U.S. Department of Energy

Arctic Strategy

U.S. Department of Energy Strategy To Support Arctic Activities and Priorities

October 2022

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Executive Summary

The North has recently attracted more interest and concern, in part because warmer Arctic conditions and rapidly decreasing ice on land and sea have been linked to mid-latitude weather extremes, intensified storms, longer droughts, wildfires, floods, and rising sea levels. Additionally, potential resource development, new shipping patterns, altered fisheries, and increased tourism all require countries, companies, and communities to focus on adjusting and preparing for these new opportunities and challenges. The U.S. Arctic (Alaska) has traditionally not received equitable benefits from our energy system. For economic, cultural, environmental, geopolitical, equity, and security reasons, the commitment to science-informed and evidence-based decisions and investments is essential to the future of the entire region and our nation.

U.S. policy goals for the Arctic are a secure and stable region where U.S. interests are safeguarded, the U.S. homeland is protected, and Arctic states work cooperatively to address shared challenges. This requires focused investments in energy, science, and security, which the U.S. Department of Energy (DOE) is already making. Increased coordination of DOE investments in energy, science, and security will increase the impact and effectiveness of DOE Arctic work and support U.S. policy goals, including the White House's National Strategy for the Arctic Region (NSAR).

DOE's mission is to ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions. DOE catalyzes the timely, material, and efficient transformation of the nation's energy system and secures U.S. leadership in energy technologies. DOE maintains a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity with clear leadership in strategic areas. In addition to enhancing nuclear security through defense, nonproliferation, and environmental efforts, DOE oversees the national lab complex as a resource for the entire federal government. The three pillars of the Arctic strategy reflect the DOE mission priorities—energy, science, and security through excellence in operations and management.

Recognizing DOE's role in meeting the increasing Arctic opportunities and challenges, the Senate Report for the Energy and Water Development Appropriations Bill for fiscal year 2022 stated that "the Committee supports the promotion of research, development, and deployment of electric power technology that is cost-effective and well-suited to meet the needs of rural and remote regions of the United States, especially where permafrost is present or located nearby. The Committee encourages the Arctic Energy Office [AEO] to continue to bring together assets from across the Department to work together in collaborative and innovative ways to meet the energy, science, and national security needs of the United States and its allies in the Arctic. Further, the AEO is encouraged to lead cross-cutting operations in the Arctic with a mission to tackle the energy, science, and national security challenges of the 21st Century." S. REP. NO. 117-36, at 75 (2021).

The DOE Arctic strategy has been developed with insights from extensive internal and external stakeholder coordination activities. This comes from interagency collaboration and coordination across the DOE national lab complex, state, local, tribal, and academic partners. The strategy is intended to inform DOE Arctic activities over a decadal timescale.

Vision

The Department of Energy will be an essential source of science, technology, and engineering solutions for accelerating the energy transition, enabling science-based decision making, and ensuring national security in the Arctic.

The **DOE Arctic strategic goals** are underpinned by these foundational principles:

- DOE's Arctic efforts will be appropriately balanced and integrated across the three strategic goals of energy, science, and security.
- DOE will coordinate with Arctic inhabitants (including Indigenous Peoples), other Federal agencies, state and local organizations, and international partners and allies to ensure broad-based understanding of Arctic challenges, energy equity, and applicability of solutions.
- DOE, through the Arctic Energy Office, will collaborate across program offices; leverage DOE's national laboratories; facilitate public and private sector engagement; and partner with foreign allies to strategically address Arctic challenges.
- DOE will prioritize community-based and place-based solutions as defined by the people of the Arctic, including Indigenous Peoples.
- DOE will prioritize local capacity building and decision making for all DOE goals.
- DOE will catalyze, support, and leverage private-sector adoption and capacity for secure and sustainable U.S. Arctic interests.
- DOE data stewardship and application responsibilities will be integral to DOE Arctic activities.
- DOE will address diversity, justice and equity issues in its efforts throughout the Arctic.
- As elsewhere across the nation, the DOE's actions in the Arctic region will align with the President's goals to:
    - Establish a carbon pollution-free power sector by 2035;
    - Achieve a net-zero carbon emissions economy by 2050; and
    - Ensure that disadvantaged communities realize at least 40 percent of the overall benefits from clean energy investments.

Strategic Goals

1. DOE will lead and partner to advance the decarbonization, resilience, and equity of the Arctic **energy** sector.
2. DOE will lead and partner to advance the **scientific** understanding of Arctic challenges.
3. DOE will lead and partner to ensure Arctic **security**.

Table of Contents

1 DOE Arctic Context

Many of the entities that were combined into DOE (both DOE program office predecessors and the national labs) have been involved in the Arctic since well before DOE was created in 1977. The DOE activities in the Arctic have spanned the three pillars of energy, science, and security, and this section provides an illustrative, rather than comprehensive, overview of current ongoing DOE Arctic activities.

The 2022 National Strategy for the Arctic Region (NSAR) emphasizes four pillars: advancing U.S. security interests, climate change mitigation and environmental protection, economic development, and international cooperation and governance. These four U.S. strategy areas are the foundation for DOE's Arctic strategy. The National Strategy for the Arctic Region has five core principles that crosscut the four pillars: Engage, Coordinate, and Collaborate with Alaska Native Communities; Deepen Relationships with Allies and Partners; Pay Attention to Long-Lead Time Investments; Cultivate Cross-Sectoral Coalitions and Innovative Ideas; and Commit to a Whole of Government Approach. DOE's priorities include combating the climate crisis, creating clean energy union jobs, promoting energy justice, and ensuring national security. These DOE priorities directly support the National Strategy for the Arctic Region.

DOE re-established the Arctic Energy Office (AE) in order to develop and coordinate this DOE Arctic strategy as well as serve as a single coordinating point of contact for all DOE Arctic activities. AE's re-establishment demonstrated the Department's commitment to and prioritization of the Arctic region. AE's goal is to "bring the Department of Energy to the Arctic and bring the Arctic to the Department of Energy."

The importance of DOE's efforts in the Arctic is clear in the Senate Report for the Energy and Water Development Appropriations Bill for fiscal year (FY) 2022 (the "FY 2022 Senate Report"), with comparable language in reports accompanying appropriations acts in prior years. Specifically, the FY 2022 Senate Report indicates that "the Committee supports the promotion of research, development, and deployment of electric power technology that is cost-effective and well-suited to meet the needs of rural and remote regions of the United States, especially where permafrost is present or located nearby. The Committee encourages the Arctic Energy Office [AEO] to continue to bring together assets from across the Department to work together in collaborative and innovative ways to meet the energy, science, and national security needs of the United States and its allies in the Arctic. Further, the AEO is encouraged to lead cross-cutting operations in the Arctic with a mission to tackle the energy, science, and national security challenges of the 21st Century." S. REP. NO. 117-36, at 75 (2021). The FY 2022 Senate Report further highlighted the energy challenges and opportunities in Alaska, noting "Alaska is home to some of the highest energy costs in the nation, making diverse research, development, and deployment opportunities more cost-effective to meet the needs of rural and remote regions of the United States. There are also a wide variety of energy resources and technologies, both traditional and innovative, available in Alaska, including more than 200 microgrids."

This strategy responds to the FY2022 Senate Report's guidance to meet the energy, science, and national security needs of the United States and its allies in the Arctic and demonstrates the Department's renewed focus on the Arctic region.

2 DOE Arctic Activities

Many of the entities that were combined into DOE (both DOE program office predecessors and the national labs) have been involved in the Arctic since well before DOE was created in 1977. The DOE activities in the Arctic have spanned the three pillars of energy, science, and security, and this section provides an illustrative, rather than comprehensive, overview of current ongoing DOE Arctic activities.

Energy

Arctic energy work funded by DOE spans many of the department's technology areas. DOE efforts focus on the transition to a low carbon energy system (e.g., microgrid integration of renewable energy resources, electric transportation, and beneficial electrification) with various projects spanning the research-development-demonstration-deployment continuum. DOE is investing in science and technology to enable the modernization of the U.S. electrical infrastructure (or "grid"). The Grid Modernization Laboratory Consortium (GMLC) was established as a strategic partnership between DOE and the national laboratories to bring together leading experts, technologies, and resources to collaborate on the goal of modernizing the nation's grid. The benefits of the GMLC include more efficient use of resources; shared networks; improving learning and preservation of knowledge; enhanced lab coordination and collaboration; and a regional perspective and relationships with local stakeholders and industry. Several of the GMLC projects are Alaska based and Arctic relevant.

Recent DOE Arctic investments have also included engineering studies, field tests and analyses addressing technical and economic challenges related to effective and responsible leveraging of the region's fossil energy and carbon management resources. For example, the Alaska North Slope gas hydrates field experiment program is a DOE sponsored collaboration focused on advancing responsible development of an emerging natural gas resource. DOE has also published a draft Supplemental Environmental Impact Statement (SEIS) for the Alaska Liquefied Natural Gas (LNG) Project which includes a life cycle analysis (LCA) calculating the greenhouse gas (GHG) emissions for Alaskan LNG exports to Asia and other gas markets around the globe.

DOE also sponsors research on critical minerals in Alaska. One of DOE's place-specific Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) projects is funded by multi-year grants and focused on identifying rare earth / critical mineral resource sites in Alaska and assessing the techno-economic feasibility for their development. Preliminary market studies have been performed to assess possible Arctic applications of the emerging micro nuclear reactor and small modular reactor systems being matured by DOE investments complementing efforts by the

industry and defense sectors. DOE provides technical assistance to communities and various organizations to support resource assessment, strategic planning, energy efficiency / weatherization, resilience assessment/enhancement, building design, sustainable community design, policy analysis, skills training, and technology integration.

Science

For decades, DOE has been a leader in expanding scientific understanding and modeling the Earth's climate system. Arctic amplification[1] is causing the most dramatic changes and the most complex nature system behavior and interactions to occur in the Arctic region. The Arctic Monitoring and Assessment Programme (AMAP) working group of the Arctic Council published the "Arctic Climate Change Update 2021: Key Trends and Impacts" with "an important update [being] the increase in Arctic annual mean surface temperature (land and ocean) between 1971 and 2019 was three times higher than the increase in the global average during the same period. This is higher than reported in previous AMAP assessments."

DOE is the lead federal agency on Arctic system modeling, and DOE has the largest federal footprint for atmospheric experimental observations in the Arctic. DOE coordinates Arctic efforts with other federal science agencies including NASA, NOAA, and NSF, and coordinates with DHS and the National Geospatial-Intelligence Agency (NGA) for DOE national lab support to DHS, NGA, and other security agencies for application of DOE scientific capabilities. DOE regularly participates in interagency groups such as the Interagency Arctic Research Policy Committee, the Civilian Application Committee, and the Environmental Security Working Group.

Arctic science is a critical part of the cryosphere component of DOE's flagship earth system model—Energy Exascale Earth System Model (E3SM). Development of sea-ice (CICE) and land-ice modeling to better simulate sea-ice and Greenland ice sheet changes is included in this effort, coordinated with interagency collaborators through the CICE consortium. Using E3SM and other more specialized models, the High-Latitude Application and Testing (HiLAT) project focuses on understanding interactions and feedbacks within the Arctic and between the Arctic and the mid-latitudes. The Interdisciplinary Research for Arctic Coastal Environments (lnteRFACE) project seeks to improve understanding of how the coupled, multi-scale feedbacks among land processes (permafrost thaw, hydrology, and erosion), sea ice (morphology and coupling), ocean dynamics (stratification, waves, and tides), coastal change (erosion, deposition, and flooding), biogeochemistry (river and marine), atmospheric processes, and human systems (transportation, resource availability and extraction, and settlements) will control the trajectory and rate of change in the Arctic system, with particular emphasis on the eastern half of the north slope of Alaska.

DOE projects address the physics, chemistry, and dynamics governing clouds, aerosols, and precipitation interactions, with the goal of reducing the uncertainty in global and regional climate

[1] https://earthobservatory.nasa.gov/images/81214/arctic-amplification

simulations and projections. DOE maintains one Atmospheric Radiation Measurement (ARM) permanent observatory at Utqiaġvik (formerly Barrow) that has been continuously collecting radar, lidar, tethered balloon, and aircraft observations for several decades. Mobile ARM facilities have been deployed for multi-month periods to the Arctic Ocean and northern Norway and for multi-year periods at Oliktok Point, Alaska.

The Next-Generation Ecosystem Experiments (NGEE) Arctic project is a 10-plus year effort to improve the predictive understanding of carbon-rich Arctic permafrost ecosystem processes and feedbacks to climate. NGEE enables systematic improvements to physical, ecological, and biogeochemical process representations of the DOE E3SM Earth system model for application to Arctic science challenges. The study collaborates with NASA's Arctic-Boreal Vulnerability Experiment (ABOVE) to help validate remote sensing products and to provide high resolution data that enables spatial analyses and scaling. DOE facilitates the sharing of data sets and endorses the FAIR (Findable, Accessible, Interoperable, and Reusable) data management principles and CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) Principles of Indigenous Data Governance and according to Foundations for Evidence-Based Policymaking Act of 2018 Public Law 115-435.

Security

As an Arctic Nation, the United States has committed to maintaining the security of our homeland, allies, and partners. In addition to ensuring national security in the Arctic, DOE includes a broader systems perspective on Arctic security including community and individual security, such as increased community resilience. DOE is the lead agency in the U.S. government for all nuclear related activity. This includes the potential deployment and integration of microreactors, increasing nuclear powered shipping in the Arctic, historic radioactive source recovery, and nuclear related environmental management. DOE is responsible for monitoring Arctic nuclear activities and being prepared to respond to potential Arctic nuclear incidents. DOE is also responsible for long-term surveillance and maintenance, workforce restructuring and benefits, property management, land use planning, and community assistance for sites and activities related to the legacy of World War II and the Cold War. Two DOE legacy sites are located in the Arctic.

DOE, in conjunction with other agencies, is working to ensure access to critical minerals and infrastructure located within the Arctic. DOE works with the Department of Defense and other agencies on initiatives to enhance the resilience of critical energy infrastructure in the Arctic. DOE, through the national lab complex, delivers capabilities to support DHS, DOD, and the intelligence community security missions. In addition to these more traditional global and national security roles, DOE has invested in developing local capacity and ongoing research to support community and individual level security (such as research in the critical food-energy-water nexus).

The potential U.S. deployment of nuclear power to Arctic and/or Alaskan locations is a critical issue that can uniquely be addressed by the DOE. Building on the NAS 2050 Arctic Futures tabletop exercise on Arctic nuclear incident response, DOE must be prepared for and should anticipate the increased Arctic activities and the potential for nuclear incidents. Changes in natural systems and the level of human activity in the Arctic has implications for DOE's non-proliferation and treaty-verification missions.

International

DOE is strengthening bilateral relationships with individual Arctic states across the DOE pillars of energy, science, and security. Multi-lateral engagement is conducted through support of Arctic Council activities, including the Arctic Remote Energy Network Academies (ARENA), and DOE has actively worked to develop and support an Alaska to Arctic link between Alaska institutions and international partners.

Interagency

DOE actively supported inter-agency efforts to maintain America's Arctic interests. As a statutory member of the National Security Council, DOE actively participates in interagency support for Arctic decision making, including implementation of the 2014 National Strategy for the Arctic Region and other initiatives. DOE also serves on the Arctic Policy Group chaired by the State Department, i.e., the Committee on the Maritime Transportation System (CMTS) Arctic Interagency Action Team, to support Arctic maritime access and research, the Civil Applications Committee, the Environmental Security Working Group, the Arctic Executive Steering Committee, the Interagency Arctic Research Policy Committee, and other tasks as directed. In addition, in collaboration with EPA and their Region 10 experts focused on activities in Alaska, DOE is acquiring new technical insights regarding Arctic operations, specifically focusing on ecological sensitivities and prospective permafrost impacts tied to LNG and CCS infrastructure development; whether favorable geology exists to support carbon storage; and implications for communities having limited access to energy.

Government-to-Government Alaska Native Relationship Building

DOE is committed to outreach, notice and consultation with Alaska Natives relating to decisions affecting the Arctic. DOE's commitment includes complying with federal cultural resource protection and other laws and executive orders to preserve and protect historic and cultural sites and traditional Indigenous practices. DOE also seeks to coordinate among programs to provide technical assistance, education and training programs. DOE further seeks to work with other federal and state agencies relating to tribal matters in the Arctic.

3 The DOE Strategy

VISION The Department of Energy will be an essential source of science, technology, and engineering solutions for accelerating the energy transition, enabling science-based decision making, and ensuring national security in the Arctic.

The DOE Arctic strategic goals are underpinned by these foundational principles:

- DOE's Arctic efforts will be appropriately balanced and integrated across the three strategic goals of energy, science, and security.
- DOE will coordinate with Arctic inhabitants (including Indigenous Peoples), other Federal agencies, state and local organizations, and international partners and allies to ensure understanding of Arctic challenges, energy equity, and applicability of solutions.
- DOE, through the Arctic Energy Office, will collaborate across program offices; leverage DOE's national laboratories; facilitate public and private sector engagement; and partner with foreign allies to strategically address Arctic challenges.
- DOE will prioritize community-based and place-based solutions as defined by the people of the Arctic, including Indigenous Peoples.
- DOE will prioritize local capacity building and decision making for all DOE goals.
- DOE will catalyze, support, and leverage private-sector adoption and capacity for secure and sustainable U.S. Arctic interests.
- DOE data stewardship and application responsibilities will be integral to DOE Arctic activities.
- DOE will address diversity, justice and equity issues in its efforts throughout the Arctic.
- As elsewhere across the nation, the DOE's actions in the Arctic region will align with the President's goals to:
- Establish a carbon pollution-free power sector by 2035;
- Achieve a net-zero carbon emissions economy by 2050; and
- Ensure that disadvantaged communities realize at least 40 percent of the overall benefits from clean energy investments.

To fulfill this vision, the Department of Energy (DOE) will apply its core mission competencies and capabilities to achieve these strategic goals:

1. DOE will lead and partner to advance the decarbonization, resilience, and equity of the Arctic **energy** sector.

   Objective 1.1: DOE will ensure investments towards energy transition are informed by and relevant to Arctic climate challenges and equity considerations.

   Objective 1.2: DOE will develop, demonstrate and deploy energy technologies, and make available technical assistance and loan programs, to enhance the resilience of Arctic communities and critical infrastructure in the Arctic region.

   Objective 1.3: DOE will lead and partner to ensure decarbonized energy is a part of future Arctic infrastructure.

   Objective 1.4: DOE will lead the safe and secure integration of small, modular, and mobile nuclear energy to support energy resilience and decarbonized energy.

2. DOE will lead and partner to advance the **scientific** understanding of Arctic challenges.

   Objective 2.1: DOE will use Exascale[2] computing to lead the high-resolution Earth system modeling of natural, managed, and man-made systems to answer pressing Arctic problems.

   Objective 2.2: DOE will engage with federal, state, local, tribal, academic, and international partners to advance the scientific understanding of the Arctic.

   Objective 2.3: DOE will ensure Arctic relevance of fundamental scientific and engineering investments in infrastructure.

   Objective 2.4: DOE will lead the integration of new technological advances (e.g., artificial intelligence) to enhance our ability to inform response and support decision making about climate changes.

3. DOE will lead and partner to ensure Arctic **security**.

   Objective 3.1: DOE will provide technical capability and solutions to execute traditional homeland, national, and global security missions with a focus on the impacts of a changing climate.

   Objective 3.2: DOE will develop and deploy solutions to support individual and community security in the Arctic.

Objective 3.3: DOE will steward lab resources and facilitate increased cooperation between labs and USG interagency, state, local, tribal, academic, and international partners to address Arctic security.

[2] https://www.exascaleproject.org/

Objective 3.4: DOE will lead and partner to improve Arctic all-domain awareness.

The DOE Arctic vision was crafted to enable a cohesive, cross-department Arctic strategy integrating activity across the three pillars of energy, science, and security.

To enable implementation of the DOE Arctic Strategy, the Arctic Energy Office will lead the coordination of programmatic activities across the DOE complex. As appropriate for specific objectives and contexts, DOE will make use of different programs and partnership mechanisms, including DOE program-directed activities, DOE-sponsored cross-discipline science and technology initiatives, externally sponsored National Laboratory projects, National Laboratory-directed research and development activities, technology transition and private-sector partnership initiatives, and interagency collaboration networks.

4 Goals, Objectives and Strategies

The programmatic objectives supporting the DOE strategic goals are described in more detail here, highlighting some of the unique contributions that DOE can offer to support the DOE Arctic Strategy and the National Strategy for Arctic Regions. The foundational principles identified earlier are also described in more detail.

VISION The Department of Energy will provide essential science, technology, and engineering solutions to support the increasing U.S. Arctic engagement.

To fulfill this vision, DOE will apply its core mission competencies and capabilities to achieve these strategic goals:

1. DOE will advance the sustainability, resilience and equity of the Arctic **energy** sector.

Energy is critical to the physical, environmental, and economic viability and vitality of Arctic communities and industries. The isolated nature of the Arctic mandates an energy sector that can provide affordable, reliable, accessible services without vulnerability to interruptions in its ties to other regions. Climate change is introducing rapid and radical effects that require energy systems able to adapt resiliently to the rapidly evolving natural and societal conditions. Energy accessibility and security is required to address the extreme disparities in well-being that exist across the Arctic.

These challenges are not unique to the Arctic. Business-as-usual energy approaches are not able to address the present and evolving needs in the Arctic and elsewhere. The Arctic provides an effective and compelling venue for demonstrating to the rest of the world how to effectively transition to a lower carbon future while maintaining socioeconomic viability and cultural resources with a focus on energy equity.

Working in collaboration with the people of the Arctic, leveraging inter-regional synergies wherever possible and appropriate, the DOE will develop and deploy the energy technologies required to enable sustainable life and work in the Arctic region.

> Objective 1.1: DOE will ensure investments towards energy transition are informed by and relevant to Arctic climate challenges and equity considerations.

Climate change effects are introducing widespread and severe challenges to the Arctic energy system. Permafrost degradation and subsidence is damaging, or establishing imminent threats to, the physical integrity of Arctic energy infrastructure (e.g., pipelines, electricity distribution systems, fuel tank farms, power plant buildings, etc.). Spring and summer storms are accelerating shoreline erosion in the vicinity of ocean and river communities. Changes in precipitation (e.g., rain, snow, etc.) are shifting the availability (e.g., location, quantity, and timing) of water for hydroelectric (e.g., dams, run of the river, etc.) systems, reducing navigability of rivers and availability of winter ice roads to the detriment of fuel/supplies delivery, and changing river channel locations and debris loads. Wildfire frequency and severity is rapidly increasing in the midst of climate-compromised forests. Climate change is impacting the types, amounts, and location of species (e.g., fish, mammal, plant, etc.) that provide food, employment, cultural and recreational resources for many Arctic residents. For many coastal and riverside communities, partial or complete relocation to safer, less vulnerable settings are the only viable options for their future vitality.

Climate change is impacting the availability and accessibility of local renewable energy resources. Changing wind patterns and weather conditions are adversely affecting the performance of some existing wind and solar installations and making existing meteorological databases and models less relevant as a means of forecasting the available energy resources.

Climate change is also introducing new economic opportunities in the Arctic. Northern maritime activity is increasing directly in response to reductions in sea ice distribution and thickness. With that comes the need for new northern ports, better navigation aids, and expanded emergency capabilities (spill response, search and rescue, emergency shelter). Awareness of, and access to, mineral resources, including rare earth elements and critical minerals, is expanding because of permafrost changes, glacial and sea ice retreat, establishing new sites for extraction, processing, and transportation. Seafood processing locales and techniques are shifting as species migrate and evolve in response to water temperature and food chain characteristics.

DOE efforts in the Arctic will prioritize accurate and accessible databases and climate modeling capabilities to guide human and infrastructure capacity investments in this highly dynamic and complex environment. DOE will ensure technology development focuses on solutions that enable residents of the Arctic to effectively navigate and adapt to their changing natural and economic setting.

> Objective 1.2: DOE will develop, demonstrate and deploy energy technologies, and make available technical assistance and loan programs, to enhance the resilience of Arctic communities and critical infrastructure in the Arctic region.

Arctic energy requirements include heat, power, and transportation. While the specific technology, fiscal and human considerations vary across the Arctic, there are many similarities within portions of the region.

Energy efficiency in built structures (e.g., residences, community, and government), public-serving infrastructure, industrial operations and military installations is vitally important as a pathway to reducing reliance on imported fossil energy and appropriately scoping investments in new energy system elements. Because of the low population density, difficult natural environment, and challenging logistics of the Arctic, local capacity building is a critical part of energy infrastructure deployment.

In the Arctic, as globally, transitioning to more sustainable and resilient energy systems will include moving from a few large monolithic systems to aggregates of smaller, self-sufficient solutions that integrate a diverse mix of energy resources and can be selectively interconnected or disconnected, depending on optimal responses to external conditions. Energy sourcing, processing, storage, distribution, and management functions must be addressed.

The geographic vastness and isolation of the Arctic mandates availability of transportation systems that are reliable, affordable, and able to accommodate changing local conditions. Transportation applications involve moving people and goods by road, rail, water (e.g., sea, river, lake, etc.), and air within and between Arctic settings, and between the Arctic and the exterior world.

Technology transition can be accomplished more robustly and extensively via technology demonstrations that provide opportunities for incorporating lessons learned from the field experience and enable multiple entities to observe installations that are place-relevant for them and to benefit from the experience of others via inter-stakeholder communication and networking. Effective technology transition includes building local capacity (from general energy literacy to technology-specific installation/operation/maintenance capability) and ensuring that technology implementation can be accomplished affordably.

DOE’s expertise includes energy technology development and its transition to the field, benefiting public, private and government partners. DOE will work with local Arctic stakeholders to ensure changes to the energy infrastructure serving community, industry and government interests address regional priorities, are appropriate for climate and culture conditions in the Arctic, engage and build in-region capacity, and maximally integrate flexible, adaptable architectures in order to yield truly sustainable and resilient solutions.

Objective 1.3: DOE will lead and partner to ensure decarbonized energy is a part of future Arctic infrastructure.

Arctic Alaska also depends economically on the export of energy commodities. Minimizing the environmental impacts associated with the extraction, processing, and transport of fossil energy sources produced in the Arctic, with a specific focus on methane mitigation, is a key part of a decarbonization strategy. In addition, DOE can support the responsible development of rare earths and critical minerals as an economic diversification strategy.

In much of the Arctic, there is a strong reliance on fossil fuels to generate electrical power, provide heat, and transport people and goods. Ironically, in a region where export of its oil, natural gas and coal resources contributes significantly to the regional economy, much of the fossil fuel used locally must be imported. Diesel, natural gas and coal are used most widely. In some larger locations, combined heat and power systems are used. Energy prices vary drastically, depending on the options available for acquiring the fuel. If a pipeline is not economically viable, fuel must be transported to the end user. Often fuel delivery is only possible on a seasonal basis – for example, by barge while the ocean and rivers are free of ice, or by tanker truck during only the very coldest months when ice roads can be constructed and used. In some cases, fuel must actually be flown in. The resulting energy burden exceeds 10% in even the more populated areas and can be considerably greater than 25% in rural areas or among lower income city neighborhoods (both of which typically have high disadvantaged population demographics).

As a matter of necessity, the Arctic region has become a leader in renewable energy development and integration, with more than double the global average in the percentage of power generated from renewable resources. Countries like Iceland and Norway source virtually 100% of their energy for heat and power from renewable resources. The United States is actively working with partners across the region to share best practices and enhance the region's overall energy resilience. In an estimated 250 locations, diesel fuel is augmented with local sources of renewable energy such as hydropower, wind, solar, biomass, marine hydrokinetic or geothermal energy. Alaska has played a leadership role in incorporating renewable resources into community-scale microgrids.

Effective decarbonization of the Arctic energy sector must address fiscal realities (e.g., economic reliance on export of energy commodities, high energy burden in disadvantaged communities, etc.), climate-related requirements for efficient buildings, bimodal (i.e., concentrated urban, widely separated rural communities) population distribution, and stranded (i.e., physical separation between energy supply and demand centers) renewable energy resources in much of the region.

Objective 1.4: DOE will lead the safe and secure integration of small, modular, and mobile nuclear energy to support energy resilience and decarbonized energy.

Nuclear energy can enable resilient, reliable heat and power for years with low physical and on-site labor footprints. The DOE (i.e., Office of Nuclear Energy and national laboratories), US military, NASA, NRC, industry, universities, and state agencies are evolving technologies, analytic tools, and permitting procedures that may establish small reactors as a viable resource for Alaska and other Arctic or remote settings. The smaller systems (1-10 megawatt) are being designed for factory-assembly that can be readily transported and installed as modular units. Small Modular Reactors (SMR), generating from 60 to 300 megawatt, may replace thermal power stations presently running on fossil fuels. Additional flexibility for deployment in the Arctic region is provided by small mobile reactors (1-5 megawatt) that will undergo testing in the near future in DOE labs. Other Arctic states are actively engaged in similar development efforts.

DOE efforts will prioritize advance engagement with Arctic Indigenous Peoples to ensure their effective inclusion in establishing siting considerations / constraints and identifying preferred applications for the small nuclear systems. DOE will provide technical, environmental, and economic insight to undergird state and regional roadmaps for exploration and implementation of small nuclear reactors. DOE will pursue technical and economic development in both reactor (e.g., capacity, heat/power ratio, transient response) and integration (energy storage, remote monitoring, etc.) technologies. DOE will provide expertise for development of the local workforce required for reactor installation, operation, maintenance, and decommissioning. DOE will ensure reactor testing and demonstration activities incorporate Arctic requirements (e.g., performance, integration) in their planning and execution.

2. DOE will lead and partner to advance the **scientific** understanding of Arctic challenges.

DOE Arctic research support spans earth science, ocean science, space science, and more. The Department's Office of Science advances climate change research to provide knowledge of effects of greenhouse gas emissions on Earth's climate and biosphere. In the Arctic, DOE supports modeling and prediction, including the Regional Arctic System Model; atmospheric system research, including Atmospheric Radiation Measurement facilities on the North Slope of Alaska; the Interdisciplinary Research for Arctic Coastal Environments (InteRFACE); and the Next Generation Ecosystem Experiment (NGEE) - Arctic. DOE is committed to integration of traditional ecological knowledge.

> Objective 2.1: DOE will use Exascale computing to lead the high-resolution Earth system modeling of natural, managed, and man-made systems and to answer pressing Arctic problems.

DOE investments in both achieving Exascale computing and developing next generation global climate models capable of utilizing Exascale computing platforms have dramatically advanced scientific understanding of climate change and the Arctic ecosystem. DOE will continue to invest

in advancing the computing platforms and the modeling infrastructure. Improved Arctic process knowledge, the co-production of this knowledge, and advancing Exascale computing are high priority areas for DOE. Regional downscaling is necessary to support Arctic decisions and policy.

Current Earth system models are increasingly refining their resolution and addressing multi-scale phenomena in ways that will prove invaluable in thinking about future directions and impacts in the Arctic. However, their ability to fully integrate key processes and landscape components (e.g., permafrost, glaciers, soil moisture, etc.) across critical local, regional and global scales is still a work in progress. Furthermore, these models are in very early stages of thinking about how to consider and ultimately integrate built systems (infrastructure, energy systems, water resources, and gas distribution) in ways that enable true systems approaches to the existing and future economic, societal, and security concerns in the Arctic. As the region works to cope with a changing climate and its resultant impacts on buildings, energy needs, and the local and extended economies, significant enhancements in the predictive capability of models and analytical tools at a variety of scales are required to support planning and decision making. An additional gap exists between the complexity of process representations reasonable for global earth system model simulations and those needed for place-specific simulations in support of decision analysis and planning.

> Objective 2.2: DOE will engage with federal, state, local, tribal, academic, and international partners to advance the scientific understanding of the Arctic.

DOE will continue to engage through venues such as the Interagency Arctic Policy Committee (IARPC), the United States Arctic Research Commission (USARC), and the Arctic Council which includes organizations such as the Inuit Circumpolar Council. DOE activities directly support the National Strategy for Arctic Regions strategic objectives of expanding research to better understand climate change and the USARC goal of "Enhance International Scientific Cooperation in the Arctic." One example of this is the mix of DOE activities underway at Utqiaġvik. DOE work at Utqiaġvik (including but not limited to the permanent ARM site) is done in cooperation with the Ukpeaġvik Iñupiat Corporation, several federal agencies, Alaska state agencies, multiple academic partners and international collaborations. To support the National Strategy on Arctic Regions, DOE will expand our monitoring and predictive capacity with better data collection and observational tools and global climate models.

> Objective 2.3: DOE will ensure Arctic relevance of fundamental scientific and engineering investments in infrastructure.

Leveraging long-standing DOE expertise in assessing the risk, vulnerability, and interdependence of critical infrastructure faces challenges in the Alaskan Arctic. Most Alaskan Arctic communities have local power and water systems that are not connected to a larger system or grid. Most risks to this infrastructure, as well as water supply and wastewater systems, are local and site specific. A key challenge is how to best leverage DOE Earth System,

infrastructure, and multi-sector dynamic expertise to assist communities in assessing vulnerability and resilience at actionable time scales.

> Objective 2.4: DOE will lead the integration of new technology advances (e.g., artificial intelligence) to enhance our ability to inform response and support decision making about climate changes.

As a science agency, the Energy Department plays an important role in the innovation economy. The Department catalyzes the transformative growth of basic and applied scientific research, the discovery and development of new clean energy technologies, and prioritizes scientific innovation as a cornerstone of US economic prosperity. Through initiatives like the Loan Programs Office (LPO) and the Advanced Research Projects Agency-Energy (ARPA-E), the Department funds cutting-edge research and the deployment of innovative clean energy technologies. DOE is working to develop new technologies, such as Artificial Intelligence (AI), which is poised to be the most transformative technology of this, or perhaps any, generation in American history. The challenges and opportunities in the Arctic are some of the most extreme, requiring the technological advances that DOE frequently delivers. Also, the harsh proving ground of the Arctic provides a living laboratory to prove out these new technologies and potentially provide global solutions. DOE must exercise its world-leading science and technology enterprise to deliver Arctic solutions, capturing this opportunity and associated economic, environmental, and energy and national security benefits for the American People.

3. DOE will lead and partner to ensure Arctic **security**.

Significant changes are occurring in the Arctic. These changes are obvious in both the natural system (climate change and Arctic amplification) and the geopolitical system. The changing Arctic is increasing geopolitical interest, and DOE brings significant investment in capabilities and potential new investments to increase individual, community, national, and pan-Arctic security.

Arctic security, from a domestic perspective, has traditionally been viewed through a Cold-War and post-Cold-War great power competition perspective which waxes and wanes with international relationships between the U.S. national interests, our allies, and peer or near-peer adversaries. This national security aspect of Arctic security is not diminishing. The “opening” of the Arctic and a recognition of the individual and community security needs of Arctic residents has expanded the Arctic security demands that DOE and the national lab complex must help address.

> Objective 3.1: DOE will provide technical capability and solutions to execute traditional homeland, national, and global security missions with a focus on the impacts of a changing climate.

Arctic energy systems are vulnerable to both natural hazards and malicious or accidental human activities. The Arctic has a broad range of natural hazards–earthquakes, such as the 2021 May 30 magnitude 6.1 in Alaska; extreme cold (-40F or colder for two weeks or longer); boreal forest wildfires; volcanos (impact transportation required to support the Arctic energy system); and more. Human activities that diminish Arctic energy system reliability, resilience, safety, and security include cyber and cyber-physical threats, supply-chain vulnerabilities, and even neglect or lack of local capacity to perform necessary maintenance. DOE will consider this broad range of hazards as the Arctic energy transition is accomplished.

> Objective 3.2: DOE will develop and deploy solutions to support individual and community security in the Arctic.

Many remote Alaskan communities were traditionally semi-nomadic prior to settlement by the federal and state government. Communities were often sited along routes that allowed for easy barge access for construction of schools and other buildings. These locations—while stable in the 1950's—are increasingly impacted by the effects of climate change. Relocation of entire communities will become increasingly common over the next few decades as roughly 70% of all Arctic infrastructure sits atop degrading permafrost. Co-development of village infrastructure that is affordable, safe, and climate appropriate will be key to ensuring that past injustices do not get repeated in this process. Additionally, the lands of many Indigenous Peoples of the Arctic are heavily relied upon for fossil fuels and critical minerals. Ensuring adequate consultation of communities and appropriate compensation for extraction activities is key to addressing economic and environmental justice in the Arctic. Federal, state, and local economic policies require coordination to ensure maximum benefits.

> Objective 3.3: DOE will steward lab resources and facilitate increased cooperation between labs and USG interagency, state, local, tribal, academic, and international partners to address Arctic security.

DOE utilizes the Arctic Energy Steering Group to coordinate departmental Arctic policies and activities. The DOE has established the Arctic Lab Partnerships (ALPs) to facilitate DOE lab Arctic activities and improve collaboration. DOE is utilizing the Arctic Energy Office to provide a single point of contact for DOE Arctic engagement.

> Objective 3.4: DOE will lead and partner to improve Arctic all-domain awareness.

Planning and conducting activities by operational entities within the U.S. Arctic Extended Economic Zone (EEZ) and across the maritime domain of the pan Arctic region is complicated by environmental changes that challenge the ability for predictive models to characterize sea ice and associated marine and atmospheric conditions. Achieving environmental domain awareness and associated understanding in the Arctic is one of the more significant challenges for operational entities, especially as the physical environment of the Arctic undergoes significant change. Advancing an intelligent, data driven decision framework to support Arctic regional

domain Awareness in support of Arctic Security, should consider means for Environmental Data acquisition, integration and presentation (useful to improve Arctic operator decision making).

The enormous geographic size of the Arctic, coupled with its limited population, sparse environmental sensing, inadequate communication networks, and insufficient satellite coverage (requiring polar orbiting, as latitudes preclude effective use of equatorial based geo-stationary orbits), exacerbate the problem of maintaining a consistently useful situational awareness of the Arctic environment. Even when environmental data are available, the timeliness, resolution, fidelity and predictability are generally insufficient for planning and operational activities.

Principles: The DOE Arctic strategic goals are underpinned by these foundational principles:

- DOE's Arctic efforts will be appropriately balanced and integrated across the three strategic goals of energy, science, and security.

DOE's responsibilities cross energy, science, and security missions. AEO will maintain cognizance of DOE Arctic activities across all three areas and will provide feedback to DOE leadership regarding the balance of DOE Arctic work across these disciplines.

DOE will coordinate with Arctic inhabitants (including Indigenous Peoples), other Federal agencies, state and local organizations, and international partners and allies to ensure understanding of Arctic challenges, energy equity, and applicability of solutions.

In accordance with DOE order 144.1 guiding DOE's relationship with Tribal Nations and Alaska Native Corporations, DOE Arctic activities will be guided by mechanisms for outreach, notice, and consultation, to ensure integration of Indian Nations into decision-making processes.

- DOE, through the AEO, will collaborate across program offices; leverage DOE's national laboratories; increase private enterprise engagement; and partner with foreign allies to strategically address Arctic challenges.
- DOE will prioritize community-based and place-based solutions as defined by the people of the Arctic, including Indigenous Peoples.

Community engagement in regional energy planning processes has been successful in the Arctic. Regional Energy Plans provide a mechanism for identifying regional solutions and fostering collaboration between communities in order to achieve economies of scale. The DOE Alaska Strategic Technical Assistance Response Team (START) program is a successful model implementing regional energy plans at the community level. DOE funded and collaborative science projects should engage in the best practices for co-production of knowledge as described by the Inuit Circumpolar Council (ICC) and based on the guidance to U.S. agencies described by the IARPC five-year plan: (ICC Alaska, 2020, p. 32) co-production of knowledge is a process by which Indigenous Knowledge and science are brought together to understand the Arctic for adaptive and holistic decision-making. IARPC adopts this definition as it encompasses the many formal and informal processes by which Indigenous Peoples, Arctic communities, researchers, and policy makers work together to define challenges and conduct research collaboratively.

- DOE will prioritize local capacity building and decision making for all DOE goals.

DOE will, primarily through the AEO and the Office of Indian Energy, increase the number of projects developed within the context of rural Alaska workshops; facilitate internships, work/studies, and practicums with the National Lab's technician training programs; facilitate site visits to other villages, national laboratories, and other locations with innovative energy technology; provide in-depth, hands-on training for rural utility operators; work with the private sector to develop tools for advanced energy system operation and management (O&M) in the rural Arctic context; and provide technical assistance for development, operation, maintenance, and troubleshooting of innovative energy systems.

- DOE will catalyze, support, and leverage private sector technology adoption and operational capacity for secure and sustainable U.S. Arctic interests.

In order to advance the energy transition in the Arctic, the gap between innovation and deployment must be addressed. The DOE and DOE labs have made long-term, significant investments in energy technologies. Deployment of these technologies, including technologies for improving efficiency, must be a high priority. Through partnerships with the DOE Office of Technology Transitions and other deployment focused offices, the AEO must prioritize technology deployment. Additional technology development and basic research must continue, so AEO should remain cognizant of fundamental research investments by DOE, especially through continued engagement with ARPA-E.

- DOE data stewardship and application responsibilities will be integral to DOE Arctic activities.

As described in the IARPC five-year strategy (2022-2026), Arctic data, which can include Indigenous Knowledge, are irreplaceable. Often stemming from difficult and remote conditions, Arctic data are invaluable in this time of rapid environmental change. Data management is critical to basic research, monitoring, and applied research in the Arctic. DOE will follow best practices described in a 2018 National Academies' study related to open, searchable, and rapidly accessible data. As appropriate, DOE will adopt open data collections, develop intelligent data management tools and practices, and use existing data and metadata platforms to achieve interdisciplinary and interagency coordination. Arctic research, co-production of knowledge, and data management now operate in an environment of FAIR (Findable, Accessible, Interoperable, and Reusable) data management principles (Wilkinson et al., 2016) and CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) Principles of Indigenous Data Governance (Carroll et al., 2020). While working toward open and accessible data, DOE will pursue nuanced approaches that protect private and sensitive data and that respect Indigenous data sovereignty (Carroll et al., 2019) and autonomy.

- DOE will address diversity, justice and equity issues in its efforts throughout the Arctic.

DOE works to ensure that everyone is afforded an opportunity to participate fully in the Department's programs, opportunities, and resources. This commitment includes all DOE Arctic efforts, and DOE encourages partnerships with Minority Serving Institutions and other minority-owned and serving entities. DOE seeks to increase contracting opportunities for small and disadvantaged businesses by establishing goals, crafting smart policies, and developing programs to increase the support going to small businesses through government contracts. In addition, DOE assures equal opportunity for minorities, women, persons with disabilities, and people with limited English proficiency. Lastly, DOE works to create and sustain a high-performing, inclusive workforce by leveraging diversity and empowering all employees to achieve superior results in the service of our Nation.

- As elsewhere across the nation, the DOE's actions in the Arctic region will align with the President's goals to:
    - Establish a carbon pollution-free power sector by 2035;
    - Achieve a net-zero carbon emissions economy by 2050; and
    - Ensure that disadvantaged communities realize at least 40 percent of the overall benefits from clean energy investments.

5 List of Acronyms

ABOVE	Arctic-Boreal Vulnerability Experiment
AEO	Arctic Energy Office
AMAP	Arctic Monitoring and Assessment Programme
ARENA	Arctic Remote Energy Network Academy
ARM	Atmospheric Radiation Measurement
ARPA-E	Advanced Research Projects Agency-Energy
CAC	Civilian Application Committee
CARE	Collective Benefit, Authority to Control, Responsibility, Ethics
CCS	Carbon Capture and Storage
CICE	Sea ice model
CMTS	Committee on the Maritime Transportation System
CORE-CM	Carbon Ore, Rare Earth and Critical Minerals
DHS	Department of Homeland Security
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
E3SM	Energy Exascale Earth System Model
ESWG	Environmental Security Working Group
FAIR	Findable, Accessible, Interoperable, and Reusable
GHG	Greenhouse Gas
GMLC	Grid Modernization Laboratory Consortium
HiLAT	High-Latitude Application and Testing
IARPC	Interagency Arctic Research Policy Committee
ICC	Inuit Circumpolar Council
lnteRFACE	Interdisciplinary Research for Arctic Coastal Environments
LCA	Life cycle analysis
LNG	Liquefied Natural Gas
LPO	Loan Programs Office of the U.S. Department of Energy
NASA	National Aeronautical and Space Administration

NGA	National Geospatial-Intelligence Agency
NGEE	Next-Generation Ecosystem Experiments
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
NSAR	National Strategy for the Arctic Region
NSF	National Science Foundation
SMR	Small Modular Reactors
START	Alaska Strategic Technical Assistance Response Team
SEIS	Supplemental Environmental Impact Statement
USARC	United States Arctic Research Commission

For more information, visit:
energy.gov/arctic/arctic-energy-office

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