Fission Vision:
Doubling Nuclear Energy Production to Meet Clean Energy Needs

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NUCLEAR INNOVATION ALLIANCE

Fission Vision:

Double domestic nuclear energy production by 2050 to help achieve 100% clean energy in the United States

Decarbonizing the American economy means reducing carbon emissions from everything – the electric grid, the cars and trucks, the trains, the ships, the factories, the home heating systems, the steel mills, the cement kilns, the chemical refineries, and everything that heats, cools, lights, spins a motor, pumps a gallon of water or a gallon of sewage, ventilates a classroom or runs a hospital's heart-lung machine.

This scale of decarbonization will require massive quantities of zero-carbon energy, including nuclear energy. **Fission Vision** is a vision for America's clean energy future developed by the Nuclear Innovation Alliance: double domestic nuclear energy production by 2050 to help achieve 100% clean energy in the United States.

Several other low-carbon generating technologies like wind and solar have been deployed in increasing numbers in the past decade and will reduce emissions from fossil fuels. These technologies alone, however, will not suffice for an entire energy system. The nation's energy system, a complex web of production and consumption, will require generation that can be dispatched when needed, when abundant but variable renewable energy isn't available, and when safety, economic activity, and human health and comfort demand energy.

Advanced nuclear energy has the potential to greatly reduce carbon emissions by mid-century and help achieve 100% clean energy in the United States. This promise can only be achieved with the timely, efficient, and widespread deployment of advanced reactors.

Fission Vision - doubling domestic nuclear energy production from 800 TWh to at least 1600 TWh by 2050 - requires rapid and sustained deployment of advanced nuclear energy. Doubling domestic nuclear energy by 2050 in the United States requires constructing at least 100 gigawatts of new nuclear energy production in the next 30 years. This deployment rate may seem daunting, but nuclear energy has been constructed this quickly in the United States before. Over 100 gigawatts of light water reactors were constructed in the United States between 1960 and 1990. Application of modern manufacturing and construction practices can help us meet or exceed historic nuclear energy deployment rates and enable the doubling of domestic nuclear energy production by 2050 using advanced nuclear energy.

Fission already provides reliable, carbon-free energy at scale. **Fission Vision** focuses industry, government, and civil society on a substantial buildout of advanced reactors to meet the public need for safe, reliable, affordable, and clean energy. **Fission Vision** requires a whole-of-society strategy – industry, government at all levels, and civil society all have important roles to play in creating the technical, policy, social and commercial conditions for success. Enabling the rapid deployment of domestic advanced nuclear energy to meet clean energy and climate goals is critical to the successful realization of **Fission Vision**.

Fission Vision – the doubling of nuclear domestic energy by 2050 – can be realized by achieving three key objectives:

- **Catalyzing a robust U.S. innovation and commercialization ecosystem**
- **Ensuring "social license" to operate advanced nuclear energy**
- **Re-imagining and integrating advanced nuclear energy with other clean energy sources**

Fission Vision is an ambitious but achievable national goal to double nuclear energy production. It will catalyze deployment of advanced nuclear energy technologies and play a major role in transitioning the United States to 100% clean energy by 2050.

Crosscutting technical and policy leadership by the U.S. Department of Energy is an essential first step towards realizing **Fission Vision**. Creation of a new Advanced Nuclear Energy Earthshot at the Department of Energy, based on the DOE Earthshot initiative model pioneered for other technologies, could rapidly accelerate U.S. development and deployment of advanced nuclear energy technologies.

Fission Vision will catalyze significant global progress on both energy access and energy decarbonization through deployment of advanced nuclear energy. The U.S. is uniquely suited to developing innovative technologies. A coordinated national effort can make U.S. advanced reactors available worldwide to decarbonize power, heat, transportation, and other sectors in developed and emerging economies.

Objective 1: **Catalyzing a robust U.S. innovation and commercialization ecosystem**

The U.S. innovation and commercialization ecosystem is complex web of universities, national laboratories, technology developers, entrepreneurs, a variety of businesses across the advanced nuclear energy supply chain, and federal agencies. A robust ecosystem for advanced nuclear energy is key to U.S. success in achieving **Fission Vision**.

Advances in the design, manufacturing, and construction of advanced nuclear technology could enable the more rapid deployment of domestic nuclear energy but require deliberate business and policy decisions to create the conditions for success.

Catalyzing a robust U.S. innovation and commercialization ecosystem requires:

- Rebuilding the Supply Chain
- Completing Nuclear Projects on Time and on Budget
- Creating Incentives for Deployment
- Enabling Private Investments

Creating these conditions for success requires a whole-of-society effort. Utilities and energy end users must clearly communicate their needs and essential characteristics for new low-carbon energy sources. Advanced reactor developers must create products and projects that statisfy market needs and are completed on schedule and on budget.Investors must receive market signals adequate to induce major investments in advanced nuclear energy projects to support rapid deployment. Government must accelerate commercialization of advanced nuclear technologies by supporting research, development, demonstration and deployment.

Development of a new national strategy to realize **Fission Vision** should leverage existing thought leadership on the needs facing the advanced reactor community. In early 2021, the Nuclear Innovation Alliance and the Partnership for Global Security released the U.S. Advanced Nuclear Energy Strategy, which outlined how the U.S. can establish global leadership in next generation nuclear energy technologies. This Strategy can act as a foundation for a national strategy and be elaborated as needed to incorporate the needs of all stakeholders.

Rebuilding the Supply Chain

- Provide assurances of fuel availability for advanced reactors (including high-assay low-enriched uranium) to catalyze a mature commercial advanced reactor fuel cycle
- Build out the nuclear manufacturing and supply chain, including factories for reactor construction domestically or in allied countries

Completing Nuclear Projects on Time and on Budget

- Utilize best practices in project management, contracting, and oversight for advanced nuclear energy projects to meet schedule goals at a reasonable cost
- Incorporate design innovations to simplify reactor projects, such as modularity, smaller size, more factory production of components, more standardized components, and less onsite construction

Creating Incentives for Deployment

- Include advanced nuclear energy with all other clean technologies in policy incentives to decarbonize energy systems
- Structure advanced reactor projects and schedules to achieve end-user priorities and project timelines
- Utilize incentives for early advanced nuclear energy projects to reduce first-mover risks and enable learning-by-doing

Enabling Private Investments

- Support deployment of multiple advanced nuclear energy projects to demonstrate learning-by-doing and accelerate commercial viability
- Create financing support programs to reduce market risk of early-mover advanced nuclear energy projects
- Structure advanced reactor tax incentives to encourage private investment in advanced nuclear energy projects

Objective 2: **Ensuring "social license" to operate for advanced nuclear energy**

Ensuring "social license" for new clean energy technologies is imperative for the successful, rapid and wide-scale deployment of new energy infrastructure. Citizens and communities must have confidence that new clean energy technology is safe, and that risks and benefits are well understood and fairly distributed. Citizens and communities need effective, efficient and consent-based processes to ensure their priorities and concerns are taken into account.

Advanced nuclear energy must develop a strong social license to support the doubling of domestic nuclear energy production by 2050 to help achieve 100% clean energy in the United States.

Developing strong social license for advanced nuclear energy requires:

- Modernizing Advanced Nuclear Energy Regulation
- Making Progress on Spent Nuclear Fuel
- Getting Siting Right for Advanced Nuclear Energy
- Prioritizing Environmental and Energy Justice

These conditions for success are critical to the successful deployment of advanced reactors. Developing social license for new projects by prioritizing environmental and energy justice and getting siting right not only create more equitable energy systems but can reduce overall commercial project risk by reducing the likelihood of legal or political challenges during or after construction. Modernizing advanced nuclear energy regulation can create more effective and efficient licensing processes that benefit both the public and advanced reactor applicants. Making progress on spent nuclear fuel management for existing reactors can demonstrate that solutions are possible and that spent nuclear fuel is not an insurmountable barrier to deployment of advanced nuclear energy.

Although nuclear energy has historically struggled to develop social license for operation, advanced nuclear energy can change the narrative on the social license for nuclear technology. Public trust in advanced nuclear energy and social licence to operate will be earned through constructive and on-going public engagement. Creating the social conditions for success is critical to the successful deployment of advanced nuclear energy to meet national clean energy needs.

Modernizing Advanced Nuclear Energy Regulation

- Modernize the Nuclear Regulatory Commission to account for advanced reactor characteristics and to complete safety reviews for a high volume of licensing applications
- Make licensing by the Nuclear Regulatory Commission more efficient and focused on the most safety-relevant considerations
- Develop an effective Part 53 licensing process for new reactors through proactive Nuclear Regulatory Commission engagement with stakeholders

Making Progress on Spent Nuclear Fuel

- Restart federal progress on a long-term geologic repository using consent-based processes, with interim-storage facilities in the near-term
- Open spent fuel storage up to private sector innovation including more efficient fuel utilization, deep borehole storage, and recycling

Getting Siting Right for Advanced Nuclear Energy

- Utilize consent-based siting processes to obtain stakeholder approval for new projects
- Improve Nuclear Regulatory Commission and other regulatory siting processes to ensure equitable and efficient outcomes through just processes
- Incorporate community concern on emergency planning and spent fuel into siting discussions even when not legally required

Prioritizing Environmental and Energy Justice

- Incorporate environmental justice considerations and community perspectives into advanced nuclear policy and projects
- Ensure energy transition communities benefit from repowering retiring fossil infrastructure with advanced reactors

Objective 3:
Re-imagining and integrating advanced nuclear energy and other clean energy sources

Achieving 100% clean energy in the U.S. by 2050 will require re-imagining the role of nuclear energy and the integration of all low-carbon energy technologies including solar energy, wind energy, geothermal energy, energy storage, hydrogen, carbon capture, conventional nuclear energy, and advanced nuclear energy.

Each low-carbon energy technology has distinct energy generation characteristics. The needs of different energy users can be satisifed through robust, diverse, and integrated energy systems. These different needs can be met through tailored solutions and/or through an integrated electric grid that matches energy supply and demand.

Development of clean energy systems through incremental additions to energy generation and energy storage could create unstable or unsustainable energy systems that require significant additional investment to stabilize or achieve 100% clean energy production. Effective planning for deployment of clean energy systems and integration of all low-carbon energy technologies is essential to meeting climate goals.

Re-imagining and integrating advanced nuclear energy deployment with other clean energy sources to double domestic nuclear energy production requires:

- Creating Sensible and Technology-Inclusive Climate and Energy Policies
- Coupling Advanced Nuclear with Renewable Energy and Storage Systems
- Repowering Fossil Fuel Facilities with Advanced Nuclear Energy
- Meeting Non-Traditional Electric and Non-Electric Energy User Needs

Re-imagining and integrating nuclear energy deployment with other clean energy sources requires both policy and technological planning. Including advanced nuclear energy and other clean energy technologies in energy system planning is critical to ensuring development of safe, reliable, affordable, and clean energy systems. Aligning policies at the national, state, and local level are all critical to the successful integration of advanced nuclear energy with other clean energy sources.

Matching the unique attributes and advantages of advanced nuclear energy with appropriate use cases and ensuring complementarity with other clean energy technologies enable the development of novel energy systems that can facilitate rapid decarbonization. Achieving 100% clean energy production in the United States will require the decarbonization of non-traditional electric systems (e.g., remote grids) and non-electric energy users (e.g., industrial users) that have historically relied on fossil fuels for energy. Advanced nuclear energy developers must recognize these markets and identify where advanced nuclear energy can play a unique role in decarbonization.

Collaboration between energy generators, energy system operators, and energy end-users is vital to establishing technically, commercially, and politically viable pathways to 100% clean energy.

Creating Sensible and Technology-Inclusive Climate and Energy Policies

- Include advanced nuclear energy as a clean energy source in grid design, policy and planning at all levels – local, state and federal
- Focus energy deployment incentives on achieving complete decarbonization and not just incremental decarbonization
- Ensure energy system market design, financing, and operation catalyzes long-term investments in safe, reliable, affordable, and clean energy

Coupling Advanced Nuclear with Renewable Energy and Storage Systems

- Incorporate energy storage or generation flexibility into advanced nuclear energy designs to complement variable energy generation
- Support development of nuclear-renewable hybrid systems to accelerate deployment of novel clean energy solutions

Repowering Fossil Fuel Facilities with Advanced Nuclear Energy

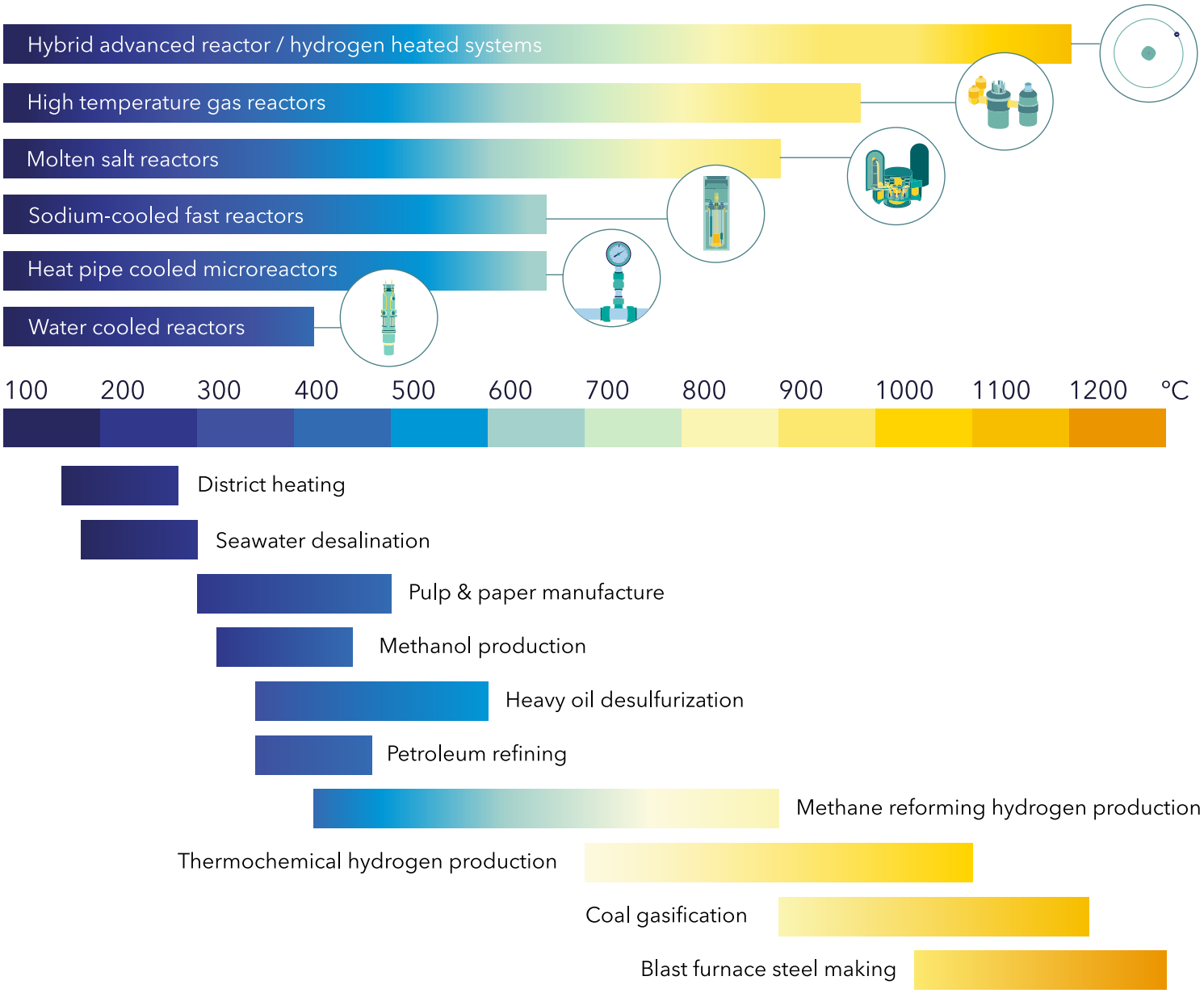
- Prioritize reuse of existing fossil fuel sites and transmission infrastructure for new advanced nuclear energy facilities
- Establish a technical and regulatory basis for fossil site reuse

Meeting Non-Traditional Electric and Non-Electric Energy User Needs

- Facilitate faster build-out of microreactors with quick construction timelines to enable technological learning across multiple generations of reactors
- Identify and characterize the technical needs of non-electric energy users (e.g., heating, industrial process, transportation)
- Address and resolve technology, performance, and regulatory barriers to the use of advanced nuclear energy for non-electric energy applications

Highlighting non-electric energy applications for advanced nuclear energy

Applicability of advanced nuclear energy sources for industrial decarbonization will vary based on the specific application and advanced reactor technology. Focusing research efforts and policy creation on energy decarbonization applications including district heating, combined heat and power, industrial process heat, hydrogen production, and direct air capture of carbon dioxide would create new opportunities for advanced nuclear energy projects.



Advanced Nuclear Energy Earthshot: A catalyst for Fission Vision

Creating the conditions for success to enable doubling domestic nuclear energy production by 2050 requires a whole-of-society effort. Successful realization of **Fission Vision** will require coordinating these efforts across industry, government, and civil society to substantially buildout advanced reactors. The U.S. Department of Energy (DOE) can play a key role in leading, coordinating, and catalyzing progress towards **Fission Vision** across society.

The DOE Earthshot initiative model pioneered for other technologies should be used to organize an integrated, cross-cutting approach to achieve dramatic reductions in nuclear project costs and timelines this decade. According to DOE, Energy Earthshots:

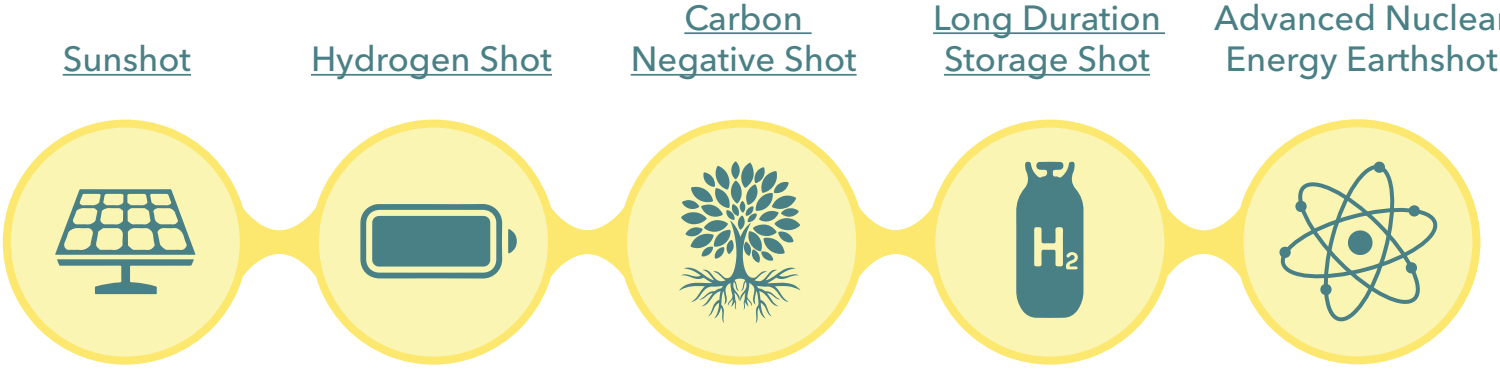
> *"accelerate breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade. They will drive the major innovation breakthroughs that we know we must achieve to solve the climate crisis, reach our 2050 net-zero carbon goals, and create the jobs of the new clean energy economy."*

Based on the successful DOE Sunshot program, these Earthshots are integrated approaches that bring the full capabilities of the Department to solve the most challenging energy problems and bring transformational technologies to market.

An Advanced Nuclear Energy Earthshot would integrate DOE activities across multiple dimensions. It would integrate DOE Office of Nuclear Energy's more traditional R&D efforts with demonstrations in the new Office of Clean Energy Demonstration, innovative financing through the Loan Programs Office, and commercialization and testing capabilities of the national laboratories. It would integrate innovation efforts from the front end through the back end of the fuel cycle. It would integrate advanced reactor innovation with supply chain innovation.

It would also integrate DOE's efforts with the broader innovation and commercialization ecosystem that includes a wide array of private companies. This will likely require DOE to develop new skills, new contracting and financing mechanisms and new partnerships, as well as better utilize existing ones.

Through an Advanced Nuclear Energy Earthshot, DOE would help create the conditions for success for **Fission Vision**.



Displace 1 Gigaton of Carbon Emissions Worldwide by 2050: Global impacts of Fission Vision

While **Fission Vision** focuses on doubling nuclear energy production in the United States to meet clean energy needs, the impact of achieving **Fission Vision** can be global. Creating a robust U.S. innovation and commercialization ecosystem, building social license to operate for advanced nuclear energy, and integration of advanced nuclear energy with other clean energy sources would catalyze deployment of advanced nuclear energy in the United States. A robust advanced nuclear energy industry could enable decarbonization around the world through technology exports.

In 2004, well-known Princeton University professors Pacala and Socolow developed the concept of climate stabilization wedges, which breaks down the achievement of the world's climate goals into a small number of discrete large-scale climate solutions, each of which could achieve 1 gigaton (1 billion tons) of carbon emission reductions. Nuclear energy was originally envisioned as a potential carbon wedge by Pacala and Socolow. Advanced reactor technology that can decarbonize multiple sectors at competitive costs can realize the promise of nuclear energy as a climate stabilization wedge.

An analysis in 2020 by Third Way found that while most energy demand growth will come from emerging economies through 2050, almost all of these economies could use advanced nuclear energy for climate mitigation in the next several decades. American nuclear innovation can thus provide the basis for a global climate stabilization wedge by the middle of the century. A one-gigaton carbon emission reduction wedge for advanced reactors could be achieved by the deployment and continued operation of approximately 180 gigawatts of advanced nuclear capacity through 2050. This carbon emission reduction wedge could include the deployment of advanced nuclear energy for both electricity production and industrial decarbonization.

The U.S. can enable the export of nuclear technology by:

- Developing a proactive whole-of-government export strategy for advanced reactors.
- Working with U.S. allies and trading partners to compete in global markets for nuclear energy while furthering non-proliferation objectives.

The U.S. government must support American industry competing with foreign and state-owned enterprise business models by opening foreign markets to American exports. Actions include proactive export agreements, memoranda of cooperation, financing, export control reform, and integrated deals for advanced reactor commercial projects to compete with state-owned companies. The U.S. and its trading partners also should strengthen their position in international nuclear energy technology trade, with licensing compatibility facilitating reactor standardization. The U.S. must assure non-proliferation and security of advanced reactors designs by working with allies and international institutions like the International Atomic Energy Agency (IAEA).

Catalyzing the U.S. advanced reactor industry through **Fission Vision** has the potential to make significant global progress on both energy access and energy decarbonization. The U.S. is uniquely suited to developing innovative technologies. A concerted national effort can make advanced reactors broadly available to decarbonize power, heat, transportation, and other sectors in developed and emerging economies.