FINDINGS REPORT:

Ownership Models and Data Strategy for Microgrids

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Think Microgrid

Oak Ridge National Laboratory

www.thinkmicrogrid.org

For contact: cameron@thinkmicrogrid.org

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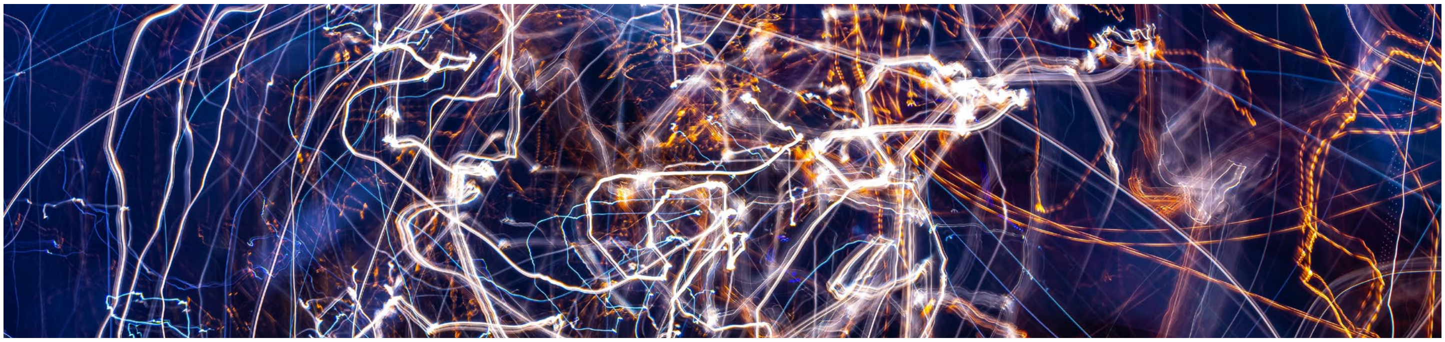

EXECUTIVE SUMMARY

In early 2023, Think Microgrid and Oak Ridge National Labs launched a collaborative initiative that complements ongoing research on microgrid deployment, operations, and communication. The primary objective of this initiative is to engage the broader microgrid industry to better understand the real-world opportunities, challenges, and impediments related to the digital landscape surrounding microgrids and, by extension, the rapidly expanding domain of distributed energy resources that are currently transforming many aspects of the utility industry today.

> **A core objective of this initiative is to identify the most pressing operational data challenges faced by various microgrid configurations**

The U.S. Department of Energy envisions microgrids as a key building block of an emerging grid architecture, providing mechanisms to aggregate diverse distributed energy resources (DER) and increase the flexibility of customer demand to align the operating conditions of the larger grid. A core objective of this initiative is to identify the most pressing operational data challenges faced by various microgrid configurations, especially those that require data exchange with other actors in the electricity ecosystem. Microgrid deployments often involve interactions and data exchange across ownership and control boundaries. Coordination of sensitive information between microgrids and customers, distribution utilities, system operators, and third parties requires a sophisticated approach to data and digital infrastructure.

The initiative included a phased approach including:

1. INFORMATIONAL INTERVIEWS
with industry participants and microgrid operators were used to develop a data ecosystem framework

2. FACILITATED DISCUSSIONS
to validate the characterization of the digital interfaces identified and microgrid taxonomy, including an in-person workshop hosted by Oak Ridge in November 2023

3. FINDINGS REPORT
and supplemental materials that identify opportunities for future research and technical support

A key finding from this initiative is that data-sharing activities are currently quite limited, especially when compared with the level of robust, secure, and ongoing data exchange that will characterize the high-DER grid of the near future. Accordingly, participants highlighted the value of continued collaboration and revisions to the conceptual tools, such as the data ecosystem framework, developed through these discussions.

The facilitated discussions revealed a broad consensus that the digital systems that facilitate information exchange will play as vital a role in our electricity system as the physical infrastructure. This report is intended to facilitate discussions among the diverse group of policymakers, system operators, technology providers, industry stakeholders, and, most importantly, energy customers that will define this energy future.

PROJECT OVERVIEW

Think Microgrid, an industry coalition focused on advancing awareness about microgrids in key policy discussions, was engaged to collaborate with the COMMANDER project at Oak Ridge National Labs to complement ongoing research on microgrid deployment, operations, and communication. Think Microgrid represents a unified voice of the microgrid industry and is dedicated to advancing thought leadership and commercialization of microgrids. The coalition leveraged this role, leading outreach to industry leaders and hosting discussions with the goal of better understanding the data ecosystem surrounding microgrid integration.

Microgrids are the key building block of an emerging grid architecture, providing intelligent aggregation of diverse distributed energy resources (DER) and customer activities, and flexibly coordinating their operations to align the operating conditions of the larger grid. However, microgrids are also extremely diverse in their configurations, applications, and participant actors. A core objective of the outreach and research led by Think Microgrid in this initiative was to better understand the operational requirements and challenges of various microgrid configurations, especially those that require data exchange with other actors. The identification of those data 'pain points' has allowed Think Microgrid to develop specific policy principles and future research priorities supporting streamlined microgrid integration.

Microgrid deployments often involve interactions and data exchange across ownership and control boundaries. Coordination of sensitive information between microgrids and customers, distribution utilities, system operators, and third parties requires a sophisticated approach to data and digital infrastructure. Inevitably, successful microgrid integration will benefit from clearly characterizing a "digital interconnection" that enables the safe, secure flow of information. Modern digital infrastructure will be adaptive across various time horizons and between diverse actors with ranging needs and objectives, some of which may conflict with one another.

This initiative was designed to provide insight into the actors, data types, and time horizons involved with these data exchange activities, articulate a common framework that can support productive conversations with diverse stakeholders, and identify opportunities to address barriers that may impede market development.

In many respects, policy environments developed at the federal, state, and local levels will define the characteristics of the digital infrastructure and determine the degree to which this infrastructure can support data "liquidity" between various actors that is reliable, trustworthy, and adequately transparent. Governing entities remain in the early stages of moving towards such determinations. This research effort intends to offer foundational insights and guiding principles around which decision-makers can design rules and processes.

This initiative was designed with a phased approach including:

1. INFORMATIONAL INTERVIEWS
with industry participants and microgrid operators

2. FACILITATED DISCUSSIONS
that serve to validate the resulting data ecosystem framework, configuration taxonomy and characterization of identified digital interfaces

3. FINDINGS REPORT
that identifies opportunities for future research and technical support

This vision is informed by industry experts with both a direct understanding of current operational challenges and a pragmatic vision of future opportunities for the microgrid industry. These perspectives provide a breadth of stakeholders with varying relationships to microgrid projects including microgrid operators, distribution utilities, state and federal regulators, transmission operators, distributed energy developers, and demand flexibility aggregators. These stakeholders exist within, outside, and in interaction with the distribution system and utility companies that operate it. Their diverse observations and perspectives fundamentally informed the consolidated findings presented in this report.

This initiative represents a unique partnership that combines the research and technical expertise of Oak Ridge National Lab and the direct industry experience of the Think Microgrid coalition and its members. Think Microgrid was founded in 2021 in order to foster a better understanding of the role that microgrids can play in achieving resilience, equity and clean energy policy goals that is based on the real-world experience of the microgrid industry. Think Microgrid has built trusted relationships with policy makers, project developers, microgrid customers and technical experts. Building from this foundation, Think Microgrid led the outreach to industry leaders so that they could share their experience with the Oak Ridge team.

Think Microgrid also developed conceptual frameworks, referenced in this report, that were intended to foster collaborative discussions and elicit feedback from participants. We hope that these conversations will continue to evolve these conceptual models and support the broad objectives of this initiative, which include developing a rich understanding of the ways in which data governance and data policy will shape our common energy future.

INFORMATIONAL INTERVIEWS

Beginning in mid-2023, Think Microgrid led a series of over 40 informational interviews with representative leaders from the microgrid industry, including microgrid owners and operators, distribution utilities, regulators, transmission system operators, and members of the policy community whose background spanned national associations, national labs, and academia. In this initial phase, informational interviews were organized to better understand:

1. The experience of microgrid operators and other parties related to access to and exchange of critical data.
2. The primary interfaces and current characteristics that define the data landscape.
3. The characteristics and challenges related to data exchange.

The result of this initial research was the development of a preliminary taxonomy of microgrid configurations and identification of landscape actors, data types, and a model characterizing representative data use cases associated with microgrids deployed in the field today. This taxonomy and the resulting diagrams served as engagement tools to identify 'pain points' that stakeholders are experiencing in the data exchange landscape. The discussions were an opportunity to iteratively develop and solicit feedback on these tools, build an internal understanding of the most pressing challenges being experienced by stakeholders, and identify research priorities to address more deeply in the workshop and later inform ongoing research at Oak Ridge National Labs (ORNL) and program activity led by Department of Energy.

Stakeholder interviews had several goals. The first was to hear first-hand experiences from individuals managing data exchange challenges related to microgrid integration. This process involved requesting information about one or several specific projects that interviewees were managing and involved with, including project details and descriptions of data interactions with other landscape actors. A second was to iteratively solicit feedback and ideas related to the several frameworks Think Microgrid developed throughout the project, including the categorization of existing and new data interfaces, data types, and interactions. Another core goal of these interviews was to begin developing a network of trusted advisors with direct experience developing, operating, and coordinating microgrids in the United States. Building this foundation of advisors – through direct interviews, virtual meetings, interactive convenings, and written comments – has served to provide ongoing validation of the findings and categorization systems developed through this initiative.

Advisors and industry experts were asked to share their experiences from projects in the field to help characterize the data flows associated with common and anticipated microgrid deployments. Interview questions covered a wide range of topics, including:

WHAT are the configurations and operating characteristics of the microgrid systems that you have direct experience with?

WHAT are the primary applications, functional capabilities and received values to you or others?

WHAT is the capacity and energy resources used in the microgrid?

WHAT are the most important interconnections with the distribution system, transmission system and other customer systems?

DOES the microgrid interact with any other data-related, control or coordination systems? (E.g., distribution management, federated microgrids, building management)

WHAT are the ownership boundaries for the microgrid?

WHO is responsible for microgrid operations?

WHAT existing communications systems are being utilized?

ARE THERE identifiable or standards-based communication protocols used within the microgrid and to interact with other assets?

WHAT microgrid information are you willing to share or not share in terms of assets/data?

WHO controls this data and how does this affect access to critical information?

HOW sensitive do you consider this information to be?

PARTICIPANT SURVEY

The Think Microgrid team developed a semi-standard survey utilized as a follow-up to each interview. The goals of the surveys were to formally capture details and characteristics about specific microgrid projects; to apply Think Microgrid's data type framework to specific projects; to further engage interviewees on the principal microgrid data challenges they are facing or sensitive data types they are managing; and offer an opportunity for interviewees to comment on Think Microgrid's data type framework or reflect on the research effort generally. The results of the interviews allowed Think Microgrid to gain a deeper understanding of stakeholders' innovative project use cases. It also allowed the team to build categorical and comparative visibility into what types of data access were of most pressing concern to interviewees, as well as capture interviewees' opinions about principal barriers involved in enabling that access.

DATA ECOSYSTEM FRAMEWORK

Think Microgrid used data collected from interviews and survey responses to develop a microgrid data ecosystem framework. The purpose of this framework was to provide a common language for stakeholders to articulate and examine data flows. Think Microgrid structured these data flows based on the actors, data types, and time horizons they involved. These tools were intended to be applied to specific projects at the workshop, prompting discussions about challenges and pain points. The intention was that this framework could serve as a tool for dialogue around 'pain points' being experienced by stakeholders as they participate in specific data flow use cases. Think Microgrid visualizes the data ecosystem framework through a diagram, as well as separate diagrams for the variables of actors, data types, and time horizons. These tools were intended to be applied to specific projects at the workshop, opening discussions about challenges and pain points. The team's presentation of the framework at the workshop was also framed to leverage the group's collective expertise to challenge and/or validate its broad application.

The full pre-workshop supplemental report is available as a supplement to this report, including working visualizations for the data ecosystem framework and the actors, data types, and time horizons that characterize it.

NATIONAL WORKSHOP

In November 2023, Think Microgrid and ORNL co-hosted a workshop titled "Ownership Models and Data Strategy for Microgrids" in Knoxville, Tennessee. The objective of the workshop was to share findings and a draft version of a data ecosystem map that was developed following and informed by the informational interviews and participant surveys. The workshop was designed to open discussions about microgrid integration and its data challenges, engaging experts from government, industry, thought leadership, and academia with direct experience. In addition to opening statements and presentations from Think Microgrid, ORNL, and local experts, attendees provided valuable feedback regarding Think Microgrid's preliminary data ecosystem framework and its components. Breakout group discussions addressed organizational and technical microgrid data challenges and the workshop concluded by collectively identifying microgrid data policy principles and future research needs.

At the outset, Think Microgrid and ORNL personnel emphasized goals for each participant speaking honestly, for themselves, and for their organizations, and not to shy away from disagreements or debate. In this context, the workshop encouraged participants to react to and challenge models presented by Think Microgrid, ground theoretical representations in real-world examples, and distill the landscape's uncertainties and challenges into actionable priorities. The workshop was framed as an opportunity to translate 'pain points' being experienced by a variety of stakeholders into policy principles and future research priorities to be leveraged and considered by DOE and other stakeholders.

MICROGRIDS, DATA AND THE FUTURE GRID

The electric grid in the United States is experiencing a fundamental transformation. Technology innovations are driving the grid toward a future that features ubiquitous, integrated distributed energy resources (DER), electric vehicles (EVs), and microgrids. The DOE Microgrid Program envisions a future electricity delivery system in which microgrids are "essential building blocks" and DER provides 30-50% of electric capacity as early as 2035.

This vision can only be realized if the digital infrastructure is as robust and comprehensive as the physical infrastructure it supports. Building this digital infrastructure will involve tremendous investments in systems and technologies that support the transformation of a one-way, centralized system of controls to a multilateral, self-organizing network that can be optimized for clean energy and resilient power.

This envisioned future requires more than just physical systems and controls. It also involves the development of policy frameworks and data systems that support a broad range of optimization objectives, respect the independent needs of each autonomous actor, and ensure appropriate levels of transparency across this new energy landscape. Understanding the landscape will guide investments overseen and made by federal and state governments, utility regulators, grid operators, consumers, and private industry.

To an extent, the energy infrastructure in the United States was predominantly developed under a system of regulated monopolies. As a result, data flows and data governance policies have largely evolved in an environment where data is exchanged within organizations, rather than between organizations. This legacy presents several challenges that are coming to light in the context of microgrids and DERs, including:

1. Transitioning physical systems where the fundamental architecture did not consider flexible demand interactions and two-way flows of energy,
2. Upgrading data platforms and software systems for modern capabilities and exchanges between organizations, and
3. Supporting a broader range of commercial interactions between customers, grid operators, regulated markets and independent service providers.

In this context, DOE and the national laboratory system have an abiding interest in developing a comprehensive data vision that can guide their independent activities and support the maturation of the electric industry such that data governance is considered to be a fundamental component of the modern, distributed, resilient grid.

KEY FINDINGS

There is a fundamental observation that motivates many of these activities and frames the findings generated throughout months of direct research, interviews, surveys, and a national workshop. The recent and anticipated rise of DER involves a dramatically increased need to coordinate these grid-edge resources. In the DER future, microgrids are envisioned to serve as a fundamental building block. Information exchanges will take place not just amongst technological systems, but across ownership boundaries as well. It may be tempting to consider the great challenge of the DER future to be a control problem or an economic problem, but there is an underlying digital optimization problem that requires flow across ownership boundaries in a consistent, reliable, and secure manner.

Information flows must be far more fluid and frictionless in a world with very high penetration of DER and microgrids. This requires sophisticated technological infrastructure, well-designed policy, and inter-organizational trust and engagement that does not exist at scale today. While the topics surrounding data and digital infrastructure are nuanced, the findings presented below provide insight into pragmatic actions that policymakers and industry leaders can take today that align with the envisioned DER future.

The findings of this process complement the technical research being led through the COMMANDER project and other ORNL activities. The COMMANDER project has tested the capabilities of various physical and digital infrastructure systems to enable new applications of microgrid communications and controls, including next-generation models like networked microgrids. As technology continues to evolve, the lab's pioneering findings suggest a heightened need for a comprehensive view of the data dynamics that cause friction in microgrid integration today.

The following findings were developed throughout the project, integrating a literature review of existing data access thought leadership, expert interviews, survey responses, and feedback generated in the November 2023 workshop.

In the DER future, microgrids are envisioned to serve as a fundamental building block. In this context, information exchanges will take place not just amongst technological systems, but across ownership boundaries as well

SCALE DEMANDS DIGITAL INFRASTRUCTURE

There is broad consensus among the participants in this initiative that the proliferation of DERs (including microgrids) and the demands for more flexible, decarbonized energy are increasing the need for digital infrastructure and data policies. Digital infrastructure in this context includes the digital systems used by grid actors to communicate with each other, participate in markets, and ensure grid and customer security. Unlike physical infrastructure, which is mostly owned and operated by dedicated entities (e.g., distribution utilities), digital infrastructure includes a diverse set of resource and data owners, proprietary systems, and market interfaces. Highly coordinated digital infrastructure will be essential for electricity markets seeking to balance supply and demand in a diverse resource mix.

Expert stakeholders expressed concerns that policymakers were not dedicating sufficient attention to the importance of coordinated digital infrastructure

In interviews, survey responses, and workshop discussions, expert stakeholders expressed concerns that policymakers were not dedicating sufficient attention to the importance of coordinated digital infrastructure. To move towards this future, stakeholders addressed priorities around 1) better characterizing the tools and technologies that comprise digital infrastructure, 2) identifying or imagining what characteristics of data standards or policies would effectively streamline coordination, and 3) identifying activities that have been proactive in highlighting the need for digital infrastructure.

Stakeholders highlighted examples of each of these priorities throughout the research process. Workshop participants in the 'data needs' breakout discussed one area where microgrid integration technology interfaces with emergent protocols, which is the evolution of modern microgrid controllers. Traditional Modbus technologies, which may rely on cellular or fiber networks, may experience growing pains as they adapt to digitalized communication use cases like automated demand response dispatch signals. New York's Integrated Energy Data Resource (IEDR) platform represents one example of a proactive policy to promote coordinated digital infrastructure at the state level, which more than one interviewee brought up as an effort to watch.

LIMITED INCENTIVES EXIST TO SHARE INFORMATION

At the workshop, one participant representing a microgrid operator admitted that only about one in ten of their company's projects interface with the utility. Survey respondents similarly chose to highlight their company's most complex project or a developing project that will require more external coordination or be considered representative of the future digitalized grid. In reality, most of the respondents' operational projects are simpler and more insulated from data exchange needs. These anecdotes reflect a reality across the landscape: compared to expectations, few of data exchanges are taking place in today's microgrid integration landscape. Stakeholders engaged throughout the research process voiced the reality that, given the option, they would rather not exchange data with external entities.

While workshop participants representing microgrid developers, utilities, and third parties generally agreed on a need for data sharing, it was also clear that few incentives exist to promote it. Sharing data may require financial investment in physical or digital infrastructure, the imposition of new privacy or security protocols, and organizational considerations around the value of keeping certain data types proprietary. Organizations may be disincentivized to engage with other organizations due to the opportunity cost of deploying workforce labor to prepare outdated internal systems for external distribution, or conversely the cost of synthesizing extensive and disorganized datasets.

Some workshop participants reasoned that altruism or pursuit of a digitalized policy vision will not alone incentivize microgrid operators to invest in more integrated projects or the systems and reforms that come with them. By contrast, maintaining proprietary data can be strategic for organizations. In this environment, the growing microgrid market has skewed heavily towards less sophisticated configurations and business models. A 'zero-sum' dynamic has chafed actors' willingness to grant external entities observability to their information, even when increased coordination may lead to mutually beneficial outcomes. For example, a utility's decision not to share data related to circuit performance, hosting capacity, or interconnection queues may hinder the possibility of a mutually beneficial non-wires alternative in favor of expensive distribution system upgrades.

Creating meaningful incentives for more data sharing is a far from straightforward task, but one that stakeholders argued is needed. Successful approaches will lead to positive financial outcomes and subsequently overcome organizational stigma around data sharing. This could include policy incentives for projects that specifically require enhanced coordination among entities (including the implementation of sophisticated data-sharing systems, and protocols) and lead to mutual economic benefit.

COORDINATION SHOULD BE PRIORITIZED FOR ESSENTIAL OPERATIONS

Stakeholders reported sensitivity, especially between incumbent utilities and microgrid operators, on the topic of ultimate control. In the context of an interconnected microgrid, which entity can ultimately decide to override microgrid operations, initiate island mode, or determine market participation at any given time? Stakeholders recognized that both utilities and microgrid operators have access to information that is relevant to these important operational decisions. In discussion at the workshop, several stakeholders suggested a reframing of the traditional 'command-and-control' idea behind microgrid operations, which implies a single 'commander'. While the incumbent utility has traditionally assumed the 'commander' role, stakeholders posed that policies or precedents addressing ultimate control should hold the utility and microgrid operator as a 'meeting of equals', as described by one workshop participant.

The previous finding around enhanced mutual observability ties into a need to focus closely on prioritizing coordination over control as it pertains to essential microgrid operations. Certain stakeholders argued that future reliability needs will likely be "hyper-localized" at the circuit or feeder level, due in part to geographically variable grid stresses driven in part by widespread electrification. Microgrid operators emphasized that increased autonomy will be essential to safely and responsibly operate their infrastructure and directly address commercial, environmental, or sustainability objectives. Microgrid operators should be considered independent agents within a federated system, in which each participant coordinates resources to align with grid operations while also maintaining a degree of customer autonomy.

DIFFERENTIAL SECURITY, DIFFERENTIAL ACCESS

In discussions throughout the research process, actors often questioned the way other entities represented their own data needs. This predominantly included, this included microgrid operators challenging utilities for exaggerating security concerns, and utilities and grid operators challenging what constitutes adequate data access for microgrid operators, DER companies, or other third parties to robustly operate and expand operations. This dynamic suggests a need to frame both security and data access as 'differential' priorities, or priorities that require different levels of disclosure and observability depending on the context or use case.

To achieve differential security and differential data access, policymakers and regulators have the responsibility to gain a clear and honest view of the needs of various parties and proceed accordingly. As a general principle, DER penetration remains low while security breaches are relatively uncommon, suggesting that past policy and regulatory processes may have prioritized utility security

Policymakers and regulators should assume the responsibility of more rigorously evaluating the costs of easing security with the benefits of enabling more DER development

over DER data access. Policymakers and regulators should assume the responsibility of more rigorously evaluating the costs of easing security with the benefits of enabling more DER development at both a high level and on a use-case-specific basis. They should ask themselves the questions: What are my DER or microgrid penetration goals? How much and what types of data access will be sufficient to achieve those goals? How can utility privacy and security concerns be appropriately managed to enable that data access?

PRIORITY DATA USE CASES SHOULD BE LEVERAGED AS GUIDING PRINCIPLES

This research process represents an early effort to describe the microgrid data landscape ecosystem, identify core challenges, and present principles to guide future research and/or policy efforts. During this process, a clear gap has emerged between what the ecosystem is today and what could be in the future. As noted in previous findings, data exchanges today are minimal, and often to core operational or financial use cases. Data exchanges in a future scenario of 30-50% DER penetration, by contrast, would be ubiquitous and extremely diverse.

Prioritizing pressing data use cases offered a way to ground a dynamic landscape, leading to productive discussions that identified actionable future research. This approach permeated the research process: expert interviews often naturally focused on specific use cases, the post-interview survey was designed for interviewees to further comment on the challenges of certain use cases, and much of the workshop discussions were dedicated to applying ecosystem framework to specific use cases. Stakeholders that the team engaged throughout the initiative provided feedback that this approach helped them to tangibly apply a topic that can feel like a 'moving target' to their own experience.

Prioritizing pressing data use cases offered a way to ground a dynamic landscape, leading to productive discussions that identified actionable future research

This sentiment suggests that future research or policy actions should focus on addressing specific data use cases representing current 'pain points' or those on the horizon. Furthermore, use cases should be prioritized recognizing that there are differential needs for privacy, security, latency, and other factors involved in typical data exchanges. While iterative, workshop participants gave positive feedback to Think Microgrid's data type table as a tool to categorize such use cases.

Across dozens of interviews and surveys and a full day of discussions, the team fielded a wide variety of high-priority data use cases. In this case, 'high priority' includes data types deemed to be current and critical, especially strained, impeding innovative capabilities, or impeding market participation. Today, many of the data use cases of the highest concern are those essential to microgrid operation (DER authentication and status, dispatch data, and weather data) and market participation (power prices, capacity markets, utility tariffs). Microgrid operators interviewed and who participated in the workshop praised certain high-priority data use cases for their consistency and clarity, like ERCOT's locational marginal pricing or CAISO's nodal pricing, and criticized others for their inaccessibility or poor quality, like utility tariffs and customer historical energy usage. In the near future, stakeholders highlighted the importance of data enabling both new DER ancillary and grid services markets (e.g., those enabled by FERC Order 2222) and specifically operational and market opportunities related to increased automation (e.g., smart home aggregation for load flexibility). See below for details on several high-priority use cases identified repeatedly by stakeholders throughout the research process.

TAXONOMY OF DATA TYPES

DATA TYPE	DEFINITION	SUBCATEGORIES
ARCHITECTURAL	Data related to physical system configuration and capacity. This includes:	• Grid Topology - Contours of grid architecture, including locations of substations, feeders, etc. • Interconnection & Registration - Types and location of resources connected to the grid, hosting capacity. • Critical Facilities - Location of critical facilities, emergency response requirements. • Equity Demographics - Census data - income, age, etc. • Adjacent Infrastructure - Parallel, energy-consuming infrastructure systems like transportation corridors, water system. • Planning Information - Vulnerability assessment, demand forecasts, resource and grid investment plans, etc. • Communications Systems - Infrastructure related to generating and transmitting data.
OPERATIONAL	Data related to the circulation of electrons on the distribution and transmission systems, including energy generation and consumption, curtailment and load-shifting, system performance, etc. This includes:	• Customer Energy Usage - Historical and real-time energy usage and demand data segmented by customer or customer class, measured in kWh & kW. • Dispatch Signals - Market signals requesting DER, demand response, load curtailment, etc. resources. • DER Authentication & Status - Active resources and availability for dispatch, e.g., level of battery charge. • Grid Conditions - Real-time distribution & transmission grid data including congestion, peak load, generation mix, bulk power system, distribution and transmission, outage management, DERMS, etc. • Weather - Current or forecasted exogenous weather data.
FINANCIAL	Data related to financial transactions between entities, e.g., services in exchange for compensation. This includes:	• Power Prices - Real-time and day-ahead distribution and bulk power market prices. • Capacity Market - Bulk power market prices for energy supply, including locational or nodal pricing where available. • Utility Rates & Tariffs - Distribution-level market prices, e.g., load curtailment/demand response, grid services tariffs. • Settlement Information - Contractual agreements between parties, "smart contracts". • Fuel Prices - Exogenous oil, gas, other fuel price data, including real-time and forecasts.
PERFORMANCE	Data related to the performance of resources active on the system.	• Resource Mix - Active and planned resource use. • Emissions Profile - Average emissions of resources, marginal emissions of the grid based on time and location. • Reliability - Traditional reliability metrics, SAIDI & SAIFI at the circuit or feeder level. • Resilience - Capability of microgrids withstand outage and disruption, e.g., hours islandable (for microgrids) and value of avoided lost load.
CUSTOMER	Data related to market participants and their activities, including end users.	• Account Information - Basic data collected in customer registration including CIS, address, etc. • Customer Demographic - Customer income, age, medical requirements, etc. • Customer Assets - Home smart devices, DERs, EV charger. • Enrollment - Participation in utility programs (e.g., managed charging), third-party offerings (e.g., DER aggregation).

HIGH PRIORITY USE CASES

The following use case 'pain points' were identified repeatedly by stakeholders in interviews, surveys, and the November 2023 workshop. Strategizing around these use cases should be a priority to initiate future research and policy.

HISTORICAL CUSTOMER USAGE INFORMATION:

Microgrid developers, operators, and customers emphasized that obtaining historical customer usage information was a challenge that limited their ability to adequately plan and specify microgrid project requirements.

UTILITY TARIFF INFORMATION:

Stakeholders noted a lack of consistent, accessible rate and tariff information in digital formats. While the information is often available as a matter of public record, there is little consistency in how the information is cataloged and presented. There is no consistent format to help standardize this information across the country.

OUTAGE INFORMATION:

Many stakeholders noted that traditional reliability metrics often do not accurately reflect customer experiences with service disruptions and outages. Most reported outage information is not geographically specific, important information for targeting reliability and resilience investments and customer solutions. Stakeholders highlighted a need to create a consistent, standardized methodology to capture and report this information.

CIRCUIT-LEVEL CAPACITY INFORMATION:

Visibility in the capacity and constraints of the distribution system was highlighted as a limitation for the microgrid community, especially as broad electrification strains certain circuits. Working with distribution utilities to responsibly share this information with the public or qualified developers will allow observability into network topology and specific areas where DERs and microgrids could support anticipated infrastructure investment.

DER STATUS:

Distribution and transmission grid operators highlighted the need for greater visibility into the status of DER and microgrids in real time. This information is important for optimizing grid operations and ensuring reliable service. Currently, there is little consistency in how or whether DER status is shared, which may be compounded by a lack of incentive structure in specific market or program constructs.

KEY OUTCOMES

Several key outcomes supplement the substantive findings above that may contribute to ongoing development of microgrid data priorities. These include:

DEVELOPMENT OF A NETWORK AND ADVISORY COMMITTEE

Throughout this initiative, a broad cross-section of professionals, experts, researchers, and policymakers were engaged to provide perspectives on the multi-faceted aspects of data governance and policy. "Over 60 experts and practitioners contributed to these findings. This network of experts and advisors represents the vanguard of activity in the microgrid community. It includes microgrid developers and operators, officials representing distribution utilities and transmission operators, regulatory staff, policymakers, and researchers from academia and national labs. Some of these individuals, including many members of Think Microgrid, have expressed their commitment to serve in an ongoing advisory capacity, prepared to offer their perspective on the priorities for future research and collaborative activities. A full annotated list of these individuals and their contacts is included as a supplement to this report.

INITIAL DATA FRAMEWORK

Throughout this initiative, an initial data framework was developed and presented to both individual stakeholders and the assembled workshop participants. Based on the feedback received, many elements of the data ecosystem map can now be updated and revised. The goal of updating the framework is to provide a conceptual framework that can be applied to a wide range of microgrid deployments, configurations, and data use cases. Experts engaged throughout the initiative recommended that the data ecosystem framework, as well as a taxonomy of microgrid configurations and applications, strive to be mutually exclusive and collectively exhaustive. Together, updated versions of these tools will equip stakeholders with a common language around core microgrid data issues and the actors, data types, and data flows associated with various data use cases. An updated framework should also be used as a continued stakeholder engagement tool to identify existing barriers to and principles around an improved data ecosystem, which can in turn be used to inform action and technical assistance. Workshop participants highlighted the opportunity to align Think Microgrid's conceptual frameworks with other existing and long-established conceptual models, including the NIST Interoperability Framework, the NARUC Grid Data Sharing Playbook, and others. These revisions will benefit from ongoing stakeholder feedback and collaboration.

IDENTIFIED DATA PRINCIPLES

The discussions throughout this initiative included observations from participants about the policy principles that are foundational to any discussion about data exchange across all data types. Participants agreed that there was value in a set of overarching principles that might inform productive conversations across stakeholders. Identified policy principles correlate to several of the overall findings:

- Digitalization requires strong data systems and the demands of more flexible, decarbonized microgrids are driving the transformation of digital grid infrastructure. The level of anticipated data exchange required to coordinate a diverse landscape of resources suggests that the deployment of data systems and digital infrastructure is a core requirement of a more digitized grid.
- Customer sovereignty is a core objective and policymakers should clearly articulate the rights customers, companies, and other stakeholders have over the energy data pertaining to them, giving customers control over what data they choose to share with whom.
- Data systems and policies should plan for differential security requirements and differential access rights. Not every stakeholder needs the same level of granularity or access to sensitive data, so policymakers can recognize that some forms of sensitive data, such as critical facility mapping, circuit performance, and hosting capacity data, are essential for building microgrid market pathways.
- Policymakers should focus efforts on stimulating increased data sharing between actors for mutual benefit and positive financial outcomes. This may take the form of programs or incentives that facilitate new data-sharing systems in the development of lucrative projects.
- Focusing on the highest priority data use cases will allow pragmatic near-term solutions to emerge in an otherwise complicated landscape. As a result, there is ongoing value in continuing to identify areas that present complications or barriers to data sharing that can impede innovative capabilities or market participation.

Participants agreed that there was value in a set of overarching principles that might inform productive conversations across stakeholders

RECOMMENDED ACTIONS

In addition to the key findings and procedural outcome of this overall initiative, the discussions revealed several potential recommended actions or next steps. These are not presented as prescriptive solutions but do highlight where participants felt there may be value going forward, including:

LEVERAGE NETWORK TO CONTINUE DISCUSSION

Participants highlighted the value of the collaborative discussions that were part of this initiative and many encouraged the continuation of workshops, discussions, and opportunities to contribute to future work products. In particular, many noted the unique aspect of being able to hear from a broad range of perspectives and how that informed their views. Going forward, it was noted that there are opportunities to continue to leverage the wisdom of the assembled network to refine the ecosystem mapping tool, microgrid taxonomy, and overall data governance principles. There was also broad interest in continuing to inform the list of data types, subtypes, and the specific areas where impediments or complications might benefit from continued collaborative discussion with a broad set of industry experts represented by the expert network assembled as part of this effort.

ADAPT DATA LANDSCAPE TO MODEL HIGH-PRIORITY USE CASES

In addition to continued collaborative discussions, it was noted that the application of the ecosystem map to specific use cases was highly valuable. Participants observed that having more concrete examples that were grounded in real-world examples allowed for more robust conversations and a greater understanding of the scope and objective of the discussions. As a result, there was strong encouragement to refine the data ecosystem map to apply it to various "high-priority" use cases, which were defined as data use cases that are either prevalent in the market today or where there are identified challenges or barriers that currently impede data sharing that could result in increased consumer value and enhanced system operations.

ENGAGE AND SHARE FINDINGS WITH REGULATORY AND POLICY COMMUNITY

It was noted during discussions that there would be value in creating summary or educational materials that present an updated version of the materials prepared during this initiative to share with leaders and decision-makers in the regulatory community. Because so many of the complications surrounding the availability of, for example, utility system data require specific processes and requirements that are subject to regulatory review and approval, it is ultimately critical that these stakeholders are fully engaged in establishing the protocols for sharing data.