The Coordination Burden: Energy Data and Governance in Alaska and Iceland

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This article compares Alaska and Iceland to explore how energy data infrastructure shapes, and is shaped by, energy governance capacity in the Arctic. Arctic energy operational environments share climate stress, aging infrastructure, fluctuating costs, and shifting geopolitics even as the system diverge widely: low-cost hydropower and geothermal systems in Norway, Sweden and Iceland contrast high-cost, diesel-dependent microgrids in Alaska and remote Arctic regions of Canada, Greenland and Russia. In Alaska, energy data needed for governance is collected from multiple state, federal, and private entities. University researchers developed the Alaska Energy Data Gateway (AEDG) to help communities and policymakers compare energy systems, costs, and supply chains. In Iceland, by way of contrast, the national government designed, manages, and runs Iceland's Umhverfis og Orkustofnun [Environment and Energy Agency] and Hagstofa Íslands [Statistics Iceland] which together are the definitive energy analysis tools for Iceland. While Iceland's energy authority maintains national energy data systems, Alaska's energy data is synthesized through a portal managed by university partners. The article examines where computational and institutional priorities meet to shape, and be shaped by, data and governance. The article hypothesizes that data environments affect participation, planning, coordination, and decision-making; and that data and metadata shape what can be known about energy systems. The comparison between Alaska and Iceland suggests that governance systems produce different informational architectures, and as such, distribute the labor of sense-making and interpretation of energy data in different ways. As Arctic regions navigate geopolitical uncertainty, Indigenous sovereignty movements, climate disruption, cybersecurity risks, and the growing influence of AI, energy data infrastructure will become increasingly important for Alaska, Iceland, and other regions operating isolated microgrids.

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1. Introduction

Arctic energy systems are expensive. Funding models and governance structures influence how energy decisions are made, who participates in those decisions, and what kinds of information are available to support them. Across the circumpolar north, nations manage these costs in different ways including through subsidies, national investment, state ownership models, ratepayer structures, and public infrastructure spending. Like costs, energy governance also varies considerably across the region. Iceland (pop. 394,300, [Hagstofa Íslands, n.d.]) uses national institutions to maintain a highly centralized oversight of energy resources, energy production, and electricity markets through, most notably the Icelandic Environment and Energy Agency (formerly Orkustofnun). Energy governance in the U.S. Arctic (pop. 731,500, U.S. Census, 20) is distributed across utilities, cooperatives, tribal governments, state agencies, private operators, and federal programs. Between these two energy governance extremes are many more variations and permutations of ownership and operation in other Arctic states.

Governance requires a broad set of indicators and information on energy systems: data on generation, fuel costs, outages, infrastructure conditions, changes in demand, seasonal variability, and future planning needs. But energy governance systems collect, validate, share, and use energy data in different ways. In Alaska, critical energy information such as bulk fuel infrastructure conditions, utility service areas, generation capacity, and community-scale electric rates have historically been scattered across multiple agencies, and as a result, incompatible reporting structures, PDFs, and disconnected databases. In some cases, differences in reporting standards, geographic aggregation, and regulatory oversight make comparison across communities and utilities difficult. As a result, the ability of Alaskan communities, utilities, and policymakers to make coordinated energy decisions is limited by an unevenly structured, incomplete data landscape.

These challenges become more acute in rapidly changing energy environments where fuel prices, infrastructure conditions, regulatory requirements, and resource availability can shift quickly, faster than underlying datasets or data structures are updated. Data infrastructure shapes what can be known about energy systems, what forms of analysis are possible, who can participate in decision-making, and how agency is distributed across communities, utilities, researchers, and governments. This paper's core hypothesis is that energy data and its supporting infrastructure are not merely a support tool; they are a primary site of energy governance, a site where value judgements, power, and other social and governance constructs are mediated and enacted.

To support this claim, this paper examines Arctic energy data infrastructure as governance infrastructure through a case study of the Alaska Energy Data Gateway (AEDG), a statewide energy data platform developed to improve access to community-scale energy information across Alaska. A comparison is made between AEDG and Iceland's energy data warehouse, Environment and Energy Agency (EEA), where Iceland's public organizations are responsible for the collection and publication of energy data. Such centralized and unified data governance is key to supporting energy innovation and research in Iceland. This research can, in turn, inform energy policy and support ongoing advancements within the energy sector (Gudleifsson, 2026). Through this comparison, this paper explores how data infrastructure redistributes agency and decision-making capacity across scales of governance, from local communities to state agencies. It argues that the

design of energy data systems has material consequences for participation, planning, and energy sovereignty, three key elements for energy resilience and security in the Arctic.

1.1 Key Terms

Several terms are used throughout this paper in specific ways that differ from their common or disciplinary usage; key definitions are provided below to establish a shared vocabulary for the discussion that follows. Energy data refers to information about how electricity, heat, and transportation fuels are sourced, generated, stored, distributed, used, and governed, including impacts on the built, natural, and socioeconomic environments (Alaska Energy Data Subcommittee, 2023). Energy governance refers to the institutions, policies, actors, funding structures, and decision-making processes that shape how energy systems are planned, operated, regulated, financed, and maintained. By that measure, participatory governance refers to decision-making processes where multiple actors can meaningfully engage because they have access to information they can understand, compare, and act upon. Data infrastructure refers to the technical, institutional, and human systems that make data usable, including databases, standards, metadata, software, reporting requirements, maintenance practices, and the people who sustain them. Informational architecture refers to the way information is produced, organized, standardized, maintained, and shared. Interpretive labor is an umbrella term used to refer to the work required to assemble, clean, reconcile, contextualize, validate, and make sense of information from multiple sources.

2. Conceptual Framing: Data Infrastructure as Governance

Data systems shape how institutions understand energy systems, and at the same time, data infrastructures are themselves shaped by governance priorities, funding structures, regulation, institutional histories, and political choices. Politics play a role: data infrastructures are shaped by institutional incentives, regulatory asymmetries, political priorities, security concerns, and development agendas. Decisions about what data are collected, standardized, shared, or withheld are rarely neutral technical choices; they reflect governance priorities and the distribution of authority across agencies, utilities, communities, and industries. Spending on data may also compete with spending on infrastructure itself; no easy decision to make. Data is not neutral.

This framing is particularly important in U.S. Arctic energy systems, where multi-lateral governance requires coordination. In this context, where energy data may be generated, collected, validated, stored and published by utilities, tribal governments, city or borough entities, state agencies, federal programs, researchers, cooperatives, and private operators, data gaps or mismatches are not merely technical problems, they impact planning capacity, coordination, funding allocation, and public participation.

This paper views energy governance through a participatory lens. Participatory governance requires more than formal opportunities for civic engagement; it requires many people to have the comfort and ability to understand and evaluate the energy systems within the context of community need and desire. Community members and decisionmakers cannot meaningfully participate in energy planning processes if energy data are inaccessible, inconsistent, delayed, or unintelligible (Geist & Samuels, 2020, Jeong et al 2026). If energy data are collected using incompatible standards, aggregated across mismatched geographic scales, or distributed unevenly across institutions, community members and decision-makers are not able to compare, contrast, or make sense of the

system. When energy information remains difficult to access or synthesize, decision-making authority is more accessible to those with the technical, institutional, or financial capacity to assemble and interpret disparate data sources.

This orientation about the role that data plays in participatory governance aligns with broader global movements toward open data, public transparency, and freedom of information, all of which assert that access to information is foundational to democratic participation and accountability (Lee & Butler 2019). Participatory governance depends on data systems that produce information that can be understood and acted upon by multiple decision-makers across multiple scales.

It's important to note that the availability of data does not guarantee that political or infrastructure decisionmakers will make use of it, or related technical analyses. Energy governance remains shaped by competing institutional interests, uneven power relationships, and political negotiation. Data infrastructure therefore does not replace politics; it structures the informational conditions within which political decisions are made (Jungs de Alameida 2024).

3. Problem: Fragmentation limits Arctic energy governance

Fragmentation in Alaska's energy datascape occurs at different points in the data lifecycle. Some fragmentation happens at the moment the data is created while other fragmentation takes place when the data is published or made publicly available. Some challenges occur at the system level - with changes to funding or staffing levels that lead to energy data system failures or disruptions in services. Taken together, these multiple points of fragmentation create a complex operational setting for those trying to make sense of Alaska's energy systems.

Table 1. Alaska example of data lifecycle and energy data fragmentation at scale

<table>
<tr><th>Stages of data lifecycle</th><th>data sources</th><th>data workforce</th><th>data funding</th></tr>
<tr><td>Data collection</td><td>Each organization may have different data standards</td><td>May be untrained or non-data experts responsible for data collection</td><td>May be limited funding for data collection</td></tr>
<tr><td>Data cleaning</td><td>Each organization may have different assurance / quality control processes, and some may have non QA/QC processes</td><td rowspan="2">May be untrained or non-data experts responsible for data cleaning & analysis

If there is trained staff, persons with this expensive skillset are easily poached to private sector, or prone to burn out</td><td>May be limited funding for data cleaning</td></tr>
<tr><td>Data analysis</td><td>Each organization may have different priorities for analysis, some will have no priorities or funding for analytical activities</td><td>May be limited funding for data analysis</td></tr>
<tr><td>Data publication</td><td colspan="2">Will rely on federal or state infrastructure for publication; however, will comply where required to (and less likely to volunteer)</td><td>Some public data sources will have funded mandates for publication, private or smaller orgs will not</td></tr>
<tr><td>Data archiving</td><td>Will rely on federal or</td><td>Will rely on federal or</td><td>Public data sources will</td></tr>
</table>

	state infrastructure and regulation for archiving; however, will comply where required to (and less likely to volunteer)	state staff for archiving assistance	have funded mandates for archiving and data retention policies, private or smaller orgs will not

Below, Sections 3.1 through 3.3 outline specific aspects of data fragmentation in the U.S. Arctic energy sector.

3.1 Data floods & data deserts

In the U.S. Arctic, energy data may originate from state agencies such as the Alaska Energy Authority (AEA) or Alaska Housing Finance Corporation (AHFC); from remote and rural energy subsidy programs such as Power Cost Equalization (PCE); from regulated utility reporting submitted to the state Regulatory Commission of Alaska (RCA) or federal reporting entities such as the U.S. Energy Information Administration (EIA). By some measures, this could be considered a proliferation of energy data.

The socio-technical context for energy data also comes from multiple sectors: federal, state, non-profit, tribal, and private industry. These data infrastructures were developed for different institutional purposes and as such, their data varies in design, consistency, and frequency. Regulatory exceptions and uneven reporting requirements further complicate statewide analysis, particularly in Alaska where some datasets are not required to meet standardized reporting structures common in the contiguous U.S. Again, these socio-technical data sources create a wealth of knowledge about the contexts under which Alaska's energy systems operate.

There are, however, data gaps and missing data makes it incredibly difficult to ascertain, analyze, or assess certain aspects of Alaska's energy datascape. Like the concept of food deserts, these data deserts create challenges for people, communities, and decision makers seeking insights. An example of this extreme data desertification in the state of Alaska is the lack of data related to how much Alaskans spend to heat their homes. While there is information on natural gas sales as a metered and regulated utility, much of the state uses heating fuel for both residential and commercial buildings which is provided by a variety of retailers and not a regulated utility. Therefore, it is incredibly difficult to accurately quantify state heating costs, especially for more rural residents.

This bifurcation of data availability – in some cases a flood and in others a desert – is indicative of the decentralized and deregulated nature of Alaska's energy sector and makes it difficult to determine what is known or unknown. This uncertainty further exacerbates challenges related to community planning and energy sovereignty.

3.2 Data accessibility challenges

There are differences in data accessibility both at the points where data is collected and where it is published. Critical information such as utility service areas, bulk fuel infrastructure condition, generation capacity, intertie relationships, and community-scale electric rates may exist across PDFs, spreadsheets, static reports, disconnected databases, or institutionally restricted systems. In some cases, data are aggregated at scales too granular, or not granular enough; obscuring

meaningful differences between communities or utilities. In others, information may technically be public, but operationally inaccessible due to formatting, discoverability, or lack of interoperability. For comparison, this structure is the opposite of how energy data is collected and shared in Iceland where one public organization is mandated by law to collect and share data on energy generation and consumption.

Tables 2 and 3 are illustrative and reflect the likelihood that energy data produced within different governance environments will satisfy FAIR data principles (Wilkinson et al., 2014). These assessments are based on reporting requirements, publication mandates, institutional capacity, and governance authority rather than the quality of any individual dataset. When compared with the FAIR data principles, the findability, accessibility, interoperability, and reusability / reproducibility of Alaskan energy data generation and distribution varies depending on the scales of governance. On the one hand, at the federal or national level, data is standardized and published according to the FAIR data principles. That data, however, only covers some electric utilities and communities. At the state level, energy data is collected and published by state agencies in well defined formats.

Regional entities include organizations that operate above the community level but below the state level, such as borough governments, Alaska Native regional corporations, regional tribal organizations, housing authorities, and regional development organizations. Regional entities often aggregate information across multiple communities and organizations, creating additional opportunities for standardization and coordination, however in many cases will be operating outside formal state and federal reporting structures. Tribal data sources create another layer of governance - some tribes are power producers and collect data, but due to tribal sovereignty these data may not be made accessible to others. At the local level where energy is being generated, as well as energy data, the data may be findable and accessible, but may not be interoperable with other data sources, and the methods to create those data may not be easily reproducible. Tables 1 and 2 are for demonstration purposes, and presented here to clarify and contextualize the differences that may contribute to the energy data in Alaska and Iceland.

Table 2. Alaskan energy data context: Data sources at scales within a FAIR data framework

Data sources at different scales of governance	**findable**	**accessible**	**interoperable**	**Reusable / reproducible**
national	High probability	High probability	Medium probability	High probability
state	Medium probability	Medium probability	Medium probability	Medium probability
regional	Medium probability	Medium probability	Low probability	Low probability
tribal	Low probability	Low probability	Low probability	Low probability
local	Medium probability	Medium probability	Low probability	Low probability

The Icelandic context differs from Alaska not only in its energy systems, but also in its governance structure. Iceland lacks many of the overlapping governance layers that shape energy data production in Alaska, including tribal governments, state-level governance, regional Native organizations, and numerous independent utility operators. As a result, energy data collection, standardization, and publication occur within a smaller number of institutions operating toward shared national objectives. This does not eliminate fragmentation entirely, but it reduces the number of organizational boundaries across which information must be coordinated, reconciled, and interpreted.

3.3 Funding, prioritization, and disruptions of service

Energy data infrastructure relies not only on technical systems and trained personnel, but also on sustained institutional investment. Maintaining Arctic energy data infrastructure requires funding not only for storage and web hosting, but for programmers, developers, analysts, data engineers, statisticians, and long-term institutional coordination that results in compatible, standardized data products useful by the many as opposed to the few. Valuing the role that energy data play in participatory energy governance is essential (Jungs de Alameida 2024); policymakers have many competing interests to fund and technical systems can feel like an expensive luxury.

In Iceland, EEA is funded through two different streams of funding where the majority comes from the state's annual budget process, EEA also collects fees and service charges for permits, regulatory reviews, oversight activities and other services. The AEDG, on the other hand, has been rebuilt one time since its inception in 2010, after falling out of date in both software, security, and data offerings, leading to a multi-year disruption in availability of the seminal energy data portal for the state of Alaska. Disruptions lead to the phenomenon that Bowker and Starr call "organizational forgetting" in their 2000 book *Sorting Things Out.* Organizational forgetting can include erasure, or closure - with both positive and negative outcomes. The gateway is currently funded by the State of Alaska Legislature, but not as an automatic budget line item. Historically it has been funded by Alaska Energy Authority, national labs, as well as the state. Since this is not developed or consistently maintained by state agencies, and is an effort to compile, aggregate, and collate disparate datasets, it is funded on an irregular basis, as the governor or legislature decides to prioritize access to energy data over other competing budgetary priorities.

Calculating the long-term costs of inaccessible, delayed, inconsistent, or inaccessible energy data remains an open question (Jungs de Almeida et al., 2024; Lee & Butler, 2019; Giest & Samuels, 2020). These costs may emerge through planning inefficiencies, delayed infrastructure investment, failed investments or infrastructure projects, constrained public participation, weakened coordination, or policy decisions made under conditions of incomplete situational awareness (Pokorny, 2026). This becomes more prevalent in rapidly changing environments, as seen in the Arctic which is buffeted by extreme weather events at increasing frequency; events with catastrophic consequences on Arctic infrastructure, and community wellbeing such as ex-Typhoon Halong's devastation on 49 communities in Western Alaska in 2025 forcing the relocation of Kipnuk and Kwillingwok, and the displacement of those villages (Murkowski, 2026, Rosen, 2026) . For Iceland recent examples are present, where severe snowstorms and delayed investments in the transmission system have shown to present examples of cost both in terms of outages and stranded energy. The most recent example is demonstrated by the state power company that

claimed loss of about 200 GWh of power due to bottle necks in the transmission system (Landsvirkjun, 2023). Delayed or incomplete information has impacts on planning horizons and coordination efforts.

4. Alaska Energy Data Gateway: Rebuilding Energy Visibility

The Alaska Energy Data Gateway (AEDG) was developed by a joint university team with researchers from the University of Alaska Anchorage's Institute of Social and Economic Research and the University of Alaska Fairbanks's Alaska Center for Energy and Power. AEDG was originally designed as a state-supported platform to aggregate, standardize, and visualize Arctic energy data across community, regional, and statewide scales. Its purpose was not simply to centralize information but to make Alaska's energy systems easier to understand, compare, and act upon within a variety of governance contexts. AEDG's second revitalization (2025 - present) was designed to address the fragmented or siloed nature of Alaska's energy data landscape.

As outlined previously, Alaska's energy data exists, but it is difficult to access, compare, interpret, or operationalize into a holistic picture for comprehensive planning and decision-making. There is not a need for more data, but perhaps a need for more coordinated data in Alaska's energy datascape (Rocha de Siquera & Ramalho, 2024). More than just coordination, the context and setting for how a broader set of users are able to access the data, what Loukissas calls the *data settings* in his seminal 2019 publication *All Data Are Local*. In his book, Loukissas asks, "how can we rework open data initiatives to make data settings versus data sets both accessible and actionable?" It is this sentiment that informed the ACEP-ISER team's revitalization and redesign of settings for Alaska's energy data.

At a technical level, AEDG integrates datasets from multiple state and federal reporting systems, including utility reporting, PCE data, EIA datasets, infrastructure records, socio-technical data, and community energy statistics. These datasets are cleaned and standardized into shared analytical structures. The AEDG system presents data in standardized dashboards that allow users to compare communities and grids within a shared analytical framework, such as the ability to see EIA-reported communities such as Anchorage alongside PCE-reported communities such as Kotzebue using consistent formats and metrics.

Furthering that comparative and contextualizing user experience, the 2025 AEDG revitalization made it easier to compare or visualize the energy systems of a single community from a holistic point of view. Community summaries and data dashboards for individual communities create a comprehensive look at electric rates, generation mixes, fuel dependencies, utility service areas, and infrastructure characteristics. For example, the integration of bulk fuel locations, type, and capacity as tabular and geospatial data in the AEDG community summaries allows communities and planners to more easily view bulk fuel facilities and support discussions around infrastructure and long-term energy planning.

While many components of Alaska's energy infrastructure could be viewed individually before the 2025 AEDG revitalization, they could not be viewed relationally. Regional grids, utility territories, generation assets, fuel systems, and community conditions often existed in disconnected, ad hoc, analytical environments, making it difficult to understand the energy system as a coordinated, interconnected, regional infrastructure.

4.1 Addressing legibility and visibility for the many, not the few

For non-specialist users, AEDG provides foundational awareness about how Alaska's energy systems are structured and how communities relate to broader regional infrastructure networks. AEDG's developers and subject matter expert team describe AEDG being used to support fisheries-related investment discussions, legislative analysis, infrastructure grant development, teaching, research, regional analysis and regional planning conversations. Journalists, legislative staffers, and national lab researchers regularly contact the AEDG team with questions about a dataset, sharing information they have living in a community, or pointing out issues or discrepancies.

The AEDG data team prioritizes engaging thoughtfully with users: explaining, asking questions, meeting with users, and spending time getting to know them and their work in order to better understand the needs of different users of the system. This work has resulted in short term, immediate fixes, and longer-term features that require months of development time and data manipulation to accommodate user desires. The result is a simplified, clarified user experience.

This increased visibility afforded by the revitalized AEDG reduces the transaction costs associated with energy analysis and planning. Where acquiring baseline energy information had previously required significant time, institutional familiarity, or consultant support, it now only requires internet access. Prior to AEDG, even relatively straightforward comparisons often required significant manual effort by expert analysts or consultants. Workflows that previously required hours or days of custom analysis are now instantly accessible through its shared dashboards. AEDG's developers and subject matter expert team describe how the revitalized dashboards make spotting trends such as changes in Cordova's generation mix over time immediately visible to any user.

These benefits impact different scales of governance. At the community level, the platform supports local operational understanding, energy planning, and infrastructure discussions. At the regional level, AEDG improves ability for coordination, comparative analysis, and infrastructure prioritization within interconnected systems and organizations, which includes regionally specific levels such as House District and Alaska Native Corporation. At the state level, the platform supports policy analysis, legislative communication, strategic planning, and broader discussions around energy investment and infrastructure development. Nationally, researchers across the country are using the AEDG for their analysis and planning.

4.2 Designing for the Future

AEDG was intentionally designed for future flexibility and long-term extensibility as new datasets, governance priorities, and analytical needs emerge. The platform team adopted a modern cloud-oriented application architecture uncommon within Alaska's energy data landscape. Within the newly designed AEDG system, resilience and future-proofing in the system design adapts to changing data availability, formats, or, for example, new data types.

Technical Infrastructure for Interpretability

AEDG was designed using modern web application and cloud infrastructure practices that are still relatively uncommon within Alaska's energy data landscape. The platform architecture emphasized interoperability, reproducibility, extensibility, and standardized relationships between datasets.

The application was developed using a Ruby on Rails MVC architecture with standardized ActiveRecord data models that normalized database relationships between communities, utilities, fuels, technologies, geographic boundaries, infrastructure systems, and reporting structures. The platform also required significant geospatial normalization work to reconcile mismatches between utility reporting structures and community-scale geographic boundaries, particularly within interconnected systems such as the Railbelt. This included transforming and standardizing service area data into interoperable geospatial formats capable of supporting community-level analysis, circumventing previously incompatible reporting systems. Together, these technical systems support and in fact, make possible AEDG's broader governance objectives: making layered Arctic energy governance transparent.

4.3 Reducing fragmentation

The process of revitalizing AEDG also exposed the gaps within Alaska's energy data infrastructure. Integrating datasets revealed inconsistencies in reporting structures, geographic boundaries, update schedules, and regulatory frameworks - even the loss of key personnel at an organization. In some cases, important infrastructure such as heating fuel use information remains unavailable, inconsistently reported, or difficult to validate. AEDG development team and data engineers identified continuing gaps related to heating fuels, natural gas systems, Railbelt energy transfers, and infrastructure-level operational data. In this sense, AEDG is not always able to resolve data fragmentation, but the system can make it more visible.

The source of data fragmentation may lie within the underlying governance and energy systems themselves. Alaska's energy data revealed the continued asymmetries embedded within Arctic energy governance: data providers, regulatory systems, and platform designers still influence what information becomes visible, how systems are categorized, and which forms of analysis become possible. Local knowledge, lived experience, and community priorities are not fully captured through standardized datasets alone.

While the 2025–2026 revitalization of the AEDG expands opportunities to engage with Alaska's energy data, it does not change the socio-economic inequalities across the state nor address the unequal distribution of political and economic power in energy decision-making in Alaska. Alaska experiences some of the highest energy burdens in the United States, with "stark geographic disparities" between urban areas with relatively lower energy burdens and Southwestern and Northwest Alaska, where burdens are highest (Boettger, 2025). These disparities also exist across household income thresholds, and Alaska's lowest-income households spend a median of 22.9% of their annual income on energy (Boettger, 2025).

The 2025 *Energy Burden in Alaska* report identifies several institutional barriers that contribute to these inequalities, including cost-share requirements in high-burden communities, complex funding applications, limited grant-writing and technical assistance, and funding timelines that may conflict with subsistence activities. The report further recommends accepting traditional knowledge, where appropriate, in place of written documentation, developing culturally responsive communications, and establishing funding timelines that accommodate subsistence activities (Boettger, 2025). Communities with the greatest need for energy investment may also have the least institutional and technical capacity to demonstrate that need through the data-intensive

processes required to secure funding. Communities with the highest energy burden also often have the least say in how energy resources are distributed across the state.

Energy planning requires far more than access to utility rates or energy consumption statistics. The 2015 Denali Commission publication "Strategic Energy Planning: a Guide for Rural Alaska Communities" outlines many types of data a community will need to prepare for energy improvements, including: technical information on infrastructure energy use; an inventory of community buildings that describes ownership and land rights; an inventory of energy audit reports from public buildings and community housing; data on problems with power generation, transmission, and bulk fuel storage systems; data on financial and administrative capacity; data from current community plans; data on community growth trajectories; a community strengths assessment; fieldwork to verify on-the-ground conditions against data; housing surveys; lighting surveys, and more (Gove, 2015). Existing data must also be verified against conditions on the ground, reconciled across sources, and analyzed over time to identify trends, gaps, and future demand. Similarly, the *Alaska Affordable Energy Strategy* identifies improved data collection, analysis, and public access as necessary to identify cost-effective energy projects (McMahon, 2017). Oftentimes, small Alaskan utilities may have the least capacity to perform these data-intensive activities; yet their need for energy improvements may be the greatest.

Access to data is not the same as having the capacity to use it, and being able to interpret information, develop projects, and navigate funding processes is also unevenly distributed. State and federal policy, regulation, and investment play important roles in determining which energy improvements are possible. The Alaska Municipal League emphasizes the Alaska Legislature's role in supporting local energy investments across public, private, and tribal sectors (AML, 2026). The *Alaska Affordable Energy Strategy* similarly identifies the Alaska Energy Authority and a combination of efficiency programs, policy, regulation, and investment as important mechanisms for improving energy affordability, safety, stability, and reliability outside the Railbelt (McMahon, 2017). AEDG may reduce some of this coordination burden, but it does not resolve the broader policy and institutional inequalities that determine access to affordable power. AEDG's contribution must be assessed by both the data it makes available and who is able to use that data to participate in energy decision-making.

Metadata as Infrastructure for Interpretability

A recurring challenge in Arctic energy governance is that datasets often outlive the context in which they were created. Critical details about collection methods, geographic coverage, update schedules, transformations, assumptions, units, or responsible organizations are frequently difficult to locate. To address this challenge, AEDG developed a metadata generation system based on the Open Energy Metadata (OEMetadata) standard and FAIR data principles. Rather than treating metadata as an afterthought, AEDG treats metadata as core infrastructure. Every dataset published through AEDG is accompanied by structured, machine-readable documentation describing data provenance, contributors, collection methods, transformations, licensing, geographic applicability, and relationships to other datasets.

This approach serves both technical and governance functions. Technically, metadata supports interoperability, searchability, reproducibility, and future system integration. From a governance perspective, metadata creates transparency around how information was produced and what

limitations accompany its use. It helps users understand not only what the data show, but what the data mean. By preserving contextual information alongside datasets, the metadata system reduced the need for future users to repeatedly reconstruct analytical context through institutional memory, informal relationships, or external documentation.

The metadata system also supports AEDG's broader objective of standardization. By creating shared structures for describing datasets, contributors, energy technologies, geographic units, and data transformations, AEDG establishes common reference points between previously disconnected information systems. In doing so, the platform shifts effort away from repeatedly rediscovering context and toward analysis, interpretation, and decision-making.

Metadata is an antidote to organizational forgetting. As datasets move between organizations and outlive the people who created them, metadata preserves the context needed to understand where information came from, how it was transformed, and what it means. In doing so, it helps sustain institutional memory and reduces the need for future users to repeatedly reconstruct analytical context from scratch. This function is not merely technical. By making data more understandable and transparent to a broader range of users, metadata also supports participatory governance, expanding the ability of communities, planners, researchers, and decision-makers to engage with energy systems from a shared informational foundation.

5. A Circumpolar Comparison: Iceland and Alaska

Circumpolar energy systems operate under different governance structures, and those governance structures produce different informational architectures. A comparison between Alaska and Iceland illustrates the wide range of energy governance structures influencing how coordination, standardization, and interpretive labor are distributed differently between Arctic nations.

5.1 Spotlight on Icelandic energy data institutions

A historical examination (1995–present) of the Icelandic Energy Act (Alþingi, 1967) using the parliamentary digital archive shows that Orkustofnun has long been responsible for collecting energy data. Despite the extensive availability of data on the production and capacity of Iceland's energy systems, information on historical price development is more fragmented. Statistics Iceland's digital archive provides historical information on both electricity and district heating prices, with continuous numerical series dating back to 1959 and 1965, respectively (Hagstofa Íslands, 2017). However, these series cannot be disaggregated by sector or municipality and are primarily intended to provide a macroeconomic perspective.

Over the years, Iceland has gradually strengthened and refined the role of its national energy agencies, as reflected in discussions about institutionalizing geothermal knowledge in Iceland (Gudleifsson, 2026). Recently, two separate state agencies, the Environment Agency and the Icelandic Energy Agency, formerly known as Orkustofnun, were merged into a new state agency, the Icelandic Environment and Energy Agency (UOS). The new agency assumes its predecessors' duties, including responsibility for collecting Icelandic energy data (Alþingi, 2024). With this reform, the National Regulatory Authority (NRA) oversees the electricity sector (Alþingi, 2003), and while this discussion focuses on electricity and geothermal energy, UOS's responsibilities extend beyond these two sectors.

Both transmission of power in Iceland and many of the district heating networks are regulated by the state (Alþingi, 1967, 2003). This regulatory framework gives the NRA oversight of transmission tariffs and investment plans, while UOS oversees tariffs and relevant investment plans. Regulatory oversight includes transmission rates, district heating service rates, and investment plans in both sectors. These regulatory arrangements require operators to comply with established financial and reporting requirements, a function of energy data.

The Icelandic energy legislation distinguishes between energy sector operators based on their roles, with certain activities operating under regulated monopolies, particularly in the district heating and electricity distribution sectors (Alþingi, 1967, 2003). This monopolistic arrangement also applies to electricity transmission, where the state-owned company Landsnet is solely responsible for operating and maintaining the security of Iceland's national transmission system (Holdmann & Guðleifsson, 2023). This regulatory framework requires ongoing reporting on performance, tariffs, and investments in the electricity transmission and distribution sectors, contributing to Iceland's energy data holdings.

Notably, reporting and data sharing in the electricity sector appear more extensive than in the district heating sector, which may partly reflect Iceland's significant industrial electricity consumption (Orkustofnun, 2023) and Iceland's adoption of European Union (EU) energy market liberalization policies (Holdmann & Guðleifsson, 2023). The EU's energy market liberalization framework mainly covers electricity, gas, and hydrogen markets but does not, to the same extent, cover district heating, for which Iceland extensively uses geothermal energy (Becker & Ciucci, 2026; Orkustofnun, 2021).

The NRA recently launched a detailed dashboard that provides frequently updated information on prices, generation (and power source attribution), consumption, and system losses in a new interactive, combined format, providing a more integrated presentation than the former spreadsheet-based data-sharing method. This dashboard distinguishes between industrial and public electricity consumption (Umhverfis- og Orkustofnun, n.d.). Currently, UOS does not provide similarly detailed information for the district heating sector, where data continues to be published primarily through spreadsheets. Landsnet, Iceland's Transmission System Operator (TSO), publishes information on electricity transmission tariffs, connection fees (Landsnet, 2026), and available transmission capacity at individual connection points within the transmission system (Landsnet, n.d.). These institutional and reporting arrangements influence how Icelandic energy data are collected, standardized, and made available. Table 3 illustrates how these arrangements relate to the findability, accessibility, interoperability, and reusability (FAIR) of energy data across different scales of governance.

Table 3. Icelandic energy data context: Data sources at scales within a FAIR data framework

Data sources at different scales of governance	**findable**	**accessible**	**interoperable**	**Reusable / reproducible**
national	High probability	High probability	Medium probability	High probability

Data sources at different scales of governance	findable	accessible	interoperable	Reusable / reproducible
state	N/A			
regional	High probability	Medium probability	Low probability	Medium probability
tribal	N/A			
local	Medium probability	Medium probability	Low probability	Low probability

5.2 Where the Coordination Burden Falls

In Iceland, much of the coordination required to produce comparable energy information occurs upstream through centralized institutions and standardized reporting structures, where the primary coordinating and reporting responsibilities lie within a single public organization. Other national-level agencies and statistical organizations then support this structure to maintain more integrated relationships between energy governance, regulatory oversight, and public reporting. As a result, energy information is more consistently organized within shared national frameworks, reducing the amount of reconciliation work required to compare systems, evaluate trends, or support national-scale planning and analysis. Coordination and interpretive alignment are more directly embedded within governance structures themselves.

In Alaska's decentralized energy landscape, energy governance is also decentralized and as such takes place in multiple institutional environments involving tribal governments, municipal utilities, cooperatives, state agencies, federal programs, regional entities, and private infrastructure operators or investor-owned utilities. These systems may have incompatible geographic boundaries, reporting timelines, regulatory structures, and data standards. Under these conditions, the burden of coordination shifts downstream toward the actors responsible for assembling, reconciling, and interpreting a variety of different information systems.

Table 4. Comparing energy governance and data in Iceland and Alaska

	Iceland	**Alaska**
Governance structure	More centralized	More decentralized
Reporting environment	Standardized	Fragmented
Coordination burden	Embedded within institutions	Distributed across actors
Reconciliation labor	Mostly upstream	Mostly downstream

	Iceland	**Alaska**
Role of data platforms	Publishing and dissemination	Reconstruction and coordination

This distinction is not simply technical; it reflects broader differences in governance structure and institutional organization. More centralized informational architectures may reduce coordination burdens and support more consistent statewide comparability. More decentralized systems may preserve greater local flexibility, institutional autonomy, and responsiveness to community-specific conditions. At the same time, decentralized governance environments often distribute the labor of interpretation, rather than provide a streamlined analytical or interpretation layer that is directly embedded within reporting systems themselves.

Within this context, AEDG can be understood not only as a data platform, but as infrastructure for interpretation and coordination within a decentralized Arctic governance environment. Much of AEDG's work involved reconstructing relationships and creating visible connections across disconnected analytical and institutional environments. Geospatial normalization, metadata generation, standardized relational models, and cross-sector data alignment were all forms of reconciliation labor required to produce shared interpretability.

The comparison between Alaska and Iceland therefore suggests that informational architectures both reflect and reinforce governance architectures. Data systems do not emerge independently from governance systems themselves. They are products of institutional alignment, reporting structures, regulatory authority, and the ways coordination burdens are addressed in a complex, multi-stakeholder environment.

6. Looking forward and next steps

The AEDG case suggests that the future challenge for Arctic energy systems is not simply collecting more data. It is sustaining the ability for multiple decision makers to interpret complex data over time. Without common reporting structures, metadata practices, geographic standards, and interoperable formats, energy planning becomes a recurring exercise in reconstruction. Organizations spend time rebuilding context, reconciling incompatible systems, validating inconsistent records, and recreating analytical baselines, leveling the playing field, so to speak, before meaningful planning can begin. Organizations with the resources to do this work are able to justify additional infrastructure funding - but entities without these analytical baselines may not be able to compete for the same funding sources.

Future Arctic energy data systems should therefore prioritize transparency, reproducibility, cybersecurity, and contextual continuity from the beginning. Structured metadata, documented methodologies, secure infrastructure practices, and clear provenance standards help preserve not only datasets, but the context required to interpret them responsibly across institutions and time. These practices align with FAIR data principles (Wilkinson, et al 2016) and emerging energy metadata standards such as OEMetadata (Hülk 2025), but they also serve a broader governance function by reducing dependence on institutional memory, consultant intermediaries, and

disconnected reporting systems in order to sustain shared analytical capacity across regions and scales.

These questions become more urgent as energy systems become increasingly dependent on computers and networked infrastructure. Recent advances in artificial intelligence may help identify patterns across disparate systems, support load forecasting, improve anomaly detection, and reduce some forms of reconciliation labor, and there is talk of AI-empowered energy systems for remote access, control, and even automation. At the same time, AI systems also increase pressure on data standardization, shifting data requirements toward machine-readable, standardized, "clean" data while introducing new governance concerns around provenance, cybersecurity, consent, and informational control.

Current and prior versions of AEDG do not incorporate artificial intelligence (AI) into the software design, metadata, or data processing workflows. Given Alaska's highly variable energy data quality and the need for verification by local and technical subject matter experts, AI alone is unlikely to replicate the verified and ground-truthed data available through AEDG. However, AI agents may use AEDG data because they are published in standardized, accessible formats with corresponding metadata. Without sufficient context and ground-truthing, outputs generated by these agents may be unreliable and require additional verification by human subject matter experts.

Future applications of AI within AEDG could include anomaly detection across large datasets, identification of patterns and trends, automated metadata classification, and assistance in identifying missing or inconsistent records. Across the Arctic, AI could also support energy data accessibility by helping users navigate complex datasets, compare information across jurisdictions, and translate technical information into more accessible formats. These applications may be particularly useful for communities and smaller utilities with limited technical capacity. However, the effectiveness of this technology depends on high quality data that is well situated within local context and verified by local experts. While AI may reduce some of the technical work associated with collecting and interpreting energy information, it cannot address institutional inequalities that shape how data are collected, whose knowledge is recognized, and who has the authority to use that information in energy decision-making. In this context, metadata and cybersecurity are no longer secondary technical concerns. They become part of the infrastructure of trust required for future Arctic governance.

The comparison with Iceland highlights how differently governance systems distribute coordination burdens. In Iceland, much of the interpretive alignment required for national energy analysis is embedded upstream within centralized institutions and reporting structures (Hagstofa Íslands, 2026; Landsnet, 2026; Orkustofnun, 2026). In Alaska, that coordination work occurs downstream across agencies, utilities, geographies, and governance systems. AEDG therefore functions not only as a data platform, but as infrastructure for interpretive coordination within a decentralized governance environment.

The broader lesson is that Arctic energy transitions depend not only on physical infrastructure, but on the ability to sustain shared interpretability – the core needs for understandability– across systems under conditions of accelerating change. As Arctic regions confront climate disruption, infrastructure transition, geopolitical pressure, cybersecurity risk, and increasingly AI-mediated

decision-making, interpretive coordination may become one of the defining governance capacities of the circumpolar north.

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