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ENERGY EFFICIENCY &
RENEWABLE ENERGY

From Watershed to Energyshed

Determining the Implications of Place-Based Power Generation Workshop and Request for Information Summary Report

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Foreword

The U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE) invests in a diverse portfolio of technologies to ensure domestic energy security, continued economic competitiveness, environmental sustainability, and the availability of cleaner fuels and power. This report summarizes the input received from attendees of the public workshop sponsored by DOE-EERE on July 13–14, 2021 as well as a public request for information, which was open from July 8–August 10, 2021.

Acknowledgments

DOE-EERE would like to thank all the participants who contributed invaluable experience and insights to the *From Watershed to Energyshed: Determining the Implications of Place-Based Generation Workshop* and to the *Energysheds: Exploring Place-Based Generation Request for Information (RFI)*. The list of individuals who attended the workshop is provided in Appendix A of this report. The list of organizations that responded to the RFI is provided in Appendix C.

We appreciate the support and opening workshop presentation from Alejandro Moreno, Deputy Assistant Secretary of Renewable Power, EERE. We also gratefully acknowledge the keynote speaker who framed the workshop topics for attendees – Martin L. Adams, General Manager and Chief Engineer with the Los Angeles Department of Water and Power.

Workshop conceptualization and planning was led by Kevin Lynn (Director of Grid Modernization, EERE) with support from Arlene Fetizanan (Senior Advisor, EERE), Alexis McKittrick (Program Manager, EERE) and Kelly Yee (BCS, LLC). Lauren Illing (BCS, LLC) led the facilitation planning, including group discussion process and virtual collaboration platform. Stacey Young (The Building People) conducted logistics planning. Workshop scribes, who recorded workshop presentation and discussion highlights, were Ryan Knapp (BCS, LLC) and Jay Lenker (BCS, LLC).

This summary report was prepared by Lauren Illing with contributions from Kelly Yee and Ryan Knapp.

List of Acronyms

BA	Balancing Authorities
BIPOC	Black, Indigenous, and People of Color
CAIDI	Customer Average Interruption Duration Index
CCA	Community Choice Aggregator/Aggregation
CHP	Combined Heat and Power
DAS-RP	Deputy Assistant Secretary of Renewable Power
DEI	Diversity, Equity, and Inclusion
DER	Distributed Energy Resources
DERMS	Distributed Energy Resources Management Systems
DG	Distributed Generation
DOE	U.S. Department of Energy
EIA	U.S. Energy Information Administration
EERE	DOE Office of Energy Efficiency and Renewable Energy
EJ	Energy Justice
EMS	Energy Management Systems
ERCOT	Electric Reliability Council of Texas
EV	Electric Vehicle
GHG	Greenhouse Gas
IPUMS	Integrated Public Use Microdata Series
IRP	Integrated Resource Planning
ISO	Independent System Operator
LADWP	Los Angeles Department of Water and Power
LCOE	Levelized Cost of Energy
LOLP	Loss of Load Probability
MPO	Metropolitan Planning Organization
MW	Megawatt
NAACP	National Association for the Advancement of Colored People
NREL	National Renewable Energy Laboratory

PV	Photovoltaic
RFI	Request for Information
RP	DOE-EERE Renewable Power Office
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index

Executive Summary

In FY 2021, Congress provided funds to the Office of Energy Efficiency and Renewable Energy (EERE) at the U.S. Department of Energy to support the development and demonstration of an energyshed management system. In the report *Energyshed Framework: Defining and Designing the Fundamental Land Unit of Renewable Energy*, John C. Evarts defines an energyshed as "that area in which all power consumed within it is supplied within it."[1]

Given that the term "energyshed" is relatively new to DOE, the EERE hosted the workshop *From Watershed to Energyshed: Determining the Implications of Place-Based Generation* on July 13–14, 2021, and opened the *Energysheds: Exploring Place-Based Generation Request for Information (RFI)* from July 8–August 10. The intent of this report is to create a shared interpretation of the "energyshed" concept and its application to the electric grid, based upon stakeholder input received during the workshop and RFI. The opinions and ideas reflected in this document were expressed by individual participants and will help to inform DOE's path toward the development and demonstration of an energyshed management system.

Contributors anticipated that energysheds with locally generated renewable energy sources could offer opportunities for energy independence, security, equity, and resilience. They provided their input in defining the energyshed concept, especially as it relates to determining geographic boundaries and stakeholder coordination. Participants also suggested data, tools, and analysis that would be valuable for determining the optimal proportion of locally generated energy as well as designing functional, equitable, and resilient energyshed management systems. The planning and operations input covered several technical, economic, and regulatory considerations. With respect to resilience and energy justice, contributors noted the importance of energyshed management system information sharing and the ability for end users to be involved with planning and operations decision-making. A summary of contributor input on each of the topic areas is below.

Concept and Definition

DOE-EERE proposed the "energyshed" definition established by Evart's report for participant consideration and input within the Concept and Definition topic area. While there was considerable discussion concerning this definition, participants generally agreed that the concept is an important one for DOE to pursue, especially with respect to resilience, equity, and integrating renewables into the electric grid. As one workshop attendee commented:

> "Energyshed is a way of thinking about where energy comes from, which is particularly important when we think about how energy consumption impacts communities over time and across geographic borders. As an integrative planning concept, energyshed planning could be used much like watershed planning—to promote ideas of belonging, inclusion, responsibility, and shared benefits and costs of our energy systems."

In addition to the watershed planning analogy that DOE used to frame the call for stakeholder input, stakeholders also made analogies to other "sheds" that are not bound by strict geographical boundaries, such as foodsheds, fuelsheds, and viewsheds. Participants noted that while an energyshed may not have absolute boundaries, it can be self-contained.

Stakeholders also offered DOE-EERE input about the functional boundaries of an energyshed, suggesting that a single community could be part of multiple energysheds. For example, during normal grid operations, the energyshed can be broad, utilizing wind and solar from other areas, but when the regional grid is constrained or

[1] John C. Evarts, 2016. Energyshed Framework: Defining and Designing the Fundamental Land Unit of Renewable Energy, p. 18. https://dalspace.library.dal.ca/bitstream/handle/10222/71377/Evarts-John-MES-SRES-April-2016.pdf

unavailable, the energyshed could be restricted to a community or even a single home. The flexibility of boundary variability could contribute to resiliency within a community and provide support when needed to neighboring communities. Similarly, participants noted that neighboring, overlapping, or nested energysheds would need to coordinate closely and that each community would need to have a "hierarchy" guiding its participation in multiple energysheds, especially given the "causal geography" where decisions made upstream may impact downstream communities, but not always vice-versa.

With respect to defining an energyshed management system, participants suggested that this will likely be a set of technologies, policies, and market mechanisms that allow for people to make informed choices about where their energy comes from and provide them with options for saving money, reducing carbon, and maintaining resilience. Stakeholders made the point that energyshed management solutions will be driven by how "energyshed" is defined, which validated DOE-EERE's decision to focus attention to the concept and definition topic.

DOE-EERE also asked participants for input for identifying energyshed stakeholder groups. This was a challenging workshop discussion because, as one participant noted, "the short answer is everyone is a stakeholder." In the broadest sense, energyshed stakeholder groups include electricity suppliers, grid operators, users, and regulators. As one participant stated, stakeholders would include "the people who work to make the energyshed management system function, profit from the operation, and consume the energy."

Several stakeholders emphasized the importance of DOE-EERE considering rural communities as energyshed stakeholders, especially with respect to the energy burden related to lower average income levels, as well as the environmental and public health impacts of living in close proximity to electricity generation. One participant commented that energyshed "stakeholders are the people in the regions that produce renewable power (primarily rural) and the people in the regions that use most of the power (primarily industry or cities)."

DOE-EERE received significant input encouraging the use of energyshed management to address energy justice (EJ) issues. Participants noted the need for enhanced data collection, visualization, and information sharing to support the ability of all stakeholders to be involved with decision-making, including end users and those impacted by infrastructure and facility siting. Some contributors suggested that stakeholder input should specifically be incorporated into energyshed planning processes. Other participants specified that a combination of "top-down" system planning and "bottom-up" decision making will likely produce the most equitable and resilient energyshed systems. An academic contributor expressed this idea by saying, "As distributed renewable energy grows more prevalent, the future will not be described by either the current centralized power system or the energyshed based power system, but rather a hybrid between the two."

Tools, Data, and Analysis

In this topic area, DOE-EERE asked stakeholders to provide their input about what tools, data, and/or analyses may be required to determine the proportion of electricity that is derived within the energyshed. Stakeholders suggested that demand forecasting, analysis of historical data, and operational/financial data would be needed to determine the location of generation and the proportion of electricity that is derived within an energyshed. Contributors noted that, in addition to providing insight about where electricity is derived, energyshed tools, data, and analysis will be needed to allocate costs, design equitable rates, align the proportion of customer load served by generation within an energyshed, and optimize other factors related to the integration of multiple energyshed systems.

Data

DOE-EERE received input expressing the importance of collecting data about existing local resources and resource potential as a starting point for energyshed system planning. That data could inform risk analysis, given that power from locally generated, variable resources loses the benefits of geographical diversity. Resource footprint data would also be important to consider environmental impacts of energyshed development. Contributors suggested gathering and sharing data that measures the environmental and community impact of electric power systems.

Other participants noted the potential value of energy generation and use data. Tracking the location, operational status, and generation capacity of energy serving a particular load area has great value for a variety of stakeholders on the path toward local energy resiliency. One stakeholder noted that collecting and monitoring data related to generation equipment performance could be used to develop understanding about relative efficiency and reliability, which can help to drive sound financial investments. At the point of energy end-use, smart metering systems, which are expected to be widespread on buildings in the near future, will be able to provide granular load data for monitoring and analysis.

Tools

Stakeholders suggested that in the future, it will important that tools follow common practices and incorporate all the sectors and operational functions of an energyshed. Contributors relayed to DOE-EERE that tools should be developed to provide analysis that will not only satisfy a technological and multi-scale planning approach, but also consider the human factor. They suggested that tools should be made available to support stakeholders' diverse needs. During workshop discussions, participants expressed enthusiasm for an Energyshed "app" where users could input their zip code and visualize their electricity mix information in real time.

Analysis

At a high level, contributors suggested that analyses will need to include several levels of energyshed management systems including: 1) management of an energyshed with a single type of intermittent renewable energy source, 2) management of overlapping energysheds with different types of renewable energy and different intermittency time scales, and 3) management of a hybrid centralized/distributed system. In terms of allocation of resources, participants suggested that both actual and forecasted settlement mechanisms can apply to the operation of energysheds. Similarly, analysis may also be useful in optimizing the value of resources within an energyshed, as capacity and ancillary services values can be incorporated into planning for near-term energy use.

Planning and Operations

Stakeholders also provided DOE-EERE with their input related to planning procedures and operations systems. One individual suggested that, as a planning framework, energyshed scenario analysis can zoom in and out to evaluate trade-offs, opportunities, and operations challenges related to transitioning to renewable energy generation. Contributors suggested that this type of planning could offer benefits to ratepayers, distributed energy resource (DER) developers, and the power system as a whole. One RFI respondent encouraged DOE-EERE to see energyshed planning and operations as a way to accelerate "the efficient adoption of DERs while still maintaining a link to the wholesale power system." An academic contributor suggested that a "metropolitan energy planning organization" could serve to manage and coordinate an energy system that generates substantially more local electricity while maintaining a required connection to the regional and national grid.

Stakeholder input also noted the barriers that can be anticipated with energyshed planning and operations, commenting on technical and economic challenges. Examples of technical barriers include protection coordination, accounting for backfeed in the case of residential and commercial rooftop photovoltaics (PV), voltage coordination and control (power quality), scheduling and dispatch of participating generation, and coordinating interchange. Examples of economic barriers include levelized cost of energy (LCOE) given the cost of small-scale generation while aiming to maintain a high level of reliability and power quality, as well as incentives for end users to add generation/offset load through energy efficiency and demand response. Additional investments will be needed in the form of network augmentation through expanded sensor utilization and network control elements.

Many comments addressed distribution system changes, from overall planning at the distribution level to increasing storage and changes in utility support. Contributors suggested that integrated optimization of various sectors should be done through modeling and simulation during the design phase or data-driven analytics in the operational phase. They noted an expectation that advanced controls using predictive modeling in real time would improve performance of an energyshed.

DOE-EERE received input from RFI respondents about how daily power system operations might change to accommodate more locally derived power. An industry participant suggested that, depending on the timescales, the changes to short-term operation and planning will assist with accommodating locally derived power. The participant advised that focusing on the short-term (e.g., day-ahead planning, intra-day planning and operations, hourly and intra-hour operations) would help with scheduling interchange between the energyshed and the external system during supply shortages and excesses. Further, it could help inform needs for short-term energy reserves. These resource dispatch and power flow system studies could be conducted at hourly or several-hour frequencies, depending on the stochasticity of net load on the system.

A key takeaway from input that DOE-EERE received was that planning the future power system should consider the perspectives of many stakeholders. When asked how relationships between utilities, customers, and local governments need to change with more locally derived generation, many participant responses focused on the need for information sharing that expands the current customer-utility relationship and allows customers to be active participants in choosing their energy sources. Further, planning and implementation will vary greatly in different geographies since communities are in different stages of planning their energy transition, have different power structures, and have widely ranged levels of financial resources available.

Resilience

DOE-EERE also asked stakeholders to provide their input regarding the potential resilience opportunities and barriers associated with increasing locally generated electricity. Microgrids, cybersecurity, grid-connected buildings, emergency response, and vegetation management are all resilience considerations for energyshed management. Generally, participants expect that increasing local distributed renewable generation will improve overall resiliency. They noted, however, that to achieve that goal, planning would need to carefully consider optimal energyshed size, system architecture, storage capacity, and microgrid development. Additionally, from an EJ standpoint, workshop attendees expressed an interest in determining what mechanisms might allow lower-income communities to afford resiliency, considering that resilient infrastructure (such as microgrids) is often cost-prohibitive.

In order to build a more resilient power system, the workshop attendees recommended that DOE consider technical factors such as system architecture, energy storage, and microgrids. They suggested creating electric energyshed cooperatives or associations within existing consumer-owned cooperative or municipal utility service areas, while acknowledging the caveat that financing for planning and development will be a barrier.

Stakeholders noted several challenges related to energyshed resilience, including the ability to "island" individual customers or interconnected sub-aggregations of customers with sufficient controls to limit the extent of power outages. The "grid of microgrids" approach was also mentioned, along with the need for sufficient storage capacity to smooth electricity input to the grid from variable distributed resources. Other comments identified the challenges of ensuring accurate analysis and prediction of seasonal derating, asset degradation, and time/operational dependent risk, as well as accurate ramp forecasting to mitigate sudden increases or decreases of variable power generation. The larger challenge of how to implement demand response programs with high levels of energy customer participation through real-time information sharing and informed end-user decision making was also discussed.

Energy Justice, Diversity, Equity, and Inclusion (DEI)

DEI was a theme woven throughout the two-day DOE-EERE Energyshed Workshop. As one attendee noted, "DEI should be the centerpiece of energyshed thinking. What does a 'just transition' to the new energy system look like? This is about inclusion in energy system choices, especially for the historically marginalized and vulnerable communities who have been harmed by the current system."

Several participants provided input related to the value of expanding stakeholder involvement in energy system decision making. Stakeholders asserted that local energy distribution business models today do not lend themselves towards reaching disadvantaged communities. They suggested that energyshed management systems should be a community-driven process, and that EJ considerations should be incorporated by developing and strengthening capacity for organizations that support long-term, participatory community planning.

Stakeholders emphasized that public engagement is especially critical for underserved communities to ensure their perspectives and voices are incorporated into energyshed planning and operations. This inclusion has the potential for job creation opportunities to historically disadvantaged populations. Further, participants expressed an anticipation that with well-defined boundaries, energysheds could enable the generation of more equitable energy. In other words, public health and environmental costs associated with production would be incurred locally rather than being outsourced to under-resourced regions.

Despite these expected DEI benefits, stakeholders also mentioned potential challenges related to locating energysheds in underserved communities. Perhaps most urgently, a cohesive, all-encompassing set of metrics for energy equity needs to be developed.

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Introduction

The term “energyshed” has been defined in literature as an “area in which all power consumed within it is supplied within it.”[2] Analogous to the idea of a watershed, there are a number of similarities between the delivery of both water and electricity. Both utilities have greatly expanded in scale over the past century and both utilities deliver resources long distances through extensive networks to large population centers.

Moving into the 21st century, many communities are investigating how to use more locally derived resources to improve efficiency and decrease their dependence on water transported from long distances. To fully investigate the concept of an energyshed, DOE organized a workshop to obtain stakeholder feedback on its definition and its application to the electric grid. To supplement the collection of feedback provided during the workshop, DOE also released an RFI on energysheds.

The workshop and RFI will help inform DOE’s path toward the development and demonstration of the energyshed concept as well as an energyshed management system. Each section in this report includes a topic overview, workshop discussion highlights, key workshop participant takeaways, and a summary of RFI input. The sections in the report are summaries of the discussion and input of the workshop and RFI input. Content in quotations are exact words expressed by a participant or respondent. Report appendices include a list of all workshop participants (Appendix A), the workshop agenda (Appendix B), a list of RFI respondents (Appendix C), and a list of resources identified by stakeholders (Appendix D).

Request for Information Purpose and Content

DOE released an RFI entitled *Energysheds: Exploring Place-Based Generation* for public comment from July 8 to August 10, 2021. This public request provided an additional avenue for input and feedback on the concept of an “energyshed,” as well as the benefits of and barriers to energyshed management systems. The questions presented in the RFI covered similar topics and content to the workshop. For both the workshop and RFI, DOE sought feedback from a wide range of stakeholders, including states and cities, academia, national laboratories, non-governmental organizations, interest groups, and the private sector. The specific topic areas for the RFI included:

1. Concept and Definition
2. Tools and Analyses
3. Planning and Operations
4. Resilience
5. Energy Justice, Diversity, Equity, and Inclusion

Workshop Purpose and Content

As the term “energyshed” is a relatively new concept to DOE, a workshop was designed with a relatively loose structure to enable a more wide-ranging conversation and encourage stakeholders to freely share their thoughts, opinions, experience, knowledge, and ideas with DOE. The focus was explicitly an investigation of the challenges and opportunities related to developing more generation to serve load locally, rather than a comparison of local versus national approaches, recognizing that both have a role to play in reaching national goals.

The workshop discussions covered the same five topic areas as the RFI. Although there was a discussion at the end of the workshop focused solely on DEI, each of the sessions included a section regarding how to incorporate energy justice considerations.

[2] Evarts, *Energyshed Framework*

Workshop Discussion Format

In each of the five discussions during the workshop, attendees were asked to participate via a custom-built collaboration website on the XLeap Center hosted by BCS, LLC. Within this virtual platform, moderators provided a topic overview presentation to define relevant terms and the specific scope of discussion. Participants were asked to introduce themselves and were given an opportunity to share their thoughts about the topic with their peers during small group conversations. During the large group discussions, attendees provided their responses to key questions for each topic via typed input as well as verbal commentary. XLeap aggregated the typed participant input anonymously to create an environment where attendees could talk freely. Notetakers also captured spoken input to ensure a comprehensive documentation. The workshop agenda is provided in Appendix B.

Workshop Themes

A primary theme underlying all the workshop discussions was the need to look at energysheds from a community level, with consideration of energy efficiency, energy production, and energy consumption. Participants noted that there is not a one-size-fits-all definition that would satisfy all stakeholders of an energyshed, and that there are several nuances that one needs to consider in the definition of an energyshed.

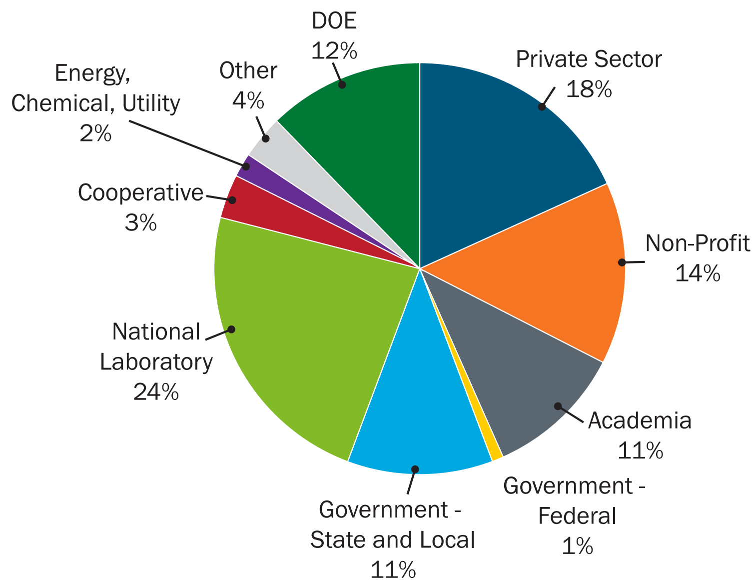
There are many sets of stakeholders that might be impacted by decision-making within an energyshed and should be involved in an energy management system. Regions are typically framed in terms of geography, but much about energysheds centers around the people who live and make decisions within those areas. Discussion emphasized the need to incorporate qualitative and social factors into analysis. Participants noted the need to look at analysis from multiple perspectives and to appropriately value non-technical factors.

Key questions also remain around data and tools needed to determine where these resources should be located. Workshop participants listed tools that analyze energy from a technology standpoint, such as multi-scale planning or system modeling.

Participants

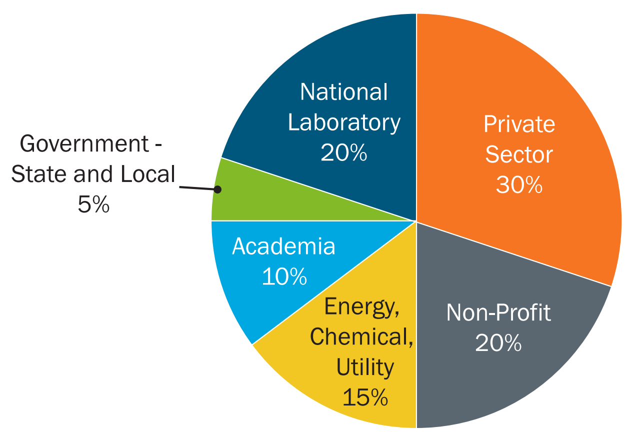
A total of 110 individuals attended the two-day workshop online workshop. Approximately 85 attendees provided responses to workshop questions, via the collaboration website, XLeap. Overall, workshop organizers were pleased with the attendee representation across the energy sector with utilities, government agencies, national laboratories, academia, technology and consulting services, and manufacturers all sharing their knowledge and insights with DOE. The largest groups of stakeholders that attended the workshop were national laboratories with 26 attendees (27%), the private sector with 20 attendees (18%), and non-profit organizations with 16 attendees (15%). A breakdown of workshop participants by stakeholder category can be found in Figure 1.

Figure 1. Workshop Participants by Stakeholder Group



Twenty organizations responded to the Energyshed RFI published by DOE-EERE. A list of RFI respondents and the organizations they represent can be found in Appendix C. The group of participants represented a diverse set of organizations, including national laboratories, technical consulting firms, utility equipment vendors, universities, a nonprofit advocacy group, an end user of renewable energy, and a local government agency. Six organizations representing private sector (30%), four organizations representing the national laboratories (20%) and four respondents representing non-profit organizations (20%) were the largest participating stakeholder groups. A breakdown of RFI respondents by participant category can be found in Figure 2.

Figure 2. RFI Respondents by Stakeholder Group



Keynote Presentations

Alejandro Moreno, Deputy Assistant Secretary of Renewable Power, EERE

The Deputy Assistant Secretary of Renewable Power (DAS-RP) at EERE, Alejandro Moreno, opened the workshop with a warm welcome on behalf of DOE leadership. He shared the EERE mission, "to accelerate the research, development, demonstration, and deployment of clean energy technology," and the office's overarching goal of achieving "a carbon-free electricity sector by 2035 and a 100% clean energy economy with net-zero emissions no later than 2050." He emphasized that EERE works to ensure that its investments benefit all Americans, including underserved or pollution-overburdened communities. EERE's approach is to work in a unified and coordinated way with state and local partners to accelerate a just, equitable transition to a clean energy economy.

DAS-RP Moreno provided workshop participants with insight about how the concept of energysheds aligns with broader EERE and DOE goals. He noted the need to develop a commonly held definition of for the terms "energyshed" and "energyshed management system." He considered that locally generated power could be critical to large scale power resilience and mentioned the wildfires in California as an example.

As society looks to go carbon-free, there are challenges as well as opportunities related to resiliency, careers, local benefits, and energy justice. These challenges and opportunities tend to be best approached on a local level, thus, EERE recognizes that working with community organizations is critical. EERE wants to support community clean energy goals and provide the tools needed for them to succeed. DAS-RP Moreno reiterated a shared interest between DOE and local communities in making renewable energy accessible and affordable, improving air quality and the environment, reducing greenhouse gas emissions, and harnessing local innovation for renewables integration.

In closing, he asked workshop attendees to envision what it would look like to view energy usage and generation from a local lens, and to help DOE to understand whether this could be a tool to contribute to an equable clean energy economy.

Martin L. Adams, General Manager and Chief Engineer of Los Angeles Department of Water and Power

Our keynote speaker, Marty Adams, General Manager and Chief Engineer at the Los Angeles Department of Water and Power (LADWP), provided an interesting perspective of his challenges, activities, and goals in his work in water and energy for the greater Los Angeles area.

This presentation made the connection between energysheds and watersheds, noting several similarities between the two utilities. For one, moving water or power across large distances is subject to disruptions and threats such as earthquakes, climate change, and wildfires. Also, when moving either water or power across a large distance, there can be a conflict between communities who use the power (often urban) and those who live where the power is being generated or distributed (often rural). Further, he explained that enough rain falls on the city "to supply LA for a year, but we can't capture it and it happens all in two days." The same is true of energy in the inability to capture of the abundance of solar power's potential in the region to meet energy supply and demand.

The LADWP has a goal of achieving 80% renewable energy by 2030, and Mr. Adams described the agency's following approach to meet that target:

- Develop an infrastructure that will support more renewable energy.
- Increase investments of short-term and long-term storage.
- Develop new solar programs and business models that will provide access to previously unavailable areas (such as rooftops to rentals).

LA is now attempting to use locally sourced energy to make the region less dependent on power generated outside of the locality. Mr. Adams worked with the National Renewable Energy Laboratory (NREL) on LA100: The Los Angeles 100% Renewable Energy Study. This project found moving LA into a 100% renewable future would require contributions from a diverse generation mix that includes wind and solar, as well as energy efficiency, load management, storage, new transmission and distribution equipment, and equipment that can supplement power supply when electricity use is at its highest, such as renewable combustion turbines.

Mr. Adams framed his presentation in terms of “instant” energy (solar, wind, etc.) and “stored” energy (fossil fuels). The challenges related to storing “instant” energy are, to Mr. Adams, the single biggest barrier to widespread renewable energy deployment. In order to optimally manage an energyshed, regions must effectively balance storage, demand, and generation. Right now, they are not well matched—in LA’s case, storing the instant energy is the main challenge. The options that LADWP is utilizing or planning to implement include pumped hydropower (filling reservoirs with a solar power pump during power surplus times then letting the water flow creating hydropower during peak demand), hydrogen (long term storage), compressed air, and batteries. LADWP anticipates 1/3 of peak demand to be generated locally by 2030, though non-local sources will still be needed, such as in case of cloud cover over solar panels. In the meantime, the current system reorganization will require utilities to use the existing system while building the new one.

While the LADWP service area is larger in scale than most areas, there are common elements (such as planning and new business models) that can be applied to any region. Mr. Adams’ experience has emphasized the importance of all local regions asking themselves, “What are the energy resources available to us and what are the local infrastructure needs to support harnessing those resources?”

Mr. Adams’ recommendations for other utilities to consider were:

- Develop programs to get more solar on rooftops, especially of non-single-family homes, through solar rebates, rental programs, community solar, etc.
- Incorporate distributed energy resources, which fall into five main categories:
  - Energy Efficiency
  - Demand Response
  - Distributed Solar PV
  - Electric Vehicle (EV) Chargers
  - Distributed Battery Storage

Energyshed Concept and Definition

The first topic presented to workshop participants and RFI respondents for input was "Energyshed Concept and Definition." The objective was to provide an opportunity for participants to provide input on the energyshed concept and working definitions, given that the relatively new concept does not yet have a widespread, shared understanding among energy sector professionals. The DOE-EERE team provided stakeholders with context for this topic, explaining that Congress has directed DOE-EERE to develop and demonstrate an energyshed management system that addresses a discrete geographic area in which renewable sources currently provide a large portion of electric energy needs.

Topic Overview

During the Topic Overview presentation, workshop attendees provided responses related to the role of community, geography, and electric grid infrastructure as energyshed considerations. The term "community sovereignty" was mentioned twice as a potential opportunity to "develop, allocate, profit from, and determine DEI/environmental impact of" local energysheds. Another participant asserted that the following questions need to be answered in pursuit of community sovereignty:

- How are limited energy resources allocated?
- Who owns and/or decides who gets to use them?
- What is the role of local leadership in land use and development rights?

Other input received during the Topic Overview presentation touched on geographic considerations, especially with respect to energyshed interconnections. One attendee noted that while watersheds provide water to be consumed within a local region, some water also flows to larger bodies, and suggested that same concept would apply for an energyshed. Another energyshed interconnection mentioned was the link between rural and urban areas. One participant even raised a question about how the energyshed concept fits more broadly within decentralized energy considerations, estimating that the connectedness of homes and feeders will need to be maximized, that planning approaches will have to change drastically, and that the grid as a whole may need to be reimagined.

Workshop Participant Key Takeaways

After meeting in small groups, volunteers shared their key takeaways from the "Energyshed Concept and Definitions" discussion. Themes that were mentioned were the inherent limitations of the "energyshed" definition, the importance of community sovereignty, and the evolving role of energy master planning.

Limitations of Definitions

Similar to a watershed, a given energyshed could be defined by its source. Participants explained that interconnections with other energysheds will be important because an isolated system has poor resilience. With watersheds, some water is consumed within local regions but some flows to a larger body. This same concept is analogous to an energyshed as some energy will be consumed within a rural region where it's generated, while some could also flow to a larger city. Members of the group discussed how energysheds should be considered from the perspectives of space and time. They also urged consideration of how and when energy flows from one area to another.

Community Sovereignty

It is important to consider how limited energy resources are allocated and owned, and who decides how to use them. Contributors encouraged DOE-EERE to develop an energyshed definition that considers issues of equity, fairness, and a community's right to self-determination. As an example, they described the dynamic that pressures local leaders to cede land rights to developers, especially in rural communities. Participants suggested that managing this will be a big factor in energyshed developments.

Energy Master Planning

As energy systems decentralize, planning concepts will be turned upside-down, magnifying the importance of energy master planning. Group members proposed considering how energysheds fit in within a decentralized energy landscape and emphasized the difference from distributed energy resources. They recommended master planners incorporate lessons learned from the Fukushima rebuild and the London Olympics.

Finally, workshop contributors relayed to DOE-EERE that within planning circles, some believe a complete reimagining of the grid is needed, questioning all existing assumptions and building a system that values DER and demand side resources. Participants noted a need to balance this analysis with the reuse of existing infrastructure and indicated that new metrics would be needed to optimize supply and demand.

Workshop Discussion Highlights

During this discussion, workshop organizers asked participants to share their responses to the question: "What nuances should EERE consider for the energyshed and energyshed management system definitions and why?" Next, workshop organizers asked stakeholders to provide input on identifying stakeholder groups that may be involved with or impacted by an energy management system. As was the case for every question during the workshop, the group was also asked to reflect on ways to incorporate EJ considerations to all of their responses.

Energyshed Definition

In short, there doesn't seem to be stakeholder consensus around one definition of "energyshed." Workshop participants suggested that the definition is necessarily dependent upon the end use being considered, such as energy storage or resilience. One participant recommended that an energyshed management system be viewed as a set of technologies, policies, and market mechanisms that allow for people to make informed choices about where their energy comes from and provide them with options for saving money, reducing carbon, and maintaining resilience.

The group noted that a single community can be part of multiple energysheds. For example, during normal grid operations, the energyshed can be broad (utilizing wind and solar from other states), but during times when the regional grid is constrained or unavailable, the energyshed could be a community or even a single home. This approach could both help to ensure resiliency within a community and provide support when needed to neighboring communities.

For purposes of summarizing discussion highlights, key themes have been categorized as related to geography, planning and management, independent system operator (ISO) considerations, or energy democracy.

Geography

Physical, geographical bounds play a critical role in defining the energyshed concept. Participants noted that energyshed boundaries, like watershed boundaries, may be arbitrary and that it may be difficult to draw static boundary lines. The Los Angeles Community Solar Opportunity Map provides a good example of how many customers can be served with local assets, reinforcing the need for boundaries to be fluid and allow overlap.

Utilities cross interstate boundaries and, since current planning tools and infrastructure don't, it can be difficult to know where energy is coming from within the system. Further, as energy generation and consumption sources vary over space and time, the energyshed boundary may benefit from remaining dynamic to accommodate changes.

Another comparison made to watersheds asserted that the fundamental problem encountered with highly distributed power is how to manage a system with stochastic demand as well as stochastic supply, which is also a challenge for watershed management systems.

Planning and Management

Discussion participants noted that energysheds can be a great planning concept and/or tool for evaluating tradeoffs between the myriad factors being considered by energy system planners, such as centralized versus decentralized energy or renewable versus nonrenewable generation.

With respect to energyshed management systems, one contributor advised DOE-EERE that a possible analog could be found in distributed energy resource management systems (DERMS), which are software platforms used by utilities to manage a group of distributed energy resource assets (such as solar panels or batteries) at the distribution level. Another participant agreed that a platform similar to a DERMS would be necessary for any energyshed management effort, and recommended analyzing large-scale building energy modeling, saying, "just like designing a building, looking at power flow analysis is really critical."

Watershed planning came up when one attendee suggested that both watershed and energyshed planning "can promote ideas of belonging, inclusion, responsibility, and shared benefits and costs of our energy systems." Some of the techniques recommended for energysheds to consider included watersheds' handling of storage, prioritization, and differential pricing, which varies with the extent that a user stays with its allocation.

Another potential analog proposed was the URBANopt Advanced Analytics Platform developed by NREL. A contributor explained that URBANopt looks at building-by-building "8760" load profiles and connects this data to a power flow analysis through OpenDSS, a "comprehensive electrical power system simulation tool primarily for electric utility power distribution systems"[3] provided by the Electric Power Research Institute.

Independent System Operator Considerations

One contributor commented that if the term "energyshed" is supposed to be used to demonstrate that a utility or ISO can generate all power within its service territory, it may be a useful tool for arguing for or against the need for new transmission assets. If the energyshed concept is to be used to demonstrate the value of customer-owned DER, however, that would likely get strong push back from utilities. That could have benefits, though, as it would require utilities to justify their costs for importing energy.

Other participants suggested that there is the need to explain to the public that the main reason the concept of energysheds, or even DER, exists today is a lack of operational economy-of-scale for solar PV. One contributor expressed:

> "For the first time in history, a homeowner can self-generate electricity with the exact same equipment used by the utilities. While the capital cost per kilowatt of power may be higher, the operation and maintenance expenses are the same and the delivery efficiency is better. The current definition of energyshed is great but the cost of that localized energy needs to be accounted for and the cost of resource adequacy needs to be factored into the equation to make it truly usable."

Energy Democracy

"Energyshed" is clearly an umbrella concept, weaving together ideas related to geography and infrastructure with energy justice, democracy, and transition planning. Several workshop participants provided input to DOE-EERE related to energy democracy. This idea relates to energy commons, or common resource management more generally, which involves governance and design principles as well as the resource. This can be referred to as a "social-ecological system," a description that can also apply to ground water management. As such, an energyshed is governed by the local community to meet its energy needs, and in partnership with other communities for the common good. Local communities' direct development, allocate benefits and profits, and determine energy justice and environmental impacts. Contributors noted that this social-ecological intersection raises considerations

[3] OpenDSS, Electric Power Research Institute. https://smartgrid.epri.com/SimulationTool.aspx

related to causal geography, such as how decisions made upstream from the energyshed might impact downstream communities (and vice-versa), and how these impacts might be analyzed and visualized in ways that would be helpful for policy.

Energyshed Stakeholders

Workshop attendees provided comments in response to the question, "What are the intended energyshed stakeholders?" The list of relevant parties was exhaustive, ranging from balancing authorities (BAs) and policy makers to consumers and community-based organizations. The input can be grouped into the following categories:

- Communities
- Energy Generators
- Energy End Users
- Regulators
- Researchers and Technology Providers
- Everyone

Communities

Multiple contributors expressed an interest in prioritizing "frontline communities" as the primary audience for energyshed efforts. This term was used to describe the populations that have been most harmed by the existing energy system, especially minority and rural communities, which have been disproportionately exposed to pollutants, emissions, and other impacts of energy production.

Participants suggested that the energyshed concept should address historical impact on Black, Indigenous, and People of Color (BIPOC) communities, their control and ownership of distributed energy resources should be sought out wherever possible. Another suggestion was to prioritize hiring minority business contractors and unions, citing a 2010 American Association of Blacks in Energy study that found that while African-Americans had paid $41 billion into the energy sector during the previous year, only 1.1% of energy jobs in America were held by African-Americans.[4] One individual estimated that a major challenge will be determining how to structure decisions to honor each stakeholder while also being practical to advance individual and collective interests.

Rural communities came up repeatedly throughout this discussion as well. One contributor shared a perspective that "the primary stakeholders are the people in the regions that produce renewable power (primarily rural), and the people in the regions that use most of the power (primarily industry or cities)." This individual continued to note that "decisions on power generation and use made in rural regions will impact power availability in urban regions." Another participant shared optimism that "energyshed planning could help bridge the rural-urban divide in the benefits and costs of the system," and recommended "a renewable rural energy transition act that benefits rural communities."

Energy Generators

Workshop participants noted that energy generators have a role to play in the energyshed, particularly with respect to information sharing. One individual explained that energy generators may have the best estimate of potential storage needs, and suggested that they should provide details regarding energy usage by local area. Other contributors specified the types of energy generator organizations that should be considered energyshed stakeholders, including ISOs, regional transmission organizations, and utilities, given their role with transmission off-sets and localized resource adequacy.

[4] National Association for the Advancement of Colored People (NAACP), *Just Energy Policies: Reducing Pollution and Creating Jobs*, December 17, 2013.

Energy Users

DOE-EERE received input from participants that energy end users need to be educated about the sources that make up their energy usage so that they can make informed decisions and be involved with community engagement to increase the proportion of renewable power that they are using. Workshop participants noted that these energy end users may also be generators via rooftop solar and home-based batteries. Community Choice Energy members and Community Choice Aggregators (CCAs) were also identified as energyshed stakeholders with the potential to provide value through their knowledge of energy sources available in real time.

Regulators

Public utility commissions were mentioned as a stakeholder, along with state government agencies. Attendees noted that local governments are critical when it comes to safety, resilience planning, and climate action planning. They also recognized that most local governments don't have sufficient staffing nor budgets to design and implement the appropriate programs. Smaller governments are unlikely to have the resources available to conduct the kind of planning that a place like Los Angeles County can.

Researchers and Technology Providers

National laboratories and academic research institutes were also mentioned as energyshed stakeholders. Additionally, technology providers and those who determine standards for technologies were also noted as important parties for enabling information flow among people and devices.

Everyone

Several contributors referenced the breadth of stakeholders that are impacted by an energyshed. One individual differentiated the levels of potential participation by saying, "everyone is involved as a stakeholder in an energy management system, but some stakeholders will be more proactive in design discussions (e.g., power providers, utilities, governmental bodies) than others (e.g. historically marginalized communities)." In this attendee's estimation, the challenge will be to make sure that the design process is truly open to and inclusive of all. Another contributor agreed about prioritizing inclusivity, noting that "it's important that people be the primary beneficiaries of the energyshed structures—and that the energy industry is accountable to the will of the people and not vice versa."

RFI Results

Energyshed Definition

RFI respondents were also asked to provide additions or alternatives to the energyshed definition initially referenced by EERE. Contributors—who represented local government agencies, universities, technical consulting firms, renewable energy associations, national laboratories, and utility equipment vendors—suggested additional specificity.

One comment provided to DOE-EERE by a university representative made the case against using the analogy of watersheds and proposed instead comparing the energyshed concept to a commuting zone, which is a geographic area where most of the origins and destinations of trips on the road network are internal to the area. This individual continued to explain that an energyshed will also have multiple origins (generation points), multiple destinations (consumption points), and a certain portion of the energy flows (like trips) will cross the energyshed boundary. This configuration is very different from that of a local watershed, which has clearly defined boundaries based upon the elevation and slope of the landscape, and a single exit point for all flows.

Other respondent comments received suggested expanding the scope of the proposed energyshed definition to include several other factors, including geographic scale and defining boundaries, environmental and human impacts, and resiliency.

Geographic Scale and Defining Boundaries

While stakeholders agreed that the definition should have a geographic component to it, the concept of scale and absoluteness of the borders varied among respondents. Determining an energyshed to be a large geographic area would incorporate a diversity of generation and load profiles. Doing so, however, runs counter to the concept of reducing delivery of energy resources over long distances to large population centers.

On the other hand, a contributor representing an industrial utility equipment vendor suggested that restricting energyshed boundaries to a relatively small geographic area may decrease the affordability and reliability of the solution. For example, defining it at a community level would limit the use of utility-scale wind, which enjoys its greatest economic benefits from wind farms comprised of multi-megawatt (MW) turbines. In places with strong wind resources, larger energyshed areas would result in both positive aggregation effects (reduced variability) and increased harvesting of cheap renewable energy.

Ultimately, the boundaries of an energyshed need to be defined in a way that accounts for reliability, resilience, affordability, and decarbonization. A national laboratory contributor pointed out that there is no upper or lower bound on the scale of the geographic extent of an energyshed. In particular, a single building or customer site (e.g., part of a building or multiple buildings on a campus) should be clearly in scope, as should smaller residential subdivisions.

Similar to workshop participants, RFI respondents expressed that energyshed boundaries may not be absolute. A national laboratory contributor explained that when considering supply chains, it is expected that there will be significant overlap of geographical boundaries that may be used to construct energysheds, which introduces a need for the concept of networked energysheds. An academic respondent noted that, in the United States, there is simply a fundamental spatial mismatch between the most productive wind and solar resources and the areas of high demand for those resources. Another national laboratory contributor added that the cost of energy delivery to a given area would be of primary importance because a given energy resource will not be utilized if it is too expensive relative to other energy resources.

Environmental and Human Impacts

Within its defined boundaries, an energyshed has an impact on people and the environment. Respondents proposed expanding the definition provided by DOE-EERE to include the land, water, and air that host the infrastructure, and the ecosystems that coexist in these landscapes. They suggested that the stakeholders would include the people who work to make the system function, profit from the operation, and consume the energy (e.g., energy system owners, operators, end users).

Resiliency

The third topic that RFI respondents indicated as important to the definition of energysheds is energy resilience, which is a measure of energy independence or how resilient a community might be against losses of an energy source. For instance, communities that are able to produce all of their energy locally and from a variety of sources are going to be more resilient than those that have to import most of their energy from a single source.

Input provided to DOE-EERE expressed that, although the existing infrastructure provides reliable low-cost energy, the consumer of the energy cannot connect the energy back to its ultimate source. This disconnection becomes an issue as attributes of the delivered energy are therefore not understood, chiefly the resilience and the environmental impact. According to a contributor representing an industrial utility equipment vendor, an energyshed concept, properly defined and controlled, could potentially help better manage the resilience and the environmental impact of an energy system.

Energyshed Stakeholders

Like workshop participants, RFI respondents were asked to describe the different stakeholder groups involved or impacted, and how each stakeholder group might find value in the energyshed. A national laboratory contributor proposed that stakeholders span the entire value chain. On the energy-supply side, stakeholders include grid operators, regulators, utilities, and any organization involved in energy extraction, processing, and transportation. From the energy-demand side, stakeholders include leadership at the community, county, state, and federal levels.

Another national laboratory respondent organized stakeholders based on economic cost, environmental benefits, and energy resilience. The economic cost component would be of primary interest to the users within an energyshed who are paying to use electricity. Their interest is in keeping energy prices low enough to have an affordable supply of electricity that is competitive with markets located in other communities. Alternatively, the providers who set prices for electricity are interested in keeping prices high enough to continue operations without any lapses or deterioration in service.

The environmental benefits component is of greatest interest to the local community within the immediate vicinity of where energy is being produced. This would include environmental justice groups, because pollution from energy production activities has disproportionately impacted underserved communities. These stakeholders are also users of the electricity being produced, so they are also included with those concerned about economic cost. Because of the impacts on greenhouse gas (GHG) emissions, the environmental benefits stakeholders would also include the global community, which stands to benefit from less GHG being emitted. In addition, leaders at the local, national, and international level would be interested because of how these decisions feedback into policy.

Finally, the energy resilience component is likely to impact stakeholders at a more local level. Governments at the municipal or even state level might also encourage higher energy resilience to strengthen local economies and avoid a widespread lapse or deterioration in electricity service among their communities.

However, with more stakeholders comes more complexity. To manage the growth of stakeholders, one participant suggested a phased approach, focusing first on smaller energyshed management areas, such as hospitals, apartment complexes, schools, individual farms and ranches, food processing facilities, and water treatment plants. These smaller management areas, especially those that either have distributed generation installed near the point of end use or have direct connection to the local grid (e.g., distribution lines with interconnected electric load, typically at a voltage of 34.5 kilovolts or less), could help demonstrate the concept at local levels. In turn, that could lead to the development of larger, more efficient, resilient power systems for future energysheds that could cover entire Native American Reservations, counties, and other targeted communities.

Energyshed Management System Definition

The participants were asked what additional or alternate definitions EERE should consider for "energyshed management system." One participant representing a national laboratory suggested that the energysheds could operate as grid-integrated distributed energy infrastructure consisting of renewable energy technologies, energy storage devices, dispatchable sources, and energy conversion devices (e.g., heat-pumps, chillers) that provides energy services at the scale of a district or a neighborhood. Energysheds could, according to the contributor, cater the demand for electricity, heating, and transportation sectors within the locality while maintaining a close interaction with these sectors through demand response strategies. These interactions could theoretically help to decarbonize the building and transportation sectors while improving both the flexibility of energysheds and the penetration levels of renewable energy. The participant posited that energysheds could facilitate sector coupling, which would then enable decarbonization of multiple sectors.

The participants were also asked to provide the benefits and drawbacks of having more specific and detailed definitions for the terms “energyshed” and “energyshed management systems.” One participant stated that the energyshed definition will drive the needs, requirements, and research focus of the energy management solution, but added that a narrow definition, especially one that consolidates a product requirement in the initial stages of research, may be unfavorable. It was suggested that it may be more beneficial to contrast the energyshed concept against the already existing definition of microgrids, identify where the differences lie, and consider a microgrid just one instantiation of a energyshed.

Tools and Analyses

The second topic presented to workshop participants and RFI respondents was "Energyshed Tools and Analysis." The objective of this topic area was to identify the data, tools, and analysis that will be required to determine the proportion of electricity that is derived within the energyshed.

Topic Overview

DOE-EERE recognizes several foundational assumptions related to data that will impact required energyshed tools and analysis. For one, it is important to have data on existing local energy resources and resource potential as a starting point for energyshed analysis. Further, there is a clear need to incorporate a variety of data sources (not just utility or Energy Information Administration [EIA] data) that provide a local perspective in understanding of the big picture. Another underlying assumption is that, in the near future, local load data could be available in greater granularity due to smart metering systems on buildings. At the same time, there could be challenges associated with collecting utility data due to privacy and competitive reasons. Lastly, resource footprint data will be important to consider environmental impacts of energyshed development. With respect to tools and analysis, stakeholders were asked to consider how to measure the potential risks and benefits of local generation.

Workshop Key Participant Takeaways

The theme of this discussion was a general need for a greater variety of data, more localized data and analysis tools, and methods for sharing more information with a broader stakeholder group. As one contributor noted, "Energy system design needs buy-in from the broader community and all people impacted." As such, tools and analysis need to focus on building a greater understanding of resources in an energyshed. That same participant emphasized a need to consider temporal aspects and to understand characteristics of demand beyond just generation technologies or capacity.

Unlike current planning processes, in which a majority of decisions come from the top down, participants suggested that energysheds adopt a bottom-up method of decision making. In order to support this approach, there would need be substantial data collection, visualization, and information sharing. Any information that helps stakeholders to understand the interactions between load, production, and storage will be valuable, along with specifics about where on the grid those functions are needed. Discussion participants emphasized that all energyshed stakeholders are important recipients of data. Data sharing and information transparency will be critical, as are platforms for communication and policy conversations. Contributors suggested that the ability to aggregate information from existing tools is better than creating any single tool itself.

Raising the topic of required tools and analysis led to participant discussion related to the importance of environmental and social indicators to account for during energyshed planning efforts. In order to monitor these indicators on an ongoing basis, energyshed operators will need to gather environmental and social data in addition to technical system data. Another participant said, "To assess the impact on environmental justice communities, we need to ensure we have data on how people are impacted by race and economic class."

Workshop Discussion Highlights

During the second workshop discussion, stakeholders shared insights about what tools, data, and analyses may be required to determine the proportion of electricity that is derived within the energyshed. DOE-EERE asked contributors to specify what potential planning and operations functions their suggested resources might fulfill. They were also asked to provide context about whether the resources already existed or needed research and development efforts in order to become available.

Most of the discussion focused on data and analysis needs, but workshop attendees did mention a few existing resources, including:

- Hourly Electric Grid Monitor, from EIA, provides a "centralized and comprehensive source for hourly operating data about the high-voltage bulk electric power grid in the Lower 48 states."
- Justice in 100 Scorecard, from the Initiative for Energy Justice, is a rubric for evaluating states and territories' 100% clean energy commitments.
- System Advisor Model, from NREL, simulates renewable energy systems and cost profiles using different technologies.
- Regional Energy Deployment System, from NREL, "simulates the evolution of the bulk power system—generation and transmission—from present day through 2050 or later."
- Energy Management Systems (EMS), currently used by electric utilities to collect, display, and analyze data from the field to support grid operations.
- Distributed Energy Resource Management Systems (DERMS) are "an operational technology system that monitors, forecasts, optimizes and ultimately dispatches DERs under management directly by the utility or indirectly through an aggregator."[5]

Specific needs identified included:

- Energyshed supply interoperability.
- Technology tools and software to analyze energy-end use for larger-scale grid analyses, perhaps modelled after the resources provided by DOE-EERE Building Technology Office for building energy modeling.
- DERMS research and development investment to improve upon the quality of existing platforms.
- Household-level smart metering tools similar to ones widely deployed in Europe.
- Platform that facilitates stakeholder engagement in energyshed planning (e.g., includes metrics and considerations that are responsive to a set of stakeholders engaged in the process and helps the diverse set of stakeholders weigh options across those metrics).

Multiple contributors expressed a perspective that current tools need to be expanded to address the level of granularity necessary for energyshed analyses. The existing resources provided by utilities and BAs may be considered a starting point for future developments.

Data Needed

In response to the DOE-EERE question about data needed to determine the location of generation and the proportion of electricity that is derived within an energyshed, participants focused on forecasting and predictions, analysis of current and historical data, and operational and financial data.

[5] Andrew Mulherker, *North American DER Management Systems 2017–2021*, 2017. GTM Research.

Forecasting and Predictions

Contributors noted that documenting time-of-day and seasonal generation compared to predictions based on resource modeling can help in future planning to ensure adequate storage capacity is planned for a particular facility or community. Forecasting and monitoring of competition levels at every shared generation source between all consumers of those resources will also help to plan for sufficient energy supply. Relevant data for forecasting includes:

- Energy yield estimates by technology type.
- Resource assessment for renewable sources and non-renewable (e.g., microturbines and diesel generators)
- LCOE estimates
- Network planning based on system integration studies and system adequacy assessment

Analyzing Current and Historical Data

RFI respondents suggested that generation and demand could be optimized by correlating aggregated historical demand and real-time generation data with ambient and external factors (e.g., weather and event forecasts). It would also be critical to track the location, operational status, and generation capacity of all energy resources serving a particular load area. A wind energy industry representative noted that documenting time-of-day and seasonal generation compared to predictions based on resource modeling can help in future planning to ensure adequate storage capacity is planned for a particular facility or community.

Operational and Financial Management Data

Measuring and monitoring equipment performance can be used to develop understanding about relative efficiency and reliability, which can help to drive sound financial investments. Contributors also mentioned that multiple datasets will be needed with a particular emphasis on infrastructure topology and supply chain data that encompasses multiple users (e.g., producer, intermediate users, end users) and spatial scales.

Analysis Needed

Participants were asked what analyses will be required to determine the location of generation and the proportion of electricity that is derived within an energyshed. The balance between demand and capacity plays a key role in determining the location of energysheds. Machine learning with analysis techniques such as k-means clustering could be used to analyze census tract-level generation and consumption to group areas that balance and, therefore, constitute an energyshed. Information such as electricity, heat and cooling demand, and potential for onsite solar PV generation would be critical. The City Building Energy Saver (CityBES) extracts this information which connects urban data with building simulation in the system design process.

Region / Geographic Analyses

The ability for an energyshed to meet demand are tied to the resources the energyshed has within it. For example, average wind speed in an area will be a factor in an energyshed's ability to provide wind power.

Temporal Analyses

Forward planning for intra-day and day-ahead energy, capacity, and ancillary service values can optimize the value of resources within an energyshed. Hierarchical prioritization would logically apply to resource allocations between products with emphasis on system reliability and network optimization. Coordination will be required between those entities operating distribution networks and entities (in restructured markets) serving retail supply relationships, in which a transparent accounting of cost and value to customer-sited resources must be available to all stakeholders. Procurement mechanisms for local services must be well defined in the forward market applications. Actual measurements must then deliver revenue-grade readings to market participants for purposes of financial settlement.

Holistic Analyses

While it's important to balance demand and capacity, a technical consultant suggested that balancing other factors such as carbon can also help define an energyshed. In a "carbonshed," sources and sinks of carbon dioxide are, or could be, balanced. Fossil fuel consumption for energy results in large anthropogenic carbon dioxide emissions, therefore, an energyshed analysis should also consider "carbonsheds."

Additionally, new analyses will be needed to balance metrics and the optimization of existing and potential energy infrastructure with consideration to energy justice. A contributor representing a university noted that "as distributed renewable energy grows more prevalent, the future will not be described by either the current centralized power system nor the energyshed based power system discussed above, but rather by a hybrid between the two (as is also the case with water and food)."

Metrics Needed

RFI respondents were asked what specific metrics should be used to characterize an energyshed or an energyshed management system. In response, participants responded with the following:

- Environmental
    - Tons of CO_2 created and eliminated
- Energy Storage
    - Amount of energy stored
    - Stored energy expended
    - Utilization of public and private storage pools within the energyshed for peak demand response and economic arbitrage
- Energy Production
    - Energy supplied by grid
    - Energy production on-peak
- Renewables
    - Wind and solar resources
- Reliability
    - Outages (grid and energyshed)
    - Equipment availability
    - Unscheduled maintenance
    - Performance of on-site back-up generation
        - Reliability Metrics
            - Loss of Load Probability (LOLP)
            - System Average Interruption Duration Index (SAIDI)
            - System Average Interruption Frequency Index (SAIFI)
            - Customer Average Interruption Duration Index (CAIDI)
- Generation and Demand
    - Energy consumed
    - Energy exported
    - Curtailment events

        - Amount and location of power that was curtailed and the reason (i.e., economic dispatch, islanding, topology limitations, lack of timely dispatch response, etc.)
    - Frequency and generation imbalance in the energyshed
        - Retroactively on monthly and quarterly bases
    - Variance of forecasts for demand and generation from every source within the energyshed
    - Competition metrics of all consumer areas for shared resources
    - Potential generation resources that were underutilized
- Other
    - Transmission utilization rates
    - Levelized cost of energy
        - Including full-cost accounting, which would account for avoided costs on the external grid (i.e., reduced peak load costs, reduced system losses, impact on bulk grid locational marginal price, reduced ancillary service costs, etc.)

One national laboratory representative suggested a framework for characterizing metrics that incorporates three primary factors to define an energyshed: 1) economic cost for energy development, 2) environmental benefit, and 3) some measure of energy resilience. Correspondingly, metrics to evaluate these factors would be needed to characterize an energyshed.

In principle, the environmental benefit and energy resilience components could be built into the cost, thereby not requiring explicit representation in this characterization. In practice, however, as these effects are not currently adequately built into the price of energy, they should exist as second and third dimensions of necessary metrics that must be calculated to define an energyshed. Each of these three dimensions could be normalized in a way such that the value obtained from each could be comparable to one another.

As an example, consideration of these three metrics (rather than simple economic cost decision-making) might lead to the development of solar over a cheaper energy resource due to the environmental and resiliency benefits associated with using locally sourced energy instead of imports. This contributor expects that this type of scenario will increasingly hold true given the push to net-zero carbon emissions as a way to combat climate change.

RFI Results

RFI respondents were also asked what tools and data will be required to determine the location of generation and the proportion of electricity that is derived within the energyshed. While many tools and data sets will need to be developed, several national laboratory participants suggested that existing tools and data sets could be used to support the initial energysheds development. Respondents also provided examples of tools from other fields that could be leveraged, such as tools that conduct net flow dynamics, as well as commodity flow tools for the transportation sector.

Standards and Interoperability

In the future, contributors suggested that it will important that tools follow common practices and incorporate all the sectors and operational functions of an energyshed. As one national laboratory participant said, it will be important that future tools be interoperable and be built upon common data models that model interactions among diverse sectors of an energyshed (e.g., buildings, DER, transportation, urban environment). Representative energysheds of various typology and configurations can be developed to enable modeling and evaluation of energyshed design and operation by diverse tools and stakeholders. Tools should provide a standard set of metrics to evaluate the energy efficiency, energy flexibility, and climate resilience performance of an energyshed. Tools at different levels of detail and requiring different amounts of data should be made available to support stakeholders' diverse needs.

Financial Management

The operation of energysheds will require a financial management component. As one participant pointed out, financial tools could be implemented by a utility, retail supplier, aggregator, or some combination of entities. Local generation is, in many cases, likely to be a combination of customer-sited resources behind the meter as well as distribution-interconnected generation (e.g., community solar). The ability to allocate cost, design equitable rates, and align the proportion of customer load served by generation within an energyshed necessarily requires integration between multiple systems.

Data Visualization

Participants expressed that the development of tools to visualize tradeoffs among economic, environmental, and social indicators would be useful. A valuable dataset to visualize would be from intelligent metering at the home/building level, including real-time load demand and inverter information for small-scale solar installations. Data and analysis are also needed for disaggregation of electric vehicles' electricity loads, detecting storage availability, and monitoring to maintain a real-time understanding of all distributed generation resources and storage resources within an energyshed. Lastly, virtual and hybrid network controls would be useful for consumers with multiple sources of power.

Data Completeness, Transparency, and Security

RFI respondents emphasized that tools developed for the purpose of energysheds need comprehensive data sets. The data needs to be regulated, encrypted, and properly secured against attacks. Further, data needs to be transparent and shared between stakeholders directly involved with managing resources, dispatching resources, and grid operations. Contributors urged that, to manage models holistically, data access should be available to any stakeholders within an energyshed as well as any adjacent operators who may share resources.

Planning and Operations

In the "Planning and Operations" topic area, DOE-EERE sought to expand its understanding of the impact of more locally derived generation, expectating that this may require planning efforts that are different from traditional integrated resource planning (IRP) efforts. As more generation is located within the energyshed, the way the power system is operated on a day-to-day basis may need to change. Workshop attendees and RFI respondents were asked to share their perspectives on how planning procedures or tools need to be updated in a more locally derived generation mix.

Topic Overview

In this topic area, DOE-EERE sought energy sector stakeholder input related to considerations of energyshed planning and operations. Since each community has different sources of energy available, a question raised was: "Which planning procedures or operations need to be updated, changed, or added in a more locally derived generation mix?" DOE-EERE specified an interest in stakeholder input regarding how the IRP process might need to change if energy generation and consumption become more localized. Additionally, contributors were asked to consider how the relationships between utilities, customers, and local governments needed to change with more locally derived generation. As more generation is placed in hands of consumers, how will their relationship with utilities evolve?

One of the themes that became clear during this discussion was a commitment to the "principle of simplicity" with respect to utility regulation[6]. When discussion participants mentioned unbundling utility rates, workshop organizers expressed a potential challenge due to the complexity involved. The need for simplicity was also mentioned as a critical component of the consumer-utility relationship, recognizing that having a single point of contact within the utility will be valuable.

Workshop Key Participant Takeaways

Following small group discussions, participants shared their key takeaways from the planning and operations topic. At a high-level, they described energysheds as a way to knit together the planning elements, and as an organizing framework at community scale. In addition to the watershed analogy, some used a foodshed analogy. Local foodshed movements think about benefits, tradeoffs, and costs of producing food locally, but are not strictly limited by geography like watersheds. Food is produced all over and aggregated in distribution centers to reach end users. Workshop attendees thought about the roles of various stakeholder groups with respect to planning and operations, especially the roles of utilities, local governments, and communities.

Utility Role

Several participants expressed the need to include more voices from the stakeholder community when planning and operating the power system. For example, conversations between the utility and owners of DER could lead to a better operation of the system. Discussion raised the question of what technology will need to be developed to facilitate new system planning.

Local Government Role

Contributors explored the role of local government as well, recognizing that coordinating stakeholders will require staffing and technology resources. One suggestion was to engage sustainability officials, and another was to consider creating a role for a local energyshed ombudsperson. Policy challenges that local governments may need to overcome could be related to data privacy regulations, distributed generation for lower income households and nonprofits, and allocating sufficient real estate to meet energy demand using distributed resources (i.e., parking lots for solar power generation).

[6] James C. Bonbright, *Principles of Public Utility Rates*, 1961. Columbia University Press. https://www.raponline.org/knowledge-center/principles-of-public-utility-rates/

Community Role

With respect to community leadership roles, participants mentioned the importance of strengthening community organizations and building capacity for needs-based participatory planning. Contributors advised that utilities and local governments should allow Community Choice Energy and CCAs to organize, and proposed a paradigm that allows for community-owned power and models similar to rural electric cooperatives in urban settings. Communities will need to consider questions about the cost tradeoffs of using local generation versus importing, and whether using local generation may create an economic justice issue.

Workshop Discussion Highlights

This group provided a variety of perspectives when asked, “What are the implications of moving to more locally generated energy systems?” Organizers also asked, “How do the relationships between utilities, customers, and local governments need to change?” Responses can be generally categorized as related to the following:

- Planning Approaches
- Technical Considerations
- Social Considerations
- Stakeholder Coordination
- Case Studies

Planning Approaches

Contributors commented that energysheds can be considered a “localized energy generation IRP” and represent a multifaceted—rather than an isolated—approach to planning. Similar to watersheds, energysheds are multi-scale and can have flexible geographic boundaries. One individual suggested that as a planning framework, energyshed scenario analysis can zoom in and out to evaluate trade-offs, opportunities, and operations challenges.

Technical Considerations

In contrast to standard IRPs, which are generally concerned with resource adequacy at least cost, an energyshed region may need to expand for resiliency. One comment during the discussion indicated that a target pattern may be warranted, with different percentages of energy coming from various geographic distances. With respect to power distribution, contributors noted that energyshed planning can avoid or manage reverse power flows from excess distributed generation that wasn’t planned for in advance. The conversation continued with one contributor saying, “Local distribution networks are typically able to handle distributed generation as long as there is self-consumption (e.g., batteries or zero export systems) in place. The short- and long-run distribution are the issue—with backflow prevention and old controls that cannot deal with bi-directional flows.”

Another participant suggested that the concept of energysheds could be used to leverage the involvement of consumers owning distributed energy resources. For example, multiple owners of energy storage could serve as a virtual battery for the local power system. A third workshop attendee added that there may be potential for a local distribution area, such as a substation or feeder, to “island” as a microgrid during a power outage, which would require a full microgrid control system to balance generation, load, and storage.

Social Considerations

During the Planning and Operations discussion, participants indicated an interest in building capacity for more participatory "need-based" planning at local and regional level. In this sense, energyshed management offers a way to engage energy stakeholders. One recommendation offered was to incorporate community-driven processes, as described in reports such as Our Communities, Our Power: Advancing Resistance in Resilience in Climate Change Adaptation.[7]

Another contributor mentioned procedural justice[8] in general, and suggested investing to develop and strengthen capacity and organizations for long-term, participatory community planning. For example, communities may be interested in considering how to provide access to distributed generation for lower income individuals, nonprofits, or others who cannot take advantage of tax credits.

Stakeholder Coordination

The primary theme with respect to stakeholder coordination was that customers need to have a seat at the table, but do not necessarily have the knowledge required to make decisions. As such, contributors suggested that a campaign to educate stakeholders would be "essential." Participants also brought up a general need for communication and advocated for a mobile application that could provide real-time energy usage, pricing, and other relevant information. Another point raised was the potential need for a local energyshed ombudsman.

Examples Provided by Participants

Workshop attendees noted that Vermont has state-level goals such as 90% total energy from renewables by 2050, but the execution of that goal is being drafted at community scale through an energy-siting law that requires each town energy committee to develop a plan. The state is an energyshed, and individual communities are also energysheds. A contributor who has been extensively involved with the energyshed management in Vermont explained that since the focus is on total energy, there is also an effort to integrate electric, heating, and transportation energy.

Another example mentioned was that of a municipal utility located in Denton, Texas. The local utility started purchasing wind power assets and using biogas from a local landfill. However, it also started implementing advanced natural gas combined-cycle facilities because they were cleaner than gas-fired facilities and could serve as a bridge while more renewables are being developed.

RFI Results

Implications of Locally Derived Generation

Like workshop participants, RFI respondents were asked by DOE-EERE to provide their input related to the implications of more locally derived generation on grid planning efforts. Addressing impacts of more locally derived generation, along with how energyshed managements systems may affect grid operation both on a day-to-day and long-term basis, are important for grid and community planning.

One national lab participant expressed that planning, design, and operation of an energyshed should include all needed sensing, monitoring, and data collection to enable performance analysis, diagnostics, and benchmarking. Planning and design should consider life cycle needs as well as potential impacts from extreme weather events and climate change. Integrated optimization of various sectors should be done through modeling and simulation in the design phase or data-driven analytics during the operational phase. Advanced controls using predictive modeling in real time can improve performance of an energyshed.

When considering community planning, one university participant drew a parallel to transportation planning. Metropolitan planning organizations (MPOs) are the organizations tasked by the federal government to carry out

7 NAACP, *Our Communities, Our Power: Advancing Resistance in Resilience in Climate Change Adaptation*, April 2019. https://toolkit.climate.gov/reports/our-communities-our-power-advancing-resistance-and-resilience-climate-change-adaptation

8 "Procedural justice concerns who is at the decision-making table, and whether, once at the table, everyone's voice is heard." Initiative for Energy Justice, *The Energy Justice Workbook*, 2019. Section 1.3. https://iejusa.org/section-1-defining-energy-justice/

regional transportation and air quality planning. MPOs model the transportation system, analyze transportation needs in the context of multiple objectives, develop long-range transportation plans, allocate federal transportation funds, and facilitate public engagement. Their responsibilities can extend beyond the transportation network to include growth management and land use planning.

This academic contributor suggested that a "metropolitan energy planning organization" (MEPO) could manage and coordinate an energy system that has much more substantial local electricity generation, but also a continuing requirement to be connected to the regional and national grid. A MEPO could also be equipped to coordinate the transitions from petroleum-powered transportation and natural gas combustion to systems based upon electricity or zero-carbon hydrogen.

A MEPO, for example, will be able to coordinate the introduction of electric vehicle charging stations across an entire metropolitan area, incentivize higher-density (and lower energy-use) land development, introduce energy efficiency building code and building retrofit regulations, and require changes in land use and zoning regulations to maximize local energy generation. Furthermore, a metropolitan-scale organization will be needed to manage the complex tradeoffs between multiple energy objectives including low prices, high reliability, low greenhouse gas emissions, substantial local generation, energy justice, and energy democracy.

Planning Procedures and Operations Systems

Participants were asked what planning procedures or operations systems need to be updated, changed, or added in a more locally derived generation mix. A contributor representing a non-profit energy policy organization told DEO-EERE that robust input from civil society, community, and regional planners into technical planning processes is integral to guaranteeing better outcomes on energy justice, diversity, equity, and inclusion.

Energyshed management systems are key to managing locally derived generation mix within energysheds. A university respondent described the function of an EMS as similar to the current ISO, but focused on the power supply to a given energy sink (e.g., a city) from the different sets of energysheds (related to different energy sources) that feed into that sink. Thus, within each energyshed, the EMS would manage electric energy storage, purchase of energy supply, energy pricing, and energy curtailment to different types of energy suppliers and users in order to provide reliable power both to consumers within the energyshed and those in the downstream energy sink (city).

Deriving a more locally sourced generation mix may involve complexity but, from one respondent's perspective, it is a worthy and achievable goal with potential benefits to ratepayers, DER developers, and the power system as a whole. This participant, who represented a technical consulting firm, specified that value will be found by accelerating the efficient adoption of DERs on distribution while still maintaining a link to the wholesale power system. This approach is similar to the "total distribution system operators" outlined in DOE's work on grid architecture. In addition to advanced distribution management systems to execute dispatch, implementation may require market mechanisms capable of settling along the distribution networks and opening distribution tariffs to ensure fair and non-discriminatory access to the network.

In many cases, the locally derived generation mix will be renewable. One national lab participant suggested that energysheds will help to accommodate renewable energy technologies with the support of local flexibility, storage, and dispatchable sources. As a result, there will be a possibility to integrate higher penetration levels of renewable energy technologies with a minimal impact on the grid. The grid will facilitate the interactions between different energysheds located in different localities to cater the mismatch between demand and generation.

Accommodating More Locally Derived Power

RFI respondents were asked how daily power system operations might change to accommodate more locally derived power. An industry participant suggested that depending on the timescales, the following changes to short term operation and planning will assist with accommodating locally derived power:

- Day-ahead planning: Forecasting the net load on an hourly basis will help with scheduling interchange between the energyshed and the external system, such as import schedules during shortages and export schedules during excesses.
- Intra-day planning and operations: To manage deviations in either load (native) or generation (forecast deviation, unforced outages), an intra-day planning exercise that periodically runs system operation scenarios would help determine interchange needs, reserve requirements, and operation of short-term reserve designated resources. The frequency of such studies may be hourly or every four hours depending on the stochasticity of net load on the system.
- Hourly and intra-hour operations: System studies (dispatch and power flow) conducted to determine close to real-time requirements can further help establish energyshed requirements.

Barriers to Overcome

Participants were asked to provide DOE-EERE with input regarding the barriers that must be overcome for power system operations when more electricity is locally generated. One industry participant offered the following assessment of the barriers:

- Technical barriers
  - Protection coordination
  - Accounting for backfeed in the case of residential/commercial rooftop PV
  - Voltage coordination and control (power quality)
  - Scheduling and dispatch of participating generation
  - Coordinating interchange
- Economic barriers
  - LCOE given cost of small-scale generation while aiming to maintain high level of reliability and power quality
  - Incentives for end users to add generation/offset load through energy efficiency/demand response
  - Need for additional investments in the form of network augmentation through expanded sensor utilization and network control elements
- Regulatory barriers
  - Discrepancies between reliability and power quality metrics versus benchmark metrics from conventional grids
  - Safety concerns related to islanded operation during outages
  - Rate base determination
  - Incentives for market participation

Utility / Customer / Government Relationships

DOE-EERE asked RFI respondents to provide insight about how traditional utility operations may need to change as more generation is locally derived. This question also involved considering how relationships between utilities, customers, and local governments may need to change. A wind industry association contributor suggested that the cost and time needed to for utility interconnection may be a significant barrier to DER deployment, especially for large-scale wind projects. The grid and prudent power engineering practice do not vary from utility to utility, and two detailed and well vetted models are available: 1) the Interstate Renewable Energy Council (IREC) Model Interconnection Procedures, which were released in 2019, and 2) New York State Standardized Interconnection Requirements. The Distributed Wind Energy Association recommends instituting these procedures to accelerate energyshed development.

Resilience

In the "Resilience" topic area, DOE-EERE sought to identify system architecture and operations practices that will lead to a more resilient power system with more locally derived generation. Workshop attendees and RFI respondents were asked to consider how locally generated electricity may lead to the development of a more resilient power system, including microgrids. For the purpose of this workshop discussion, resilience is defined as the ability "to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions, including the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents."[9]

Topic Overview

When asked to provide input about resilience opportunities and barriers related to increasing locally generated electricity, workshop participants made the point that planning resilience into local generation will be critical. Participant responses to this topic also raised issues related to investment in infrastructure development, factors in the cost-benefit analysis, and value "stacking." From a community's perspective, resilience and backup power is a good place to start, but there are additional values to the system that can be unlocked.

This group proposed several creative ideas with respect to resilient energysheds and also presented many questions that remain to be answered, including:

- What level of resilience are we aiming for?
- Should storage capacity be in place at the local, household/building, or grid level?
- How do we build an integrated and shared mesh network of power and information across more islanded infrastructures?

Workshop Key Participant Takeaways

This group recognized an opportunity to create electric energyshed/microgrid cooperatives or associations within existing consumer-owned cooperative or municipal utility service areas, which could serve as an extension of the existing consumer-focus of these utilities. Participants suggested DOE look into both CCAs and the Rural Utility Service at the Department of Agriculture as templates for how microgrids can be more easily procured.

Workshop Discussion Highlights

One of the most overarching barriers related to energyshed resiliency mentioned during this discussion was the standard expectation and default to imported fossil fuel, especially in emergency situations. Participants emphasized that if energysheds are focused on energy available within a defined region, then planning will need to follow regional commitments to phase out fossil fuels.

The role of microgrids and resilience within microgrids was also explored by workshop participants. The other themes that emerged during the workshop session were:

- Cost
- Infrastructure and Development
- Interconnection and Communications
- Emergency Response

[9] Grid Modernization Laboratory Consortium, *Grid Modernization: Metrics Analysis – Resilience Reference Document, Volume 3*, April 2020. https://gmlc.doe.gov/sites/default/files/resources/GMLC1.1_Vol3_Resilience.pdf

Cost

A barrier proposed by discussion participants is that energyshed management systems are potentially more expensive than the alternatives. Contributors expressed concern that since this cost would be borne by the customers it could lead to increased financial burden on communities. One participant asked, “Who will pay, who will benefit, and how will we fairly share the value and include those of lower incomes?”

Several contributors mentioned that utilities often consider DER and two-way energy flow as not cost-effective. Another participant posited that a reliance on local generation could increase the need for energy storage and related expenses. One potential solution mentioned providing energy consumers with ongoing incentives to invest in the grid balancing capabilities that come with both conventional storage (batteries) and non-conventional storage (e.g., grid interactive water heaters or geothermal storage).

Infrastructure and Development

Participants indicated that the power system as it exists now performs relatively well from a resilience perspective. At the same time, DOE-EERE received input related to the technical upgrades needed to grid infrastructure, noting a particular urgency to adopt the most current code standards for new developments. One contributor explained that the distribution system in most locations doesn’t have the switches and mechanisms in place to utilize resilience benefits of locally generated electricity. For example, re-syncing with the grid when grid service is restored needs to be assured. Also, utility supervisory control and data acquisition upgrades may be needed.

For resiliency across troubled areas with power issues, commentors urged moving microgrid pilot projects, such as the Autonomous Energy Grid Basalt Vista housing project, into the mainstream. This model may shift the role of utilities towards that of a distribution provider. From a developmental perspective, workshop attendees suggested that transitioning to a local electric generation system presented a potential opportunity to move ownership and control of these DER to community groups, co-ops, and CCAs.

Interconnection and Communications

During this session, the concept of interconnected microgrids and interconnected smart buildings were both mentioned, along with the related need for communication and control protocols. Participants suggested that grid interconnected smart buildings could be leveraged to manage load and DER. Interconnected microgrids, set up as standalone nodes that can connect and disconnect from the larger grid, were also proposed as an opportunity, with the contributor explaining that the microgrid could aggregate the production and demand from a specific geographic area.

To implement these types of interconnections, contributors stressed the need for continued software and hardware development. Communication and control protocols need to be improved to accommodate different forms of generation that can easily be added to the mix. Participants cited the lack of common connection infrastructure for electric vehicles as an example of this issue. One commentor suggested that the National Institute of Science and Technology and DOE might collaborate with stakeholders to develop some generalized, secure protocols, akin to W3C/IETF internet standards.

Emergency Response

Several discussion participants mentioned the need for overcoming the fossil fuel dependence that is often the default mode in emergency situations (e.g., disaster or critical failures during extreme weather events). A barrier to this is the currently steep price tag of local (household) storage options, specifically batteries, compared to gasoline/diesel generators. Contributors suggested that there is an opportunity for utilities or grid operators to pay incentives to their customers associated with the energy storage value of storage options.

The issue of cybersecurity was also discussed from two perspectives. One participant noted that decentralized systems with gateways would reduce the potential impact of cyber-attacks. Another participant noted that utilities typically think of DER as increasing the cyber security risk to the grid. Continued conversation raised the points that smaller energy systems may be less attractive to bad actors and, separately, that "cybersecurity needs to be improved for the existing grid anyway, so cyber protocols can be developed along with DER platforms."

Energy Justice

The group highlighted investment into disadvantaged communities as a key issue for resilient energysheds. Participants told DOE-EERE that electricity providers need to shift focus towards vulnerable communities, some of which are more likely to experience blackouts, load shedding, and may wait longer for service to be restored in an outage. With respect to financing, contributors wondered if there will be differential resilience in more affluent communities.

RFI Results

Resilience Opportunities

DOE-EERE asked RFI respondents to share their insight about resilience opportunities related to increasing locally generated electricity. Contributors noted that a single transmission failure at a centralized power plant will leave a large population without power. Therefore, more local generation is expected to be more resilient, though participants varied in their opinions about the optimal size of an energyshed to increase resilience.

Energyshed Size and Reliability

A non-profit policy research organization representative suggested that the larger the catchment area for renewable resources, the larger the energyshed, and the larger the energyshed, the more resilience is enhanced. Conversely, according to a national laboratory participant, failures could be limited simply by reducing distance between generation and load/demand needs. Spatial distribution of generation could increase redundancy (i.e., serve as hubs) for prioritizing recovery responses.

One industry participant suggested that an energyshed that is served largely—but not exclusively—by local generation has potential for resilience and reliability benefits. Collective self-consumption and the commensurate increased utilization of distribution infrastructure should reduce the probability of outages that result as a function of overloads. Contributors expect that would also reduce the net load requirements at the point of transmission interconnection, which should help mitigate requirements on the wholesale system.

Renewable Energy and Reliability

A wind industry association representative shared a perspective that distributed renewable energy could increase the resilience of an energyshed. Critical community services, such as medical facilities, water supply infrastructure, communications facilities, and military facilities could install microgrids that would strengthen the grid and build manufacturing volumes for Distributed Generation (DG) technologies. Expanding DG development at schools and other governmental facilities with lower energy expenditures could reduce overall regional carbon intensities, and also support local economic development. Further, this contributor expects that combining solar and wind resources could make for stronger and more effective microgrids that would be less susceptible to losing power due to fire, extreme weather events, and other natural disasters.

District Energy Systems as a Model

A contributor representing a non-profit district energy association explained that resilience and reliability are the cornerstones of the district energy industry in the United States. These district energy systems are community-scale markets such as cities, campuses, airports, military bases, and healthcare facilities. District energy microgrids utilizing combined heat and power (CHP) represent a range of technologies that are effective in all the climate zones of the U.S. Integrating power and thermal energy use enables very high efficiencies and reduces downstream carbon emissions. District cooling systems, especially those with thermal storage, provide dramatic peak demand benefits to local power distribution networks and avoid reliance on costly, inefficient, and fossil fuel generation assets.

This participant provided several examples of districts that have experienced resiliency benefits from utilizing CHP in a self-sufficient microgrid.

- The University of Texas at Austin (UT Austin) CHP system fully supplies the heating, cooling, power, and energy optimization of the entire 20 million square feet of buildings on campus, supporting nearly 70,000 daytime occupants with mission-critical heating, cooling, and power. In 2020, the UT Austin district energy system reported overall energy efficiency exceeding 86% and fully maintained energy services throughout the Texas deep freeze of Storm Uri in early 2021.
- Texas Medical Center in Houston, the world's single largest healthcare campus, relies on CHP and large-scale thermal storage. This campus withstood and maintained 100% reliability to customers during multiple hurricanes, record flooding, and the near grid collapse experienced by Electric Reliability Council of Texas customers during Storm Uri in 2021.
- Princeton University maintained energy services to the campus community throughout Hurricane Sandy in 2012. As one of the few areas with energy services intact, Princeton was able to serve as an area of refuge for first responders. Maintaining service also preserved and protected invaluable research stored on campus while grid interruptions impacted over 8.1 million people across 21 states.

Data Analysis for Resiliency

One industry participant suggested that edge data analysis at the meter will provide real-time, detailed insight to the state of the resource allocation within the energyshed which can be used for either artificial intelligence-informed or automated resource allocation optimization and topology reconfiguration during unexpected events or demand volatility. Micro analysis of the waveform data at the millisecond level and inter-meter communication in an Advanced Metering Infrastructure mesh can also increase the resiliency of the grid by detecting transient anomalies. It can measure reactive power imbalances at a community-level, provide proactive fault risk for repeated high impedance detections, and manage microgrid resources at the community level while also providing analyzed data back to the substation for aggregation and regional analysis.

This analyzed data can then be passed for centralized analysis of the microgrid within an energyshed, and also shared with overlapping energysheds and operators that are influenced by the energyshed. During an event that may require Public Safety Power Shutoff operations, real-time, far edge data along with disaggregated consumption analysis can allow for intelligent, surgical offloading of power instead of blunt regional outages.

Insight behind the meter can also inform utilities of factors such as the temperature of a home where freezing pipes are at risk, medical equipment inside a home that is critical to be powered, private energy storage equipment, etc.

Demand Response

Increases in large storage and EV battery connectivity can provided a source of backup power during peak load times but must be defined, monitored, and dispatched optimally. This could be voluntary for private citizens, but also utilized for public resources such as EV school buses and public transportation vehicles. Real-time energy consumption information (especially in disaggregated, device-level form) can give the customer up-to-the-minute insights regarding their personal energy usage, which they can, in turn, use to make "good citizen" decisions, such as adjusting thermostats, turning off pool pumps, or delaying heavy load activities such as drying clothes during peak events.

Resilience Barriers

DOE-EERE asked RFI respondents to share input about the resilience barriers related to increasing locally generated electricity. A participant representing a technical consulting firm shared that during an outage, individual customers or sub-aggregations of customers who share generation and storage behind a common point of interconnection and have sufficient controls in place should be able to island. Ideally, an energyshed concept would include some coordinated, partial-reliability scheme to maintain community-level resilience, though best practices for coordination and controls under this approach are still being established.

System Architecture and Operations

RFI respondents provided DOE-EERE with their input regarding what system architecture and operations will lead to a more resilient power system with more locally derived generation. One national laboratory participant suggested that resilience of an energyshed should be considered from the beginning, during the planning and design phase, then implemented and refined during the operational phase. Resilience considerations should include cybersecurity, energy resilience, climate resilience, and socioeconomic conditions.

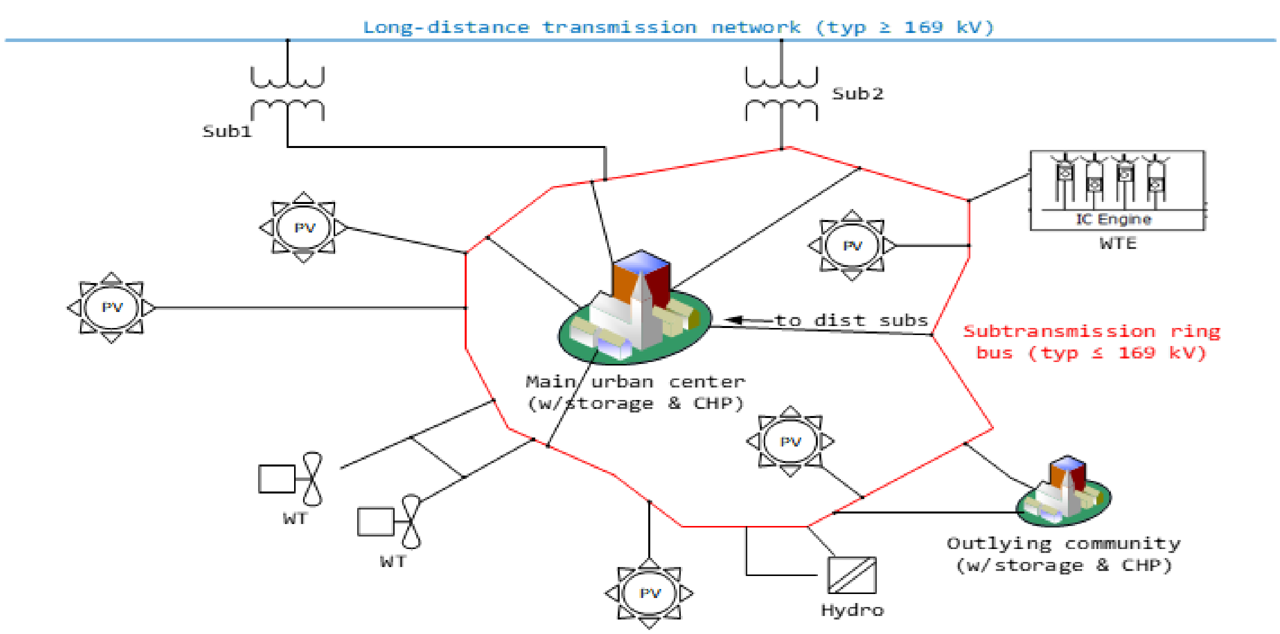
Coordination between Energysheds

Another national laboratory contributor suggested that coordination between energysheds will be needed to balance the "islanding effect" with the "grid of microgrids" approach. The security of energysheds could also be increased by connecting emergency planning with energy systems planning. This could involve conducting evaluations of energyshed vulnerabilities related to different natural and intentional threats to identify optimal investment and response solutions across the reliability-resilience spectrum. The respondent suggested that this approach should effectively recognize and prioritize critical infrastructure needs to ensure that resources are being distributed equitably across regions. Cross-cutting capabilities will also be needed to ensure:

1. an effective, standardized monitoring strategy
2. human-machine teaming for reliability
3. improved metrics for quantifying system optimization/benefits

Planning for Urbanization

Figure 3. Long Distance Transmission Network from a RFI Respondent



A national laboratory respondent noted that America's population (as well as that of the rest of the world) is continuing to urbanize. Thus, this participant suggested to DOE-EERE that resilient renewable power architectures should focus on urban centers. Renewable resources tend to have low energy densities, requiring significant space to generate large amounts of power at very high availability levels. Urban areas, on the other hand, tend not to have sufficient space to host such renewable plants within the urban boundary. Thus, a resilient electric power system might be architected like what is shown in Figure 1 , which can be thought of as an energyshed.

A ring bus circles the main urban area, with multiple feeds from the ring bus into distribution substations inside the urban perimeter. The ring bus itself provides N-1 resilience. Large renewable-energy plants of several types are distributed around the ring bus. Energy storage (electrical) would be located at the distribution substations within the urban area, augmented by smaller energy storage (electrical and thermal) in buildings or at facilities. Combined Heat and Power would also be a part of the urban landscape, as CHP facilities have a strong track record of both high resilience and high overall energy efficiency, and can take advantage of both electrical and thermal storage. The smaller, outlying community or suburb shown in Figure 1 does not have its own ring bus, but it does have its own storage and CHP, and can tap the larger-city ring bus in more than one place, offering it some resilience benefits as well.

A high-voltage transmission network provides resource sharing capabilities between urban areas. The electrical backbone of this architecture, or something similar to it, is already present in most urban areas, smoothing the transition toward this type of system. This contributor concluded by noting that investments would be needed to re-envision these concepts to rural regions that are characterized by different resource densities.

Energy Justice, Diversity, Equity, and Inclusion

The objective of the "Energy Justice, Diversity, Equity, and Inclusion" topic area was to identify DEI opportunities related to energyshed management system demonstration and deployment. Each of the previous sessions had considered energy justice, with respect to the specific topics being raised. The final participant discussion was an opportunity to explore how these activities can be implemented with respect to tools and analyses, planning and operations, as well as resilience.

Topic Overview

The EJ and DEI topic raised discussion related to social, environmental, economic, and technical values and decision making. One workshop participant stated an opinion with which many group members agreed: "DEI should be the centerpiece of energyshed thinking."

Workshop attendees were asked: "What does a 'just transition' to the new energy system look like?" In response, attendees suggested an all-inclusive participatory "energy democracy" that will provide energy system choices to communities, especially the historically marginalized and vulnerable populations that have been harmed by the current system. Energyshed thinking also moves responsibility to the system via collective action, instead of just to the individual. One attendee noted, however, "Justice isn't inherent in the energy transition and development of energysheds. The grid is going through big, expensive changes. Without intervention, the default outcome would be likely to increase the financial burden and exacerbate existing inequities and divisions."

Workshop Key Participant Takeaways

A key takeaway of this conversation was that energyshed thinking can help us come to terms with the costs and benefits of our energy choices. The participants wondered whether locally generated energy may be a way to provide benefits to the community. Further, they went beyond considering justice and economic opportunities for communities by discussing ecosystem restoration for forests, farmlands, and wetlands. Contributors noted that "the Principle of the Commons needs more consideration as we begin to see energy like water, clean air, and other common resources."

Participants also recommended developing methods for cumulative health risk analysis in the community (e.g., identifying who is vulnerable to energy stressors such as air and noise pollution from refineries, heat islands, lead, etc.). The specific question was raised: “Can we figure out how the people who have borne the burden of fossil energy can benefit from energy transition?”

Several contributors suggested that energysheds represent a social opportunity and that energy co-ops are a vehicle to implement the approach. As one stakeholder who represented a community energy cooperative stated, “Transferring ownership and control into the user’s hands helps them want to participate and become educated.” The group identified challenges that would need to be addressed regarding specific frameworks, including community-level decision making processes and visualizing energysheds that provide stakeholders with data for informed choices.

There are also significant challenges related to siting and cost implications. Participants emphasized that it would take money and commitment from localities to implement energysheds. They also noted that high energy rates can be burdensome, so passing along costs to ratepayers is not an attractive option. Ultimately, data and tools will be necessary to develop the ability to understand system-wide siting and cost implications.

In addition to these points regarding energyshed potential costs and benefits, the group provided significant insight about rural communities, as well as case studies about existing efforts.

Rural Communities

Workshop participants urged that reducing energy burden should be an objective of energyshed management systems. Energy burden, which is the percentage of household income spent on energy, is higher in rural regions, where about 40% of income is spent on energy in some communities.[10] Attendees noted a large rural-urban divide in the energy transition, with rural areas (which, as of 2015 census, have lower income levels[11]) bearing most of the transition burden. Resources are often sited in rural regions, though these areas have a history of losing out when it comes to reaping the benefits.

New renewable energy infrastructure is going into rural communities with the highest energy poverty. Discussion participants emphasized that utilities have been taking land in rural areas that may have low monetary value, but which may be priceless to the owners or indigenous land users. For instance, utilities often use eminent domain to acquire land from private owners and public lands for transmission lines, then use the road and highway corridors for distribution lines. Because of this dynamic, attendees expressed interest in re-thinking the process of right-of-way acquisition and property valuation. Contributors encouraged DOE-EERE to consider how rural communities can benefit from the renewable energy transition and “not just be an afterthought in a new wave of extractive energy systems.”

Examples from the Participants

Cooperative Energy Futures, an energy efficiency and community-owned clean energy cooperative based in Minnesota, is an example of an organization that has no barriers to access, such as credit checks, to gain access to community solar gardens. A representative of this community organization explained that staff goes door to door explaining the opportunity being offered, but that individuals sometimes expect there to be a “catch” because they have been historically exploited. This group has found it to be effective to go to churches and hire local representatives to reach out to their networks. This strategy was successful in increasing co-op membership. These members are actively involved, taking on board of director positions and advocating for EJ issues at the state legislature. Their experience has shown that if people are given agency in energy systems, they are driven to affect ongoing change.

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10 American Council for an Energy Efficient Economy, *The High Cost of Energy in Rural America: Household Energy Burdens and Opportunities for Energy Efficiency*, July 2018.. https://www.aceee.org/research-report/u1806

11 “A Comparison of Rural and Urban America: Household Income and Poverty,” census.gov, https://www.census.gov/newsroom/blogs/random-samplings/2016/12/a_comparison_of_rura.html

Eco El Paso is a nonprofit organization in Texas that works to reduce energy expenditures of low income, underserved areas and organizations. For example, the group was able to accumulate donated equipment for locations such as migrant shelters in El Paso. The organization is motivated to assist these types of organizations since the less they need to pay for energy costs, the more funding is available for them to spend on their socially beneficial mission.

The Institute for Advanced Sustainability Studies has found that college students studying energy system design have innovative ideas on how to integrate justice and communal participation into energy transition and community level projects. A representative of this organization recommended including youth into this conversation, given that old school expertise is not the only thing driving the form of energy transition. A professor from the University of Vermont agreed that the energyshed concept engages young people. He even contended that the current system is actually designed to prevent one from thinking about one's energy choices. "You do not think about impact of choices, of who, where, when. Energysheds have to engage everyone around the choices." This, he predicted, would create a sense of individual and community level accountability and responsibility, declaring, "This is a socio-technical transformation."

Workshop Discussion Highlights

A major theme throughout the workshop discussions was that energy inequity is systemic and needs to be addressed by actively providing ownership and decision-making authority to communities. Participants recommended that member-owned co-ops are one approach to accomplish an "energy democracy," with the caveat that viable co-ops must be available to communities of all income levels, not only affluent neighborhoods. Discussions raised a few questions to this point:

- How much and how fast do we want to provide energy equity to underserved communities?
- Do we want to provide tools for these communities—which might not break the cycle of health risks associated with some forms of energy production in a timely manner—or do we want to subsidize something more aggressive?

Contributors suggested that, in addition to examining where energy currently comes from, analysis needs to answer the question of where energy could and should come from. To create a new energy system that is less exploitative and more inclusive, specific data should be consulted such as census tract data locations, home mortgages, minority businesses, and schools. One participant suggested utilizing Integrated Public Use Microdata Series (IPUMS) data and existing tools to disaggregate the IPUMS data.

When talking about a "just transition" one of the pillars of energy justice is to empower the marginalized groups to own and control their energy, and to be trained in "green jobs" so they can fully participate economically in the development and operation of these energysheds. Group members encouraged DOE-EERE to think of this workforce development component as one of the ways to repair the economic, social, and political harm done to historically marginalized communities. Further, a focus on job opportunities is key to enable meaningful involvement beyond just consumers.

DEI Opportunities

Energyshed planning helps to move the energy transition conversation beyond just the technical and into a social movement. One discussion participant reflected on energyshed visioning as a community building exercise with the potential to evolve stakeholder conversations from "not in my backyard" to "yes in my backyard." One attendee suggested that demonstration projects in priority census tract areas could show residents how they could become an energy producer, contributing to the grid while combating climate change. This, the contributor anticipated, could lead to a high level of community engagement at a low price point.

Other opportunities that were identified include:

- R&D to establish better data and tools to locate vulnerable communities.
- Cooperative decision making and/or ownership mechanisms to provide equal or equitable access to energy preferences, including type of generation, cost structure, resilience, etc.
- Workforce development training for managing local energy systems both technically and institutionally.
- Public investment in renewable energy generation on government owned buildings (i.e., rooftop solar on schools).

DEI Challenges

The workshop attendees cautioned DOE-EERE about potential challenges to DEI with respect to energysheds. They warned that developing localized energy could drive up the consumer costs, which may outweigh the other benefits of localized energy production. One stakeholder suggested making efforts to ensure that energy quality, availability, and cost are equitable in energyshed systems as it grows to replace a larger grid.

In addition to the cost required for transitioning the energy system, commitment from the localities involved will also be required. As such, some energyshed communities may not be willing to actively participate in energy management, sourcing, and resilience. Further, there will be a need for coordination between communities in order to manage competing and overlapping energyshed power supplies and environmental footprints. One contributor suggested that energysheds will need to be thought of as place-based, as well as a series of nested networks, since one community bears the "downstream" environmental/health burden of another community's energyshed.

DEI challenges that discussion participants think will need to be addressed include:

- Community engagement.
- Community-to-community coordination.
- Equity monitoring systems including environmental, economic, and social metrics; baselines and targets for those metrics; and appropriate spatial resolution of measurement of those metrics.
- Prioritization methods for fairly restoring power to the community after outages.
- Policy framework to ensure that nobody has an energy burden above 10% of income.

RFI Results

Energyshed Opportunities and Challenges

Like workshop participants, DOE-EERE asked RFI respondents to identify potential energy justice opportunities and EJ challenges that should be considered in developing energysheds. Respondents described an anticipation that energysheds with locally generated renewable energy sources could offer opportunities for energy independence, security, and resilience. However, they acknowledged a number of potential challenges related to locating energysheds in underserved communities, including reaching remote locations, defining boundaries, and navigating policy and permitting processes across several levels of government. The various RFI responses covered several themes that include both challenges and opportunities identified, including:

- Defining Energy Justice and Equity
- Job Creation
- Affordability
- Rural Development

Defining Energy Justice and Equity

One of the fundamental challenges that exists has roots in the evolving (and sometimes confusing) terms that define the communities that would most benefit from the local placement of an energyshed. Oftentimes, the first step in this effort is to define terms clearly so that the coordination between Energy Justice and Equity initiatives is effective. The concepts and approaches to address Equity and EJ are related, but it is difficult to define any hierarchical relationship between the two. There may be significant overlap between the two concepts, and there may also be aspects of both that warrant distinct approaches toward evaluation.

Once terms are properly defined and understood, attention can then be focused on identifying potential EJ opportunities and challenges that should be considered in developing energysheds. A contributor said that it is of particular importance for DOE-EERE to define the concept and operational bounds of an energyshed along with developing tools for tracking the location of energy serving a particular load area for different stakeholders, as well as specific capabilities and information that would be most useful for that end. With well-defined boundaries, energysheds would enable us to generate more equitable energy environments. In other words, costs associated with production should be "felt" locally, rather than being outsourced in under-resourced regions.

This respondent also noted that defining energyshed boundaries will be a significant challenge and could potentially create large geospatial variations in sizes (analogous to gerrymandering). Since future developers of large energysheds might operate across state lines, there could potentially be multiple entities involved in the process of developing, siting, and zoning an energyshed, along with numerous entities from which approval to build the energyshed must be obtained. In addition, the permitting process that must be completed before obtaining approval to develop an energyshed to serve an underserved community can be difficult and complicated by many disparate governance entities and policy sectors.

Job Creation

As one industry participant pointed out, energyshed development starts with planning, and including underserved communities within a geological area when planning and designing an energyshed is an opportunity to create clean energy jobs in addition to bringing clean and affordable energy to these historically disadvantaged communities. Collaborations on developing energysheds with diverse businesses and institutions, this respondent said, will help to achieve entrepreneurship, innovation, and sustainable development outcomes in these communities.

Affordability

A national laboratory participant also commented about energysheds' potential affordability benefits for underserved communities, which include low-income rural and urban communities and communities of color. The lab representative cited U.S. Congressional data suggesting that about 50 million households, or 44% of the U.S. total, fall into the category of "low-income."[12] The contributor noted that there is an opportunity for energysheds to be built for communities that represent the approximately 31% of households that have difficulty paying energy bills or maintaining adequate heating or cooling due to a lack of energy affordability.[13] Opportunities for the placement of an energyshed can be determined once underserved communities within specific service territories are identified. A related challenge could be that underserved communities often reside in very remote locations, and options for extending the main grid to remote households can be prohibitively expensive.

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[12] "Low-Income Community Energy Solutions," Department of Energy. https://www.energy.gov/eere/slsc/low-income-community-energy-solutions

[13] Residential Energy Consumption Survey: One in three U.S. households faced challenges in paying energy bills in 2015," EIA. https://www.eia.gov/consumption/residential/reports/2015/energybills/

Rural Development

A university participant pointed out the relationship between rural and urban areas. Renewable energy systems such as solar PV, wind, and biofuels require large amounts of land, and are, therefore, generally located in rural areas. While this can provide employment opportunities in these communities, it also leads to problems such as noise pollution, competition with farmland, unsightly structures, etc.

A wind industry association respondent shared their experience that BIPOC and frontline communities "prefer local small-scale wind so as not to encroach on sensitive and protected lands." A university participant also stated that cities and industries require large amounts of power, so much of the energy generated in rural communities will be transmitted to cities and industrial regions. This contributor suggested that one of the key objectives of the energyshed framework is to provide a tool for better understanding and remunerating the economic contributions of rural regions in a renewable energy system.

Strategies for Addressing Energy Justice

RFI respondents provided DOE-EERE their perspective about approaches for ensuring that EJ challenges are addressed and that EJ opportunities are enhanced, particularly in the planning stage and in defining boundaries for specific energysheds.

Energy Equity Metrics

A national laboratory participant pointed out that without measuring equity over time, it will be difficult to develop, evaluate, and evolve an approach to achieving energy justice simply by developing an energyshed in a specific location. Because EJ constitutes several dimensions, several metrics must be used to track performance. To date, a cohesive, all-encompassing set of metrics for energy equity has not been developed.

Citizen Participation

One university participant suggested that energy consumers may also be producers and play active roles in energy management. Unlike current electric utility systems, management of a highly distributed power system will require large amounts of citizen participation. Citizens will serve as energy producers, with solar panels on roofs, wind turbines on farmland, and so forth. Citizen consumers also play an active role in the energy management strategies necessary for dealing with a highly variable energy source, in terms of energy price variation and energy curtailments. In some designs, different uses of energy (such as for heating or electric vehicle charging) might be assigned lower priority under energy curtailment than other uses (such as computers or lighting). A spin-off company of the University of Vermont, Packetized Energy, is developing new software and system control strategies for just this purpose. The energyshed framework provides an essential tool for helping both distributed suppliers and consumers understand the impact of their energy decisions on surrounding communities, whether positive or negative.

Market-Based Approaches

Beyond physical planning and development activities, one industry participant suggested that resources should be devoted to design, testing, and implementation of market-based approaches and rate design activities that offer discounts and/or bill savings to customers participating in energysheds. This should be a clear objective of energyshed planning that reflects the opportunity to align energy justice and equity needs for participating communities. Optimizing local production and consumption of energy minimizes the use of the transmission system (and potentially, other constrained parts of the distribution network). Accordingly, such consumption should be incentivized economically to reflect the impact to broader networks. This is an opportunity for DOE to coordinate with state regulators in the design of performance-based ratemaking activities for host utilities and network operators.

One respondent suggested that guidance could be taken from the European Union's implementation of the energy communities legislative mandate.[14] Each member country is promulgating its own set of regulations governing such design, which is similar in concept to energysheds in the virtual (if not physical) accounting of generation and load within communities.

Ensuring Energy Needs in Underserved Communities

DOE-EERE also asked RFI respondents to provide some ways to ensure the energy needs of underserved communities located within an energyshed are considered in a meaningful manner. Participants provided feedback on the following:

- Identifying Underserved Communities
- Reaching Underserved Communities
- Incorporating Open Stakeholder Input
- Collecting and Analyzing Data
- Forming Community Ownership Models

Identifying Underserved Communities

According to a national laboratory participant, perhaps the most important key to ensuring the energy needs of underserved communities are being considered in a meaningful manner is to first ensure the accurate identification of specific underserved communities. A particular community may find that multiple population groups within a specific service territory can be included within a classification of "underserved communities." For instance, some households may be over-burdened with energy costs, while other households may be fundamentally challenged in receiving information and opportunities for energy service, whether due to a language barrier, technology gap, or some other constraint. Yet both represent examples of underserved communities. Engagement of the public is especially critical for underserved communities to ensure their perspectives and voices are incorporated.

One effective tool for identifying underserved populations is to utilize a full scope of local stakeholders, which should include a range of representatives from nonprofit organizations, businesses, and city or county staff, as well as community leaders, to provide diverse ideas and perspectives. Upon gathering data from the appropriate stakeholders, understanding the gaps in services, policies, and programs, as well as the needs of local underserved populations, is an important first step.

Reaching Underserved Communities

A challenge that is often overlooked is that underserved populations may not use the same channels that other community engagement efforts use, such as digital advertising, social media, or the standard press (newspapers, etc.). While engaging stakeholders, it will be important to understand what communication channels will be most effective for engaging underserved communities in a specific location.

Additionally, throughout these engagements, there is a need to account for how investments in energysheds are being distributed between private sectors and community members. Investments should be accounted and managed such that redistribution away from the underserved communities is avoided.

Incorporating Open Stakeholder Input

One industry participant suggested that to ensure the needs of underserved communities are met, planning activities should initially occur through an open stakeholder process. During initial pilot design and testing phases, prior to any commercial implementation of more capital intensive, physical infrastructure build-out, preference should be given to qualifying low- to moderate-income customers for participation. Customer surveys and feedback will help

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[14] Aura Caramizaru and Andreas Uihlein, *Energy communities: an overview of energy and social innovation*, 2020. Publications Office of the European Union, Luxembourg. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119433/energy_communities_report_final.pdf

ensure that program design, economic incentives, and participation models are established to reflect the needs of these community members.

This respondent thinks that, as part of any energysheds infrastructure development, consideration should be given to targeted deployment and incentives for adoption of behind-the-meter resources for load flexibility at customer facilities. Alignment of consumption profiles with non-dispatchable generation such as solar PV will be critical to optimizing collective self-consumption models within the boundaries of an energyshed.

Collecting and Analyzing Data

An industry participant pointed out that once an energyshed is defined, data about the underserved communities, including physical locations and energy demand will need to be collected and analyzed. Simulation and modeling of the potential impact of the physical infrastructure and energy generation to these communities may be used to guide infrastructure siting and replacement. In addition, energy consumption data of these communities would help to modify and optimize an energyshed design that provides affordable clean energy to all within the energyshed.

Forming Community Ownership Models

A wind industry association representative noted that shared community ownership models for remotely sited renewables are a proven and effective solution to urban customers without property to have their own equipment. This participant suggested that remotely sited community wind can help address urban energy equity, but that community solar has not always served low-income customers, even though it has been successfully developed around the U.S. From the representative’s perspective, distributed wind could support disadvantaged communities by applying accessibility lessons learned from solar deployments, though soft cost barriers and solar-oriented policies have limited community applications for distributed wind generation. This contributor asked that DOE-EERE work with the Federal Energy Regulatory Commission to ensure community energy deployment programs provide equal access to distributed wind so project developers can choose the most suitable technology or combination for their location and requirements.

Closing

This report was developed by DOE-EERE in response to Congressional request related to Renewable Energy Grid Integration.[15] Per guidance from Congress, the Solar Energy, Wind Energy, Water Power, and Geothermal Technologies offices within DOE-EERE will work towards the development and demonstration of an "energyshed management system" that addresses a discrete geographic area in which 1) renewable sources currently provide a large portion of electric energy needs, 2) grid capacity constraints result in curtailment of renewable generation, and 3) smart meters have been substantially deployed. The "energysheds" design will aim to achieve a high level of integration resilience and reliability among all energy uses, including on-demand and long-time energy scales, of both transmission and distribution of electricity.

This report will inform DOE-EERE activities related to energysheds moving forward, including activities to address the congressional language noted above. The document represents the input that DOE-EERE received through a stakeholder input process that involved a virtual collaborative workshop as well as a published Request for Information. Both of these input opportunities were advertised publicly through the DOE blog and website. The workshop included 120 registrants, 106 attendees, and 93 participants. The RFI received responses from 21 organizations. DOE-EERE greatly appreciates these individuals for offering thoughtful contributions as well as the organizations that they represent for supporting their staff to dedicate the necessary time involved with providing input.

In preparation for the workshop and RFI, DOE-EERE held subject matter expert discussions with established energyshed thought leaders representing Baylor University, Oak Ridge National Laboratory, and the University of Vermont. The key takeaways from these discussions were that the term "energyshed" is still a nebulous concept with a limited body of research. The experts each shared clear definitions for "energyshed" and "energyshed management system," but those concepts varied between the individuals. Further, the experts did not have well-defined responses to scoping questions such as:

- What does "success" look like for an energyshed management system?
- How do you define the boundaries of an energyshed?
- Who owns an energyshed or energyshed management system?

The report drafting process aimed to accurately synthesize the most relevant and responsive comments that DOE-EERE received through the stakeholder input process. Not all contributions were referenced in the report due to an interest in staying within the intended scope, avoiding redundancy, and remaining committed to factual accuracy. Despite not including references to all comments, report authors did make an effort to convey the range of perspectives that were represented by contributors. This exercise was necessarily qualitative since participants were not asked to rank or prioritize their responses in either the workshop or RFI.

[15] House of Representatives; Congressional Record Vol. 166, No. 218, December 21, 2020. Congressional Record House Articles | Congress.gov | Library of Congress https://www.congress.gov/congressional-record/2020/12/21/house-section/article/h8311-1?q=%7B%22search%22%3A%5B%22kratom%22%5D%7D&s=7&r=1

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Appendix B. Workshop Agenda

From Watershed to Energyshed Determining the Implications of Place-Based Power Generation U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE) July 13 – 14, 2021		
Tuesday, July 13		
Time (EDT)	**Agenda Item**	**Speaker**
10:00 AM – 10:15 AM	*Log-In and Networking*	
10:15 AM – 10:20 AM	Welcome - DOE Leadership	Alejandro Moreno, Deputy Assistant Secretary of Renewable Power, EERE
10:20 AM – 10:30 AM	Workshop Introduction and Topic Interest	Kevin Lynn, Director of Grid Integration, EERE
10:30 AM – 11:00 AM	Watershed to Energyshed	Martin L. Adams, General Manager and Chief Engineer, Los Angeles Department of Water and Power
11:00 AM – 11:15 AM	Participant Discussion Instructions and Software Demonstration	Lauren Illing, Lead Facilitator, BCS, LLC.
11:15 AM – 11:30 AM	*Networking Opportunity (Optional)*	
11:30 AM – 12:15 PM	Participant Discussion: **Energyshed Concept and Definition**	Alexis McKittrick, Program Manager, EERE
12:15 PM – 1:15 PM	Participant Discussion: Tools and Analyses	Kevin Lynn
1:15 PM – 1:30 PM	Closing Remarks	Workshop Hosts
Wednesday, July 14		
Time (EDT)	**Agenda Item**	**Speaker**
10:00 AM – 10:15 AM	Log-In and Networking	
10:15 AM – 10:20 AM	Welcome and Day 1 Recap	Kevin Lynn, Director of Grid Integration, EERE
10:20 AM – 11:20 AM	Participant Discussion: **Planning and Operations**	Kevin Lynn
11:20 AM – 11:30 AM	*Networking Opportunity (Optional)*	
11:30 AM – 12:30 PM	Participant Discussion: **Resilience**	Kevin Lynn
12:30 PM – 1:00 PM	**Participant Discussion:** **Energy Justice, Diversity, Equity, and Inclusion**	Arlene Fetizanan, Senior Advisor, EERE
1:00 PM – 1:30 PM	Workshop Review	Workshop Hosts

Appendix C. RFI Respondents

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Appendix D. Resources Identified by Stakeholders

Many resources were suggested by the workshop participants. Below is a list, the link, and short description of the resources discussed in the workshop.

Concept and Definition

- Thomas & Erickson published paper, Rethinking the Geography of Energy Transitions: Low Carbon Energy Pathways through Energyshed Design, with a number of definitions summarized:

  https://www.sciencedirect.com/science/article/abs/pii/S2214629621000347

  Abstract: Energy systems are inherently spatial entities, encompassing infrastructure and land requirements; diverse perspectives of energy system stakeholders tied to locations of supply and demand; and, ultimately, a spatial distribution of profits, environmental impacts, and societal changes. The spatial relationships between these social and physical components of the energy system drive its ongoing evolution in response to technological advancements, economic trends, and policy directives. A low carbon energy system transition undertaken in response to climate change will require rapid and substantial changes to all of these elements and more. To capture these relationships and inform the design of a low carbon future, we propose the use of energyshed planning. An energyshed is the geographic area that contains the land, infrastructure, people, profits, and environmental impacts connected to final energy consumption. Four distinct decarbonization scenarios are explored: each pathway strikes a different balance between centralized or decentralized energy systems and corporatized or democratized energy system governance. Finally, the energyshed lens is used to perform an initial assessment of the barriers and opportunities for U.S. states to implement a near-term low carbon transition.

- Evarts published paper, Energyshed Framework: Defining and Designing the Fundamental Land Unit of Renewable Energy, defines the term and reviews the purpose and function:

  https://dalspace.library.dal.ca/bitstream/handle/10222/71377/Evarts-John-MES-SRES-April-2016.pdf

  Abstract: Renewable energy systems are fundamentally different than fossil-carbon energy systems, with each having a unique set of constraints, performance characteristics, and impacts. Transition to a new primary energy resource has significant restructuring implications for human systems and their impacts on environmental systems. It is not reasonable to assume that renewable energy systems should be structured in the existing pattern of fossil-carbon systems. The energyshed concept is proposed as an organizing framework for renewable energy and related supporting systems, with focus at the city level and based upon the unique characteristics of renewables. The fundamental land unit of renewable energy is proposed as a contiguous area of land that is power-balanced. This land unit is conveniently relatable to other land-based constructs such as watersheds, ecological units, or urban development patterns for identification and analysis of coupling and land-use conflict. The concept draws from a broad swath of physical and social science fields. The framework is developed through exploration of definition, values, principles of design, discussion of cartographic tools for model development and a discussion of expected structure and behaviors of an energyshed. The energyshed concept fills an important vacancy for a robust organizing framework for renewable energy systems and is applicable to scientists, engineers, planners, and developers related to the field. The recommendations in the last chapter serve appropriately as stand-alone policy tenets for a municipal energy plan or within the context of adoption of the energyshed framework en masse.

- UCLA's Energy Atlas database shows of how many meters/customers can be served with local assets with an overlapping and fluid boundary:

  https://energyatlas.ucla.edu/about

  About: The Energy Atlas is a database of building energy consumption that links utility account information to building characteristics, sociodemographic data, and other significant attributes that can be expressed spatially. The public portion of the Energy Atlas is a front-end website which displays spatially aggregated energy consumption statistics at an annual temporal resolution for most neighborhoods, cities, and counties in Southern California.

  The Energy Atlas is developed by the UCLA California Center for Sustainable Communities (CCSC) at UCLA, in the Institute of the Environment and Sustainability (IOES), and has received funding from the California Energy Commission, the Los Angeles Department of Water & Power (LADWP), the Southern California Regional Energy Network (SoCalREN). It benefits from the support and input of numerous partners, including the Los Angeles Regional Collaborative for Climate Action and Sustainability (LARC), The Energy Coalition (TEC), and the County of Los Angeles.

- The Science Direct journal article, 'Energy regions': The Transformative Power of Regional Discourses on Socio-technical Futures, relates to energy in a geographical region:

  https://www.sciencedirect.com/science/article/abs/pii/S0048733310000314?via%3Dihub

  Abstract: 'Guiding visions' play an important role in the transition management approach as a central means of mobilizing social actors and the co-ordination of dispersed agency. 'Energy regions' in Austria are an interesting example for the strategic promotion of such guiding visions in the context of regional development. We describe the case of Murau, an alpine district in which a strong actor network has been built around a vision of systematically exploiting renewable energy sources and at the same time saving the region from economic decay. The vision gained much authority and has been institutionalized at various levels of regional governance. It furthermore was supported by and played an important role for regime level attempts to influence socio-technical change. Development and social propagation of such visions are inherently political and contested processes involving much strategizing and anticipation of conflict. We describe particular discursive strategies applied in niches—such as the combination and translation of sentiments into localized visions and demonstrations of feasibility. These strategies can be understood as systematic attempts to support discursive shifts at regime level by means of local activities, and aim to modify rather durable power structures. We suggest ways to analyze such discursive practices in order to orient strategic action in the course of such processes: analyzing 'guiding visions' and their interference with other emerging trends; extending analyses across spatial scales (e.g. translations) and across thematic fields (e.g. convergence of agendas); and focusing on processes of stabilization, institutionalization and mutually reinforcing developments.

Tools, Data, and Analysis

- National Renewable Energy Laboratory's Interconnections Seams Study tracks and evaluates the benefits, and cost of power transmission across the country:

  https://www.nrel.gov/analysis/seams.html

  Abstract—The Interconnections Seam Study examines the potential economic value of increasing electricity transfer between the Eastern and Western Interconnections using high-voltage direct current (HVDC) transmission and cost-optimizing both generation and transmission resources across the United States. The study conducted a multi-model analysis that used co-optimized generation and transmission expansion *planning and production cost modeling. Four transmission designs under eight scenarios were developed and studied to estimate costs and potential benefits. The results show benefit-to-cost ratios that reach as high as 2.9, indicating significant value to increasing the transmission capacity between the interconnections under the cases considered, realized through sharing generation resources and flexibility across regions. Index Terms— HVDC transmission, Interregional transmission, Power generation dispatch, Power system economics, Power system reliability, Power system planning, Resource adequacy, Solar power generation, Wind power generation.*

- The U.S. Energy Information Administration's Hourly Grid Monitor offers real-time electricity demand across the U.S. grid:

  https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/US48/US48

  About: The EIA's Hourly Electric Grid Monitor provides up-to-the-hour information showing electricity demand across the U.S. electric grid. Large-scale events that affect normal routines, from expected occurrences such as major holidays to unexpected situations such as the COVID-19 pandemic, can change the pattern of electricity usage in the country.

  Hourly electricity data are a valuable resource for understanding all of the daily, weekly, seasonal, and regional usage patterns woven into overall U.S. electricity consumption. Divergences from these typical patterns can indicate the impact of current events; however, isolating these impacts from other factors such as weather can be challenging.

  EIA's Form EIA-930 data collection provides a centralized and comprehensive source for hourly operating data about the high-voltage bulk electric power grid in the Lower 48 states. The data is collected from the electricity BAs that operate the grid.

  The information submitted by reporting entities is preliminary data and is made available "as-is" by EIA. Neither EIA nor reporting entities are responsible for reliance on the data for any specific use.

- Lawrence Berkeley National Laboratory's City Building Energy Saver (CityBES) models and analyzes electricity, heat and cooling demand and potential for onsite PV generation to support district or city-scale efficiency programs:

  https://citybes.lbl.gov/

  About: Buildings in cities consume 30 to 70% of the cities' total primary energy. Retrofitting the existing building stock to improve energy efficiency and reduce energy use is a key strategy for cities to reduce green-house-gas emissions and mitigate climate change. Planning and evaluating retrofit strategies for buildings requires a deep understanding of the physical characteristics, operating patterns, and energy use of the building stock. This is a challenge for city managers as data and tools are limited and disparate.

  City Building Energy Saver (CityBES) is a web-based data and computing platform, focusing on energy modeling and analysis of a city's building stock to support district or city-scale efficiency programs. CityBES uses an international open data standard, CityGML, to represent and exchange 3D city models. CityBES employs EnergyPlus to simulate building energy use and savings from energy efficient retrofits. CityBES provides a suite of features for urban planners, city energy managers, building owners, utilities, energy consultants and researchers.

- The Initiative for Energy Justice's Justice in 100 Scorecard can evaluate laws to create a clean energy environment:

  https://iejusa.org/justice-in-100-scorecard/

  About: Policy makers in urban areas around the United States seek to increase the penetration of renewables on the electricity grid, but they often lack clear policy guidance on how to design and implement energy policy that places equity at the center of policy design, rather than as an ancillary concern considered after the fact. Similarly, traditional frontline social justice and civil rights organizations have found themselves at the center of debates concerning renewable energy policy, but often lack the technical assistance and tools to participate fully in the emerging debates concerning the energy transition.

  The Initiative for Energy Justice aims to: contribute to a bottom-up movement of energy justice, originating in frontline communities, by arming movement and base-building organizations in environmental, racial, and economic justice spaces with well-supported policy research and workable transactional models for operationalizing a just transition to renewable energy; and provide city and state policymakers with concrete energy policy frameworks and best-practice tools that foreground equity in the transition to renewable energy, drawing on the best-available data collected from frontline advocates, existing energy policies, and frameworks designed by our team.

- NREL's Regional Energy Deployment System Model simulates the evolution of the bulk power system from present day through 2050+ :

  https://www.nrel.gov/analysis/reeds/

  About: NREL designed the Regional Energy Deployment System (ReEDS) to simulate electricity sector investment decisions based on system constraints and demands for energy and ancillary services.

  The ReEDS model is unique in its high-spatial resolution and advanced algorithms for representing the cost, value, and technical characteristics of integrating renewable energy technologies. Although it covers a broad geographic and technological scope, ReEDS is designed to reflect the regional attributes of energy production and consumption. The model considers a large suite of generating technologies, including fossil, nuclear, and renewable technologies, as well as transmission and storage expansion options.

- NREL's System Advisor Model simulates energy and cost profiles using different technologies:

  https://sam.nrel.gov/

  About: The System Advisor Model (SAM) is a free techno-economic software model that facilitates decision-making for people in the renewable energy industry: Project managers and engineers, Policy analysts, Technology developers, and Researchers.

  To model a renewable energy project in SAM, you choose a performance model and a financial model to represent the project, and assign values to input variables to provide information about the project's location, type of equipment in the system, cost of installing and operating the system, and financial and incentives assumptions. Once you are satisfied with the input variable values, you run simulations, and then examine results. A typical analysis involves running simulations, examining results, revising inputs, and repeating that process until you understand and have confidence in the results.

- NREL's renewable energy potential (reV) model uses SAM to simulate a techno-economic potential of various technologies and incorporates land use exclusions and connection to transmission infrastructure:

  https://www.nrel.gov/gis/renewable-energy-potential.html

  Abstract: NREL developed the reV model to help utility planners, regional and national agencies, project and land developers, and researchers assess renewable energy resource potential. Available as open source since February 2020, the reV model currently supports photovoltaic, concentrating solar power, and wind turbine technologies. The tool can model a single site up to an entire continent at temporal resolutions ranging from five minutes to hourly, spanning a single year or multiple decades.

  By automating access to resource data at unprecedented scale, fidelity, and flexibility, the reV model integrates formerly disparate analysis frameworks in the fields of resource modeling, technical potential, and renewable energy cost supply curves.

  The reV model currently provides broad coverage across North America, South and Central Asia, the Middle East, South America, and South Africa to inform national- and international-scale analyses as well as regional infrastructure and deployment planning.

- The Proceedings of the National Academy of Sciences of the United States of America journal article, A Diagnostic Approach for Going Beyond Panaceas, which explains a framework that could help social-ecological approaches to energyshed:

  https://www.pnas.org/content/104/39/15181.short

  Abstract: The articles in this special feature challenge the presumption that scholars can make simple, predictive models of social–ecological systems (SESs) and deduce universal solutions, panaceas, to problems of overuse or destruction of resources. Moving beyond panaceas to develop cumulative capacities to diagnose the problems and potentialities of linked SESs requires serious study of complex, multivariable, nonlinear, cross-scale, and changing systems. Many variables have been identified by researchers as affecting the patterns of interactions and outcomes observed in empirical studies of SESs. A step toward developing a diagnostic method is taken by organizing these variables in a nested, multitier framework. The framework enables scholars to organize analyses of how attributes of (i) a resource system (e.g., fishery, lake, grazing area), (ii) the resource units generated by that system (e.g., fish, water, fodder), (iii) the users of that system, and (iv) the governance system jointly affect and are indirectly affected by interactions and resulting outcomes achieved at a particular time and place. The framework also enables us to organize how these attributes may affect and be affected by larger socioeconomic, political, and ecological settings in which they are embedded, as well as smaller ones. The framework is intended to be a step toward building a strong interdisciplinary science of complex, multilevel systems that will enable future diagnosticians to match governance arrangements to specific problems embedded in a social–ecological context.

- The Science Direct journal article, Socio-economic Conditions for Satisfying Human Needs at Low Energy Use: An International Analysis of Social Provisioning, sheds light on energy's focus that is not only on the supply but on end use, beginning with needs and sufficiency, and could be used as an example of energyshed's potential tracking and focus areas:

  https://www.sciencedirect.com/science/article/pii/S0959378021000662?via%3Dihub

  Abstract: Using a novel analytical framework alongside a novel multivariate regression-based moderation approach and data for 106 countries, we analyze how the relationship between energy use and six dimensions of human need satisfaction varies with a wide range of socio-economic factors relevant to the provisioning of goods and services ('provisioning factors'). We find that factors such as public service quality, income equality, democracy, and electricity access are associated with higher need satisfaction and lower energy *requirements ('beneficial provisioning factors'). Conversely, extractivism and economic growth beyond moderate levels of affluence are associated with lower need satisfaction and greater energy requirements ('detrimental provisioning factors'). Our results suggest that improving beneficial provisioning factors and abandoning detrimental ones could enable countries to provide sufficient need satisfaction at much lower, ecologically sustainable levels of energy use.*

Planning and Operations

- Knoxville City Energy & Sustainability Task Force Working Groups serve as an example for an energy inventory framework:

  Task Force Work Groups - City of Knoxville (knoxvilletn.gov)

  About: Knoxville's work plan for the Energy & Sustainability Initiative is well-charted by local governments across the country and world, many of which are members of the organization ICLEI—Local Governments for Sustainability (formerly the International Council for Local Environmental Initiatives). The City joined the ICLEI network in July 2007 in order to take advantage of the resources offered to members, including access to case studies, software and methodologies developed to assist governments working towards greater sustainability at the local level. Using ICLEI's Clean Air and Climate Protection Software, the City has inventoried baseline energy consumption, expenditures, emissions and other sustainability indicators like water consumption and waste generation associated with both city government operations and the Knoxville community as a whole. This report summarizes the inventory findings, establishes greenhouse gas reduction targets, and presents an outline of existing and proposed policies and programs intended to strengthen Knoxville's urban environment and improve economic opportunity while we do our part to address the most pressing environmental challenge of our time.

- The Grid Modernization Laboratory Consortium's Grid Architecture uses a "total distribution system operators" approach:

  https://gmlc.doe.gov/projects/1.2.1

  About: The Grid Architecture project provided a set of architectural depictions, tools, and skills to the utility industry and its extended stakeholders with a goal of creating a national consensus on grid modernization. This project also provided a common basis for roadmaps, investments, technology and platform developments, and new capabilities, products and services for the modernized grid.

- The People Solar Energy Fund (under Cooperative Energy Futures) provides technical and economic assistance for communities that want to own their own solar production:

  https://www.cooperativeenergyfutures.com/

  About: By working with underserved and low-income communities - as well as the general public—Cooperative Energy Futures (CEF) creates real community wealth by reducing energy use and producing our own clean, renewable energy. CEF reframes the debate by demonstrating how communities are central to building and implementing solutions.

Resilience

- NREL's Basalt Vista project is a pilot program—which equipped homes can exchange energy and services with neighbors, matching generation and demand intelligently and on the fly while respecting the reliability limitations of the local grid—can be an example of the resilience efforts areas with limited grid capacity:

  The Future Is Autonomous: NREL's Autonomous Energy Grids Research Featured in IEEE Spectrum | News | NREL

  About: The 27 smart homes in Basalt Vista, located about 290 kilometers west of Denver, are part of a pilot for an altogether new approach to the power grid. The entire neighborhood is interconnected through a microgrid that in turn connects to the main grid. Within each home, every smart appliance and energy resource—such as a storage battery, water heater, or solar photovoltaic (PV) system—is controlled to maximize energy efficiency.

  On a larger scale, houses within the neighborhood can rapidly share power, creating reliable electricity for everyone—solar energy generated at one house can be used to charge the electric car next door. If a wildfire were to knock out power lines in the area, residents would still have electricity generated and stored within the neighborhood. From the spring through the fall, the PV systems can provide enough electricity and recharge the batteries for days at a time. In the dead of winter, with the heat running and snow on the solar panels, the backup power will last for about 2 hours.

- Two models, NREL's Interstate Renewable Energy Council (IREC) Model Interconnection Procedures and New York State Standardized Interconnection Requirements are recommended to accelerate energyshed development:

  https://www.nrel.gov/grid/ieee-standard-1547/model-interconnection-procedures.html

  About: IREC Model helps accelerate modernization of the U.S. electric power infrastructure by enabling the use of modern distributed energy resources technologies, such as grid-supportive inverters. The new standard is significantly different from the prior version, featuring new concepts and new technical requirements. The new requirements enable the use of modern distributed energy resources toward improving performance of the electric grid during day-to-day operations and improving grid resilience during abnormal grid conditions.

  And

  https://www.nyseg.com/wps/wcm/connect/e27a7e79-5acc-4357-bbab-e6050da06646/ADDE+SIR+13+NYSEGE+PSC+119+March+2016+FINAL.pdf?MOD=AJPERES&CACHEID=ROOTWORKSPACE-e27a7e79-5acc-4357-bbab-e6050da06646-ml3vKBa

  About: The New York State Standardized Interconnection Requirements is guidance for those who want apply to interconnect new distributed generation up to 5MW New York.

Opportunities and Barriers

- Community Choice Energy and Community Choice Aggregators are consumer-owned utility services that could be used as examples for the creation of energyshed associations:

  Community Choice Aggregation | US EPA

  About: CCAs, also known as municipal aggregation, are programs that allow local governments to procure power on behalf of their residents, businesses, and municipal accounts from an alternative supplier while still receiving transmission and distribution service from their existing utility provider. CCAs are an attractive option for communities that want more local control over their electricity sources, more green power than is offered by the default utility, and/or lower electricity prices. By aggregating demand, communities gain leverage to negotiate better rates with competitive suppliers and choose greener power sources.

- The European Union's implementation of the energy communities legislative mandate was cited as an example of how energyshed planning can be both individualized and part of a greater whole. Each member country is promulgating its own set of regulations governing such design, which is similar in concept to energysheds in the virtual (if not physical) accounting of generation and load within communities:

  https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119433/energy_communities_report_final.pdf

  Abstract: Community energy refers to a wide range of collective energy actions that involve citizens' participation in the energy system. Community energy projects are characterized by varying degrees of community involvement in decision-making and benefits sharing (Walker and Devine-Wright, 2008). They may describe a community limited by a geographical location or a community of interest (Walker and Devine-Wright, 2008).

  The Clean Energy Package recognizes certain categories of community energy initiatives as 'energy communities' in European legislation. Energy communities can be understood as a way to 'organize' collective energy actions around open, democratic participation and governance and the provision of benefits for the members or the local community (Roberts et al., 2019). There are two formal definitions of energy communities: 'citizen energy communities' which is included in the revised Internal Electricity Market Directive (EU) 2019/944 (European Parliament & Council of the European Union, 2019), and 'renewable energy communities' which is included in the revised Renewable Energy Directive (EU) 2018/2001 (European Parliament & Council of the European Union, 2018).

  These two EU legislative documents provide for the first time an enabling EU legal framework for collective citizen participation in the energy system. They describe energy communities as new types of non-commercial entities that, although they engage in an economic activity, their primary purpose is to provide environmental, economic or social community benefits rather than prioritize profit making (REScoop.EU, 2019).

Operations

- EERE Building Technologies Office's Grid-Interactive Efficient Building Initiative utilizes system architecture to prioritize communities:

  https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings

  About: The Grid-interactive Efficient Building (GEB) Initiative works to remake buildings into a clean and flexible energy resources by combining energy efficiency and demand flexibility with smart technologies and communications to inexpensively deliver greater affordability, comfort, productivity, and performance to America's homes and buildings.

  The GEB Initiative leads the fundamental research, development, demonstration and deployment of GEBs. The GEB Initiative also convenes and provides a variety of building sector stakeholders—including other federal agencies, state and local governments, utilities, builders, building component manufacturers, scientists, engineers, and more—with the technical support they need to advance GEB capabilities across the country in the residential and commercial buildings of today and tomorrow.

Diversity, Equity, and Inclusion

Concepts

- Communities can deliver equivalent energy to local homes and businesses, versus having electricity transmitted over long-distances:

  https://www.nytimes.com/2021/07/11/business/energy-environment/biden-climate-transmission-lines.html

  Blurb: The nation is facing once in a generation choice about how energy ought to be delivered to homes, businesses and electric cars—decisions that could shape the course of climate change and determine how the United States copes with wildfires, heat waves and other extreme weather linked to global warming.

  On one side, large electric utilities and others want to build thousands of miles of power lines to move electricity created by distant wind turbines and solar farms to cities and suburbs. On the other, some environmental organizations and community groups are pushing for greater investment in rooftop solar panels, batteries and local wind turbines.

Tools, Data, and Analyses

- NAACPs' "Our Communities, Our Power" Action Toolkit can hold communities and organizations accountable in terms of diversity and inclusion, community driven processes

  https://www.adaptationclearinghouse.org/resources/naacp-our-communities-our-power-advancing-resistance-and-resilience-in-climate-change-adaptation-action-toolkit.html

  About: This comprehensive Toolkit provides a series of modules to help NAACP chapters and other advocates mediate climate adaptation planning processes and ensure that adaptation plans and policies meet local needs, while focusing on frontline communities, environmental and climate justice, and equity. The Toolkit provides guidance to help community groups and advocates develop an Environmental and Climate Justice (ECJ) Committee to inform adaptation planning and policy through 19 different Modules. The introduction defines equity, climate resilience and adaptation, environmental and climate justice, and frontline communities. It also provides a summary of how climate change will disproportionately affect frontline communities.

  Initial modules address the procedural aspects of forming an ECJ committee; advancing equity in planning processes; and advocating, communicating and educating at the state and local levels. Subsequent modules focus on opportunities to advance equitable resilience solutions across various sectors (housing, transportation, water, waste management etc.). Each module includes core principles for enhancing equity and resilience in that topic area; useful checklists for taking actions; short case study examples of cities and states that have adopted equitable approaches; links to other resources, data and tools to help community groups get started and advance their work; and fact sheets with examples from.

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