AMERICAN PUBLIC POWER ASSOCIATION
Powering Strong Communities

PUBLIC POWER ENERGY TRANSITION ROADMAP

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The American Public Power Association thanks the members of the Energy Transition Community (ETC) Working Group for their essential role in crafting this roadmap, which is designed to assist public power utilities in developing more resilient, lower-emission electricity systems while continuing to deliver safe, reliable, and cost-effective electricity to their communities. ETC Working Group members gave their time generously, sharing their organizations' experiences, needs, and practices in workshops and conference calls. ETC Working Group members include:

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ABOUT APPA

The American Public Power Association is the voice of not-for-profit, community-owned utilities that power 2,000 towns and cities nationwide. We represent public power before the federal government to protect the interests of the more than 49 million people that public power utilities serve, and the 96,000 people they employ. We advocate and advise on electricity policy, resilience, cybersecurity, grid operations, technology, trends, and training.

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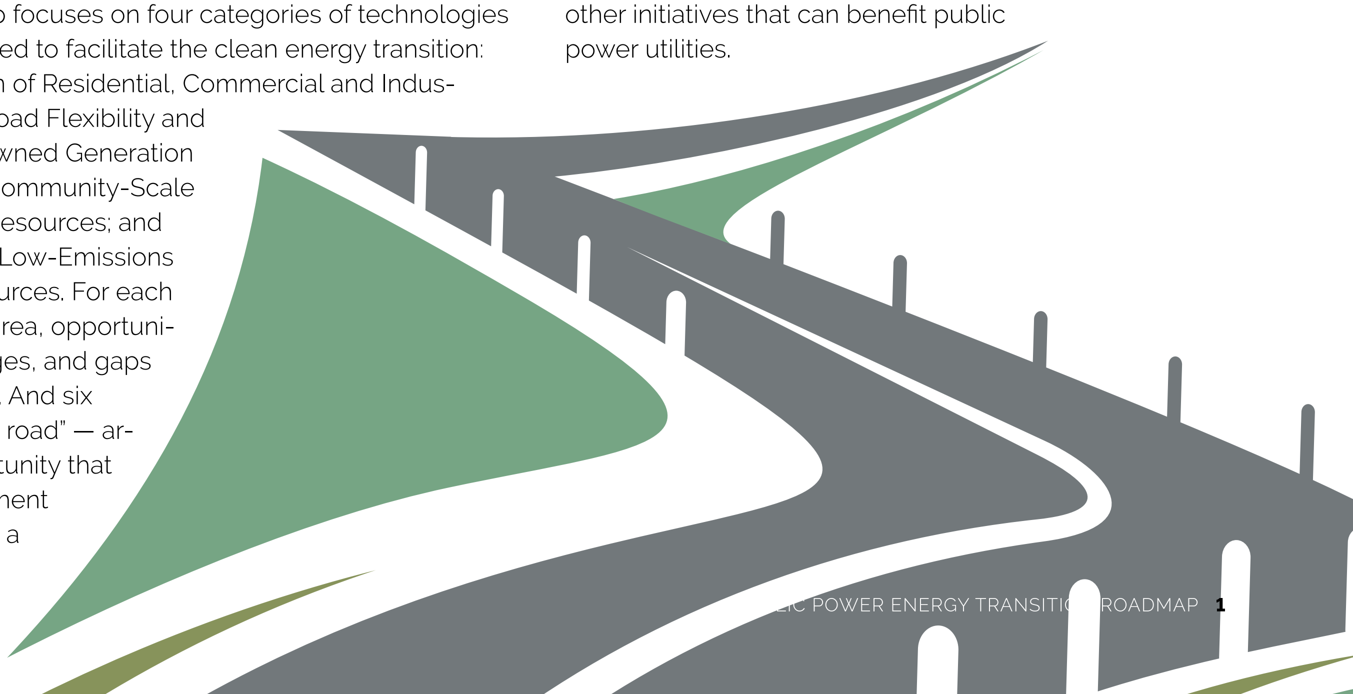
EXECUTIVE SUMMARY

The energy utility industry is in the midst of an unprecedented transition — moving from centralized systems powered primarily by fossil fuels to more decentralized systems that rely heavily on cleaner generation sources. This transition poses both opportunities and challenges for public power utilities, the communities they serve, and the environment.

This Public Power Energy Transition Roadmap offers a framework to assist public power utilities in planning and advancing more resilient, lower-emission electricity systems while continuing to deliver safe, reliable, and cost-effective electricity to their communities. Based on extensive input from the American Public Power Association's Energy Transition Community Working Group, this document identifies important gaps and barriers, opportunities, and other factors that can influence a given utility's energy transition pathway.

The roadmap focuses on four categories of technologies best positioned to facilitate the clean energy transition: Electrification of Residential, Commercial and Industrial Loads; Load Flexibility and Customer-Owned Generation Resources; Community-Scale Generation Resources; and Utility-Scale Low-Emissions Energy Resources. For each technology area, opportunities, challenges, and gaps are analyzed. And six "lanes on the road" — areas of opportunity that can complement and advance a utility's energy transition—are described. These include: program development, energy purchasing, technology planning, pilot projects, technology transfer, and leveraging funding.

This roadmap will be revised and expanded over the next five years as part of funding through an ongoing Cooperative Agreement with the Department of Energy, DE-OE0000928. The revision process will be used to facilitate collaboration and share technology and program successes, lessons learned from pilot projects, and other initiatives that can benefit public power utilities.



INTRODUCTION

The Public Power Energy Transition Roadmap builds on the American Public Power Association's (APPA) work to help public power utilities plan and execute their strategies to achieve greater resilience and lower emissions — including the Moving Public Power Forward strategic initiative and guidance on community solar, energy storage, electric vehicles, distributed energy resources, smart cities, grid modernization, and rate design.

APPA received Cooperative Agreement funding from the U.S. Department of Energy to support our members in achieving their goals of a low-carbon future while maintaining reliable and affordable electricity for their customers and refer to this work as our Energy Transition Community (ETC). Within this Community, there are two Working Groups of 2 – 25 members who volunteer to provide input on members experiences, needs and practices, and member participation is a key part of this work.

Through the Energy Transition Community Working Group, we produced this Energy Transition Roadmap, to be updated annually, to provide guidance for public power utilities on achieving their goals. Through the Energy Storage Working Group, we developed a report on energy storage challenges, solutions, and opportunities for public power.

This roadmap and subsequent iterations are designed to identify knowledge gaps and barriers, communicate lessons learned within the public power industry, and foster collaboration among public power utilities, APPA, and federal partners — aiding public power in achieving emissions reduction goals while continuing to deliver safe, reliable, and cost-effective electricity.

It should be noted that in addition to advancing greenhouse gas (GHG) mitigation in the public power sector, APPA members support enactment of a federal clean energy standard to reduce GHG emissions from the electric sector that keeps electricity affordable and reliable for customers. This roadmap does not address federal policy, it explores business and technology strategies for utilities to meet clean energy goals. Many public power utilities have already traveled a long distance toward these goals by switching to lower emitting generating resources, investing in renewable and other non-emitting generation resources, integrating distributed energy resources, and reducing energy waste with efficiency programs. Many have begun supporting transportation electrification by developing charging infrastructure, offering rebates for electric vehicles (EVs), and creating rate structures that incent off-peak charging. In addition, some public power utilities are reducing GHG emissions by supporting electrification of water and space heating and other energy end uses that have been served with onsite fossil fuel combustion.[1]

Consistent with the goals of many local and state governments, corporations, institutions such as universities, and the Biden administration, the roadmap sets 2035 and 2050 as target years for achieving emission reduction benchmarks. It provides insights, ideas and case studies useful to public power utilities regardless of their size, geography, political goals, and demographics.

1 Zummo, Paul. "Moving Public Power Forward: Community-Driven Solutions for Industry Transformation," American Public Power Association. 2021. www.publicpower.org/resource/moving-public-power-forward-community-driven-solutions-industry-transformation. Accessed October 20, 2022.

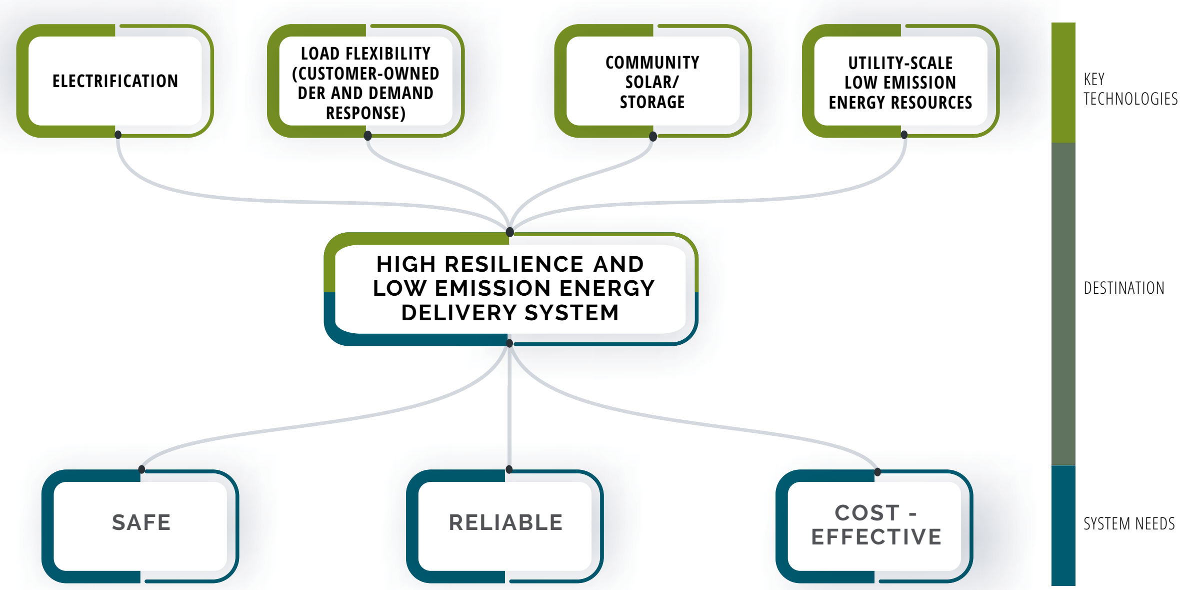
FOUR KEY ENABLING TECHNOLOGIES FOR ENERGY TRANSITION IN PUBLIC POWER

As a first step in creating a roadmap, the ETC Working Group identified the four key technologies most well positioned to enable utilities to plan and implement their clean energy transitions:p

- **Electrification of Residential and Commercial and Industrial Loads**
  Electric home heating, water heating and cooking; industrial processes; agriculture; and transportation
- **Load Flexibility or Customer-Owned Resources**
  Residential, commercial and industrial solar; behind-the-meter (BTM) batteries; distributed wind; utility-controlled heating, ventilation and air conditioning (HVAC) and water heaters; backup generators; etc.
- **Community-Scale Resources**
  Community solar; on-grid battery storage, thermal storage, pumped hydro storage, etc.
- **Utility-Scale Low-Emissions Energy Resources**
  Solar, wind, storage, hydro, nuclear, and landfill gas generation deployed by utilities.

While these four technology categories represent the best near-term opportunities to lower emissions in electricity supply, each comes with opportunities and challenges. Feedback from the ETC Working Group members indicated that none of the low-emissions technologies raise substantial new safety concerns, so their focus in this roadmap is on reliability and cost issues — which are significant. Some public power utilities already feel challenged to reliably serve existing load with the growing proportion of intermittent resources on their systems, especially wind and solar. ETC Working Group members also pointed to reliability risks associated with rapid increases in electrification and utility-scale intermittent resources and expressed some concern

Figure 1: Technology and Focus Areas of this Roadmap



about the costs and revenue impacts of implementing load flexibility and community solar and storage. The North American Electric Reliability Corporation (NERC) has also identified significant reliability risks associated with rapid increases in intermittent and distributed energy resources (DERs) and inverter-based resources. "Managing this pace of change presents the greatest challenge to reliability," said a NERC reliability assessment.[2]

There are also potential cost savings and revenue opportunities across all four technology categories and some ability to gain reliability benefits from load flexibility. Some public power utilities are building layers of programming opportunities for their customers to make decisions on how they want to approach the energy transition, and in many cases, there is a strong business case with payback that makes financial sense for the consumer and the utility. A consistent theme in ETC Working Group member discussions was how utilities could use options that provide price signals that would facilitate customer actions that would in turn minimize the costs of energy transition technology.

Leveraging the full value of these four technology categories requires a modernized grid with supervisory control and data acquisition (SCADA) systems to identify and solve issues before outages occur; advanced metering infrastructure (AMI) to collect and leverage real-time data for load management; distributed energy resource management systems (DERMS) to identify, forecast, schedule, and control DERs and link to customer-facing programs; and some level of artificial intelligence to analyze large data sets. These capabilities require modern wireline and wireless communications and accompanying cybersecurity measures, as well as investments in staffing, processes, and technologies.

Public power utilities are at widely varying positions regarding the above grid modernization capabilities, and for many, the required investments will be substantial — and at the same time largely invisible to the customers who own and govern the utility. For more information about public power and digital technologies, see APPA's [Creating a Smart City Roadmap for Public Power Utilities].

Full and immediate grid modernization and achievement of clean energy goals would require rate increases that are unsustainable for customers. Therefore, it is imperative for utilities to prioritize investments over time and develop plans for continuously improving the flexibility of the grid to better manage changing load profiles and variable generation resources.[3]

In this roadmap, the ETC Working Group assessed the opportunities and challenges of each technology category, including the most significant gaps, or potholes, in the road ahead — such as the potential for public power utilities to experience surging peak demand as consumers plug in more electricity-intensive devices. Building on this initial roadmap, the ETC Working Group will in future iterations explore strategies to reduce risks, enhance benefits, and close the gaps associated with each technology category. It is expected that the net effects of these efforts will be: 1) progress toward a lower-emissions electricity supply with minimal effect on customer cost, 2) improvements to the overall financial position of utilities, and 3) maintaining reliability of the electric system — without significant negative impacts on any of these three objectives.

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2 Cash, Cathy. "NERC: New Energy Mix, Extreme Weather Elevate Reliability Risks," cooperative.com. January 18, 2022. www.cooperative.com/news/Pages/NERC-Report-Pace-of-Industry-Change-Is-Greatest-Challenge-to-Reliability.aspx. Accessed October 20, 2022.

3 Biggins, J., Chatterjee, R., and Calhoun, C. "Grid Modernization Keystone to a Clean Energy Future". Infosys Knowledge Institute. October 6, 2019. www.infosys.com/iki/insights/clean-energy-future.html. Accessed October 20, 2022

TECHNOLOGY ASSESSMENT – OPPORTUNITIES, CHALLENGES, AND GAPS

There is growing demand from consumers, policymakers, advocates, corporations, developers, and other stakeholders for the electric sector to achieve a zero-emissions future. Yet, the nearly 100,000 public power employees must manage this imperative with attention to possible consequences on the safety, reliability, and cost of electricity. As mentioned above, ETC Working Group members found the safety risks of the four priority technology areas to be manageable within existing operational frameworks, so the most attention has been devoted to concerns about reliability and cost. Customer expectation and satisfaction were also important considerations throughout the roadmap discussions, and are often correlated to cost, reliability, and sustainability.

Electrification Opportunities and Challenges

Electrification includes the use of electricity for end-uses that would otherwise be powered by fossil fuels, such as gasoline, diesel oil, natural gas, and propane. Also known as "beneficial electrification," "efficient electrification," or "strategic electrification," the process has four goals: saving consumers money, reducing emissions, fostering a robust grid, and improving customer quality of life (for example, via improved air quality or temperature comfort in the home). Another quality-of-life factor could include jobs, as electrification increases the demand for contractors and others who can upgrade or install wiring, electric panels, chargers, and appliances.

Electrification is occurring in all sectors of the U.S. economy, including the building, industrial, agricultural, and transportation sectors. Electrification includes a range of technologies, such as: electric on-road and off-road vehicles; lawn maintenance equipment; heat pump heating and cooling systems; electric water heaters; farm irrigation systems; forklifts; electric bikes; and electric industrial equipment.

Projected growth of EV markets, more EV offerings by automakers, and state and federal pro-EV policies are driving enthusiasm and interest in electrification at many public power utilities. Bloomberg New Energy Finance forecasts that EV sales will rise from 3.1 million in 2020 to 14 million in 2025, accounting for 16% of all passenger-vehicle sales globally.[4] Meanwhile, electrification of heating and cooling systems, water heaters, and cooking appliances, as well as industrial and agricultural systems, are increasingly seen by many stakeholders as strategies to meet sustainability goals, particularly as more clean energy sources (solar, wind, nuclear, hydrogen, etc.) are added to the electric grid. While these trends represent revenue opportunities for electric utilities, they also can put pressure on reliability and affordability if not implemented with care or hamper decarbonization efforts in the near term if the electricity meeting this new demand emits more than the fossil fuel combustion it displaces.

Currently, some public power utilities are offering or implementing pilot and early programs, such as special EV charging rate structures, rebate programs for HVAC systems and appliances, and efficient electrification programs that provide low- and moderate-income

4 "Electric Vehicle Outlook Report 2022" Bloomberg NEF. 2022. https://about.bnef.com/electric-vehicle-outlook. Accessed October 20, 2022

EXAMPLE – EV Charging Program

One public power utility offers a three-tier EV charging program that includes an off-peak option for which there is an upfront cost to cover an extra meter and then a $0.04/kWh reduction in the customer's rate. The utility sees nearly 100% participation among EV owners in its service territory. This program was created in response to an analysis of EV owners' usage patterns, which revealed a potential loss of $1,000/EV/year due to charging during peak periods if the load was not managed. APPA members can read Exploring Electric Vehicle Rates for more information.

customers with options to lower their bills. The Inflation Reduction Act (IRA) directs billions in refundable, direct pay tax credits to electrification measures and every public power utility with a clean energy transition goal should review the act for related funding opportunities.

The following graphic summarizes the electrification challenges, transition enablers, and opportunities identified by the ETC Working Group. Since each utility is at a different place with respect to transition enablers, the items in this category could also be considered potential gaps for public power utilities to consider as they navigate the transition.

Electrification Gap Analysis

Reliability concerns increase with the large surges in demand expected as customers plug in more electricity-intensive devices, such as vehicles, without regard to peak loads and timing. Meanwhile, many public power utilities have yet to fully implement the information technology (IT), operational technology (OT), and customer interface/metering infrastructure that can facilitate energy management.[5] Moving fossil fuel-powered loads to electric, while at the same time removing fossil baseload generation, may require sacrifices and/or significant changes in customer behavior. On the other side of the coin, public power utilities may find it difficult to recover increased demand/capacity costs for the short periods of peak consumption by customers with electricity-intensive equipment. Transitioning to more electrified solutions will require strategic planning to fill these gaps so that utilities can realize the benefits of electrification and avoid unnecessary costs. However, if these challenges are overcome, public power utilities can benefit from increased revenue, customer engagement, and customer satisfaction.

5 APPA's Roadmap to the SEPA 51st State – Phase II. American Public Power Association. www.publicpower.org/system/files/documents/ppf_51st_state_submission.pdf

ELECTRIFICATION CHALLENGES

- If not managed, EV charging can sharply increase peak generation requirements and costs
- EV charging is likely to occur at drivers' homes or workplaces, but consumers also need access for long distance and emergency travel
- Additional transformer capacity (and supply) may be needed to accommodate electric bus and truck fleets
- There are upfront costs associated with retrofitting appliances
- Distribution sizing and panel upgrades may be needed for residential areas
- There are supply chain issues, including challenges with lithium production

TRANSITION ENABLERS

- Time-of-use and off-peak rate structures to incentivize charging during low-emission and/or low-price periods
- Partnerships with large customers that have sustainability goals
- Partnerships with customers to provide mutually beneficial rates
- Creative financing
- Implementation and ability to fully utilize IT/OT and customer interface/metering systems
- Marketing and customer engagement

REALIZING OPPORTUNITIES

- Increased sales/revenue
- Load balancing, improving load factor, and thus right sizing of systems including generation, transmission, and distribution
- Improvements in reliability and affordability with increased control of flexible energy demand
- Greater customer choice in how energy is produced, higher consumer satisfaction
- Carbon emissions reduction for buildings, industry, and transportation
- Improved indoor air quality by electrifying onsite fuel combustion

Load Flexibility/Customer Owned Resources Opportunities and Challenges

BTM energy devices can create complexity for electricity delivery systems. It may be difficult to define whether a customer-owned resource is a flexible resource, an energy load, or a generation resource. For example, a battery may be considered a flexible load if it can be coordinated with the needs of the energy grid; to a utility, it might simply look like an energy load if it is only used to provide back-up power to a home. For the purposes of this roadmap, the load flexibility/customer owned resources category includes any technology that can create a two-way flow of power or shape load: rooftop solar, residential batteries, distributed wind, commercial batteries, commercial solar, water heaters, residential air conditioners, smart thermostats, electric vehicles, backup generators, and other BTM technology.

Customer-owned resources often require active management. Onsite renewable energy is intermittent, and customers are not always fully informed of how their resources can contribute to costs and benefits of the grid. For example, onsite solar may be valuable if the grid needs energy resources at a given time, but it may be less valuable during times of oversupply. If supply

CUSTOMER-OWNED RESOURCES CHALLENGES

- Intermittency creates imbalance between generation and load
- Consumers don't understand electricity markets and push back against cost-of-service rate restructuring
- Cost shifting from those that can afford to invest in energy technologies to those who cannot
- Balancing oversupply and undersupply
- Getting it wrong will negatively impact costs and reliability

TRANSITION ENABLERS

- Increased data and automation to determine when customers might/might not generate
- Software to facilitate integration, demand response, and load control/customer action
- Rates that fairly accommodate and account for behind-the-meter resources
- Strong customer relationships that facilitate peak shaving and enable smart, balanced growth
- Time-of-use rates or price signals to consumers of electricity to shift their loads may improve system reliability.
- Smart thermostats in conjunction with AMI

REALIZING OPPORTUNITIES

- Reduced energy consumption during peak demand can save transmission and capacity costs, benefiting both utility and consumer
- Avoid infrastructure investments (through the virtual power plant concept)
- Revenue and reliability opportunities at the retail level
- Aggregation at wholesale level to save costs
- Reduce emissions
- Increased load factor
- Ability to match demand to supply, shape load, and help reduce the cost of integrating renewable energy

and demand are not properly balanced, then costs, reliability, and safety can be negatively affected. As the technology in this category is often expensive, there are concerns regarding equitable access as well as cost shifting between customers who can afford to invest in energy technologies and those who cannot.

At the same time, load flexibility provides significant cost reduction and reliability opportunities if integrated under optimal conditions. For example, at certain times of day, the grid may have plenty of power supply and low energy costs, in which case a flexible load can help improve load factor and help reduce overall costs. Likewise, when energy supply is low and demand is high, flexible loads can ease demand on the grid, and, again, lower costs and improve reliability.

Load Flexibility/Customer Owned Resources Gap Analysis

Optimizing the value of consumer-owned resources and making use of flexible loads requires AMI, two-way communications systems, artificial intelligence to analyze large data sets, and other components of a smart grid. Yet, AMI is still not deployed everywhere. At the end of 2021, U.S. utilities had installed about 111 million AMI meters, covering 67% of the 164.4 million electricity customers in the U.S.[6]

Additionally, this category of technology can benefit from broadband availability and deployment. As areas across the country deploy broadband technologies (increasingly with the participation of utilities), many are also upgrading their electric systems, enabling smart reclosers, distribution automation, Volt/Var optimization, smart thermostats, and increased DERs.

6 Annual Electric Power Industry Report, Energy Information Administration. October 6, 2022. www.eia.gov/electricity/data/eia861. Accessed October 17, 2022.

Community-Scale Opportunities and Challenges

Community solar is the most common community-scale electric generation resource in operation today. The U.S. Department of Energy defines community solar as any solar project or purchasing program within a geographic area from which the benefits flow to multiple customers. Community solar customers buy or lease a portion of a solar project's capacity, and typically receive an electric bill credit for electricity generated by their share. In most cases, customers are benefitting from energy generated by solar panels at an array that is remote from their premises.[7] The benefits of community solar to public power utilities include:

- It helps respond to unmet customer demand for solar and improves customer relationships
- It demonstrates a utility's responsible environmental stewardship
- It allows direct control and monitoring of solar resources
- It provides economies of scale (compared to rooftop systems)[8]

Definitions for community storage vary. For the purposes of this roadmap, community storage includes any energy storage device owned or contracted for by the community, which can include the public power utility. While other technologies may emerge, virtually all community storage systems currently use high-capacity batteries.

7 "Community Solar Basics." Energy.gov, Department of Energy Solar Energy Technologies Office, www.energy.gov/eere/solar/community-solar-basics. Accessed October 20, 2022.

8 Community Solar Options for Public Power. American Public Power Association, www.publicpower.org/system/files/documents/ppf_Community-Solar-options-for-public-power.pptx. Accessed October 20, 2022.

COMMUNITY SCALE CHALLENGES	TRANSITION ENABLERS	REALIZING OPPORTUNITIES
Difficulty finding land suitable for solar that is not already prioritized for other uses	Building or defining replicable business models and understanding of the technology	Customer engagement and satisfaction
Interconnection costs	Maturity of the market for batteries and solar and accompanying hardware, software, and warranties	Clean energy access for those who cannot afford rooftop solar
Balancing local supply and demand	Lowering costs of systems with technology development and economies of scale	Customers participate and share in the overall costs and benefits
Long-term maintenance and management of the assets		Cost savings through avoiding subsidies/ penalties to non-solar customers under a rooftop model
Lack of cost-effective battery solutions		Positive return on investment, especially if batteries can be paired with assets for peak shaving, dispatching, and increased reliability
Lack of knowledge for emerging options, such as flywheels		
Supply chain shortages		
Upfront costs		

The following graphic summarizes the community solar and community storage challenges, enablers, and opportunities identified by the ETC Working Group.

Community-Scale Gap Analysis

A significant challenge for community-scale generation is finding land that is appropriate, available, and affordable in or near a utility's service territory. In some cases, community projects can only move forward when the land is donated. Another challenge is the cost of interconnecting with transmission and distribution systems.

Some ETC Working Group members asked whether there is still a need for community solar if the utility is investing in large-scale systems or contracting for solar energy from independent power producers. While it's true that large utility-scale solar projects produce lower cost energy than smaller community solar facilities, community solar is generally less expensive than rooftop solar and offers a way for customers to engage and participate directly. From the utility perspective, community solar can also serve as a customer's entry point for other programs.

Looking beyond the traditional community solar model, utilities are investigating ways that community-scale resources on the distribution grid can provide peak shaving benefits and reduce transmission costs. A key element in their analyses is whether benefits fully offset the cost of equipment and upkeep, with and without the costs to administer subscriptions. Likewise, it is possible the utility and the consumer would derive greater benefit from simply deploying more large-scale solar. There is also a need to understand how effectively community-scale subscriptions impact engagement for other programs.

EXAMPLE – Smart Thermostats

A smart thermostat program with 750 participants helped one public power utility reduce demand by 1 MW during peak events over the past four years.

Utility-Scale Resources Opportunities and Challenges

Many of the large reductions in electric system GHG emissions will come from deployment of utility-scale clean generation resources. Prior to the passage of the IRA in 2022, not-for-profit entities could not benefit from federal tax credits, which had been a barrier to public power utilities public power utilities directly owning certain assets. Instead, they were essentially forced to enter power purchase agreements for solar and wind generation. Pending implementation of the IRA from the federal government, new opportunities may be available for direct investment in clean energy technologies. Another challenge is the intermittent availability of these resources, which, if not managed on the demand side, will result in higher peak energy costs.

If the challenges can be overcome, many public power customers would likely be pleased to know their energy comes from low-emission resources — as long as pricing and reliability are not jeopardized. If costs can fall and utility-scale resources can be coupled with flexible demand and energy storage, public power utilities can benefit by reducing their emissions and meeting customer demand for cleaner electricity.

Utility-Scale Gap Analysis

Expectations for cleaner energy are growing and technologies are changing rapidly. Adaptation and transition take time, and they are dependent on many factors, including geography; local, state, and federal policy goals/regulations; market forces; workforce; and cus-

UTILITY SCALE RESOURCE CHALLENGES

- Rapidly rising transmission costs in areas of significant resource change
- Transmission constraints
- Permitting due to environmental and other regulations
- Reliability
- Integration
- Management
- Disposal of used, non-recyclable solar and wind materials

TRANSITION ENABLERS

- Diversity of available low-emission resources —the more types available in all weather conditions, the better
- Continued decline in prices of solar and batteries, making projects more economical
- Reliable gas delivery system that can handle system variability
- Renewable energy certificates (RECs)

REALIZING OPPORTUNITIES

- If successfully coupled with other technologies, there is potential for long-term cost reductions
- Reduce operational, generation, and transmission costs
- Leverage resources with no associated fuel costs
- Customer engagement and satisfaction
- Emissions reduction
- Story of immediate action
- Public power utilities can access tax credits under IRA (pending implementation)

tomer preferences and tolerance for change and cost increases. One of the major gaps in integrating substantial amounts of most utility-scale renewable energy (other than hydropower) cost effectively is a lack of deployed enabling technologies from the other technology categories, especially load flexibility. Since many public power utilities purchase power from the market, the impact of increased variable utility-scale resources on each utility will vary depending on the tools they have to respond to changes in fuel mix characteristics. In some cases, public power utilities can make progress towards their clean energy goals through changes in their power purchase agreements and by purchasing renewable energy credits. However, these strategies on their own will not help the utility meet the challenge of matching the load on their system to the power supply available on the market.

EXAMPLE – Renewable Energy Certificates

In a community served by a public power utility, a customer survey revealed support for a $5/month electric bill increase to achieve its 100% carbon-free power supply goal. Additionally, the utility has a voluntary renewable energy certificate program for customers.

DEFINING THE DESTINATION

Public power utilities across the country continue to reduce their GHG emissions through a variety of means, such as fuel switching to lower-emitting resources, investing in renewable and other non-emitting resources, integrating DERs, and enacting various energy efficiency measures. They also have been reducing GHG emissions by facilitating the electrification of transportation in their communities, including the deployment of charging infrastructure, offering rebates for EVs, and developing special rate structures to incent off-peak charging. In addition, some public power utilities are reducing GHG emissions by promoting the electrification of water and space heating and other energy services.

Public power utilities are affected by national policies and therefore this roadmap acknowledges broader policy considerations that are beyond the scope of this document. APPA supports enactment of a federal clean energy standard to get to net-zero emissions by 2050 that keeps electricity affordable and reliable for customers This would provide public power utilities with sufficient time to site, permit, and construct clean energy and transmission projects and for technologies such as long-term energy storage, green hydrogen, advanced nuclear reactors, and carbon capture utilization and storage (CCUS) to reach maturity.[9]

For any roadmap, a destination must be defined. APPA recommends that all public power utilities — regardless of size, location, resource mix or other factors — set their destination as significantly reducing their emissions without negative impacts to safety, reliability, or cost. Public power utilities want to have confidence that they can match low/no-emissions electric supply to load by 2050 or sooner, if technology exists to do so, while keeping electricity affordable and reliable for all customers.

Reaching this destination will require:

- The network architecture to accommodate any low-emissions generation future without significant negative impact on safety, reliability, or cost
- The evolution of digital technologies to adapt to changing needs for information, efficiency, and more grid responsiveness to consumer needs
- Maintaining reliable power in the face of variability and changing demands
- Cost-containment strategies for times of high demand or low supply
- Load management systems that can automatically steer electricity consumption into low/no emissions and low-cost times of the day
- Electrification of new loads without fear of creating new constraints
- Offerings that support equity among consumer classes
- Offerings tailored to commercial and industrial clients with sustainability goals

9 "Resolution 22-01, In Support of a Federal Clean Energy Standard That Reduces Greenhouse Gas Emissions to Address Climate Change While Keeping Electricity Affordable and Reliable." American Public Power Association. June 2022. www.publicpower.org/policy/resolutions. Accessed October 20, 2022.

DEFINING THE ROAD FORWARD

Over the next five years, the broader ETC group will work to follow the strategy of this roadmap to: 1) identify technologies that can help achieve a low-emissions future; 2) analyze the opportunities and challenges that each present related to safety, cost, and reliability (keeping consumer interests at the center of the analysis); 3) follow implementation paths defined in this section; and 4) refine the process over time.

Using the analogy of a roadmap, this document has now defined the geography (the clean energy transition landscape for public power) and the destination (2050 vision) associated with the effort to achieve a lower-emissions future. What is left to define is the "road" to the destination.

The organizations represented on the ETC Working Group, and the ETC group more broadly, are at different places on this path. Some have well-defined goals and programs, policies, and technology in place to arrive at a low/no-emissions destination within the next decade. Others are closer to the beginning of the road. However, there are commonalities among all public power utilities — defined here with the analogy of six "lanes on the road." These lanes are complementary, and public power utilities will likely follow more than one, if not all six, toward their ultimate destination.

LANE 1: PROGRAM DEVELOPMENT

Cost-effective programs can move utilities down the road toward a low-emissions grid while simultaneously developing technology and data systems that will enable additional cost-effective programs in the future. For example, as EVs are added to a utility system, programs designed to engage customers with EVs in off-peak charging may save the customer and utility money on wholesale power costs, while also spurring investment in data collection and analysis capabilities that will be useful in future energy storage projects. Smart thermostat programs may be cost-effective today, and, at the same time, build capacity for more complicated load-flexibility programs. Some of this capacity will come from vendors that sense market opportunities. For example, software companies are already working with utilities on apps that allow customers to set preferences and react to real-time pricing and emissions intensity signals.[10]

LANE 2: ENERGY PURCHASING

Many public power utilities do not generate power themselves but purchase all their supply requirements through bilateral contracts with independent power producers or other utilities with generating facilities or through regional transmission organizations. Public power utilities can leverage their energy purchasing power to seek lower-emission electricity from their suppliers. This strategy can be most effective when consumers and decision-makers are brought into the process.

10 "Make IFTTT Your Energy-Saving Partner." ComEd, 2022. https://www.comed.com/WaysToSave/ForYourHome/Pages/IFTTTEnergySavings.aspx. Accessed October 20, 2022

LANE 3: TECHNOLOGY PLANNING

When public power utilities plan their capital expenditures to replace and upgrade equipment and systems, they should integrate new technology into their investment decisions as it becomes cost-effective. This will promote adaptation to future scenarios where, for example, system-wide electric generation will be more variable, cost signals stronger, and customers will have new electric load shapes and demands. Smart technology planning, informed by the experience of public power peers, is a fundamental strategy for minimizing the costs of the transition to clean energy.

LANE 4: PILOT PROJECTS

Public power utilities have a long history of participating in pilot projects to test the effectiveness of new technologies and sharing the results with their peers and across the electric power industry. ETC Working Group members specifically anticipate providing more energy services (internet-of-things, demand response, etc.) and using digital communication platforms with their customers. Pilot projects will be important to successful rollout of these services. APPA provides support for such pilot projects through its [Demonstration of Energy & Efficiency Developments (DEED) program](#).

LANE 5: TECHNOLOGY TRANSFER

Public power utilities are also well-positioned to share successes and lessons learned from full-scale technology deployments, use of new enabling technologies, and innovative customer programs. Creating and disseminating effective tools and resources can help public power utilities replicate their peers' successes and transition to clean energy more quickly, safely, reliably, and cost-effectively. The ETC Working Group will create avenues to facilitate this sharing and contribute to further roadmap guidance.

LANE 6: LEVERAGING INVESTMENTS

Making progress toward a low-emissions future while maintaining affordable rates and high reliability is a goal shared by stakeholders inside and outside of the power sector. As a result, federal, state, and local funding is often available to help support pilot programs, workforce development, and other initiatives to help utilities meet their low-emissions goals. Taking advantage of available funding can be a strategy to ease transition costs.

EXAMPLE – Energy Efficiency and Conservation Block Grant

On November 15, 2021, the Infrastructure Investment and Jobs Act was signed into law. It authorizes funding for the Energy Efficiency and Conservation Block Grant (EECBG) program at $550 million. Created in 2007 under the Energy Independence and Security Act (EISA)1, the EECBG program is designed to enable states, local governments, and tribes to: 1) reduce their consumption of fossil fuels, 2) reduce their energy use overall, and 3) improve efficiency. Public power utilities can use these funds, along with other infrastructure funds, such as DOE's State Energy Program, to develop programs and support projects while funding is available.

BENCHMARKS AND MILESTONES

The ETC project is a five-year effort that will work to fill the gaps identified in this roadmap. The outcomes of this five-year initiative will help arm public power utilities to make progress towards the 2050 destination defined in this roadmap in years five through 10.

REFINING THE ROADMAP

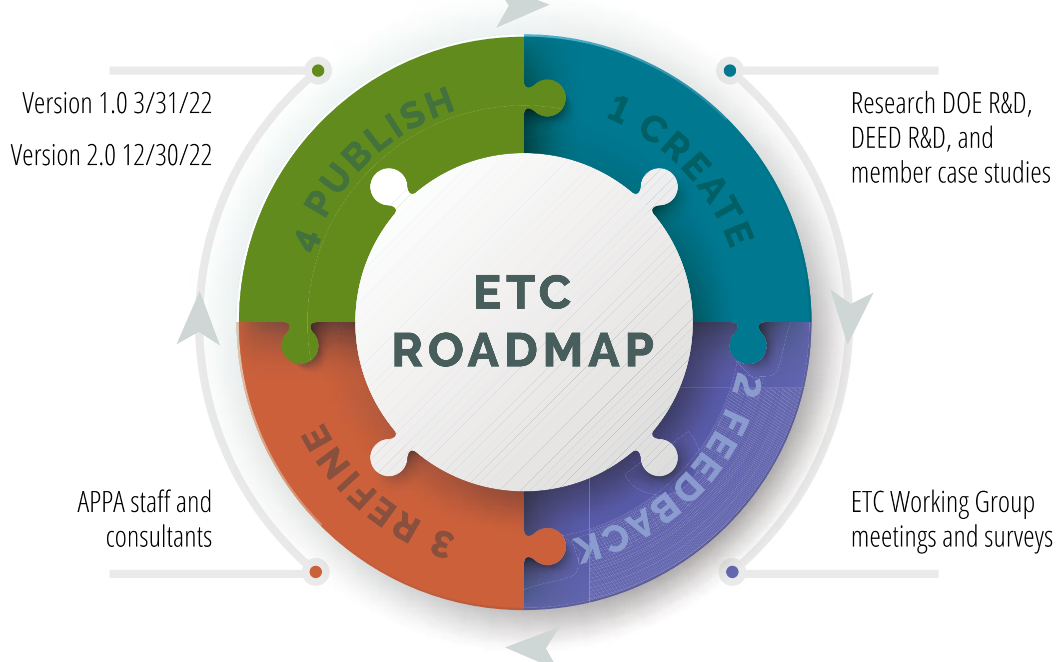
This roadmap will be a living document updated annually with input from the ETC Working Group and public power community following the process illustrated in Figure 2.

CHALLENGES TO ADDRESS IN THE NEXT VERSION OF THE ROADMAP

As part of the collaborative process in drafting this roadmap, APPA staff and consultants asked ETC Working Group members about their biggest concerns and biggest reasons to be optimistic. They also asked about the major changes the ETC Working Group members expect to see at their utilities by 2035 and 2050. A summary of their responses follows.

Between now and 2035, public power representatives expect significant advances in technologies that will help build more flexible and adaptable interconnecting systems. There are new companies offering new services, but some tools do not exist yet. Meanwhile, most investments must be justified via short-term payback. Often, the strategy is to identify enough short-term benefits to justify the upfront costs and gain the greater, long-term investment value as a "bonus." In theory, significant funding and tax credits should soon be available through grants and programs authorized in the Infrastructure Investment and Jobs Act, the Inflation Reduction Act, and other sources. Public power utilities are awaiting the forthcoming guidelines and requirements to see where interests and capabilities can align. One particular concern is that many public power utilities will not have the capacity to access and utilize these benefits.

Figure 2. Process for Updating the Roadmap



As a foundational starting point, public power utilities may need to fully deploy AMI and plan for the automation and communications applications that will enable a more nimble, flexible, and resilient system. One challenge is that AMI deployments are generally occurring slowly and in conjunction with construction or infrastructure projects. In some communities served by public power utilities, consumer advocates have questioned the return on investment. In addition, many areas do not have the communications infrastructure needed to support full AMI deployment. In an era of extreme weather events, for example, how valuable is smart feeder switching? One utility's current AMI radio system works perfectly for what it is being used for (remote reading); however, if the utility were to allow or encourage customers to deploy BTM resources, the radio communications to the meters would be insufficient.

Current efforts to expand broadband capacity will help with the transition. A strong fiber network throughout the distribution grid will make it possible for public power utilities to leverage new technologies to their full capabilities. For example, broadband could be helpful in deploying advanced distribution management systems that provide flexibility during peak demand times. Communication to substations is no longer enough. Utilities need to collect and utilize data to have remote control of field-level devices and implement automation where benefits can be gained without putting reliability, safety, or affordability at risk.

Residential and business customers are a major area of focus during the transition. Increasingly, electric customers, from large corporations to local coffee shops, are formally or informally setting clean energy goals. Many electric customers want to play a more active role in controlling their energy choices – and want options for behind the meter or community-scale resources as part of their energy supply. There is also increasing recognition that offerings must be equitable, i.e., they need to not advantage or disadvantage one group of consumers over others. More engaged customers provide utilities with opportunities for further education on their energy options and how customers can optimize their electricity usage patterns, as well as to get input on new programs and services that meet their needs and those of the utility. EVs offer a good starting point with tangible benefits for customers, utilities, and the environment. Future systems will need to adapt and evolve to match customer preferences. Digital technologies and data will help but are only a part of what is needed.

There is also broad recognition that circumstances and solutions will vary significantly from one location to another. There are no one-size-fits-all solutions for generation, transmission, distribution, or customer-facing programs. Geographies differ. Solar and wind work better in some areas than others, and they're intermittent and need to be backed by dispatchable resources. Hydropower resources can help to balance out intermittency but are not available everywhere. Policies differ. Public power utilities increasingly have renewable, clean energy, or net-zero policies. Some states have mandates, but even then, mandates may or may not apply to municipalities. In addition, public power utilities are governed locally and therefore subject to local priorities.

By 2050, ETC Working Group members expect to be dispatching energy and load to match supply, having many baseload units go offline and new energy technologies and energy storage come online. They see opportunities to advance the energy transition in ways that improve the quality of life for the communities they serve. New technologies offer the promise of customer options and sustainability without lifestyle sacrifices. At least one ETC Working Group member suggested that the social cost of carbon should be included in decision making, planning, implementation, and ongoing operations. There is a sense that utilities can be leading this work with a minimum goal of low-emissions power and some pressing for an ultimate destination of zero emissions.

Along the way, there are a range of concerns. Top of mind for most is affordability. The energy transition requires upfront investments, and especially in the context of equity and energy burden priorities and how these costs impact consumers. The expected changes also require expertise and organizational capabilities. There is concern that smaller utilities won't have sufficient capacity.

At a time when regional transmission costs are increasing, utilities are considering their options for meeting the expected fluctuations in electricity demand. Decarbonizing the grid by adding more intermittent resources and increasing end-use electrification will be difficult without building additional transmission, including facilities to link new renewable resources in remote regions to population centers. But new transmission, which could facilitate access to utility-scale clean power, usually faces regulatory obstacles, cost barriers, community opposition, and other factors that make these lines very difficult to site, permit, and build.

There is a question of how the current practice of selling and purchasing renewable energy credits (RECs) will change. Many factors are changing the market and value of RECs in both mandatory and voluntary markets. Large corporations are less content to meet their sustainable energy goals by purchasing RECs, preferring to play a more active role in developing local renewable resources. And the policies shaping mandatory REC markets are also subject to change. According to several ETC Working Group members, some state and local policymakers prefer to see renewable resources developed in their states and localities.

There will be an overarching need to balance short- and long-term priorities. For example, electrification and emissions reductions can be competing constructs in the near term, as the need to serve new load often results in higher emissions. Meanwhile, there is also concern that balancing interests and priorities will mean that our larger society will not transition fast enough to address climate change and other environmental concerns.

Despite these concerns, the ETC Working Group is generally optimistic that forward progress, especially in the context of collaboration at the regional and national level, will continue and accelerate. Emerging technologies are promising and will be deployed to improve the quality of life for the communities public power utilities serve.

CONCLUSION

Public power utilities are already implementing technologies that are part of the energy transition. Not every option is a solution appropriate for every utility — each utility's path, offerings, and solutions will be different. This roadmap serves as a guide for public power utilities looking to explore options and define their own path forward based on the needs of the communities they serve. Over the next five years, APPA will work with members to update this roadmap.

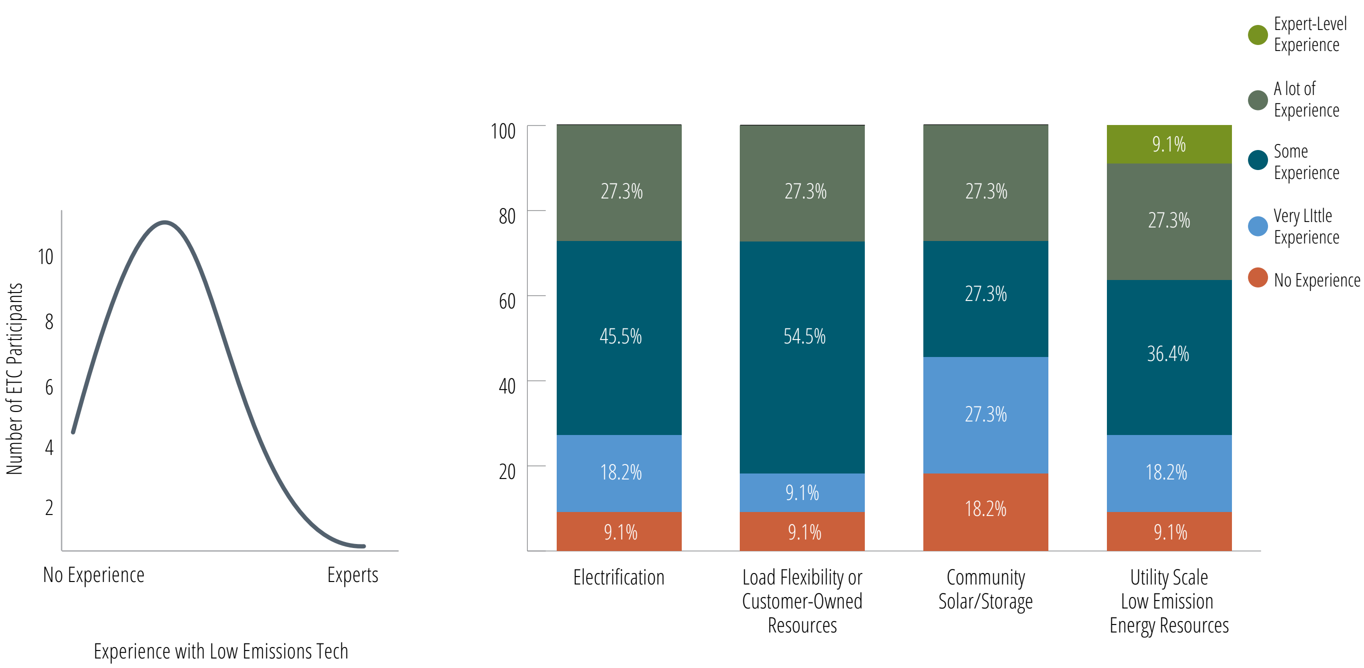
APPENDIX A

ENERGY TRANSITION COMMUNITY WORKING GROUP COMPOSITION AND EXPERIENCE

APPA's Energy Transition Community (ETC) Working Group includes 25 people representing 19 utilities from 14 states (Alabama, California, Florida, Iowa, Illinois, Massachusetts, Minnesota, Missouri, North Carolina, Nebraska, Ohio, Oklahoma, Tennessee, and Vermont) and three industry stakeholders — The Energy Authority, Leidos, and the Clean Power Marketing Group. Five participating utilities have fewer than 20,000 customers; eight have 20,000 to 65,000 customers; and two have more than 100,000 customers. The ETC Working Group also includes two joint action agencies (JAAs) and two state associations.

Made up of mid- to senior-level professionals such as program managers, directors, and vice presidents, the ETC Working Group includes members with a wide range of experience in the four key enabling technologies featured in the roadmap, with most having "some" or "a lot" of experience with each technology category. Given that the four technology categories — Electrification of Residential and C&I Loads; Load Flexibility or Customer-Owned Generation Resources; Community-Scale Generation Resources; and Utility-Scale Low-Emissions Energy Resources — are changing rapidly, only one participant ranked their experience at the "expert" level for utility-scale low-emissions resources.

Figure 3: ETC Working Group Members Experience with Various Technologies



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