Increase by Rate Class

Electric Rate Class	Year End Adjusted # of Customers	Annual % Increase
Residential Service (RS)	131,610	18.3%
General Service (GS)	29,202	12.8%
Large General Service (LGS)	579	8.9%
Industrial General Service (IGS)	71	8.6%

Kentucky Power is also losing customers; the Company has seen a 1% drop in its customer count since between March 2020 and March 2023.[6] The group most affected by the proposed rate increases, RS, is also notable for loss in customers over the course of the test year.[7] Figure JB-1 shows the number of customers in the RS class for each month of the test year.

[5] Sec. II, Vol. 1, Application Filing Requirements, Ex. I.
[6] Wiseman Direct at 4:19–20.
[7] *See* Response of Kentucky Power Company to Commission Staff's First Request for Information, Case No. 2023-00159, Question 15 (July 13, 2023) ("KPCo Response to Staff Q1.15"), Attach. 3.

Figure JB-1

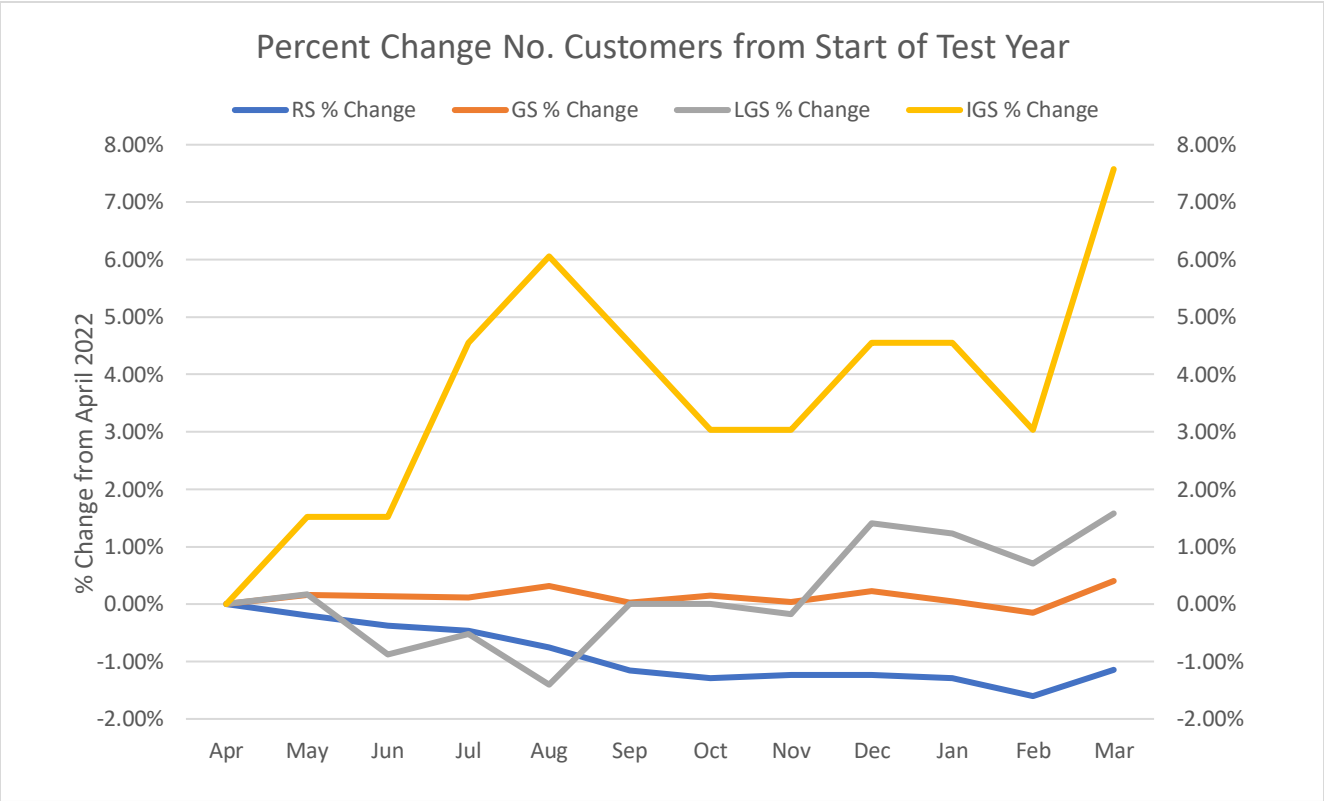


During the test year alone, Kentucky Power lost over 1% of its RS customers (1,518 in total). The dip in customers for the month of February 2023 is also notable, as it was also the month during the test year with the highest applied Fuel Adjustment Clause ($0.05047/kWh).[8]

Comparing customer classes, GS and LGS customers also experienced very slow or zero growth, as shown in Figure JB-2.[9]

[8] Kentucky Power Company's Standard Fuel Adjustment Clause Schedules (Jan. 23, 2023), https://psc.ky.gov/PSCFAC/AEP-Kentucky%20Power%20Company/2022_KP.pdf.
[9] Data from KPCo Response to Staff Q1.15, Attach. 3.

Figure JB-2



The July 24, 2022 flood, with more than eight inches of rain in 48 hours, was nothing short of total devastation for many households and small businesses in Kentucky Power territory. A significant number of customers were lost, mostly smaller load customers—homes, small businesses, organizations, and houses of worship—that, if salvageable, would take many months to recover. GS customers experienced a loss of 87 meters between August and September billing (0.30%, or one out of every 335), while RS customers experienced loss of 540 customers between August and September billing (0.41%, or one out of every 245).[10] Although, by the test year's end in March 2023, the number of GS customers has recovered (24 more than August billing), unfortunately, the number of residential customers in that timeframe has recovered very little, sitting at 515 fewer customers than August billing.

In addition to the challenging economic circumstances that contribute to this customer loss, a declining residential customer base means fewer customers available to share the fixed costs of electric service. This situation surely feeds into Kentucky Power's requested rate increases of 18.3% for homes with RS service and 12.8% for enterprises with GS service, which will certainly exacerbate the challenge of keeping lights on and doors open.

III. KENTUCKY POWER NEEDS TO EQUIP THEIR CUSTOMERS TO MANAGE THEIR OWN ENERGY CONSUMPTION.

Q. Please describe the situation in Kentucky Power's service territory, based on your experience helping customers in the area who are trying to reduce the energy costs.

A. There are significant and persistent economic challenges in Kentucky Power's service territory. Many of these challenges are mentioned in the Company's testimony, including serving counties with unusually high unemployment rates and relatively low labor force participation rates.[11] Although the Company's testimony focuses on recent job declines and population loss,[12] eastern Kentucky's economic challenges go back much further. Indeed, all the counties served by Kentucky Power are federally recognized as "persistent poverty counties," meaning that 20% or more of the population was living in poverty

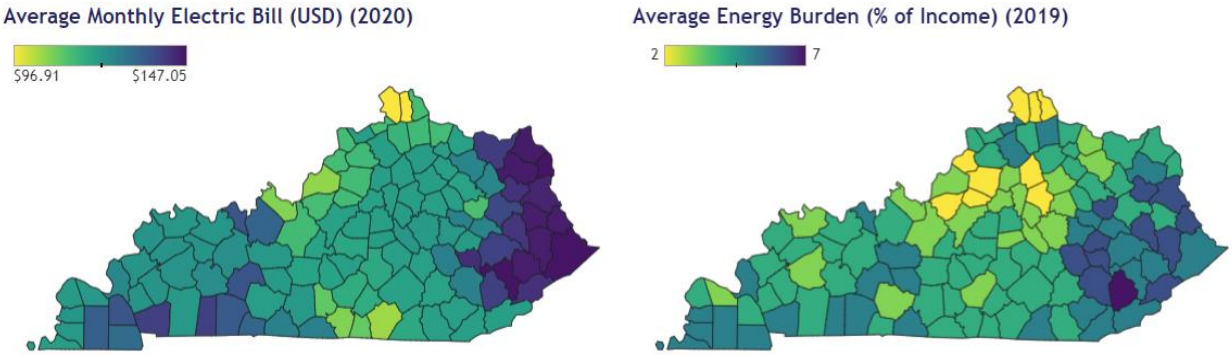
[11] Direct Testimony of Amanda C. Clark, *Electronic Application of Kentucky Power Company For (1) A General Adjustment of Its Rates for Electric Service; (2) Approval of Tariffs and Riders; (3) Approval of Accounting Practices to Establish Regulatory Assets and Liabilities; (4) A Securitization Financing Order; and (5) All Other Required Approvals and Relief*, Case No. 2023-00159, at 4–5 (June 29, 2023) ("Clark Direct").

[12] *See, e.g.*, Wiseman Direct at 5 (describing job and population declines as "now long-term trend in the area . . . that began in the early 2000s.").

over the last 30 years, measured by the 1990 and 2000 decennial censuses and 5-year data series from the American Community Survey of the Bureau of the Census.[13]

Kentucky Power already has the highest residential energy bills in the Commonwealth, reflecting an increase of over 33% since 2010,[14] and the highest energy burdens. The figures below reveal the near complete overlap between Kentucky Power service territory (above) and the state's counties with the highest energy bills and burdens (below, in blue).[15]

[13] Craig Benson, *Persistent Poverty in Counties and Census Tracts*, U.S. Census Bureau (May 9, 2023), https://www.census.gov/library/publications/2023/acs/acs-51.html.
[14] Evan Moser, *Kentucky Energy Profile*, Ky. Energy & Env't Cabinet, at 11–12, 30 (8th ed. 2023), https://eec.ky.gov/Energy/KY%20Energy%20Profile/Kentucky%20Energy%20Profile%202023.pdf.
[15] Kentucky Center for Statistics, *Kentucky Energy Affordability* (2020), https://kystats.ky.gov/Reports/Tableau/2022_EnergyDash (bottom color images).



Many residential customers already cannot afford their electric bills. In 2021, Kentucky Power Company disconnected over 8,100 customers for non-payment;[16] and in the twelve

[16] Selah Goodson Bell, et al., *Powerless in the United States: How Utilities Drive Shutoffs and Energy Injustice*, Ctr. for Biological Diversity et al., at 26 (tbl. 7), https://www.biologicaldiversity.org/programs/energy-justice/pdfs/Powerless-in-the-US_Report.pdf (last accessed Oct. 2, 2023). American Electric Power Company's utility subsidiaries combined could have avoided disconnections for non-payment from 2020 through October 2022 with less than $40 million; AEP paid 105 times that amount in dividends over the same period ($4,156,900,000). *Id.* at 14 (tbl. 5).

months ending June 2023, Kentucky Power Company sent 189,584 termination notices and reported 6,135 residential disconnections for nonpayment.[17]

We have yet to see significant movement or easy opportunities available for residential customers to take steps to save electricity costs—which is even more concerning now, with RS rate class facing a potential average 18.3% increase.

On a brighter note, we have seen opportunities embraced and electricity cost-saving measures implemented by many of the enterprises we work with that are GS and LGS customers. I'll get into those a little later in my testimony, but for now I'd like to point out that for many of the enterprises we have worked with in Kentucky Power service territory, their load reduction measures have not *reduced* billed costs significantly over time, but rather have protected them from increased costs from the multiple rate increases experienced in recent years.

Q. Has Kentucky Power proposed any programs to address the impact of this proposed rate hike on low-income customers?

A. Ms. Cobern's testimony describes the Company's requested changes to programs serving low-income customers, which include raising the renewable energy adjustment (REA) surcharge on residential bills in order to increase the number of customers served by its Home Energy Assistance (HEA) Programs, which include the Home Energy Assistance in Reduced Temperatures (HEART) and Temporary Heating Assistance in Winter

[17] Case No. 2019-00366, *Investigation of Home Energy Assistance Programs Offered by Investor-Owned Utilities Pursuant to KRS 278.285(4)*, Kentucky Power Company Appendix B 2023 Annual Report on Home Energy Assistance Programs (Ky. PSC Aug. 15, 2023) ("KPCo 2023 Annual HEA Report"), KPCO_R_KPSC_A_6_Attachment1 tab "A_6", https://psc.ky.gov/pscecf/2019-00366/mmcaldwell@aep.com/08152023125323/Closed/KPCO_R_KPSC_A_6_Attachment1.xlsx.

(THAW) Programs, and extending the deadline for bill payment from 15 days to 21 days of the mailing date of the bill.[18] I support both proposals and agree that extending the deadline for bill payment will put Kentucky Power closer in line with other investor-owned electric companies. The Company also proposes to provide low-income customers with a bill credit of 50% of the savings from its Distributed Solar Garden proposal. I support this component of the Company's proposal, which Joint Intervenors' witness Andrew McDonald addresses in his testimony.

Q. Do you believe the programs proposed by the Company are sufficient to meet the needs of KPC customers?

A. While I support expanding HEA programs and recognize that raising the REA surcharge and Company match from $0.30 to $0.40 on each monthly RS bill will provide short-term relief to approximately 1,000 additional low-income customers,[19] I also recognize that these programs, as well as the Company's proposed RS seasonal provision, are quick fixes that only address symptoms experienced in winter months. They are not solutions that address the need for customers to make long-term year-round systemic changes through efficiency and customer-sited generation. Indeed, quick fixes can naturally lead to unintended dependency instead of fundamental changes. I do not believe the Company's proposals are sufficient to meet the significant needs of Kentucky Power's customers. The HEA programs and the RS seasonal provision do not target the root of the

[18] *See* Direct Testimony of Stevi N. Cobern, *Electronic Application of Kentucky Power Company For (1) A General Adjustment of Its Rates for Electric Service; (2) Approval of Tariffs and Riders; (3) Approval of Accounting Practices to Establish Regulatory Assets and Liabilities; (4) A Securitization Financing Order; and (5) All Other Required Approvals and Relief,* Case No. 2023-00159, at 2:18–3:1 (June 29, 2023) ("Cobern Direct").
[19] *Id.* at 5:3–7.

problem because they do not equip customers to lower their energy consumption and therefore lower their bills over time.

It is worth noting that the customers receiving assistance from Kentucky Power's HEA Programs have higher electric bills than residential customers do as a whole. From July 2022 to June 2023, the average monthly bills for HEA Program participants were $202.37, whereas average monthly bills were $170.70 for all residential customers.[20] Moreover, Company data shows that hundreds of customers receiving assistance from the HEA Programs experienced monthly bills higher than $500 this past winter.[21]

Company witness Cobern acknowledges the role that inadequate weatherization measures, less efficient appliances, and improper building envelopes play in exacerbating the financial strain for low- and moderate-income households, and the role that energy efficiency improvements can play to reduce customer bills, especially for those with mobile homes, older homes, and electric resistance heat or inefficient heat pumps.[22] Ms. Cobern cites the Company's Targeted Energy Efficiency ("TEE") Program, which provides supplemental funding to Kentucky Housing Corporation's Weatherization Assistance Program for low-income customers, as one of the Company's measures to help its customers manage their energy usage.[23]

[20] KPCo 2023 Annual HEA Report, Attach. KPCO_R_KPSC_A_6_Attachment1 tabs "A_6" & "A_7," *supra* n.17 (totals provided are the average of reported average monthly bill amounts).
[21] *See* KPCo Response to Staff Q.2.12(c), Attach. 2. For example, when searching the "THAW" tab, column labeled "BILL_AMT_JAN23" highest to lowest, in January 2023, 210 customers enrolled in the THAW program had monthly bills greater than $500 and household energy consumption exceeding 3,000 kWh.
[22] Cobern Testimony at 8:7–20.
[23] Response of Kentucky Power Company to Joint Intervenors' Initial Request for Information, Case No. 2023-00159, Question 1.21 (Aug. 28, 2023) ("KPCo Response to JI Q1.21"); Cobern Testimony at 9:18–21 (describing the Company's financial support for weatherization assistance through the TEE Program).

Weatherization assistance for low-income customers is critical, yet only a very small number of customers are served by the Company's TEE Program. On average, between 2019 and 2022, 67 customers per year were served.[24] Moreover, there does not appear to be an adequate link between the HEA Programs and the TEE Program. Only a very small number of the customers enrolled in the Company's HEA Programs received weatherization assistance through the TEE Program; out of the approximately 27,000 customers who received assistance from the HEA Programs in the 2022-2023 program year, only 12 also received weatherization support from the TEE Program.[25]

Q. What would better enable customers to control their energy consumption?

A. In the face of yet another increase in electric rates, Kentucky Power customers need robust targeted programs to empower many more of them to save energy. They also need reduced barriers to implementing customer-sited distributed energy resources (DERs). I will discuss examples of each in this testimony.

Q. Do you recommend the Commission take any action regarding this issue?

A. Yes, before approving any rate increase or considering approval of new investment in generation, transmission, and distribution assets, the Commission should direct the Company to accelerate investment in a cost-effective portfolio of DSM/EE Programs. The portfolio should pursue all potentially cost-effective strategies, be the result of collaborative stakeholder processes, and include an inclusive utility investment program that incorporates the PAYS® essential elements and program requirements.[26]

[24] KPCo Response to JI Q2.3(a).
[25] *Id.* at JI Q2.3(b).
[26] *See* Energy Efficiency Inst., Inc., *Pays® Essential Elements & Minimum Program*

Implementing an inclusive utility investment program can be an effective complement to market-rate programs offering customers rebates and incentives by helping to overcome financial barriers to reducing energy waste and improving energy efficiency.[27]

Q. Can you explain how an inclusive utility investment program such as PAYS® helps to overcome financial barriers to efficiency gains?

A. With an inclusive utility investment program, the utility makes capital investments directly in energy efficiency, load control, and/or storage improvements in their customers' homes and businesses. For some customers, access to the upfront capital needed to make efficiency upgrades to their home is a significant barrier, which inclusive utility investment helps them to overcome.

For example, a household might be ready and motivated to upgrade their electric resistance heating system but may not have access to the kind of cash it takes to make that upgrade. Kentucky Power could choose to make an investment in that energy-saving upgrade (as opposed to buying or generating and delivering energy) by paying those

Requirements (updated July 20, 2021), https://www.eeivt.com/pays-essential-elements-minimum-program-requirements-2/ ("A program based on PAYS® has these essential elements: A fixed monthly tariffed charge assigned to a location, not to an individual customer; Payment on the utility bill with utility cost recovery on the same terms as their other essential utility services; and Independent certification that products are appropriate and savings estimates exceed payments in both the near and long terms.").

[27] *Cf.* Case No. 2022-00392, *Electronic Application of Kentucky Power Company for: (1) Approval of Continuation of Its Targeted Energy Efficiency Program; (2) Authority to Recover Costs and Net Lost Revenues, and to Receive Incentives Associated with the Implementation of Its Demand-Side Management Programs; (3) Acceptance of Its Annual DSM Status Report; and (4) All Other Required Approvals and Relief,* Kentucky Power Company's Notice of Filing Market Potential Study at 3, 4 (Ky. PSC Aug. 11, 2023) ("KPCo 2023 Market Potential Study") ("The gap between economic potential and [Maximum achievable potential] MAP/[Realistically achievable potential] RAP represents market barriers to prospective program participants, both financial and non-financial, to achieving the full amount of economic potential.").

upfront costs and then recovering that investment through a fixed charge on the metered bill.

To be effective, the program model requires clear parameters and protections. First and foremost, the installed improvements pursued must deliver measurable savings that will *reduce* the metered bill's energy charge to an amount greater than the fixed charge intended to recover the utility's investment. That requirement is essential, both for participant- and system-wide cost-effectiveness.

Q. How would Kentucky Power Company develop a program that is adequately protective and valuable to customers and the system overall?

A. Kentucky Power does not have to go it alone, nor reinvent any wheels.[28] Kentucky Power should engage with their stakeholders in a participatory process to develop an inclusive utility investment program that addresses the biggest burdens for participants, all customers, and the company itself.

In terms of program design, I would encourage Kentucky Power to consider alignment with the full DSM/EE Portfolio, targeting participation, applicability beyond efficiency, quality control, and scale.

As I mentioned, a PAYS® program can complement other DSM/EE programs and should be considered as part of a DSM/EE portfolio planning process. Incorporating a PAYS® program alongside rebate and incentive programs will help increase market-rate program participation.

[28] *Id.*at 37 (the same "program archetypes with basic program go-to-market strategies and incentives, *e.g*. rebates, direct-install, marketplace, etc. for Kentucky Power's service territory" are already identified and can be accessed by a broader pool of customers with DSM/EE programs complemented by a PAYS or similar tariff on bill financing).

Kentucky Power should also engage local organizations in the stakeholder process, including those doing flood relief work. By partnering with local groups—from the design phase all the way to implementation—the Company can best understand customer needs and opportunities to align the utility's program with other efforts and strands of funding.

Q. What do you mean by targeting participation?

Program design can be targeted or tailored to prioritize high value savings potential. For example, Kentucky Power could mitigate winter exposure to wholesale energy price risk with programs directed at single-family households and manufactured housing[29] with electric resistance heating or propane heating. Those homes present opportunities to reduce coincidental peak demand and reduce wholesale power cost exposure with a core set of measures that will also make the homes healthier, safer, and more comfortable. Optional measures that could be packaged appropriately for each home could include:

- Upgrading resistance and propane heat to efficient heat pump systems, central or ductless (with minimum HSPF of 8.8), and with inclusion of smart thermostats;
- Whole-home weatherization and air sealing;
- Upgrading to ENERGY STAR-certified windows appropriate for our region[30];

[29] Investment in manufactured housing should be limited to structures that are no more than forty years old, or similarly protective benchmark. By applying a reasonable limit to the age of manufactured homes, Kentucky Power can ensure that it is investing in homes constructed after passage of the 1976 Manufactured Home Construction and Safety Standards and can be expected to have economic lives that continue at least as long as the installed measures.

[30] *See* ENERGY STAR, *What Makes it Energy Star?*, https://www.energystar.gov/products/residential_windows_doors_and_skylights/key_product_criteria (last accessed Oct. 2, 2023).

- Replacing resistance water heaters with more efficient heat pump water heaters where able;
- Installing smart appliances and/or load control;
- Customer-sited solar and battery DERs[31]; and
- Customer-sited electric vehicle charging infrastructure.[32]

This mix of measures would align with a Home Energy Improvement Program considered in Kentucky Power Company's Market Potential Study ("MPS").[33] As contemplated in the MPS, a Home Energy Improvement Program would offer financial incentives and energy audits. Even with incentives, some customers may not be able to bear the upfront costs of new HVAC equipment, or be able to also afford attic insulation, duct insulation, and air sealing to reduce *wasted* heating energy.[34] A PAYS® program helps those customers achieve energy savings that otherwise would have been missed or delayed.

A PAYS® program, especially one inclusive of both residential and small commercial customers, could also be leveraged to help meet peak demand and strengthen the ability to achieve hour-by-hour energy. The program could support investment in measures that

[31] Batteries have the potential to further reduce home electric bills under RS-TOD or Residential Demand (RSD) with TOD components.
[32] For customers who have switched from gas power vehicles to electric vehicles, include the cost for implementing customer's EV charging infrastructure, namely to install an accessible, level 2 EV charging outlet, and give the customer the option to incorporate charging on RS-LM-TOD separately metered provision (with service charge for the separate meter at $4.30 per month) by adding EV charging to the currently approved electric thermal storage space heating and water heating loads allowed with the $4.30 separate metering provision in RS-LM-TOD.
[33] KPCo 2023 Market Potential Study at 40–41 (explaining modeled program design for Home Energy Improvement Program).
[34] *See, e.g.*, Cobern Direct at 8 (noting prevalence of households with inadequate weatherization measures, contributing to higher usage and bills).

increase site-specific resiliency, with potential to be aggregated into a Virtual Power Plant (VPP), as is also discussed in Joint Intervenors' witness Andrew McDonald's testimony. For example, San Diego Gas & Electric has implemented a pilot VPP program to reduce energy demand and put electricity back on the grid during peak hours, "all through leveraging the capabilities of customer-owned smart thermostats, rooftop solar, energy storage and other connected resources such as water pumps."[35] With the "internet of things," direct load control capable appliances can be an additional resource.[36] With energy storage, larger commercial projects can offer wider community benefits with focus on hospitals, emergency shelters, and households with critical medical devices. With storage, it is important that the VPP deployment be limited to a portion of the battery storage in order to leave some room available, if needed, for backup power.

In addition to the residential-targeted measures listed earlier, many of which also apply to business, faith-based, mission-based, and municipal customers, there are also targeted commercial measures that could be included in an inclusive utility investment program:

- Hard-wired LED and other efficient commercial lighting fixtures and controls;
- Refrigeration waste heat recovery for space and water heating;
- Solar alone or with battery storage for load shifting, thus reducing demand charges; and

[35] SDG&E News Release, *SDG&E Pioneers Virtual Power Plant to Help Ease Strain on the Power Grid During Extreme Heat*, SDGE (Aug. 28, 2023), https://www.sdgenews.com/article/sdge-pioneers-virtual-power-plant-help-ease-strain-power-grid-during-extreme-heat. *See also* SDGE, *Shelter Valley Virtual Power Plant Pilot Project*, https://www.sdge.com/major-projects/shelter-valley-virtual-power-plant-pilot-project (last accessed Oct. 2, 2023).

[36] *See* Poushali Pal et al., *IoT-Based Real Time Energy Management of Virtual Power Plant Using PLC for Transactive Energy Framework*, 9 IEEE Access 97643–60 (2021), https://ieeexplore.ieee.org/document/9466870.

- Charging infrastructure for electric vehicles, particularly including school buses, commercial fleets, and bi-directional chargers.[37]

Q. What would make a PAYS® program, or similar program, adequately protective for all involved?

A. There are several things you can bake into program design to make sure the program is successful from the perspective of participants, all customers, and the Company. I mentioned the importance of ensuring that the investment costs are less than the value of energy savings. It is also important to have access to a robust network of contractors, capable of quality work that delivers real savings. To that end, Kentucky Power could also consider playing a role in workforce development.

In terms of participation, the option could be open to all residential and commercial customers (with appropriate measure mixes for each). Within the residential class, participation can include both homeowners and renters—providing everyone with access to capital for energy savings. The more critical qualifiers should be simply whether a structure is retrofit-ready (i.e., structurally sound with no visible health or safety concerns) and whether savings can be cost-effectively achieved.

Q. Do you have any comments on the potential scale of a program?

A. Yes, and this is another important detail. I would recommend Kentucky Power consider at least a ten- to twelve-year commitment of meaningful energy efficiency investment on

[37] P.S.C. KY. No. 12, 1st Rev. Sheet (No. 7-3), Kentucky Power Company, Load Management Time of Day Provision, Tariff Codes 223 and 225 General Services, at 51-52 (effective Aug. 1, 2021), https://psc.ky.gov/tariffs/Electric/Kentucky%20Power%20Company/Tariff.pdf (PAYS® upgrade could include the EV charger and electrical work necessary to install with customer having the option of including as separately metered Load Management Time-Of-Day Provision (Tariff Code 223 and 225)).

the customer side of the meter. Continuing evaluation of the program and mid-term updates would certainly also be warranted, and the minimum ten-year commitment is important for workforce development in particular. Just as customer participation needs to be ramped up over time, some certainty for contractors helps to build the workforce needed to scale programs.[38] If Kentucky Power could begin with reaching 150 to 200 participants in year one, with annual increases of 10–20%, a program could reach 5,000 participants by 2033.

Table JB-3. Possible Participation Targets

Year	Participants
1	200
2	240
3	288
4	346
5	415
6	498
7	597
8	717
9	860
10	1,032
Total Participants	5,193

Q. Has this been done anywhere else?

A. Yes, here in Kentucky some of our rural electric distribution cooperatives invest in behind-the-meter energy savings through the How$mart! Program, also known as the

[38] *See, e.g.*, KPCo 2023 Market Potential Study at 37 (observing that "markets in the Kentucky Power service territory may not react immediately and/or the program may require time to mature operations").

Kentucky Energy Retrofit Rider. Regulated utilities in Missouri, Georgia, and Arkansas have approved tariffs based on PAYS®, and PAYS® programs have also been implemented in North Carolina, New Hampshire, California, and Tennessee.

Q. How would this benefit customers participating in the program?

A. Participating customers should see all the ordinary benefits of improving home efficiency, starting with reduced energy usage and reduced monthly bills. Homes can be made healthier, safer, and more comfortable, helping to maintain and improve property values. Money saved on utility bills can be spent elsewhere in the local economy.

Participants get these benefits without incurring debt or assuming a loan, instead returning the utility's investment gradually over time with reduced energy usage.

Q. How would this benefit ratepayers as a whole?

A. With utility investment in energy savings, the entire system benefits. The cheapest, cleanest kilowatt hour is the one that does not need to be generated and delivered. Well designed and implemented programs can defer and reduce the need for new supply-side capital investments and reduce exposure to wholesale energy prices. This can translate into a rate decrease for all customers, as was the experience of Ouachita Electric Cooperative with a similar program:

> We wrote a tariff to collect on-bill, sent that to the public service commission in the fall of 2015, and it was approved in 2016 without any changes. After the first year, we had invested in almost $3 million in local member homes. With weatherization and HVAC, we're averaging an 18% reduction in demand across all members. Some are as high are as 30-40%. Adding solar moves the savings up to 70-80%. Overall, our cost of power has decreased. For every residential project completed, we're seeing a 1.5 to 2 MW reduction for peak demand. Because we've done 700 projects and added solar, we've reduced our summer peak by about 30%. These, and

other factors, all contributed to OEC implementing a 4.5% rate decrease on February 1, 2020.[39]

A PAYS® or similar tariff inclusive utility investment program makes it newly possible for some customers to access energy savings potential today, reducing system energy and capacity needs.

Q. How would this benefit the economy and create jobs in Kentucky Power service territory?

A. There would be direct and indirect benefits for our economy. Direct employment effects of energy efficiency investments are mostly in the construction industry, followed by work in product design and manufacturing fields, and professional services.[40] In 2016, Environmental Entrepreneurs (E2) and E4TheFuture observed that "most energy efficiency workers are at small companies with 25 or fewer employees," spanning installation (40%), trade and distribution (26%), professional services and more.[41] Within the energy sector, efficiency investments have a notably high employment multiplier.[42] Along with recognizing "a critical need for the Company to assist with efforts to maintain existing customers and further develop the region's economy,"[43] the workforce

[39] Southeast Energy Efficiency Alliance, *A Tale of Two Tariffs: Ouachita Electric Cooperative and Roanoke Electric Cooperative* (Mar. 16, 2020), https://www.seealliance.org/a-tale-of-two-tariffs-ouachita-electric-cooperative-and-roanoke-electric-cooperative/.
[40] *See, e.g.*, Marilyn Brown et al., *Estimating Employment from Energy Efficiency Investments*, 7 MethodsX at 100955 (June 2020), https://www.sciencedirect.com/science/article/pii/S2215016120301758, attached to my testimony as Exhibit JB-2.
[41] Sarah Lechmann et al., *Energy Efficiency Jobs in America*, Environmental Entrepreneurs (E2) & E4TheFuture (Dec. 2016), https://www.e2.org/wp-content/uploads/2016/12/EnergyEfficiencyJobsInAmerica_FINAL.pdf.
[42] Marilyn Brown, et al., Exhibit JB-2, *supra* n.40.
[43] Wiseman Direct at 8–9.

development and job sustaining benefits of utility-sponsored DSM/EE programs must be remembered. In terms of direct spending on energy services, helping customers achieve energy savings provides more economic benefits to the region than any supply-side generation option.

Q. Why is it important to do this now?

A. Reducing energy waste and increasing energy efficiency is always an important and rewarding place to start in system planning. Right now, for Kentucky Power and their customers, significant investment in energy savings is important to address some of root issues challenging us all. Kentucky Power Company is asking for a significant rate increase, with a demonstrated need for more energy and capacity resources. Before customers are asked to pay even more for more Company capacity, we need to see investment in energy savings.

IV. CHALLENGES FOR KENTUCKY POWER'S GS AND LGS CUSTOMERS

Q. What has been your experience working with small commercial customers in Kentucky Power service territory?

A. We have witnessed firsthand the struggles facing small commercial customers seeking to improve operations and reduce electric expenses. Many have too many competing demands to give time and resources to making lasting efficiency improvements. Many have been unclear on how to prioritize and evaluate energy saving opportunities in part due to having the fixed service charge, the energy charge, and the demand charge lumped together on their bills. Assisting commercial customers often involves as much explaining the separate components that make up "Rate Billing" as it does identifying energy saving opportunities. Simply understanding demand charges can often lead to

simple low- to no-cost solutions that these customers can implement day one on their path to even further savings.

Q. Are there any issues regarding GS and LGS customers that you would like to raise with the Commission?

A. Yes. There are three issues that we regularly come across with Kentucky Power Customers that I would like to raise with the Commission: (1) certain issues regarding publicizing and accessing significant incentives recently made available with passage of the Inflation Reduction Act (IRA) in 2022, including increased funding for USDA Rural Energy for the Americas Program (REAP) and the direct-pay option for eligible nonprofits to access applicable energy investment tax credits; (2) some problems with Kentucky Power billing statements that create a lack of transparency; and (3) inequitable application of the demand charge to smaller GS customers. I will address each issue in my testimony below.

A. Opportunities for REAP Grants and Direct-Pay for Kentucky Power Customers

Q. Please describe your experience working with commercial customers receiving USDA REAP grants in Kentucky Power service territory.

A. We have worked with commercial customers packaging USDA REAP grant applications for many years, and REAP has become even more of an essential tool for supporting small businesses in Eastern Kentucky today. The last 14 months since the floods of 2022 have been exceptionally challenging for many GS and LGS customers. A number of enterprises lost virtually everything. Many have not fared as well as one example we have owner's permission to highlight: Isom IGA, a grocery store and LGS customer in

Letcher County. Isom IGA lost nearly everything, with more than six feet of muddy water filled the entire building. It took over eight months of hard work, with no sales, to get the store in shape to reopen in April 2023.

We had worked with the grocery store over the previous decade to support efficiency measures including LED lighting, an upgrade to the refrigeration rack system with waste heat recovery to supplement space heating, and rooftop solar installation in 2020.[44] Kentucky Power Commercial Energy Rebates supported many of those upgrades before their elimination on January 1, 2018.[45] Many of the upgrades, including rooftop solar, were supported in part by USDA REAP grants.

Not all was lost; fortunately, the lighting fixtures escaped damage, as did the rooftop solar, which incidentally provided welcome bill relief while the store renovations took place. For over two months, early in the recovery, the store was a net energy producer, up until December 2022, when usage drained down the earlier credits gained. Unfortunately, all of the store's refrigeration cases had to be replaced, and the refrigeration rack system had to be refurbished, but that did open up the opportunity to add water heating to the waste heat recovery system, which was formerly space heating only. Some of these post-flood improvements were made possible in part with the even larger incentives in the USDA REAP grant program made available in 2023.

[44] *See*, Ariel Fugate, *Isom IGA – Isom, Kentucky*, Mountain Association (Aug. 17, 2020), https://mtassociation.org/energy/isom-iga-isom-ky/.
[45] Case 2017-00097, Electronic Investigation of the Reasonableness of the Demand Side Management Programs and Rates of Kentucky Power Company, Order at 16 (Ky. PSC Jan. 18, 2018).

The passage of the IRA is an historic opportunity, especially for rural small businesses. With its passage, REAP has been provided over $2 billion to support renewable energy systems and energy efficiency improvement with grants for agricultural producers and rural small business owners through 2031. On March 1, 2023, USDA announced the availability of $1 billion under the REAP program for the next six quarterly competitions.[46] This has resulted in an increase in the subsidy cap, an opportunity for many more projects to be funded and an increase in the subsidy per project from 25 percent to 50 percent of the implementation costs. We suggest Kentucky Power make this information accessible on their website to share this significant opportunity.

Q. Please describe your experience working with nonprofit customers implementing solar projects as a result of IRA expansion of clean energy tax credits through elective pay, otherwise known as "direct pay."

A. The IRA's "elective pay," often called "direct pay," provision is a means by which tax-exempt and government entities can, for the first time, take advantage of tax credits for building clean energy projects like rooftop solar. This has unlocked the opportunity for many mission-based organizations, places of worship, local governments, and school districts in the Company's service territory that are interested in pursuing solar to now implement solar with good financial return. Presently we have seven nonprofit clients in our pipeline actively implementing solar projects that are Kentucky Power GS or LGS service customers. Most of these are expected to be in operation in 2023. We are aware of

[46] Notice of Solicitation of Applications for the Rural Energy for America Program for Fiscal Years 2023 and 2024, 88 Fed. Reg. 19,239 (Mar. 31, 2023), https://www.govinfo.gov/content/pkg/FR-2023-03-31/pdf/2023-06376.pdf.

other solar projects in KPC territory that have gone out to bid that are being pursued by local government agency offices and public schools.

Q. Are there any additional changes you recommend Kentucky Power make so that customers can take advantage of REAP funding and direct pay?

A. With this USDA funding opportunity for both for-profit and non-profit enterprises, we are seeing a lot of applications for commercial solar implementation. Most are pursuing interconnections under the NMS-II rider, but we are also seeing some larger projects pursuing interconnection under COGEN/SPP I and II tariffs.

For three-phase customers, many have three-phase service types that Kentucky Power does not allow interconnection with, and historically the Company has required the customer to pay for delivery system upgrades to an approved interconnectable three-phase or single-phase service in order to interconnect DERs. This can increase the project implementation cost by $5,000 or more. Often it is an unexpected expense.

Unfortunately, we are seeing some RFPs for solar projects—at locations with this issue—that do not identify this need in the request. It often is overlooked, sometimes with no contingency in place, until later in the implementation phase. I understand that these three-phase services, which Kentucky Power interprets as incompatible with secondary side generation, can be less expensive infrastructure to provide—*e.g.*, providing three-phase service in building where only two-phase distribution is available.

To address this issue, Kentucky Power needs to do two things. First, the Company should identify incompatible three-phase service types on web or marketing materials regarding customer installation of generation equipment or customer-dispatchable resources like interconnected batteries or bi-directional EV chargers. Second, any new customer

inquiring about or being offered incompatible three-phase service needs to be informed that such service would need to be replaced if secondary side resource is pursued at some point by the customer.

B. Transparency in Customer Billing Statements

Q. Please describe the issue you have observed with regard to customers' billing statements?

A. In my work with small commercial customers, we regularly review bills to identify baseline use and help identify some areas to focus on for energy saving improvements. With Kentucky Power bills we see service charge and energy charge combined to one fee on RS bills. For GS and LGS, we see service charge, energy charge and demand charges as a combined sum on the bills, rather than reporting each of those charges separately.[47]

Q. Why is combining these charges detrimental to customers?

A. This is a problem because there is a lack of transparency around customer bills, and it is difficult for customers to determine how their use of energy and peak power impact their bill totals, making the lack of transparency especially detrimental for customers subject to a demand charge. While it is technically possible for customers to review the tariff and identify the separate charges themselves (*i.e.*, by looking up the Kentucky Power tariff and calculating out the charges for the metered readings on the bill by applying the

[47] *See* Response of Kentucky Power Company to Joint Intervenors' First Supplemental Discovery Requests, Case No. 2023-00159, Questions 2.18–2.20 (Sept 25, 2023) ("KPCo Response to JI Q2. 2.18–2.20"). On Large General Service customer bills, Service, Energy, Demand, and Excess Reactive Charges are reported as one combined charge. KPCo Response to JI Q2.20(a).

energy and demand rates), this is a cumbersome extra step that many customers do not have the time or familiarity with the tariffs necessary to complete.

If commercial customers are not able to quickly discern what charge on their bill is related to the total amount of energy used (the energy charge), along with the peak spike in average 15-minute power draw (the demand charge), then they are missing critical information about how their behavior and usage impacts their bill amount.

Without this information presented in an easy-to-read format, they may miss out on some easy changes or easily implemented efficiency measures they can make to respond effectively to the price signals presented. Seeing energy charge separate from demand charge on each bill can tell someone quickly where to focus first, because often reducing demand is an easy first step that rewards with savings that foster further measures to save more.

We see many of Kentucky Power Company's GS and LGS meters can display a date stamp that coincides with the day of the current billing cycle so far for which highest measured peak demand has occurred. This is good information for customers to have. On their website, in addition to information about energy savings, the Company should also have information about demand charges, steps one can take to reduce them, and information on reading one's electric meter.

Q. To your knowledge, is the Company aware of this issue?

A. Yes. In July, my colleague Chris Woolery and I met informally with Company representatives and raised this issue with them.

Q. Are you aware of any developments after this conversation?

A. The Company shared, in response to information requests from Joint Intervenors, that its staff were unaware of any reason that the charges are displayed this way on customer bills.[48] Moreover, the Company stated that its customer billing support team concluded that it was possible to separate out the demand charges on bills for GS and LGS customers, and could even implement this change starting with the effective date of the new rates following the conclusion of this case.[49]

I am grateful for the Company's willingness to look into resolving this issue and look forward to continuing to work with them towards informative and transparent billing practices. Ideally, the rate and amount would be in the description portion of the line, so one does not have to jump to the meter read section and know the tariff amount, *e.g.*, for an example LGS Customer:

"Base Demand Charge ($7.90 x 121.44 kW) 959.38"

Or for an example GS Customer:

"Base Demand Charge ($6.61 x (78.50 kW-10.00 kW) 452.79"

Kentucky Power should also be able to offer data meter pulses to the GS and larger customers so those customers can capture interval demand reads with their own monitoring equipment, in order to capture every 15-minute demand read, as opposed to just the date stamp that Kentucky Power revenue meter might display. Other investor-owned utilities in Kentucky offer this service for a nominal fee.

[48] KPCo Response to JI Q2.18(b).
[49] KPCo Response to JI Q2.18(c).

C. Other Concerns with the General Service (GS) Tariff

Q. Have you observed any problems for these customers taking service under Kentucky Power's GS Tariff?

A. Yes, I have observed some problems with the GS tariff that have impacted small commercial customers, small churches, community centers, and legal services, to name a few. In addition to historically not having service, energy and demand charges separated on their bills, prior to 2017 many of them were in a now retired class of customers, Small General Service (SGS), which did not have a demand charge.

In 2017, SGS customers were merged with Medium General Service (MGS) customers to make a new GS rate class. In this shift, Kentucky Power took some measures to address challenges for customers newly subject to the demand charge, including: 1) only applying demand charge to the meter read portion above 10 kW each month, 2) contacted former SGS customers to discuss mitigating the new demand charge, and 3) not automatically replacing meters or reprograming meters serving former SGS customers so that the meters would be capable of reading monthly peak demands, especially if those customers did not reach 4,450 kWh of energy use in any month.

This third item has been the cause of some dissatisfaction for GS customers who do have meters capable of measuring demand and paying for demand, even with use below 4,450 kWh in any month. They feel they are unfairly targeted because they happen to have a meter capable of measuring demand, while others with just as much limited energy use, but not already equipped with a meter capable of measuring demand, may have demand above 10kW some months but are not being charged.

Q. What do you recommend regarding the application of a demand charge to some small commercial customers?

A. There are some customers with usage under 4,450 kWh per month who are being subjected to the demand charge solely because they at some point had a demand meter installed, while their peers are not. For equitable application, I recommend GS customers with usage under 4,450 kWh each month not be subjected to demand charges.

V. RECOMMENDATIONS

Q. Please summarize your recommendations for the Commission regarding Kentucky Power's requests in this case?

A. My recommendations are as follows:

- Implement an inclusive utility investment program;
- Accelerate investment in a cost-effective portfolio of DSM/EE programs;
- Share on the Company website information for incentives available for customer investments in efficiency and DER, such as USDA REAP, and remove barriers to participation for customers taking service under NMS-II and COGEN/SPP I and II tariffs;
- Increase billing transparency by separating out the demand charge on customer bills; and
- Apply demand charges only to customers with monthly usage above 4,450 kWh.

Q. Does this conclude your testimony?

A. Yes, it does.

VERIFICATION

The undersigned, Joshua Bills, being first duly sworn, deposes and says that he has personal knowledge of the matters set forth in the foregoing testimony and that the information contained therein is true and correct to the best of his information, knowledge, and belief, after reasonable inquiry.

Subscribed and sworn to before me by Joshua Bills this 2nd day of October, 2023.

Notary Public

My commission expires: 4/17/2027

JASMINE M. BUSH
NOTARY
ID KYNP70838
MY COMMISSION
EXPIRES
4/17/2027
PUBLIC
STATE AT LARGE, KY.

Exhibit JB-1

JOSHUA BILLS, PLS, CEM, EIT

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Berea, KY 40403

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INTENT

Develop and elevate programs and projects that lead towards smart energy management and distributed low-carbon energy generation and reduced carbon energy consumption, across all sectors, from large utilities and large enterprises, down to the smallest of residences. All the while, engaging Mountain Association's Lending Team, utilities, local governments, housing groups, community organizations, contractors, and entrepreneurs; along with Kentucky's Legislature, Energy and Environment Cabinet, and Public Service Commission in conversations and engagements that raise East Kentucky Coalfield's and the wider Central Appalachia's clean energy proficiency.

EXPERIENCE

Sep 2023 – Present MACED (AKA Mountain Association)
Berea, KY

Senior Energy Analyst

- Lead the technical work and development of the Energy program and support other energy related Mountain Association programs.
- Maintain effective relationships with contractors, entrepreneurs, enterprises, local governments, community organizations, and utilities engaged in energy efficient (EE) and/or renewable energy (RE) improvements or programs.

Jul 2017 – Sep 2023 MACED (AKA Mountain Association)
Berea, KY

Commercial Energy Specialist - Commercial Energy Analyst

- Lead development and implementation of energy assessments and retrofits that result in money and energy saved. Support packaging grant and other incentives for Mt. Assoc. energy clients.

Feb 2012 – Jul 2017 MACED (AKA Mountain Association)
Berea, KY

Energy Efficient Enterprises Program Coordinator

- Provide a range of project management, implementation, marketing and reporting functions for work related to commercial retrofits and energy demonstration projects.

Mar 2008 – Jan 2012 MACED (AKA Mountain Association)

Berea, KY

Energy Specialist

- Develop relationships with key energy-related partners.
- Provide technical assistance delivering billing and energy analyses, energy consulting, and project reviews to hundreds of enterprises and contractors, along with a multitude of local governments and community groups.
- Elevate MACED's Enterprise Development Team's lending through facilitating opportunities that promote EE retrofit and RE construction efforts. Over $2 million in lending has been deployed to independent grocers in Appalachian KY for measures reducing energy consumption and costs.
- Assist enterprises and local governments in netting rebates and grants for EE and RE projects. Since 2010, these leveraged private, state, and federal funds amount to over $630,000 applied directly to EE retrofits and RE installations.

Spr 2004 – Spr 2008 Sunbelievable Services
Berea, KY

Owner, solar thermal and solar electric design/installation company

- Averaged 3 installations a month throughout Kentucky
- Designed, installed solar electric system for Peace Corps training headquarters in Niger, West Africa.
- Designed, installed solar electric system for remote clinic and school in Haiti which included a solar well pump system.
- Designed, installed 5 solar PV and 8 solar thermal systems Berea.

Spr 2001 – 2004 Appalachia—Science in the Public Interest
Mt. Vernon, KY

Coordinator, Kentucky Solar Partnership

- Worked with LG&E, KU, KY Division of Energy, and the KY PSC to establish a net metering pilot program in the Commonwealth. Subsequently installed Kentucky's first net metered grid interactive solar electric system at ASPI's Mt. Vernon main office in 2001.
- Informed Legislature, Electric Utilities, and Kentucky's Energy and Environment Cabinet, resulting in the expansion of the net metering pilot program into a statewide statute in 2004.
- Worked directly with the Federal Department of Energy's Million Solar Roofs Initiative to identify barriers to utilizing RE. To also develop and implement programs aimed at reducing those barriers.
- Fundraised over $200,000 for the Kentucky Solar Partnership program.

1999 – 2001 CDP Engineers, Inc. Berea Land Surveying, Inc.

Lexington, KY Berea, KY

Engineering/Surveying Technician

- Initiated and coordinated daily work to be performed by survey crews
- Computer-aided drafting
- Developed a project log database
- Surveyed various terrain, performing topographic and boundary surveys

1995 – 1999 Appalachia—Science in the Public Interest
Mt. Vernon, KY

Appropriate Technology Consultant

- Designed and implemented appropriate technology demonstration systems
- Wrote numerous technical papers and grant proposals
- Assessed over forty facilities around the country and as a team, developed methods to reduce their energy consumption and waste.
- Led volunteers on clean up projects, workshops, and event preparations.
- Developed and led educational programs

EDUCATION

1988–1992 Berea College Berea, KY

- B.A., Mathematics

1993-1995 Washington University St. Louis, MO

- B.S., Mechanical Engineering
- Member PI TAU SIGMA, Mechanical Engineering Honor Society
- Certified by U.S. Department of Energy/FEMP in Life-Cycle Costing Training
- Licensed Kentucky Engineer in Training (EIT)
- Licensed Kentucky Professional Land Surveyor (PLS #3537)
- Certified Energy Manager (CEM #12932)
- Former NABCEP Certified Solar PV Installer (#110112-17) and Solar Heating Installer (#SH032412-15)
- Berea Utility Advisory Board Chair (Member since Jan. 2011 and Chair since Aug. 2012)

REFERENCES

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Exhibit JB-2

MethodsX 7 (2020) 100955

Contents lists available at ScienceDirect

MethodsX

journal homepage: www.elsevier.com/locate/mex

Method Article

Estimating employment from energy-efficiency investments

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A B S T R A C T

We develop a methodology for estimating the number and types of jobs that would result from investments in energy efficiency in homes, businesses, and industry. The methodology involves the development of input-output (I-O) bills of goods that characterize how energy-efficiency funds would be spent across sectors of the economy. The methodology builds on and adds greater articulation to the research conducted in prior studies of U.S. energy-efficiency policies.

- The first two steps involve estimating the magnitude of investments in energy-efficient technologies and systems required to produce a unit of energy consumption reduction, and then identifying how these investments are expensed across the broad investment categories, which creates the preliminary "bills of goods" for investments in energy efficiency in homes, businesses, and industry.
- The third step involves soliciting feedback on the preliminary bills of goods from experts in delivering and evaluating energy-efficiency programs, and then making necessary modifications.
- In the final step we apply the input-output coefficients representing the bills of goods to estimate the direct, indirect and induced employment per million dollars of investment in energy efficiency.

A R T I C L E I N F O
Method name: Input-Output Estimates of Clean Energy Jobs.
Keywords: Clean energy jobs, Employment impacts, Green jobs, Input-output analysis
Article history: Received 25 December 2019; Accepted 5 June 2020; Available online 8 June 2020

DOI of original article: 10.1016/j.apenergy.2019.114354
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https://doi.org/10.1016/j.mex.2020.100955

Specifications Table

Subject Area:	Energy
More specific subject area:	*Energy efficiency*
Method name:	*Input-Output Estimates of Clean Energy Jobs*
Name and reference of original method:	*Clean energy "bills of goods"*
Resource availability:	*Climate and Energy Policy Lab, Georgia Institute of Technology*

Method details

[Methodological protocols should be in sufficient detail to be replicated. There is no word limit! You can include figures, tables, videos – anything that you feel will help others to reproduce the method. The main focus of the paper should be on the technical steps required for this method, more than results; where appropriate, guide the reader through the procedure and provide all extra observations or "tricks" alongside the protocol. Results and Discussion are not sections included in the MethodsX format. However, providing data that validate the method is valuable and required. This section could become a "method validation" paragraph within the Method Details section.]

Prior work estimating employment from energy-efficiency investments comprises a wide range of studies, across different types of technologies, sectors of the economy, and scales. Typically, these studies rely on an input-output modeling approach to estimate the macroeconomic impacts, including employment generation. The employment impacts can be categorized into direct, indirect and induced. The direct effects relate to sectors that get affected by direct economic activity due to higher investment through various programs. Indirect effects primarily include the materials and industry demand as a second order effect. Finally, induced effects reflect the increased spending on consumer goods and services by those earning higher incomes due to the direct and indirect effects across the economy.

As the world grapples with a pandemic with devasting effects on health systems, consumer spending, and the entire U.S. economy, with widespread shutdowns causing significant economic retrenchment, there are major consequences in store for our energy systems. These may challenge the ability of energy economy models of historic U.S. conditions as used in this study to provide robust forecasts of employment from energy efficiency investments in the future.

In the short-term, the reduction in industrial activity and closure of non-essential industries is likely to reduce investments in energy and related upgrades. One exception could be the expanded use of residential energy as the result of stay-at-home orders. "EIA assumes, in particular, that household usage of electronic equipment such as computers and televisions will increase. Other uses of electricity, such as for cooking and for heating water, may also rise. Household use of air conditioning during the summer months is also likely to be higher than normal as more people stay home during the daytime."[1]

In the medium-term, as federal stimulus investments revive the global economy and household spending, the clean energy sector may gain some additional spending as witnessed in the 2008–09 recession. Legislators and stakeholders are already seeking funding for clean energy technologies in Coronavirus stimulus packages.[2] The International Energy Agency and many other cleantech advocates recommend that clean energy be put at the heart of stimulus plans to counter Covid-19, which could cause a resurgence in energy-efficiency investments, perhaps with altered patterns of investment that are yet to be determined.[3]

Literature

Bell et al. [3] provide an evaluation of different methodologies used to measure job creation in energy efficiency improvements. The authors summarize the prevailing studies as following one of

[1] https://www.eia.gov/outlooks/steo/report/electricity.php.

[2] https://www.greentechmedia.com/articles/read/clean-energy-groups-seek-tax-credit-extensions-direct-pay-provisions-in-coronavirus-stimulus-package.

[3] https://www.iea.org/commentaries/put-clean-energy-at-the-heart-of-stimulus-plans-to-counter-the-coronavirus-crisis

two approaches – bottom-up where surveys and interviews are used to generate the number of jobs in the sector, and top-down approaches where economic modeling (such as computable general equilibrium, input-output, econometric models) is used to estimate the macroeconomic effect of investments in clean energy. The authors also describe a combination of the two major types, i.e. hybrid approaches where top-down and bottom-up analyses are combined.

The US Energy and Employment Report [13] estimated that in 2016 there were nearly 2.2 million jobs in the energy efficiency sector. By 2018, energy efficiency jobs had grown to 2.35 million jobs [11]. More than half (1.3 million) of these employees work in the construction industry; others work in the design and manufacturing of products, and the delivery of professional services. In the report on Energy Efficiency Jobs in America, Environmental Entrepreneurs and E4TheFuture [7] find that jobs in the energy efficiency industry tend to be concentrated in smaller business, with 25 or fewer employees. Further, these companies focus primarily on installation, trade and distribution related aspects of the industry.

The latest World Employment and Social Outlook by the International Labor Organization deploys an I-O modeling approach to estimate the employment impacts of sustainability [10]. Similarly, the report by Pollin et al. [12] examines the net implications of expanded investments in clean energy and energy efficiency by using the IMPLAN I-O model [9]. The authors find the net effects of rising clean energy investments and falling share of fossil fuels lead to an increase in the total jobs generated over two decades. The job growth is primarily because clean energy investments are more "labor intensive" and require a larger share of "domestic content". Garett-Peltier [8] takes a similar approach, examining the net employment effects of redirecting fossil fuel investments towards clean energy. Incorporating a similar input-output analysis into the results or a computable general equilibrium analysis of carbon taxes, Brown et al. [4] estimate significant employment growth from energy-efficiency investments. The novel application of input-output analysis to energy efficiency, in combination with general equilibrium modeling, is the subject of this Methods-X paper.

Looking across metropolitan areas, Yi [14] uses an econometric approach to examine the employment effects of clean energy policies. He finds that overall, each clean policy adopted for the sector leads to a 1% increase in the number of green jobs. At a local scale, DeShazo et al. [6] also examine the wide range of clean energy programs in the Los Angeles County and use an I-O model to assess the actual expected job impacts. The authors find that more than 16 job-years could be created for every million dollars invested in these programs operated by the Los Angeles Department of Water and Power. And finally, in the evaluation of Maryland's EMPower energy efficiency program, Baatz and Barrett [1] estimate a total of 2000 jobs were generated in 2011.

Methodology and approach

Several models are available to analyze employment impacts, including ACEEE's DEEPER model and NREL's JEDI model. However, for this study we first deployed Georgia Tech's version of the National Energy Modeling System (NEMS), the premier and arguably most influential U.S. energy modeling tool. NEMS data is more up-to-date than the data in DEEPER, and it better represents energy-efficiency investments compared with JEDI. The model uses an I-O approach to calculate employment across 49 sectors of industry and services. The Macroeconomic Activity Module Documentation provides detailed information on industrial classification and employment calculations.[4]

Preliminary analysis identified a gap in the NEMS employment calculations. It was detected empirically when the estimates showed a small net loss of U.S. jobs through 2030, despite large-scale investments in energy efficiency, which is a labor-intensive activity. Examination of the NEMS architecture, and subsequent discussions with EIA NEMS modelers revealed that the investments in energy efficiency are not recycled back to the IHS Global Insights macroeconomic model that estimates GDP and employment. As a result, NEMS underestimates the employment and GDP impacts of scenarios that model energy-efficiency incentives. It does not include the direct, indirect, and induced jobs generated by the incremental expenditures on high-efficiency equipment and materials.

[4] https://www.eia.gov/outlooks/aeo/nems/documentation/macroeconomic/pdf/m065(2018).pdf

Fig. 1. Approach to calculating additional jobs from I/O data.

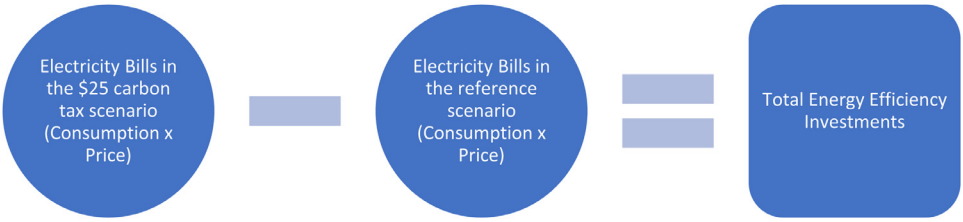

Fig. 2. Approach to calculating step 1: energy efficiency investments.

These overlooked jobs were then estimated through independent input-output (I-O) modeling, and the results added to the NEMS employment estimates to provide a more complete assessment.

To estimate the employment impact of investments in energy efficiency, we develop an approach that applies employment coefficients from the IMPLAN input-output model to results from the National Energy Modeling System (NEMS) (Fig. 1).

Step 1: identify the investments in each sector

The first step estimates investments in energy efficiency technologies and systems required to produce the energy consumption reductions. As noted earlier, the NEMS model predicts large scale improvements in energy efficiency as a result of a $25/ton carbon tax. However, in order to calculate the monetary value of the investments, we calculated the difference in electricity bills in the two cases. Since the energy consumption in all three sectors (residential, commercial and industry) is expected to go down but the prices are expected to increases, utility revenues will likely increase, thus spurring additional investments in energy efficiency. The energy efficiency investments are assumed to be equivalent to the value of the energy saved in each (as would occur in an on-bill financing program). This involved estimating the energy consumption, prices and bills in the $25 carbon tax scenario modeled in NEMS, by year and census region. For this, we first calculate the change in electricity consumption and prices. We multiply these to arrive at the bills for households and the resulting change in energy-efficiency jobs (Fig. 2). The results are presented in Table 1.

Step 2: identify composition of each sector

The second step involves distributing these investments across the broad investment categories. This step creates the “bills of goods” that characterize how energy efficiency expenditures are spent. This follows an approach similar to that of Baer et al. [2] and Garrett-Peltier [8], which focus on industry spending patterns. We build on the prior works as we combine the results of the NEMS (general equilibrium approach) and somewhat incomplete recycling of revenues in the NEMS I-O model by superimposing the energy-efficiency job gains from an external I-O model in IMPLAN. Bills of goods are available for many green energy systems such as solar and wind, but they are not well defined for energy efficiency. To estimate the effects of energy-efficiency investments in each sector, we created separate bills of goods for each of the three major end-use sectors: residential, commercial, and industrial. For simplicity, we assume that energy-efficiency expenditures are spent similarly across the census regions.

Table 1
Derivation of energy-efficiency job estimates of a $25 carbon tax.

		Reference Case			$25 Carbon Tax			$25 Carbon Tax – Reference Case			
		Electricity Consumption (a) (TWh)	Prices (b) (cents/kWh)	Electricity Bills *c*=axb (Billion 2017$)	Electricity Consumption (d) (TWh)	Prices (e) (cents/kWh)	Electricity Bills *f*=dxe (Billion 2017$)	Change in Electricity Consumption (d-a) (TWh)	Change in Prices (e-b) (cents/kWh)	Change in Bills (f-c) (Billion 2017$)	Change in Energy-Efficiency Jobs (Thousand)
Residential	2020	1408.9	13.4	188.3	1395.9	14.5	202.0	−12.9	1.1	13.7	**172.3**
	2025	1389.1	13.8	192.1	1346.7	15.5	209.3	−42.4	1.7	17.2	**216.2**
	2030	1409.4	14.0	197.9	1362.3	15.8	215.3	−47.0	1.8	17.4	**218.4**
	2035	1434.7	14.1	201.8	1375.3	16.2	222.2	−59.3	2.1	20.4	**256.7**
	2040	1471.0	14.1	207.1	1400.1	16.4	230.0	−71.0	2.4	22.9	**288**
	2045	1506.5	14.0	210.9	1425.1	16.7	237.4	−81.3	2.7	26.5	**332.5**
	2050	1545.6	13.9	215.4	1450.7	16.8	243.9	−94.9	2.9	28.5	**357.8**
Commercial	2020	1374.0	11.1	151.9	1365.1	12.1	165.2	−8.9	1.0	13.3	**166.8**
	2025	1397.3	11.2	156.9	1363.4	12.8	175.0	−33.9	1.6	18.1	**227.4**
	2030	1417.5	11.3	160.6	1377.8	12.9	178.4	−39.7	1.6	17.8	**223.7**
	2035	1443.4	11.2	162.1	1390.1	13.1	182.3	−53.3	1.9	20.3	**254.3**
	2040	1481.4	11.2	165.6	1412.2	13.3	187.3	−69.2	2.1	21.8	**273**
	2045	1533.4	11.0	168.9	1446.4	13.3	192.9	−87.0	2.3	24.0	**301**
	2050	1614.5	10.9	175.7	1506.6	13.3	200.2	−107.9	2.4	24.5	**307.1**
Industrial	2020	1023.7	7.3	75.1	995.5	8.8	87.8	−28.2	1.5	12.7	**108.7**
	2025	1099.0	7.4	81.5	1053.9	8.9	93.7	−45.1	1.5	12.2	**152.8**
	2030	1139.9	7.5	85.0	1077.4	9.0	97.4	−62.5	1.6	12.4	**149.8**
	2035	1165.6	7.4	86.3	1081.7	9.2	99.6	−83.9	1.8	13.3	**164.8**
	2040	1200.7	7.4	88.7	1097.2	9.3	102.3	−103.6	1.9	13.6	**170.8**
	2045	1226.7	7.3	89.8	1099.8	9.5	104.9	−126.9	2.2	15.1	**187.7**
	2050	1246.2	7.3	91.0	1097.2	9.6	105.6	−149.0	2.3	14.5	**183.6**

Note: Changes in prices are correct; they may differ from “e-b”, as shown, due to rounding.

Table 2
Summary of bills of goods for three energy-efficiency sectors.

	Residential	Commercial	Industry
Construction	20%	20%	9%
HVAC&R	20%	20%	7%
Water heating	6%	5%	3%
Lighting	10%	10%	5%
Material for envelope	12%	7%	6%
Motors, drives and back-up generators	0%	3%	10%
Other electrical equipment	5%	5%	12%
Industrial machinery manufacturing	0%	0%	16%
Energy and environmental management and smart controls	15%	18%	20%
Insurance and finance	2%	2%	2%
Program administration	5%	5%	5%
Architecture and engineering services	5%	5%	5%
Total	100%	100%	100%

Step 3: solicit and review expert feedback

The third step is to seek expert opinion on these estimates and validating the bill of goods created in Step 3. Draft bills of goods were developed by the authors and reviewed by a group of energy-efficiency experts in the Southface Energy Institute, ACEEE, the Greenlink Group, Georgia Public Service Commission, University of Massachusetts, Sterling Energy and Independent Consultants. As a result of the experts' feedback, we incorporated the following changes:

- Increased the allocation to construction in residential and commercial sectors – The reviewers' feedback converged in that the new investments in energy efficiency will require additional construction spending. Responding to this, we increased the share of energy efficiency investment allocated to the sector.
- Reduced the level of investment in Program Administration – In our initial distribution of investments, we had assumed that a significant share would be allocated towards the administrative expenses of government-led energy-efficiency programs. However, the experts suggested that the shares would be lower than our estimates and accordingly, we reduced the share of related categories in the final distribution.
- Added a sector called Architecture and Engineering Services – Finally, one of the reviewers suggested including a new category given that some energy investments would also require changes to the current architectural and engineering approaches in building construction and design. Accounting for this suggestion, we added this category in our distribution. This also allowed us to redistribute some of the investments from the reduced share of "Program Administration".

We implemented a two-step approach, following up with the experts once the first round of changes had been incorporated. No additional changes were suggested in the second round. The final distribution of the Bills of Goods is shown in Table 2.

Step 4: distribute the broad categories across IMPLAN sectors

The fourth step uses the IMPLAN I-O coefficients to estimate the direct, indirect and induced employment per $1 million of investment. The shares from Step 3 were further decomposed to reflect the specific industries covered in the IMPLAN software. The software lists 536 industries reflecting the first 3-digits from the North American Industry Classification System (NAICs). This detailed breakdown is presented in Tables 3–5. The tables summarize the bills of goods for all three energy-efficiency sectors. These tables have four columns – the first represents the broad spending category as noted in Table 2. The next column reflects the IMPLAN industry description/name as provided within the software. The next two columns are the shares we attribute to the sub-sector and the aggregate across the broad sector identified in the first column.

Table 3
Bills of goods for residential energy efficiency.

Sector	Description	Sub-sector shares	Sectoral shares
Construction	Construction of new single-family residential structures	5.00%	20%
	Construction of new multifamily residential structures	5.00%	
	Construction of other new residential structures	4.00%	
	Maintenance and repair construction of residential structures	2.50%	
	Manufactured home (mobile home) manufacturing	1.50%	
	Brick, tile, and other structural clay product manufacturing	2.00%	
HVAC&R	Air purification and ventilation equipment manufacturing	6.00%	20%
	Heating equipment (except warm air furnaces) manufacturing	5.00%	
	Air conditioning, refrigeration, and warm air heating equipment manufacturing	5.00%	
	Household cooking appliance manufacturing	1.00%	
	Household refrigerator and home freezer manufacturing	1.00%	
	Household laundry equipment manufacturing	1.00%	
	Other major household appliance manufacturing	1.00%	
Water heating	Plastics pipe and pipe fitting manufacturing	1.00%	6%
	Pottery, ceramics, and plumbing fixture manufacturing	1.00%	
	Iron, steel pipe and tube manufacturing from purchased steel	1.00%	
	Power boiler and heat exchanger manufacturing	1.00%	
	Plumbing fixture fitting and trim manufacturing	1.00%	
	Fabricated pipe and pipe fitting manufacturing	1.00%	
Lighting	Electric lamp bulb and part manufacturing	5.00%	10%
	Lighting fixture manufacturing	5.00%	
Material for envelope	Wood windows and door manufacturing	2.00%	12%
	Paint and coating manufacturing	2.00%	
	Polystyrene foam product manufacturing	2.00%	
	Urethane and other foam product (except polystyrene) manufacturing	2.00%	
	Mineral wool manufacturing	2.00%	
	Flat glass manufacturing	2.00%	
Other electrical equipment	Small electrical appliance manufacturing	1.00%	5%
	Power, distribution, and specialty transformer manufacturing	1.00%	
	Storage battery manufacturing	1.00%	
	Wiring device manufacturing	1.00%	
	All other miscellaneous electrical equipment and component manufacturing	1.00%	
Energy and environmental management and smart controls	Optical instrument and lens manufacturing	1.00%	15%
	Electronic computer manufacturing	1.00%	
	Computer storage device manufacturing	1.00%	
	Computer terminals and other computer peripheral equipment manufacturing	1.00%	
	Broadcast and wireless communications equipment manufacturing	1.00%	
	Other communications equipment manufacturing	1.00%	
	Bare printed circuit board manufacturing	1.00%	
	Semiconductor and related device manufacturing	1.00%	
	Printed circuit assembly (electronic assembly) manufacturing	1.00%	
	Other electronic component manufacturing	1.00%	
	Industrial process variable instruments manufacturing	1.00%	
	Analytical laboratory instrument manufacturing	1.00%	
	Data processing, hosting, and related services	1.00%	
	Computer systems design services	1.00%	
	Other computer related services, including facilities management	1.00%	
Insurance and finance	Insurance carriers	1.00%	2%
	Insurance agencies, brokerages, and related activities	1.00%	

(*continued on next page*)

Table 3 (*continued*)

Sector	Description	Sub-sector shares	Sectoral shares
Program administration	Federal electric utilities	1.25%	5%
	State government electric utilities	1.00%	
	Local government electric utilities	1.00%	
	* Employment and payroll of state govt, non-education	0.50%	
	* Employment and payroll of local govt, non-education	0.50%	
	* Employment and payroll of federal govt, non-military	0.75%	
Architecture and engineering services	Architectural, engineering, and related services	1.50%	5%
	Specialized design services	1.50%	
	Environmental and other technical consulting services	2%	

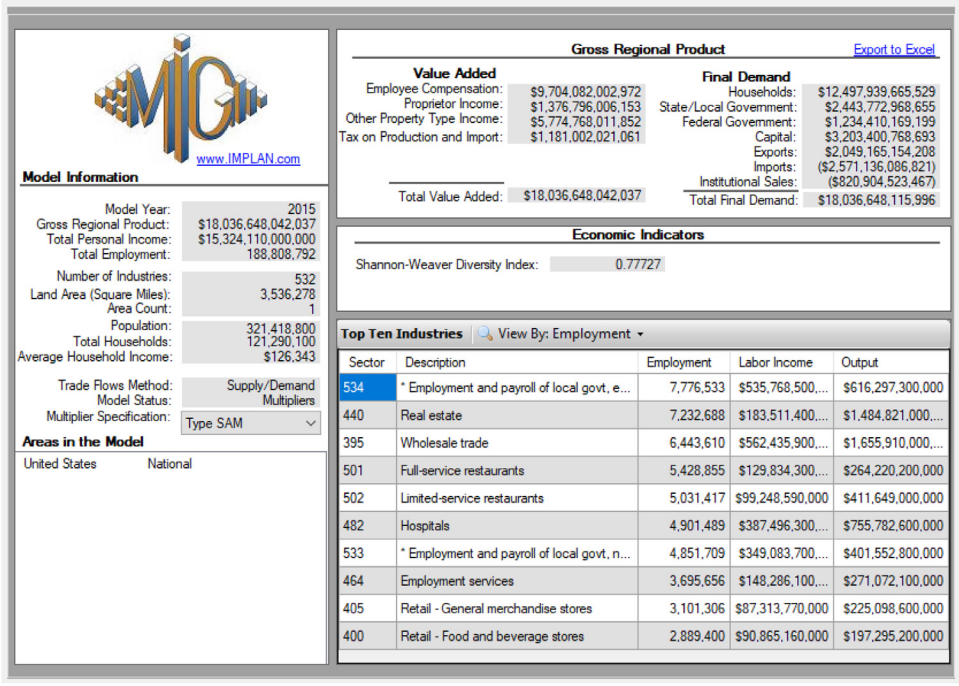

Fig. 3. IMPLAN 3.0 interface.

It is interesting to note here that the indirect and induced effects surpass the direct effects in all cases. Across the three energy-efficiency sectors, the jobs multipliers are highest in the commercial sectors, which is a function of the way spending is distributed across different sub-sectors (Table 2). The spending in smart management and controls is higher in the commercial and industrial Sectors than in the residential. Further, spending on materials is a smaller share of the total investments in the sector.

This distribution was then used to calculate the spending in each industry and the consequent implications on total additional jobs generated.

We used IMPLAN version 3.0 for generating the multipliers (Fig. 3).

Table 4
Bills of goods for commercial energy efficiency.

Sector	Description	Sub-sector share	Sectoral Shares
Construction	Construction of new health care structures	5.00%	20%
	Construction of new educational and vocational structures	5.00%	
	Construction of new commercial structures, including farm structures	10.00%	
HVAC&R	Air purification and ventilation equipment manufacturing	5.00%	20%
	Heating equipment (except warm air furnaces) manufacturing	5.00%	
	Air conditioning, refrigeration, and warm air heating equipment manufacturing	10.00%	
Water heating	Plastics pipe and pipe fitting manufacturing	0.50%	5%
	Fabricated pipe and pipe fitting manufacturing	0.50%	
	Iron, steel pipe and tube manufacturing from purchased steel	0.50%	
	Plumbing fixture fitting and trim manufacturing	1.50%	
	Power boiler and heat exchanger manufacturing	2.00%	
Lighting	Electric lamp bulb and part manufacturing	5.00%	10%
	Lighting fixture manufacturing	5.00%	
Material for envelope	Flat glass manufacturing	1.00%	7%
	Metal window and door manufacturing	0.25%	
	Plastics material and resin manufacturing	0.25%	
	Adhesive manufacturing	0.50%	
	Fabricated structural metal manufacturing	0.25%	
	Mineral wool manufacturing	1.25%	
	Polystyrene foam product manufacturing	1.00%	
	Urethane and other foam product (except polystyrene) manufacturing	1.25%	
	Spring and wire product manufacturing	0.50%	
	Blind and shade manufacturing	0.25%	
	Valve and fittings, other than plumbing, manufacturing	0.25%	
	Sheet metal work manufacturing	0.25%	
Energy and environmental management and smart controls	Optical instrument and lens manufacturing	1.00%	18%
	Electronic computer manufacturing	1.00%	
	Computer storage device manufacturing	1.00%	
	Computer terminals and other computer peripheral equipment manufacturing	1.00%	
	Broadcast and wireless communications equipment manufacturing	1.00%	
	Other communications equipment manufacturing	1.00%	
	Bare printed circuit board manufacturing	1.00%	
	Semiconductor and related device manufacturing	1.00%	
	Printed circuit assembly (electronic assembly) manufacturing	1.00%	
	Other electronic component manufacturing	1.00%	
	Industrial process variable instruments manufacturing	1.00%	
	Analytical laboratory instrument manufacturing	0.50%	
	Data processing, hosting, and related services	0.50%	
	Computer systems design services	0.50%	
	Automatic environmental control manufacturing	4.50%	
	Other computer related services, including facilities management	1.00%	
Motors, drives and back-up generators	Speed changer, industrial high-speed drive, and gear manufacturing	1.00%	3%
	Fluid power pump and motor manufacturing	1.00%	
	Motor and generator manufacturing	1.00%	
Other electrical equipment	Power, distribution, and specialty transformer manufacturing	1.00%	5%
	Storage battery manufacturing	1.00%	
	Wiring device manufacturing	1.00%	
	Small electrical appliance manufacturing	1.00%	
	All other miscellaneous electrical equipment and component manufacturing	1.00%	
Insurance and finance	Insurance carriers	1.0%	2%
	Insurance agencies, brokerages, and related activities	1.0%	

(*continued on next page*)

Table 4 (*continued*)

Sector	Description	Sub-sector share	Sectoral Shares
Program administration	Federal electric utilities	1.25%	5%
	State government electric utilities	1.00%	
	Local government electric utilities	1.00%	
	* Employment and payroll of state govt, non-education	0.50%	
	* Employment and payroll of local govt, non-education	0.50%	
	* Employment and payroll of federal govt, non-military	0.75%	
Architecture and engineering services	Architectural, engineering, and related services	1.50%	5%
	Specialized design services	1.50%	
	Environmental and other technical consulting services	2%	

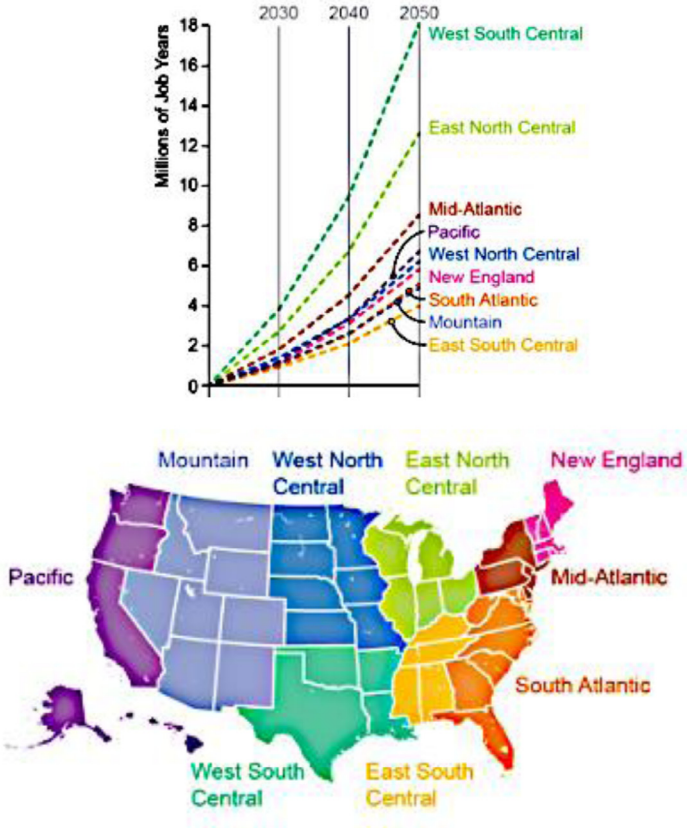

Fig. 4. The cumulative difference in employment, by region, with a $25 carbon tax (figure created by authors using data published in [5]).

Employment estimates

The employment multipliers for investments in energy supply (based on IMPLAN-defined sectors) are lower than for investments in energy efficiency (Table 6). As noted earlier, using the I-O model allows us to disaggregate the total employment effects into Direct, Indirect and Induced effects. Taking the example of investments in industrial energy efficiency here, as per Table 6, an additional spending

Table 5
Bills of goods for industrial energy efficiency.

Sector	Description	Sub-sector share	Sectoral Shares
Construction	Construction of new manufacturing structures	5.0%	9%
	Construction of new power and communication structures	4.0%	
HVAC&R	Air purification and ventilation equipment manufacturing	2.0%	7%
	Industrial process furnace and oven manufacturing	1.5%	
	Heating equipment (except warm air furnaces) manufacturing	1.5%	
	Air conditioning, refrigeration, and warm air heating equipment manufacturing	2.0%	
Lighting	Electric lamp bulb and part manufacturing	2.5%	5%
	Lighting fixture manufacturing	2.5%	
Material for envelope	Wood windows and door manufacturing	1.5%	6%
	Paint and coating manufacturing	0.8%	
	Polystyrene foam product manufacturing	0.8%	
	Urethane and other foam product (except polystyrene) manufacturing	1.0%	
	Mineral wool manufacturing	1.0%	
	Sheet metal work manufacturing	1.0%	
Water heating	Plastics pipe and pipe fitting manufacturing	0.5%	3%
	Concrete pipe manufacturing	0.5%	
	Iron, steel pipe and tube manufacturing from purchased steel	0.5%	
	Power boiler and heat exchanger manufacturing	1.0%	
	Fabricated pipe and pipe fitting manufacturing	0.5%	
Motors, drives and back-up generators	Turbine and turbine generator set units manufacturing	3.5%	10%
	Mechanical power transmission equipment manufacturing	3.5%	
	Motor and generator manufacturing	3.0%	
Other electrical equipment	Small electrical appliance manufacturing	3.0%	12%
	Power, distribution, and specialty transformer manufacturing	3.5%	
	Storage battery manufacturing	1.5%	
	Wiring device manufacturing	1.5%	
	All other miscellaneous electrical equipment and component manufacturing	2.5%	
Industrial machinery manufacturing	Speed changer, industrial high-speed drive, and gear manufacturing	3.0%	16%
	Pump and pumping equipment manufacturing	3.0%	
	Air and gas compressor manufacturing	2.5%	
	Conveyor and conveying equipment manufacturing	2.5%	
	Welding and soldering equipment manufacturing	2.0%	
	Fluid power cylinder and actuator manufacturing	2.0%	
	Fluid power pump and motor manufacturing	1.0%	
Energy and environmental management and smart controls	Optical instrument and lens manufacturing	1.0%	20%
	Electronic computer manufacturing	2.0%	
	Computer storage device manufacturing	2.0%	
	Computer terminals and other computer peripheral equipment manufacturing	2.0%	
	Broadcast and wireless communications equipment manufacturing	1.0%	
	Other communications equipment manufacturing	1.0%	
	Bare printed circuit board manufacturing	1.0%	
	Semiconductor and related device manufacturing	2.0%	
	Printed circuit assembly (electronic assembly) manufacturing	1.0%	
	Other electronic component manufacturing	0.5%	
	Automatic environmental control manufacturing	1.0%	
	Industrial process variable instruments manufacturing	0.5%	
	Analytical laboratory instrument manufacturing	1.0%	
	Data processing, hosting, and related services	1.0%	
	Computer systems design services	1.5%	
	Other computer related services, including facilities management	1.5%	
Insurance and finance	Insurance carriers	1.0%	2%
	Insurance agencies, brokerages, and related activities	1.0%	

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Table 5 (*continued*)

Sector	Description	Sub-sector share	Sectoral Shares
Program administration	Federal electric utilities	1.25%	5%
	State government electric utilities	1.00%	
	Local government electric utilities	1.00%	
	* Employment and payroll of state govt, non-education	0.50%	
	* Employment and payroll of local govt, non-education	0.50%	
	* Employment and payroll of federal govt, non-military	0.75%	
Architecture and engineering services	Architectural, engineering, and related services	1.50%	5%
	Specialized design services	1.50%	
	Environmental and other technical consulting services	2%	

Note: sectoral shares are correct; they may differ from the sum of the sub-sector shares as shown, due to rounding.

Table 6
Comparison of employment multipliers across energy sectors (FTE/$million investment in $2015).

	Direct	Indirect	Induced	Total
Electric power generation*				
Wind	0.47	1.49	1.62	3.58
Transmission & distribution	0.70	2.11	2.92	5.73
Fossil fuel	0.64	2.57	3.13	6.34
Solar	2.00	0.70	3.69	6.38
Nuclear	1.02	2.56	3.44	7.02
Geothermal	1.25	3.26	3.94	8.45
Hydroelectric	1.32	3.38	4.24	8.94
All other	1.87	3.40	5.05	10.32
Biomass	0.73	5.87	4.27	10.87
Energy efficiency				
Industrial	3.69	3.39	5.06	12.15
Residential	3.78	3.74	5.04	12.55
Commercial	4.07	3.48	5.10	12.64

Source: IMPLAN Group [9].
Note: total values are correct; the sums of components as shown may not add to the totals, due to rounding.
* Source: IMPLAN Group [9].

of $1 million increases the total jobs in sectors affected by higher investments in Table 5 creates 3.69 additional FTE jobs. Additionally, each sector that benefits directly also generates second-order effects in sectors that provide raw materials and support series to the sector. For example, as a result of spending in the construction of new structures (Row 1 in Table 5), jobs will be generated in sectors that produce construction materials. Such second order effects constitute the indirect effects. In our example of industrial energy efficiency, the indirect jobs account for 3.39 additional FTE jobs per million dollars of investment. Finally, the increased employment and resultant wages in the hands of direct and indirect beneficiaries will lead to an increase in consumption spending in sectors such as restaurants, hotels etc. leading to 5.06 additional induced jobs as a result of industrial energy efficiency spending.

To further illustrate the use of this methodology, we apply the multipliers to an analysis of the employment impact of implementing a $25 carbon tax on the U.S. economy starting in 2020 and escalating 5% each year. We use GT-NEMS to analyze the employment impacts on the energy supply-side economic activities. We then estimate the additional employment that would occur as the result of energy-efficiency jobs based on the bills of goods shown in Table 2 through Table 5.

This methodology was used by Brown and Ahmadi [5] in their analysis of a $25 carbon tax, showing that a tax could boost U.S. employment significantly. If implemented in 2020, a $25 carbon tax could expand U.S. employment by 1.4 million jobs each year between 2020 and 2030, which is nearly a 1 percent increase above the baseline forecast of 160 million jobs in 2030. Altogether, an estimated 72 million “job years” would be created over the three decades with a $25 carbon tax.

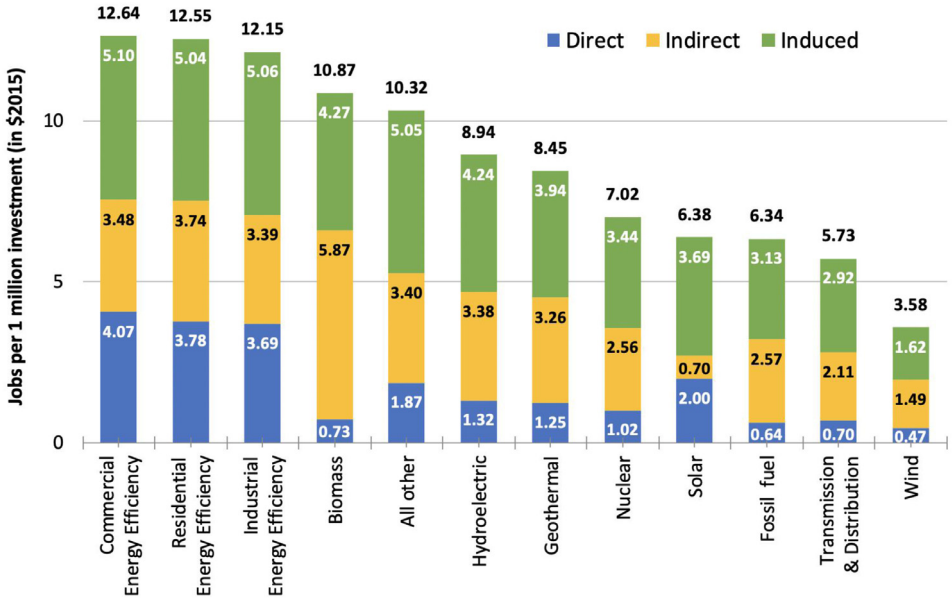

Fig. 5. Comparison of employment multipliers across energy sectors (FTE/$million investment in $2015).
(Note: total values are correct; the sums of components as shown may not add to the totals, due to rounding.).

(Note that if one job continues after one year for another 12 months, it represents two job years.) Fig. 4 summarizes these results.

Summary

Illustrations of how this methodology can be deployed are available in several recent publications [4,5 2]. Fig. 5 portrays our estimates of jobs per million dollars of investment (in $2015) across energy sectors of the U.S. economy, including three energy-efficiency domains.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Marilyn A. Brown: Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing, Visualization. **Anmol Soni:** Methodology, Investigation, Writing - original draft, Writing - review & editing, Visualization. **Yufei Li:** Data curation, Methodology, Investigation, Visualization.

Acknowledgements

Several MethodsX reviewers provided valuable and detailed comments, which are greatly appreciated. We also are grateful to the participants in our expert survey who provided detailed estimate the types of the expenditures required to complete energy-efficiency upgrades. During the course of the project we received valuable insights from discussions at Georgia Tech's School of Public

Policy, Climate and Energy Policy Lab, and Global Change Program. GT's Majid Ahmadi helped to verify our data analytics and assisted with our visualizations. In addition, Laura Martin, Russell Tarver, Erin Boedecker, and others at the U.S. Energy Information Administration provided helpful advice on key NEMS modeling issues.

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