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Introduction

Chairman Manchin, Ranking Member Barrasso, and distinguished Members of the Committee, thank you for the opportunity to testify on behalf of the Department of Energy's (DOE's) vision for and activities in Artificial Intelligence (AI). All of us in DOE particularly appreciate the interest, leadership, and partnership from this Committee at this critical juncture in AI development.

Advances in AI are enabling enormous progress and breakthroughs that can help address key challenges of our time – from more effective cancer screening and targeted treatments to world-changing advanced manufacturing, from improving the reliability of our electricity grid and response to natural disasters, to state-of-the-art production capabilities for our nuclear stockpile. At the same time, the rapid pace of AI development, accelerating investment by global competitors and widespread AI access also carries unprecedented risks.

This testimony will first outline the Department of Energy's substantial AI foundation and experiences to date. It will secondly outline the full range of broader AI trends and dynamics with respect to our core energy, science, and national security missions. Finally, the testimony will present for the Committee's consideration a vision for how DOE can play our role within a broader U.S. strategy to best harness AI breakthroughs and to mitigate AI's unprecedented risks.

DOE's AI foundation

Let me begin by thanking this Committee for your strong support and sustained investments in DOE for many years that have enabled DOE's existing infrastructure and capabilities for cutting-edge AI. These extensive investments to date include:

- **Advanced computing**: DOE designed, developed, and currently operates four of the top ten fastest openly-benchmarked supercomputers in the world – DOE's Frontier supercomputer, the Nation's first exascale supercomputer, is currently *the* fastest – and Congress's investments have been critical to ensuring continued U.S. leadership in the supercomputing industry.
- **Advanced software**: DOE has created a wealth of science and engineering algorithms that can run on the most advanced supercomputers, and through the **Exascale Computing Project**, DOE is developing the world's first capable exascale software ecosystem that will drive breakthroughs

in critical areas as varied as materials science, AI, cancer research, earthquake risk assessment, energy production and storage, and computational weapons applications.

- **Largest producer of unclassified and classified scientific data**: Across a network of 34 national user facilities around the country, DOE provides the scientific community with instruments to enable research while also generating tremendous volumes of high-quality data.
- **Largest skilled scientific workforce**: Most importantly, DOE's National Laboratory system houses a workforce of over 70,000 scientists, engineers, researchers, and support personnel with world-leading scientific expertise, and serves as a resilient talent and training pipeline for personnel who serve the American people.

It is particularly important to underscore that DOE advances in AI are not just in the realm of the future; DOE is currently leveraging in real-time our core strengths in AI applications and leading high-performance computing systems to deliver across our energy, security, and science mission:

Energy*:*

- *Assisting in emergency response:* Researchers at DOE's Pacific Northwest National Lab used their AI-based image analytics and model to assist the Coast Guard with modeling fire spread and evacuation efforts in Maui.
- *Accelerating clean energy deployment and energy accessibility:* DOE and its labs have worked with States, local governments, Tribes, cities, and communities across the country and around the world to help implement clean energy solutions. AI is being used to conduct the complex analytics, forecasting, and technology road mapping necessary to help plan energy investments that could potentially shorten the timeframe for planning and permitting critical infrastructure from years to weeks.
- *Enhancing efficiency and safety:* Today, we are already utilizing AI to help determine the condition of oil and gas wellheads, making it safer and more efficient for human operators to do their jobs.
- *Protecting our electric grid.* DOE has developed an edge machine learning model that was deployed on a microprocessor card to detect gunshots to enable physical protection of our electric grid.

Nuclear Security and Nonproliferation:

- *Nuclear nonproliferation and nuclear security:* National Nuclear Security Administration (NNSA) laboratories are pursuing research in foundation models for nuclear nonproliferation and nuclear security applications in HPC, cloud, and hybrid environments, making inroads in test and evaluation, and addressing transparency, usability, and robustness in human-AI teaming.
- *New materials discovery:* DOE is using AI and machine learning (ML) methods to enhance and extend pit production, additive manufacturing of new components, component/system surveillance, design of new experiments, and proliferation detection. NNSA laboratories have active AI development programs for materials discovery, which have shortened the time for analytical processes for critical weapons materials from weeks to seconds, uncovered key interactions among new materials, and revealed deep fakes.
- *Understanding the battlefield of the future:* NNSA is also utilizing computing and algorithmic innovations to improve dynamic decision support - from better understanding the battlefield of the future to discovering and countering novel proliferation pathways. DOE will also assess the potential role for AI in enhancing defenses against new cyber threat vectors and enhance the security of systems (whether physical or virtual) from all threats and hazards.

- *Nuclear Threat Reduction and Information Security:* NNSA laboratories are assessing the various ways in which AI and machine learning could enhance an adversary's understanding of nuclear threat devices. NNSA is working with industry to analyze AI model outputs and to develop safeguards that can be implemented to prevent AI from aiding malevolent actors.

Science and Technology:

- *Transformative advances in computing hardware for AI:* Large-scale AI training commonly relies on large deployments of computing hardware, such as graphics-processing units (GPUs). Critical components of that computing hardware were initially developed thanks to DOE's exascale computing investments, which helped these components achieve aggressive targets for energy efficiency, performance, and reliability. DOE is working with leading U.S. firms to advance computing and AI capabilities at scale.
- *Breakthrough in Fusion:* DOE-sponsored basic research in magnetic-confinement fusion demonstrated innovative AI techniques to predict plasma instabilities. The recent groundbreaking net-positive-energy fusion demonstration from the National Ignition Facility at Lawrence Livermore National Laboratory was enabled by DOE/NNSA's development and application of these novel AI methods.
- *Understanding the evolution of the virus behind COVID-19:* A team from Argonne National Laboratory that included academic institutions and hardware companies developed a prize-winning AI based on "large language model" techniques – using the language of the virus genome instead of the language of humans – to understand the evolution of the virus behind COVID-19.

Promising opportunities

AI is a powerful technology that presents breathtaking opportunities for our nation, and the Biden-Harris Administration is taking steps to maximize these benefits and maintain the United States' technological advantage while ensuring that AI upholds our democratic values, advances equity and delivers inclusive prosperity.

Over the next few years, AI has the potential to help transform the way we utilize the grid and deploy clean energy technology. The deployment of new technologies such as wind, solar, energy storage, electric vehicles, controllable building loads, and other smart grid devices increases the complexity of energy system planning and operations by orders of magnitude, and utilities across the country are struggling to keep up with these changes. AI-enabled modernization of our nation's integrated electricity delivery system can help speed up deployment to provide energy to every last community and simultaneously achieve affordability, carbon neutrality, reliability, and resilience to extreme (both natural and intentional) events. DOE and our labs can serve as a platform for dealing with proprietary data to help with real-time energy decision-making – from where renewables should be sited to where utilities should harden the grid.

Over the next decade, AI can help unlock world-leading simulation capabilities that can be augmented seamlessly with scalable, trusted, and efficient data-driven tools, including trusted and validated machine learning methods, and greater use of complementary AI technologies and beyond. AI can help speed the discovery of novel materials, counter proliferation pathways, and help us develop real-time and predictive understanding of the battlefield of the future.

We are working under the leadership of the White House and in close partnership with interagency colleagues to leverage complementary capabilities. For example, DOE has teamed with the National

Oceanic and Atmospheric Administration (NOAA) to use supercomputers for earth system modeling, supporting sub-seasonal to decadal earth systems forecasts, and DOE is collaborating with the National Cancer Institute to develop new computing tools that integrate novel AI and uncertainty quantification technology and take advantage of DOE's advances in computing—including Frontier, the Nation's first exascale computer—to accelerate discovery in cancer research.

Clear-eyed about the risks

The Biden-Harris Administration is also addressing the significant risks that AI presents to our safety and security, democracy, economy, and civil and human rights. The Administration is tackling these risks head-on by securing voluntary commitments from major AI companies and leveraging guidance from the AI Risk Management Framework and the Blueprint for an AI Bill of Rights, in order to better inform Federal AI policy.

Global investment and competition in AI are increasing, and our continued leadership – whether public sector or private – is not assured. Our competitors have made significant strides in closing the capability gap to develop extremely complex systems over the last decades. For example, China has moved to replicate the model and investments of the DOE's National Laboratory system and is investing heavily in its own AI capabilities and workforce, with investments expected to reach nearly $27 billion by 2026. Moreover, the introduction of powerful language models in public-facing Internet services have revealed a pressing need for fundamental understanding of new, emergent capabilities of these models and the associated risks to society.

Three factors are shifting how we need to think about AI as a country:

1. Governments around the world are investing in AI capabilities as national assets critical to future economic vitality and national security. We must move faster or risk falling behind.
2. Retaining leadership in AI will require developing trustworthy AI systems that can be deployed for high-consequence uses, from healthcare to aerospace.
3. Protecting Americans' rights and safety will require alignment of national investments and policies to evaluate and mitigate risks that can be exacerbated by AI advancements. We must protect against both unintended behaviors and AI used by those with malicious intent.

In short, a robust partnership between the government, our private sector, and like-minded allies and partners is essential to ensuring that this technology is underpinned by democratic principles and values, and that all Americans benefit from its adoption and are safe from potential harms. Given the rapid pace of AI developments, we must move quickly.

DOE's strong AI foundation and expertise across energy, science, and national security give us unique insight into critical AI opportunities as well as a wide spectrum of associated risks that threaten to undermine the promise of AI technologies. AI systems can pose risks to individual safety, privacy, and civil liberties; and risks to society from information manipulation, bias and discrimination, social engineering, and market manipulation; and security risks from autonomous, biological, chemical, and nuclear, radiological, and cyber weapons.

While U.S. industry has had an outsized role in the development of AI technologies to the present day, industry alone cannot face this wide spectrum of risks. Given the nation-state-scale investments happening outside of our borders, our nation requires unprecedented industry-government partnership because:

- Industry alone cannot be fully aware of the relevant risks and threats because much of that information falls within the purview of our Intelligence Community and our national security enterprise.
- Industry investments are driven by market dynamics and the needs of their customers. The government, however, can help industry limit externalities that might harm individuals and society as a whole.
- Our industry-driven AI innovation ecosystem now faces nation-state competitors who have substantial resources at their disposal and a desire to overtake our leadership position.

Unless the US government and industry take action now, we could easily find ourselves faced with technological surprise driven by those who do not share our values or being unable to respond to the unanticipated consequences of a rapidly changing technological landscape.

A vision for AI leadership and DOE's role

We've discussed how the Biden-Harris Administration has been laser focused on a comprehensive approach to AI across federal departments and agencies. In the remainder of my testimony, I will lay out our vision for DOE's vital role in implementing the Administration's priorities on AI with our agency peers, across the scientific community and U.S. industry, and with our allies and partners to ensure continued leadership in this new AI era. We stand ready to use our vast experience in AI and its unique capabilities, in partnership with our sister departments and agencies, to take advantage of AI opportunities while helping to understand and mitigate the risks of AI.

Leadership in AI means outpacing the competition in AI development and deployment. This means AI-enabled accelerated science and technology innovation, using AI to create more efficient and equitable services in both the private and public sectors in a manner that increases trust in our institutions, and it means living in a world where we mitigate risks from AI effectively so everyone can enjoy the benefits of AI.

This is not the first time our nation has been confronted with a technological challenge and opportunity to change society as we know it. For instance, the Manhattan Project broadly mobilized our great scientific and technical talent to meet an enormous challenge – to win the race to create the atomic bomb and end World War II. The country forged the foundations of the DOE in the Manhattan Project and as the war drew to a close, established DOE's predecessor, the Atomic Energy Commission, as a *civilian* agency with a dual mission: to guarantee American superiority in the new era of nuclear science for both national security *and* for open society, to pursue both open *and* classified R&D, to create a workforce with unparalleled expertise to understand and control the *risks* of nuclear technology in order to harness its *extraordinary potential* for our national security, including economic security. The results: A nuclear navy. A strong nuclear deterrent. Technology that enables our energy security. Extreme ultraviolet technology – a key component in today's microelectronics. Targeted treatments for cancer. The first map of the Human genome. Research investments in basic research from the 1960s that laid the foundations for modern day AI through sustained investments in high-performance computing, networking, data management, and algorithms.

This legacy is not just history. It is written into DOE's DNA. Our role in the Federal Government is unique – we are entrusted with one of the nation's most potent national-security assets, we contain an element of the intelligence community – and yet we are a civilian agency that is simultaneously enabling modernization of our electrical grid and the development and deployment of clean-energy technologies to strengthen our energy security and to address climate change. Our diverse and talented workforce collaborates with universities on open science questions, the private sector on proprietary R&D, and

across the defense and intelligence communities to advance our national security, including energy and economic security.

Unlike the Manhattan Project, we are not starting from zero on AI, thanks again to this Committee's leadership and support for many years. We already possess the enabling infrastructure –hardware, software and talent – the fruits of billions of dollars of computing investments by the U.S. Congress over the past decade – that will enable us to move out with purpose and speed.

As governments around the world move forward on regulation of AI, the technology itself presents unique constraints. It is rapidly developing at a pace at which new capabilities can emerge constantly, often after a model is introduced to the public. Private-sector AI efforts alone will not meet the demands of the new scientific and national security competition of this AI era. The unprecedented computing ability offered by exascale computer systems represent the global stakes for AI competitiveness, but leadership will hinge on developing sustainable exascale and beyond-exascale (zettascale) computing environments along with the underlying theory, mathematics, and software systems necessary to utilize the power of those systems. To ensure protection of sensitive national security information while leveraging AI for our national defense, we will need to develop unique classified AI models, methodologies, and systems.

To ensure the deployment of safe, responsible, and trustworthy AI, we need to develop methods for assessing and red-teaming AI models to identify and mitigate the risks presented by cutting edge AI systems. DOE's technical expertise across multiple science and security domains, AI expertise, AI-capable hardware, and industry partnerships can be brought to bear to understand and mitigate the spectrum of AI security risks. For example, we are already working to understand the implications of these new capabilities as they relate to nuclear security challenges by integrating our authoritative knowledge of nuclear weapons to understand how AI can shorten a proliferant nation's nuclear weapon development time frame.

Throughout, we are working through our laboratories, with industry, and with university consortia to advance multidisciplinary research to enable technologies to train the next generation of scientists and bridge the gap between basic university research, industry requirements, and mission-specific applications.

Leveraging DOE capabilities

Effective execution of the DOE mission requires the best and most powerful scientific tools. The most promising advances in AI result from scaling, and computational capacity and capabilities are central to driving the future of AI. DOE's nationwide Exascale Computing Project (ECP) team of over 1,000 scientists, engineers, and program staff from DOE laboratories, academia, and industry, has created a vision for exascale computing and then developing, organizing, and executing a campaign to not merely lead the world but to redefine the field. In 2022, DOE's Exascale Computing Initiative (ECI) demonstrated this paradigm shift, deploying the world's first exascale supercomputer—the highest ranked world-wide, with more capability and capacity than the next four ranked systems combined. In 2023, the second DOE exascale machine will provide twice this capacity.

But advantages in AI and machine learning can only be unlocked through powerful computing capability and commensurate amounts of good data. DOE's network of scientific user facilities and sectoral responsibility for grid critical infrastructure makes us the largest generator and user of scientific and technical data in the country. One NNSA lab is developing a federated data management system for all of its data, which would operate across multiple classification data fabrics, enable colocation of data with

compute resources, both high performance computing and cloud, and integrate with other government data management systems to enable transformative research in nuclear nonproliferation and nuclear security.

At DOE, we are mobilizing our National Laboratories to realize advancements in AI technology, implementation, and application. Over the last five years, we have worked with stakeholders across the innovation ecosystem to identify new and rapidly emerging opportunities and challenges presented by AI, and identified how unique DOE capabilities can drive progress in AI in our mission areas, culminating in the May 2023 release of the report *AI for Science, Energy, and Security*. This vision and blueprint align precisely with the pressing need for scientific grounding in areas such as bias, transparency, security, validation, and the impact of AI on jobs.

DOE is already taking action: expanding and creating research and industry partnerships to develop energy-efficient AI computing technologies, making AI resources available to the research and business communities, curating safe data sets for AI training, and using AI to accelerate the development of technologies of the future.

We can leverage DOE's existing broad technical expertise, world-leading computing capabilities, and industry partnerships, to develop next-generation AI systems to advance and further democratize science and technology development, thus enabling our clean energy future and ensuring science and technology leadership for the nation. Working with other departments and agencies, we can enable trustworthy AI development and deployment across the government and the private sector, create more efficient and equitable services and reduce regulatory compliance burdens while providing better customer service and more-transparent actions in a manner that increases trust in our institutions.

Conclusion

We are now at a moment where we can – and must – focus on applications of AI which govern critical infrastructure that includes a more secure and reliable grid, enhanced emergency response, and strengthened nuclear security. In all these cases, safety, transparency, and security are the major challenges in AI facing the scientific community and industry with many open questions.

To develop AI that we can deploy and use safely in critical environments, we need high-quality scientific data to train AI systems. We must develop AI systems that are designed to act in trustworthy ways with appropriate human oversight. Indeed, succeeding will depend on continuing to push the frontier on AI technology – and DOE has a proven history of creating and deploying technology to solve complex challenges for the United States. And, given the speed with which AI is developing and its transformative potential, we must act urgently to leverage our existing advantages to maintain and extend U.S. leadership in AI to stay ahead of global competitors.

We are now at the cusp of our next grand challenge. Working within and outside of government, DOE stands ready to play our role in fully engaging in this grand challenge by utilizing our unique computing capacity, comprehensive and well-curated data sets from experiments and simulations, our algorithms and methods, relationships with industry, and skilled scientific workforce. We look forward to working with the Committee on this important issue.