U.S. DEPARTMENT of ENERGY

U.S. Department of Energy

Artificial Intelligence Strategy

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Introduction

The mission of the U.S. Department of Energy (DOE or Department) is to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions. With a history of innovation and discovery spanning several decades, from the birth of the atomic age and the Manhattan Project to the foundational work behind the internet and the Human Genome Project, DOE and its 17 national laboratories provide research and development infrastructure critical to American innovation and scientific discovery.

Artificial Intelligence (AI) is a transformative technology with direct impacts on the Department's core science, energy, and national security missions. DOE, though its predecessor agencies and the national labs, has been at the forefront of AI since the 1960s, sponsoring basic research in applied mathematics, high-accuracy scientific datasets, and computer science that laid the foundations for AI. Over the decades, DOE's multi-pronged strategy of investments in hardware design, open and secure research, and application development have propelled the field.

Today, AI is integral to DOE's mission, driving scientific and technological advancements and transforming the methods by which these breakthroughs are achieved. AI tools support departmental operations by streamlining complex activities such as site selection, permitting, and compliance reviews. Curated databases are being established to power AI models and enhance decision-making. Simultaneously, an AI-ready Federal workforce is being created through strategic hiring, skill development, and practical training with DOE's enterprise-wide AI productivity tool.

AI capabilities are actively advancing across multiple Departmental Elements and DOE's national laboratories, including:

Departmental Elements:

- Advanced Research Projects Agency-Energy (ARPA-E)
- Office of the Chief Financial Officer (CF)
- Office of the Chief Information Officer (OCIO)
- Office of Critical and Emerging Technologies (CET)
- Office of Cybersecurity, Energy Security, and Emergency Response (CESER)
- Office of Energy Efficiency and Renewable Energy (EERE)
- Office of Environmental Management (EM)
- Office of Fossil Energy and Carbon Management (FECM)
- Office of the General Counsel (GC)
- Office of Intelligence and Counterintelligence (IN)

- Office of Management (MA)
- Office of Nuclear Energy (NE)
- National Nuclear Security Administration (NNSA)
- Office of Electricity (OE)
- Office of Management and Budget (OMB)
- Office of Policy (OP)
- Office of Technology Commercialization (OTC)
- Office of Project Management (PM)
- Office of Science (SC)

National Laboratories:

- Ames Laboratory (Ames)
- Argonne National Laboratory (ANL)
- Brookhaven National Laboratory (BNL)
- Fermi National Accelerator Laboratory (Fermilab)
- Idaho National Laboratory (INL)
- Lawrence Berkeley National Laboratory (Berkeley Lab or LBNL)
- Lawrence Livermore National Laboratory (LLNL)
- Los Alamos National Laboratory (LANL)
- National Energy Technology Laboratory (NETL)
- National Renewable Energy Laboratory (NREL)
- Oak Ridge National Laboratory (ORNL)
- Pacific Northwest National Laboratory (PNNL)
- Princeton Plasma Physics Laboratory (PPPL)
- Sandia National Laboratories (SNL)
- SLAC National Accelerator Laboratory (SLAC)
- Thomas Jefferson National Accelerator Facility (Jefferson Lab)
- Savannah River National Laboratory (SRNL)

This strategy builds upon existing progress to focus the Department’s efforts on maximizing AI's impact across its missions.

DOE AI Use Cases

Overview

AI breakthroughs are revolutionizing how we address critical global challenges. DOE's multifaceted investments in AI encompass everything from fundamental research to hardware design, enabling innovative AI techniques and applications. The Department's investment strategy involves carefully selecting and developing AI applications that have the most significant impact across its diverse missions.

An example of this is DOE's collaborative initiatives with leading computing firms. These partnerships have been pivotal in the development of critical components for graphics processing units (GPUs) and other advanced technologies. These collaborations were strategically chosen for their direct contribution to enabling cutting-edge AI research and deployment, positioning the U.S. at the forefront of AI innovation and continuously advancing its world-leading expertise in exascale computing.

The impact of these advances is significant and growing. They are transforming and securing our electricity grid, developing efficient energy technologies, establishing streamlined manufacturing processes, enhancing production for our nuclear stockpile, and enabling new ways to detect nuclear proliferation through non-traditional signatures.

As part of its commitment to responsible and effective AI deployment, DOE maintains an AI use case inventory consistent with OMB directives. This section provides examples of AI efforts currently in use or planned for implementation, offering short descriptions that showcase the range of impactful ways DOE incorporates AI to achieve its vital missions. A full list of the use cases that were provided by Departmental Elements can be found in Appendix.

AI for Departmental Operations

The Department's strategic application of AI to operational activities are streamlining internal processes, enhancing project management, and improving cross-agency collaboration, reflecting a deliberate choice to boost overall operational efficiency.

- **Joulix AI Application Suite:** AI powered suite of tools engineered to enhance productivity and foster innovation, empowering employees to accelerate progress toward DOE's mission.
- **Data Analytics and Machine Learning (DAMaL) Tools:** Components supporting analysis, data, and automation of processes across various DOE Sites, Field Offices, and HQ.
- **Project Management AI Tools:** Includes the Project Assessment and Reporting System (PARS) AI Assistant for real-time insights, AI-powered document

management search for advanced indexing, and AI analysis for project assessment and compliance review.

AI for National Security

Strategic implementations of AI for maintaining and enhancing national security capabilities are ensuring the United States remains at the forefront of deterrence.

- **AI/Machine Learning (ML) Capabilities for Nuclear Deterrence**: The development and deployment of new AI capabilities, including mission-focused agents, models, hardware, and data infrastructure, support the acceleration of stockpile stewardship mission.
- **Multimodal Foundation Models for Nuclear Nonproliferation:** These models enhance operational mission capabilities in secure settings and are critical for assessing nuclear-related risks of external proprietary models. This directly supports the agility and understanding needed for deterrence.
- **AI-Enhanced Physical Security Systems:** AI-based technologies provide enhanced performance for detecting, identifying, tracking, and classifying physical security threats at national laboratories. This secures physical assets critical to deterrence.
- **LLM-based Tools for Intelligence and Counterintelligence Analysis:** Developing and deploying these tools that could increase the timeliness, accuracy, and impact of finished intelligence products, providing crucial insights for national security decision-making and agile responses.
- **AI/ML for Accelerator Operations and Experimental Planning:** Advancing AI/ML tools to increase efficiency of nuclear data analyses and improve quality of accelerator operations and experimental planning. This indirectly contributes to scientific underpinning for defense capabilities.
- **AI Assurance Testbed:** The CESER-led AI testbed at LLNL rigorously tests AI models for vulnerabilities, adversarial robustness, and suitability for critical energy applications, providing actionable assessments to enable the design of secure AI systems for the grid.
- **Generative AI for Engineering Design of High-Consequence Systems:** DOE is leading the application of generative AI to accelerate engineering design and digital assurance for high-consequence systems, such as in the nuclear enterprise. This innovative approach, chosen for its potential to enhance reliability and efficiency, is critical for ensuring the integrity and modernization of vital national security assets.

AI for Scientific Discovery & Innovation

Applications of AI across departmental elements are accelerating the discovery, design, and production of advanced materials and scientific discovery, vital for energy security, national defense, and economic competitiveness.

- **Materials Discovery and Design:** AI/ML techniques extract knowledge from large materials databases and accelerate discovery through innovative physics-guided AI approaches, enabling scalable, automated synthesis for new materials with desired properties - a direct contributor to finding innovative alternatives.
- **Isotope Production Efficiency:** AI/ML improves efficiencies and automation in isotope science and advanced manufacturing, leading to more effective techniques for cumbersome isotope production processes. Isotopes are critical materials for various applications, including medical and national security.
- **AI/ML for Material and Component Manufacturing:** AI/ML tools contribute to optimization of advanced materials (such as platinum group metal-free fuel cell catalysts) and also facilitate high-throughput material and component manufacturing processes. This enables developing alternatives and enhancing domestic manufacturing capacity for critical components.
- **AI Accelerated Scientific Discovery:** Converging AI/ML with exascale computing, autonomous experiments, and next-generation robotics enables AI-driven scientific workflows and provides real-time exploration and understanding of extreme-scale data from fundamental science simulations and experiments.

AI for Energy Dominance

The transformative application of AI to the nuclear energy sector is enabling increased efficiency, autonomy, and accelerated deployment of advanced nuclear reactor technologies.

- **Increase Autonomous Operation of Reactors:** Focuses on developing autonomous nuclear reactors and accelerating deployment using advanced cloud infrastructure and AI technologies, including creating AI digital twins for real-time simulations. This is essential to AI-operated reactors.
- **Reduce Nuclear Energy Operating and Maintenance Costs:** Application of AI solutions to reduce operating and maintenance costs for existing U.S. nuclear power plants, identifying and diagnosing equipment degradation for enhanced predictive maintenance. This improves the economic viability and reliability of nuclear power.
- **GEMINA Program:** Focuses on developing digital twin technology for advanced nuclear reactors and transforming operations and maintenance systems,

leveraging AI for advanced control systems, predictive maintenance, and model-based fault detection. Directly supports AI-designed/operated reactors.

- **AI/ML for Fusion Plasma Control and Prediction:** AI/ML techniques are being applied for complex data analysis, plasma control, and prediction in fusion energy research to accelerate discovery and optimize magnetic confinement regimes.
- **AI for Legacy Cleanup:** Applications of AI are accelerating the environmental cleanup of nuclear legacy and optimizing long-term stewardship, to support science discovery, national security, and energy security missions.
- **Physics-informed ML for Power Grid Control:** Algorithms significantly reduce the computational footprint of operational power grid control loops, increasing the ability of grid operators to complete complex contingency assessments rapidly. A resilient grid is essential for energy dominance.
- **Advanced Infrastructure Integrity Model:** A multi-model AI system that evaluates and informs key energy infrastructure integrity for maintenance and planning forecasting. This award-winning model, trained for natural gas and other pipelines and offshore platforms, is being expanded to address wellbore integrity evaluations, directly supporting the resilience of energy infrastructure.
- **PermitAI:** Utilizes AI to streamline energy infrastructure permitting by leveraging a machine-readable corpus of 120,000 NEPA documents from 50 years of reviews. It includes applications for searching and summarizing this data, as well as a public comment summarization tool.

DOE AI Maturity Goals

DOE possesses robust foundational capabilities in AI. These capabilities are built upon key strengths in advanced AI research, development, and innovation emanating from its National Laboratories, supported by dedicated AI testbeds at seven facilities. This strong foundation combined with DOE's deep domain-specific expertise positions the Department uniquely in the national AI landscape. While the integration of AI into the Department’s operational activities has begun, its adoption has been largely concentrated on specialized scientific applications, reflecting a strategic focus on mission-critical research.

Realizing DOE's full AI vision across its core science, energy, and national security missions faces challenges, such as uneven agency-wide adoption, persistent data silos, data use restrictions, and the complexities of legacy infrastructure. To address these challenges, the Department has strategically chosen to prioritize scaling trustworthy AI adoption, ensuring consistent data quality and access, developing a skilled workforce, and establishing robust, secure AI infrastructure for both operations and research.

To systematically enhance its AI maturity and navigate these complexities, DOE is focusing on several key initiatives. Each category represents a deliberate pillar structured to maximize AI's positive impact on national security, scientific innovation, and the lives of all Americans.

- **AI-Enabling Infrastructure:** Bolster the foundational computing and data environments essential for scalable and secure AI development and deployment.
- **Data:** Establish clear strategies for acquiring, managing, and preparing high-quality data to fuel AI innovation across DOE's diverse missions.
- **Research and Development:** Drive advancements in core AI technologies and applications relevant to DOE's scientific, energy, environmental, and national security priorities.
- **AI-Ready Workforce:** Cultivate and sustain a highly capable workforce equipped with the necessary skills to leverage AI effectively throughout the Department.
- **Governance and Risk Management:** Implement a comprehensive framework for ethical, responsible, and secure AI adoption and operation across the enterprise, specifically addressing governance and risk management principles.
- **Resource Planning and Tracking:** Optimize the strategic allocation and transparent tracking of investments and resources dedicated to AI initiatives.

These initiatives, detailed in the following sections, collectively form DOE's approach to overcoming existing challenges and harness the full transformative potential of AI for its critical missions.

AI-Enabling Infrastructure

Overview

Developing and deploying advanced AI capabilities across DOE's mission spaces presents a range of viable infrastructure options. The Department's approach acknowledges these multiple pathways and actively chooses to invest in secure, scalable, and high-performance computing infrastructure to accelerate innovation while upholding the paramount standards of security and reliability. This commitment spans the entire AI lifecycle, from development and testing to deployment and continuous monitoring. As of September 2025, DOE operates the world's three fastest supercomputers and maintains numerous other powerful computing facilities across the national laboratory complex. The continued investment in shared AI infrastructure and tools enables AI practitioners across the enterprise to collaborate and experiment efficiently and effectively.

Recent Achievements

The Department's recent achievements reflect these strategic choices, focusing on foundational capabilities and diverse test environments:

- **Advanced Computing:** DOE is actively investing in advanced computing infrastructure to accelerate AI development from foundational research to deployment.
    - **Exascale Computing Systems:** DOE operates and allocates access to its exascale computing systems: El Capitan at LLNL, Frontier at ORNL, Aurora at ANL, and Doudna at LBNL. These unique resources enable critical DOE mission applications and provide a mechanism to address national emergencies and priorities.
    - **Data-Intensive Research Capabilities:** DOE is designing managed computational and data resource facilities, such as the High-Performance Data Facility (HPDF), to support urgent mission needs in handling massive datasets and AI.
- **Diverse AI Testbeds and Specialized Research Facilities:** Recognizing the need for varied environments to validate AI systems, DOE has developed a network of diverse AI testbeds and specialized facilities. These secure and controlled environments, such as NREL's ARIES, NNSA's Nuclear Security Platform (NSP), or the American Science Cloud (AmSC), are designed to support AI hardware development, reliability testing, and application development across various domain.
- **Digital Collaboration Ecosystem:** Effective communication enables seamless information exchange and advanced research. Some platforms facilitating this include:
    - **Secure Cloud Platform:** Specifically designed to foster a cohesive work environment across the enterprise, enhance team communication and coordination, and promote AI adoption aligned with departmental objectives, prioritizing secure, centralized collaboration.
    - **Tools:** Energy Sciences Network (ESnet) provides high-performance network access, connecting all DOE national laboratories and major sites to global research networks. This is critical for transporting the massive datasets essential for AI model training and deployment. Technology Transfer and Collaboration Platforms, such as FE's Energy Data eXchange (EDX) developed by NETL, support secure, private, and multi-institution collaboration for ongoing research projects across various communities of practice, addressing the need for both broad connectivity and secure, project-specific collaboration.

Strategic Objectives

DOE's comprehensive approach to AI infrastructure is built upon a deliberate set of strategic objectives. Rather than focusing on isolated components, the Department

actively selects paths that enhance all elements from foundational development and enabling scalable deployment to ensure robust security across the entire AI lifecycle.

- **Robust Testing Environments:** The Department is establishing dedicated, secure testing environments that allow for rigorous validation and verification of AI models. This includes establishing dedicated, secure testing environments across DOE facilities and national laboratories, with competitive, merit-reviewed access for researchers, ensuring broad and fair access to critical validation capabilities.
- **Automated and Autonomous Experimentation:** Expanding investments in autonomous laboratories and AI-guided design workflows will improve the volume of experiments for AI-driven discovery and data generation. Working in partnership with the private sector, AI-orchestrated automated and often self-driving laboratories, powered by unique, DOE-generated scientific data lakes will leverage on-premises and cloud computing to develop models that will drive mission impact.
- **AI Operationalization and Scalable Deployment:** Broadening data access and utilization involves developing algorithms to anonymize critical datasets, like energy data, which facilitates widespread open-source AI algorithm development for transactional energy, optimization, and security use cases. Additionally, integrated AI operationalization across a distributed landscape is being achieved by leveraging the national laboratory network to build infrastructure for geographically dispersed AI deployment, including edge devices at experimental facilities and large-scale simulation environments, ensuring that AI capabilities can be deployed where they are most needed.
- **Securing AI Infrastructure:** DOE is fully committed to fortifying the physical and cybersecurity of its AI infrastructure by developing AI/ML predictive analytics to establish feedback loops for model performance and security vulnerabilities, as well as continuous monitoring of critical infrastructure to anticipate failures and classify physical security threats. Concurrently, DOE is elevating data security by engaging experts from across government and industry to better safeguard national assets against sophisticated, AI-driven threats, recognizing that a multi-faceted approach is essential for comprehensive security.

Data

Overview

DOE recognizes that access to high-quality, well-governed, and traceable data is foundational to responsible and effective use of AI. As a preeminent science and data-driven agency, DOE understands that its datasets, from scientific research to operational records, represent a critical national asset. Therefore, DOE is focused on

ensuring its data is not only discoverable and reliable but also meticulously managed for optimal AI application. DOE's Enterprise Data Strategy for FY25-28 outlines a comprehensive framework for strengthening the Department's data practices as it applies to business, operational and R&D data domains. In addition, Section 50404 of the One Big Beautiful Bill (OBBB) Act (Pub.L. 119-21) charges the Department of Energy to mobilize its National Laboratories to structure and preprocess scientific data for AI and machine learning applications in furtherance of the AmSC. AmSC will be a system of the United States government, academic, and private-sector programs and infrastructures utilizing cloud computing technologies to facilitate and support scientific research, data sharing, and computational analysis across various disciplines while ensuring compliance with applicable legal, regulatory, and privacy standards.

Recent Achievements

The Department's recent achievements demonstrate a commitment to making data more accessible, curated, and governed:

- **Open Data Plan:** DOE actively pursued an Open Data Plan, enabling its extensive data assets (over 3,700 on data.gov) to be more findable, accessible, interoperable, and reusable. This was a deliberate choice to maximize the societal and scientific impact of its data, rather than limiting access to proprietary systems.
- **Research Data Curation:** Data from DOE-funded activities and partnerships are curated and made accessible to the research community through DOE-developed platforms and databases, protecting R&D investments, fueling innovation, and promoting scientific discovery.
- **Streamlining Data Management and Analysis:** Efforts are underway to establish streamlined data pipelines to ensure secure and readily usable AI-ready data without extensive manual intervention. Concurrently, scalable algorithms and methods are being developed to enhance the efficient analysis of complex datasets, enabling valuable insights.
- **Data Governance Structure:** To ensure consistent and effective data management across the enterprise, DOE has established a robust data governance structure (further detail in the *AI Governance and Risk Management* section). A Chief Data Officer position was established to lead data initiatives; an Enterprise Data Management Program was established to provide guidance, tools, and support for enterprise data goals; and a Data Governance Board was formed as the collective body to set and enforce policies for managing data as a strategic asset.

Strategic Objectives

The Department's strategic objectives are specifically designed to close key maturity gaps, align stakeholders, and operationalize data capabilities that support trustworthy,

scalable, and mission-aligned AI use. These objectives represent a prioritization of specific actions based on their potential to deliver the greatest impact.

- **Modernizing Data Infrastructure and Management:** Establish and maintain robust data management frameworks, policies, and standards integrating best practices from within DOE, industry, and cross-sector data communities. This includes prioritizing Application Programming Interface (API) first approaches and common standards to reduce deployment time and resources, while improving data quality, usability, security, and sharing. Standardized metadata will accelerate data classification, discoverability, and interoperability to strengthen informed decision-making across DOE mission areas.
- **Strengthening Data Governance:** Ensure engagement and communication channels across data communities are tailored to help identify common needs, accelerate value, and reduce risks. DOE also plans to scale data governance structures to accommodate component and domain realities and establish domain data stewards. This distributed yet coordinated approach ensures that governance is both effective at the enterprise level and responsive to the unique needs of specific domains, rather than imposing a one-size-fits-all solution.
- **Enhancing Data Accessibility and Curation:** DOE will expand its AI data catalog and provide tailored connections for agency components to leverage existing data management investments. It is actively promoting and enhancing mission-related open data sharing initiatives that specifically support AI use cases and broader scientific innovation. The choice to ensure public data is accessible, machine-readable, and in open formats with robust metadata (such as DCAT-US 3.0 conformance) is a deliberate one to optimize utility for AI training and analysis, recognizing that open, standardized data is crucial for rapid AI development.
- **Protecting Critical Data Assets:** To continuously elevate, monitor, and adapt security controls protecting sensitive data assets DOE will collaborate with cybersecurity experts across government, industry, and academia. The Department also plans to incorporate Privacy-by-Design principles, exploring anonymized/synthetic data and federated learning, and enforcing strict data governance and access controls with clear transparency.
- **Optimizing Data Agility and Traceability:** DOE will optimize pathways for rapid exploration, assessment, and implementation of effective, innovative, and emerging data solutions into DOE environments through streamlined processes such as procurement, Authority to Operate, and user training. It prioritizes traceability throughout the data and AI lifecycle, from data acquisition to AI deployment, by integrating accountability and transparency measures into

existing infrastructure. This focus on agility and traceability reflects a decision to enable rapid adoption of new data technologies while maintaining rigorous oversight and understanding of data origins and uses, rather than allowing for uncontrolled proliferation of data solutions. It will also assess opportunities to use analytics and AI to automate classification and sensitivity tagging for increased data usability.

- **Mobilization of DOE's scientific data:** DOE and its national laboratories will partner with industry sectors within the United States to curate scientific data across its complex so that data is structured, cleaned, and preprocessed in a way that makes it suitable for use in AI and machine learning models; guide the generation of new AI-ready data to accelerate DOE's mission; develop self-improving AI models for science and engineering powered by DOE's data and scientific capabilities. While also mandating the use of secure, standardized AI-ready data platforms and APIs to address data silos, which can stifle AI innovation across the DOE

AI-Ready Workforce

Overview

A highly skilled, AI-ready workforce is paramount to leveraging artificial intelligence for advancing scientific discovery, enhancing operational efficiency, and strengthening national security. This requires a workforce adept in computational thinking, data-driven problem-solving, and adaptable to technological evolution, with a strong emphasis on data literacy and responsible data governance.

As a world-leading scientific and technological enterprise with over forty thousand scientists and engineers, DOE is uniquely positioned to drive responsible AI development, delivery, and adoption across its diverse missions. The Department's AI workforce needs are centered on developing and deploying scalable, efficient AI solutions that deliver tangible benefits to the American public. The Department has made a deliberate choice to strategically apply its technical talent to areas such as AI development, data science, AI ethics, infrastructure, and cybersecurity, recognizing these as the most impactful domains for mission success.

Recent Achievements

The Department's recent achievements reflect its commitment to building and nurturing a skilled AI workforce:

- **Talent Acquisition & Development:** The Department is purposefully building an AI-ready Federal workforce through strategic hiring, skill development, and cross-disciplinary collaboration. This includes prioritizing hiring and retaining data scientists, machine learning engineers, AI ethics and policy experts, and cybersecurity and AI integration experts, identified as critical roles for

comprehensive AI capabilities. DOE is also expanding academic programs to include dedicated AI workforce development initiatives focused on critical topics like adversarial machine learning, GenAI, and data science. Furthermore, it fosters early-stage research and talent development in a wider range of academic institutions to grow a more competitively diverse workforce for exascale computing, AI, and Quantum Information Science.

- **Internal AI Literacy Knowledge Sharing:** To ensure staff proficiency with frontier AI, several program offices are already conducting seminars to provide practical AI understanding. Furthermore, DOE convenes several staff-led communities of practice. These groups actively promote AI knowledge sharing, professional skill development such as foundational data literacy, and support for AI development, policies, and initiatives across the Department, accessible via DOE's AI Hub.
- **Operationalizing AI Expertise:** Dedicated staff at DOE facilities are crucial for maximizing user productivity and scientific impact. They efficiently operate and maintain world-leading research computing, networking, and data infrastructure, execute major upgrade projects, and actively explore advanced applications of AI and commercial quantum computing technologies.
- **Frontier AI Exploration:** DOE's national laboratories are actively engaged in exploring the societal and scientific impact of AI through strategic partnerships. Activities such as "AI Jam Sessions" with industry stakeholders to facilitate early access to and experimentation with private industry models, accelerates the adoption of cutting-edge AI technologies and expands strategic collaborations.

Strategic Objectives

To create an AI-ready workforce, DOE is focused on a holistic strategy that spans cultivating untapped talent and developing current talent through upskilling initiatives, all significantly bolstered by external support via strategic partnerships.

- **Talent Recruitment and Development:** DOE will develop comprehensive strategies to recruit, retain, and cultivate diverse AI and related talent. This includes utilizing resume repositories and existing Federal hiring authorities, building an early career AI talent pipeline through internships and academic alliances, outreach to AI practitioners, and building technical expertise via internships, scholarships, and fellowships within national laboratories. This broad talent acquisition strategy recognizes that a diverse set of skills and backgrounds is essential for innovation. These efforts will also explore leveraging AI to streamline Federal hiring processes directly, a strategic application of AI to solve internal challenges.

- **Targeted Training and Upskilling:** DOE will promote targeted training programs to enhance AI skills and foster AI responsibilities across the entire workforce, from technical experts to leadership and end-users. Workforce cross training at the DOE national laboratories would allow for personalized learning as experimentalists must have the tools to implement AI into their workflow, while AI scientists need to work closely with domain experts to address scientific challenges. These programs will provide foundational AI understanding, ethical/legal considerations, and incorporate best practices to improve productivity and accelerate beneficial AI adoption. This multi-level training approach ensures broad AI literacy and responsible implementation. Through the Human Resources IT system, DOE will systematically assess employee AI training and upskilling needs, collaborating with functional subject matter experts, and developing customized learning journeys.
- **Strategic Partnerships and Knowledge Sharing:** Foster partnerships between national labs, universities, and industry to build and strengthen the AI talent pipeline. These collaborations will encompass joint research, providing hands-on experience, and industry internships, offering direct pathways for emerging talent. Joint AI curriculum development will also ensure academic programs align with evolving departmental needs. DOE national laboratories will cultivate partnerships with regional academic and other training programs to recruit talent and build mission-centered skills development to advance AI for science innovation. Additionally, established communities-of-practice focused on AI will facilitate continuous knowledge sharing and best practices for AI specialists and non-specialists across the Department.

Research and Development

DOE is committed to advancing national AI capabilities to accelerate scientific breakthroughs, enhance domestic energy production and resilience, and strengthen national security.

Overview

DOE is leveraging AI to accelerate its core missions, from pushing the boundaries of scientific discovery to bolstering national security and transforming the energy sector. Recognizing AI as a pivotal technological frontier, DOE is making comprehensive investments in AI tools and capacity, enhancing critical infrastructure, data management, and specialized computational capabilities. This includes the pioneering implementation of 'edge-AI' within its experimental and computational facilities, which integrates AI models directly into hardware to optimize data collection and facility control, essential for handling the immense data rates of next-generation scientific endeavors. It also includes supporting R&D for data centers, crucial infrastructure that not only enables AI growth but also focuses on improving load flexibility and getting more energy online for all Americans.

The breadth and depth of DOE research at national laboratories, in partnership with AI, presents opportunities to generate data and leverage models to accelerate technology development in critical areas. DOE is charting a strategic course to further integrate AI across its mission, fostering an environment where AI serves as a critical enabler for new scientific insights and operational efficiencies, thereby ensuring U.S. leadership in energy, security, and scientific innovation.

Recent Achievements

Key achievements highlight the significant impact delivered by AI initiatives across critical missions, from scientific discovery to national security and energy applications:

- **Accelerating Scientific Discovery:** SC is investing in AI for computational science, scientific workflow automation, scientific programming, knowledge management, and energy-efficient algorithms, accelerating discoveries in chemical, materials, and nuclear sciences. Trained AI models can run significantly faster than conventional physics-based simulations, and language models trained on specialized scientific data show promise as research assistants. AI will also facilitate running experiments, interpreting data, and determining next steps, with AI models "at the edge" helping manage and curate data flow.
- **Infrastructure Resilience and Applied Energy:** AI is fundamentally reshaping the energy sector, driving breakthroughs in material discovery and design, resource optimization, manufacturing efficiency, and complex system integration. CESER contributes advanced computational and AI capabilities to enhance the resilience and security of the nation's energy infrastructure. Current AI in applied energy across EERE, FECM, NE, CESER, and OE focus on:
    - **Securing Critical Energy Infrastructure:** Leveraging AI for enhanced threat detection, anomaly analysis, and natural language processing for cyber data to defend operational technology and energy systems.
    - **Advanced Grid Operations, Optimization, and Resilience:** Applying AI for intelligent, autonomous, and predictive control of the power grid, optimizing energy performance, detecting and valuing risks in distributed energy systems, and simulating grid failures.
    - **Advanced Materials Discovery and Smart Manufacturing:** Utilizing AI/ML to accelerate the development of new materials for energy conversion and storage and enable smart manufacturing processes for critical energy technologies. This includes efforts like the multi-lab Minerals to Materials Supply Chain Research Facility, leveraging AI for technology development, testing, and validation across critical mineral and material processing stages.

  - **Scientific Modeling and Simulation:** Developing foundational AI/ML techniques and generating synthetic data to enhance modeling and simulation across diverse energy domains, accelerating scientific discovery and understanding complex systems. Examples include the use of AI/ML tools to improve predictive models of advanced nuclear fuels, supporting more efficient operation of light water reactors, grid and other infrastructure planning, and analysis.
  - **Streamlining Regulatory and Permitting Processes:** Applying AI to accelerate Federal permitting for energy infrastructure and related projects. This includes tools like *PermitAI,* in which machine-readable datasets train AI models for enhanced searching, summarization, and categorization of environmental documents and public comments. This will facilitate critical energy development by supporting analysts in validating data and drafting NEPA review documents.

- **AI for National Security:** NNSA integrates AI into scientific operations, infrastructure, and data management to enable faster deployment and greater reliability in dynamic conditions. Key initiatives include:
  - **Trustworthiness:** Developing capabilities to assess nuclear risks of AI systems and making investments in mathematical foundations for verification and validation to ensure trust in AI-generated results. This includes the development and publication of the Trust Calibration Maturity Model to evaluate AI system reliability within high consequence domains.
  - **Threat Assessment:** NNSA developed a “red teaming” capability that seeks to understand how an AI model could aid a non-state actor or proliferate nation in developing or advancing a nascent nuclear weapon capability.
  - **Lifecycle Optimization:** AI streamlines and reduces cost and schedule across the entire nuclear warhead system lifecycle, from discovery and design optimization to manufacturing, certification, deployment, and surveillance. It also significantly improves production processes, material performance in advanced manufacturing, and engineering more broadly.
  - **Data Management:** AI/ML digitizes historical and programmatic records, enhancing the management and accessibility of critical data for nuclear security and operations.
  - **Policy:** NNSA funds national laboratory work assessing AI/ML technology applicability to nuclear export controls and exploring necessary regulatory adaptations, including reviewing dual-use export control licenses and providing expertise for regulatory officials and enforcement agencies.

- **AI for Legacy Cleanup:** EM is investing in AI to identify opportunities to reduce the Nation's largest environmental liabilities and accelerate the cleanup of legacy waste across the DOE complex. Examples include:
    - **AI R&D Roadmap:** Developing an AI research and development roadmap to identify gaps and investment opportunities for research to support AI-enabled/enhanced mission execution, risk and cost reduction, and schedule acceleration through e.g., adaptive and real-time optimization of remediation systems and waste treatment processes, data centralization, and integrated performance and risk assessments.
- **AI Testbed for DWPF:** AI/ML based visualization, analysis, and optimization software package for the Savannah River Site Defense Waste Processing Facility that integrates plant processing data to increase processing throughout.
- **Strategic Partnerships:** DOE and its national laboratories advance AI through lab-directed activities and external collaborations. For example, LANL is partnering with OpenAI to install reasoning models on the Venado supercomputer for national security research. Regular "AI Jam Sessions" involve technical experts and stakeholders experimenting with early access to private industry models and exploring research applications, fostering industry partnerships and identifying strategic opportunities for DOE. These sessions facilitate rapid prototyping and validation of new AI technologies, promote the exchange of innovative ideas, enhance understanding of AI capabilities in practical scenarios, and accelerate the integration of cutting-edge solutions into research projects. Computational partnerships like SciDAC promote the build and use of foundation models that support new applications in science, energy, and national security through advanced computing.

Strategic Objectives

DOE's future objectives in AI are centered on leveraging its unique capabilities to advance its mission:

- **Convergence of AI, HPC, and Quantum:** DOE will strategically invest in initiatives capitalizing on the convergence of AI technology, high-performance computing, and quantum technologies, leveraging its exceptional capabilities. This is a focused effort to exploit a unique synergy that offers unparalleled potential for scientific breakthroughs.
- **Advanced AI Hardware, Software, and Algorithms:** DOE will continue investment in developing novel AI hardware, software, and algorithm designs, including co-designs with industry, and applied demonstrations. These targeted efforts aim to provide more accurate predictions and insights for decision support, enhancing U.S. economic security and competitiveness.

- **Designing Grand Challenges:** To drive targeted innovation, DOE will strategically design AI grand challenges and benchmarks highlighting the specific needs and unique expertise of its mission.
- **Fostering Research Environment Adaptability:** DOE aims to advance a research environment agile enough to rapidly respond to dynamic changes in the AI field, addressing AI infrastructure, data management, AI standards, and benchmarking. This reflects a commitment to flexibility and responsiveness over rigid, predefined paths.
- **Supporting R&D for Data Centers:** DOE will champion R&D activities to enable U.S. leadership in data centers, which are critical enabling infrastructure for AI growth. Focus areas include improved thermal management technologies to reduce energy costs and strategies for load flexibility to reduce demand on the grid and foster energy stability.
- **Ethical AI Development:** DOE is driving American leadership in AI through responsible adoption, use, and continued development, precisely aligning with Federal directives, including OMB guidance, to safeguard privacy, civil rights, civil liberties, and prevent unlawful discrimination. For high-impact AI applications, DOE ensures robust human oversight, intervention, and accountability, engineering AI functionalities with suitable fail-safes to mitigate risks. DOE will rigorously evaluate autonomous safety and security decisions as capabilities advance, all to deliver enhanced value and equitable services to the American public, fostering trust and innovation.
- **Integrating AI into Deployed Technology Applications:** The Department plans to prioritize integration of AI-enabled technologies across core applied research domains (energy grid, nuclear, advanced materials, information security engineering) to deliver value. This includes strategically applying generative AI to accelerate engineering design and digital assurance for high-consequence systems, such as in the nuclear enterprise, enhancing reliability and efficiency. This also includes AI for augmenting discovery, enhancing decision-making, enabling autonomous operation, and exploring applied energy challenges such as spent nuclear fuel storage.
- **Efficiency in Funding Processes:** DOE will proactively address the use of Generative AI by applicants for Federal funds and deploy AI tools in the funding process to streamline bureaucracy, increase taxpayer value by expediting contracts, progress reports, and merit review, and improve internal operational efficiency through AI.

Governance and Risk Management

Overview

Incorporating AI models into institutional processes requires a structured approach. DOE is committed to fostering enterprise-wide capacity for AI innovation, specifically through building enterprise capacity for AI readiness. This involves robust governance and comprehensive risk management, while concurrently developing the necessary operational structures and infrastructure to mitigate AI-related risks. These efforts specifically address information security and privacy concerns inherent in AI use. The Department emphasizes strong internal coordination among its various elements to collaboratively manage AI risks and ensure the development and deployment of explainable AI that serves the American people. DOE has opted for a balanced strategy that prioritizes both structured oversight and agile innovation. This decision is driven by the need to effectively manage diverse AI applications, from low-risk internal tools to high-impact mission-critical systems.

Recent Achievements

The Department's current governance framework reflects this balanced strategy, built upon a foundation of collaborative coordination and established leadership.

- **Centralized Coordination with a Distributed Framework:** OCIO, CET, and the CAIO co-lead DOE's AI governance. They regularly coordinate to ensure compliance with administration guidance and facilitate close collaboration with our data governance, privacy, IT, and cybersecurity teams. This co-leadership model was chosen over a single-point authority to leverage diverse expertise and ensure broader departmental buy-in, recognizing that effective AI integration requires multiple perspectives.
- **Departmental Leadership**: The AI Governance Board was established as the principal forum for improving collaboration and coordination of broad AI-related activities across the DOE enterprise. This Board is the mechanism that DOE uses to govern AI issues across the Department, focusing on both AI for DOE operations as well as developing a broader strategy for AI to advance the Department's mission. The decision to establish a board rather than a dedicated, singular office reflects the Department's commitment to cross-cutting collaboration and shared responsibility in AI governance.
- **Reference Material:** DOE released version 2 of the GenAI Reference Guide, a collaborative effort across over 30 DOE offices, sites, and labs. This resource provides information on the responsible development, implementation, and use of Generative AI technology.

Strategic Objectives

DOE's strategy focuses on effective risk management and fostering innovation, aiming to build a mature, resilient, and trustworthy AI ecosystem. The Department recognizes that a uniform "one-size-fits-all" governance approach would stifle innovation in some areas while being insufficient in others. Therefore, a differentiated strategy will be adopted, while reinforcing the human and structural foundations.

- **Implement Proportional AI Governance Frameworks**
  - **Graded Approach to Governance:** Implement a graded approach to governance and risk management. This ensures oversight is proportional to the risk and impact of AI applications, allowing agile innovation for lower-risk applications and robust scrutiny for higher-risk ones.
  - **Comprehensive Guidance and Guardrails:** Develop and disseminate comprehensive best practices and implementation guidance, including automated and manual guardrails integrated throughout the AI lifecycle to prevent misuse and ensure system integrity. This proactive guidance mechanism is preferred over purely reactive incident management, aiming to embed responsible AI practices from inception.
  - **Internal Policy Development:** Update and create internal DOE guidance for AI and GenAI. DOE’s GenAI policy will be released in December 2025. This internal policy development is crucial for tailoring Federal guidance to the specific operational realities and unique mission of the DOE, as external directives alone may not fully address the Department’s complex needs.
- **Strengthen AI Risk Management Practices**
  - **Standardize Risk Evaluation**: Standardize evaluation processes for AI systems across DOE and establish clear protocols for addressing identified risks.
  - **Prioritize High-Impact Use Cases**: Implement robust risk management practices specifically for high-impact use cases. "High-impact" will be defined not only by mission criticality but also by the potential consequences of failure. Projects with potential for negative or catastrophic outcomes will be subjected to a multi-faceted response to minimize risk exposure.
  - **Improve AI Use Case Tracking**: Track all applicable AI use cases in the publicly available DOE AI inventory. This includes developing a common approach for continuous monitoring, proactively sourcing, and overseeing AI applications across the Department.

  - **Clarify AI Research Exemptions**: Precisely define the exemption for AI research to ensure alignment with OMB M-25-21 guidance and maintain legal soundness.

- **Build Governance Capacity and Culture**
  - **Reinforce Governance Structures:** Strengthen existing AI governance bodies. This includes reinforcing the roles and coordination among the Chief AI Officer, AI Governance Board, AI Advancement Council, Data Governance Board, and the High-Impact AI Working Group.
  - **Enhance Training and Awareness:** Develop training programs to ensure employees, contractors, and leadership understand their responsibilities in the secure use of AI. Investment in education will embed a culture of responsible AI use throughout the Department, recognizing that policies alone are insufficient without informed personnel.

Resource Tracking and Planning

Overview

DOE recognizes that effectively stewarding resources for AI investments requires a deliberate strategy, particularly given the multitude of promising avenues for AI development and deployment. Achieving mission outcomes through AI necessitates robust mechanisms to identify, track, and plan for future investments. This ensures that funds are strategically allocated to high-priority initiatives, procurements are coordinated, and AI capabilities are deployed with maximum efficiency.

Recent Achievements

DOE has already established foundational elements for systematic AI investment planning and oversight. These early efforts were designed to build essential visibility into current AI activities and align with OMB requirements. The Department prioritized tools that could be rapidly implemented to provide a baseline understanding of DOE's AI landscape, a prerequisite for making informed decisions about future investments, and form a strong base for enterprise-wide scaling.

- **AI Hub:** Serves as a DOE-wide repository for AI-related resources, including training materials, case studies, and best practices. The decision to centralize this information through a dedicated hub, rather than relying on distributed departmental initiatives, was driven by the need for accessible, on-demand information for all employees, promoting consistent understanding and reducing redundant efforts across the Department.
- **AI Use Case Inventory:** Since 2023, DOE has maintained an AI Use Case Inventory to systematically track AI applications across the Department. This inventory provides crucial transparency into existing AI activities, supports

centralized oversight, identifies areas for collaboration, and ensures compliance with Federal reporting requirements more effectively than less structured methods (e.g., project-specific reporting or ad-hoc surveys).

Strategic Objectives

To optimize AI investment and procurement across the Department, the overall aim is to increase the integration and efficiency of resource tracking and planning systems.

- **Accelerating Procurement Times:** Leveraging AI to enhance the entire procurement lifecycle, including market research, planning, compliance, and reporting, is a strategic imperative to accelerating the acquisition of critical technologies. OCIO will collaborate with GC and acquisition teams to proactively identify and manage risks inherent in procuring products with AI features, recognizing that standard procurement processes may not fully address these complexities.
- **Establish Explicit Expedited Procurement**: Add language that makes an explicit commitment to "expedited procurement" and "pre-approved vendor lists" for AI technologies and data services for R&D. This is crucial for drastically reducing the time required to acquire critical AI-enabling technologies.
- **Implement Blanket Authorization to Use (ATU) Approvals**: This would create a blanket ATU for pre-vetted cloud services, allowing for rapid deployment and experimentation. This directly addresses the need for "timely approvals" and "advance protocols" by replacing burdensome, case-by-case reviews.
- **Sustaining Investment and Collaborative Deployment:** Dedicated investment in AI is critical to drive breakthroughs, strengthen international standing, spur economic growth, attract top talent, and secure DOE's leadership in this rapidly evolving field. Ensuring a sustained investment, combined with robust interdepartmental coordination and dedicated resource allocation, will enable the efficient integration and scaling of AI solutions, leading to streamlined operations and increased departmental productivity.
- **Standardizing Resource Management:** Integrating and standardizing DOE's resource tracking and planning systems is the path chosen to consolidate data, reduce redundancies, and enhance decision-making. This standardization approach, rather than allowing for varied departmental tracking and planning methods, was selected because it uniquely enables improved forecasting and optimized resource allocation across the entire Department, ensuring a holistic view of AI investments and their impact.

Appendix

In addition to the list given in the *Introduction,* the following acronyms will be used throughout the Appendix. In some areas the acronyms are defined, for others, the list below is provided for awareness:

DOE Technology Offices:

- Advanced Manufacturing and Materials Technologies Office (AMMTO)
- Advanced Research Projects Agency-Energy
- Advanced Scientific Computing Research (ASCR)
- Biological and Environmental Research (BER)
- Bioenergy Technologies Office (BETO)
- Building Technologies Office (BTO)
- Environmental Safety and Health (ES&H)
- Office of Fossil Energy and Carbon Management (FECM)
- Fusion Energy Sciences (FES)
- High Energy Physics (HEP)
- Hydrogen and Fuel Cell Technologies Office (HFTO)

Miscellaneous:

- Advanced Computing Technologies (ACT)
- Accelerator Control Systems (ACORN)
- Advanced Biofuels and Bioproducts Process Development Unit (ABPDU)
- Advanced Infrastructure Integrity Model (AIIM)
- Application Programming Interfaces (APIs)
- Advanced Plant Phenotyping Laboratory (APPL)
- Advanced Research on Integrated Energy Systems (ARIES)
- Amazon Web Services (AWS)
- Bidirectional Encoder Representations from Transformers (BERT)
- Biofuels and Bioproducts User Facility (BFNUF)
- Computational Sciences Graduate Fellowship (CSGF)
- Data Analytics and Machine Learning (DAMaL)

- Department of Energy Funding Opportunity Announcement (DE-FOA)
- Department of Commerce (DOC)
- Energy Data eXchange (EDX)
- Energy Data eXchange Critical Materials and Minerals (EDX ClaiMM)
- Energy Efficiency Scaling for Two Decades (EES2)
- Environmental Molecular Sciences Laboratory (EMSL)
- Environment and Maturity Program Assessment and Control Tool (EMPACT)
- Energy Sciences Network (ESnet)
- Earth System Sciences Deep Insight for Earth Science Data (ESS-DIVE)
- Earned Value Management System (EVMS)
- Experimental Program to Stimulate Competitive Research (EPSCoR)
- Findable, Accessible, Interoperable, Reusable (FAIR)
- FAIR, AI Readiness & Reproducibility (FARR)
- Framework for Unified Security Integration with OSCAL and NIST (FUSION)
- General Matrix Multiply (GEMM)
- Generating Electricity Managed by Intelligent Nuclear Assets (GEMINA)
- Generative Pre-trained Transformer (GPT)
- Generative Pre-trained Transformer 4 Omni (GPT-4o)
- High Performance Computing for Manufacturing (HPC4Mfg)
- Integrated Biorefinery Research Facility (IBRF)
- Inertial Fusion Energy (IFE)
- Integrated Operations for Nuclear (ION)
- Integrated Project/Program Management Maturity and Environment Total Risk Rating (IP2M METRR)
- Isotope Research and Production (IRP)
- Integrated Research Infrastructure (IRI)
- Joint Genome Institute (JGI)
- Leadership Computing Facilities (LCF)
- Microbial Molecular Phenotyping Capability (M2PC)

- Magnetic Fusion Energy (MFE)
- Major Item of Equipment (MIE)
- Model Operations (ModelOps)
- National Bureau of Economic Research (NBER)
- National Energy Research Scientific Computing Center (NERSC)
- Nuclear Energy Advanced Modeling and Simulation (NEAMS)
- National Environmental Policy Act (NEPA)
- National Nuclear Data Center (NNDC)
- National Microbiome Data Collaborative (NMDC)
- Nanoscale Science Research Centers (NSRCs)
- National Science Foundation (NSF)
- National Institute of Standards and Technology (NIST)
- OPEN Government Data Act (OGDA)
- Open Energy Data Initiative (OEDI)
- Open Security Controls Assessment Language (OSCAL)
- Office of Scientific and Technical Information (OSTI)
- Project Assessment and Reporting System (PARS)
- Predictive Science Academic Alliance Program (PSAAP)
- Quantum Information Science (QIS)
- Retrieval-Augmented Generation (RAG)
- SC Computational Partnerships (SciDAC)
- Systems for Monitoring and Analytics for Renewable Transportation Fuels from Agricultural Resources and Management (SMARTFARM)
- Strengths, Weaknesses, Opportunities, Threats (SWOT)
- Trust Calibration Maturity Model (TCMM)
- U.S. Nuclear Data Program (USNDP)
- Vision and Leadership for Operations Research (VALOR)
- Workforce Development for Teachers and Scientists (WDTS)

AI Use Cases

The use cases below represent a self-selection of inputs from Departmental Elements. These are not an exhaustive list of the entirety of AI use cases across DOE.

- **GC**: Coordinating with OCIO to build an internal AI tool to assist in management of voluminous Freedom of Information Act requests
- **ES&H Data Analytics and Machine Learning (DAMaL) Tools:** various components that support analysis, data, and automation of processes at Sites, Field Offices, HQ, and within EHSS.
- **SC/ASCR:** Accelerating Scientific Discovery through AI/ML and Exascale Computing: AI/ML is leveraged to enable the convergence of AI with exascale computing, allowing for real-time exploration and understanding of extreme-scale and complex data from simulations and experiments in fundamental science.
- **SC/BER:** AI-enabled analyses of genome organization and metabolic pathway diversity across the phylogenetic spectrum to gain a fundamental understanding of biology and harness its potential for biotechnology innovation.
- **SC/FES: AI/ML for Fusion Plasma Control and Prediction:** AI/ML techniques are being applied for complex data analysis, plasma control, and prediction in fusion energy research to accelerate discovery and optimize magnetic confinement regimes.
- **SC/S&S: AI-Enhanced Physical Security Systems:** AI-based technologies provide enhanced performance for detecting, identifying, tracking, and classifying physical security threats, including advanced AI-based video analytics at national laboratories like Argonne.
- **SC/FES:** FusionSage, a task-specific LLM, is in use at the DIII-D National Fusion Facility to enhance research efforts by rapidly referencing thousands of internal documents, including research papers, abstracts, and experimental plans, to provide accurate, fusion-specific answers for facility users as they plan and execute experiments.
- **SC/NP:** AI/ML for Accelerator Operations and Experimental Planning: AI and machine learning analysis tools are being advanced to increase the efficiency of nuclear data analyses and to improve the quality of accelerator operations and experimental planning across Nuclear Physics facilities.
- **SC/IP:** AI/ML for Isotope Production Efficiency: AI/ML is employed to improve efficiencies and automation in isotope science and advanced manufacturing, leading to more effective techniques for cumbersome isotope production processes.

- **EM:** ALTEMIS: AI/ML techniques are being applied in combination with advanced sensor networks to optimize the environmental monitoring system, resulting in early warning for contamination and up to 80% reduction in the lifecycle cost of long-term environmental monitoring.
- **EM:** AI4PFAS: Develops models that use AIML methods to determine the source/origin of PFAS in soil and groundwater.
- **EM:** Machine Learning for SWPF Process Analysis: Utilizes Artificial Neural Network to analyze filtration rates to support decision-making in optimization of the Salt Waste Processing Facility operations.
- **OCIO:** DOE's OCIO has developed and scaled a GenerativeAI application suite across the enterprise. With 7,000+ users, the tool has returned thousands of hours back to DOE's mission and saved the Department millions of dollars.
- **EERE:** DE-EE0008766 Decision Making, Demonstrated potential for 2-5% increase in annual energy production from geothermal power plants through application of machine learning algorithms, training sets, data analytics, and digital twins
- **EERE:** HPC4Mfg Spring 2021 awardee (High Performance Computing for Manufacturing, funded by EERE/AMMTO, administered by LLNL) Decision Making, Supported Spar Systems work to use machine learning to develop a new technology that generates power from low temperature "waste heat" produced by data centers. If deployed widely, technology could potentially generate up to 25TWh of energy annually
- **EERE:** NREL-41222 Prediction, Decision Making, partnered with Dallas Fort Worth Airport to forecast 5-year electric loads and optimize design of a new microgrid, identifying potential 41% reduction in infrastructure lifecycle costs
- **EERE:** NREL-40455 Detection, partnered with utilities (Berkshire Hathaway Energy, PJM) and industry (Waterfall Security, Eaton) to develop, test, validate a tool to improve the cybersecurity of hydropower plants
- **EERE:** ORNL-34306 Detection, Decision Making, supported development of "Gremlin", an AI-powered tool that challenges and strengthens the software that helps guide connected and automated vehicles [Detection and Classification]
- **EERE:** ORNL-36644, ORNL-24759 Detection, Decision Making, supported development of "Peregrine" AI software that provides real-time quality control for manufacturers using 3D printers. Broad benefits / application, including nuclear energy, make Peregrine ORNL's most licensed manufacturing technology

- **EERE:** DE-EE0009012, DE-EE0009326 Detection, Decision Making, Partnered with Terabase Energy to apply advanced analytics & digital twins to develop robotic technology for solar power plant construction, halving time to complete module and tracker installation. Successful field test in Texas led to $44 million in follow-on funding
- **EERE:** ORNL-52532 Decision Making, ORNL is developing novel, low energy AI algorithms to reduce energy demand of automated vehicles (AV). Early results indicate the potential to reduce AV on-board computation energy by more than 50%.
- **EERE:** ORNL-53167 Decision Making, Piloting the use of AI algorithms and real-time data to coordinate a series of traffic signals in Nashville, TN to optimize traffic flow. Expected benefits include reduction in congestion and travel times for travelers and businesses, reduction in fuel and energy use for transportation, and reduction in emissions.
- **EERE:** LANL-31108, NREL-31764 Decision Making , AI/ML tools contributed to activity and durability optimization of platinum group metal free fuel cell catalysts, enabling a doubling of catalyst performance since 2021; and HFTO-supported, industry-led fuel cell manufacturing technology development projects use AI/ML to facilitate high-throughput processed to enable 14GW/yr of domestic manufacturing capacity, representing approximately a ten-fold increase in current US manufacturing capacity.
- **EERE:** NREL, INL, LBNL Discovery, Decision Making, BETO is planning to fund NREL, INL, and LBNL for an R&D project that will develop and use AI/ML models and demonstrate their effectiveness for accelerating and de-risking scaleup of biofuels and biochemicals production processes. This project will create an AI/ML digital twin model that will integrate the unique capabilities of the three BETO PDU facilities (BFNUF at INL, ABPDU at LBNL and the IBRF at NREL), and simulation and ML models unique to each lab.)
- **ARPA-E: SMARTFARM (Systems for Monitoring and Analytics for Renewable Transportation Fuels from Agricultural Resources and Management):** This program aims to enhance the biofuel supply chain's efficiency and performance. This innovation supports the domestic energy sector by improving biofuel production efficiencies, contributing to energy independence and technological leadership through data-driven agricultural practices. Efficiencies are obtained by developing advanced monitoring technologies, incorporating artificial intelligence, to accurately quantify field-level emissions and impacts on soil health in feedstock production. Released December 2019, $18 Million. DE-FOA-0002250, DE-FOA-0001953

- **ARPA-E: DE-FOA-0002174 GEMINA (Generating Electricity Managed by Intelligent Nuclear Assets):** The program focuses on developing digital twin technology for advanced nuclear reactors and transforming operations and maintenance systems in the next generation of nuclear power plants. This initiative enables increased deployment of nuclear power by designing tools that introduce greater flexibility in reactor systems, increased autonomy in operations, and faster design iteration. Technologies leverage artificial intelligence for advanced control systems, predictive maintenance, and model-based fault detection. Released October 2019, $28 Million.
- **OE:** Physics-informed ML algorithms to significantly reduce the computational footprint of operational power grid control loops, which will increase the ability of grid operators to complete complex contingency assessments in operational timescales. Additional work includes tools for improving grid reliability and stability under uncertainty, outage prediction, wildfire mitigation, and optimization.
- **OE:** A General Framework for AI-Accelerated Power Systems Optimization: Developed a general framework for the next generation of hybrid power systems optimization tools combining classical optimization that uses MIP in conjunction with AI to become increasingly more efficient over time. The developed methods provides comparable optimization results to the traditional method at a less time.**CESER: AI assurance testbed:** The CESER-led AI testbed housed at Lawrence Livermore National Laboratory (LLNL) creates an assurance platform that rigorously tests AI models for vulnerabilities, adversarial robustness, and suitability for critical energy applications and provides utilities and vendors with comprehensive, actionable assessments. This enduring capability will enable the design of AI systems with built-in defenses against tampering and exploitation.
- **CESER:** Autonomous operation through compromise: Build decentralized control systems to enable rapid self-healing, reconfiguration, graceful degradation, or other operations through compromise, including the development of topology change-resistant monitoring and collaborative state estimation leveraging collaborative autonomy. Effort will result in tools that will allow optimal resource placement to enable dynamic, self-forming microgrids and will advance the field by leveraging multi-agent deep reinforcement learning to operate the grid in a decentralized manner, even when communication paths are disrupted or untrusted.
- **DOE-IN:** Is developing and deploying LLM-based tools for intelligence and counterintelligence analysis that will increase the timeliness, accuracy, and impact of finished intelligence products.

- **NNSA:** Has developed multimodal foundation models for stockpile stewardship and nuclear nonproliferation, for deployment in secure settings to enable additional research and development and integration with operational mission capabilities. NNSA also developed test and evaluation methods to assess external proprietary models for nuclear-related risks.
- **FECM:** DOE's Office of Fossil Energy and the National Energy Technology Lab are deeply engaged in acceleration technological innovation for energy systems, leveraging deep domain expertise with data and AI to advance technology rapidly. NETL's Advanced Infrastructure Integrity Model (AIIM) is a multi-modeling AI solution that evaluates and informs key energy infrastructure integrity for maintenance and planning forecasting. This is an award winning, published model that has been trained for natural gas and other pipelines, and offshore platforms. The model is now being expanded to address wellbore integrity evaluations.
- **SC/ASCR**: Foundational AI for Scientific Computing: Investments fund critical basic research in applied mathematics and computer science to merge AI with exascale computing, developing tools for building foundation models useful for science, energy, and national security applications.
- **SC/BES: AI/ML for Materials Discovery and Design:** AI/ML techniques are being used to extract knowledge from large materials databases and accelerate discovery through innovative physics-guided AI approaches, enabling scalable, automated synthesis with real-time adaptive control for new materials with desired properties.
- **SC/BER: AI-driven Biotechnology and Genomic Science:** Creation of reasoning AI models that couple LLMs trained on the published literature with experimental genomics datasets coupled to automated instrumentation to explore designs of new biomolecules, metabolic pathways and modified organisms for biotechnology innovation.
- **SC/FES:** Researchers at the DIII-D facility developed automated workflows to generate plasma state reconstructions with no manual oversight during experiments by using ESnet to exploit the NERSC supercomputing platform; this enabled the program to compute 20,000 reconstructions in 3 months versus 4,000 manual reconstructions computed in 12 years.
- **SC/FES:** A cross-facility, multi-institutional collaboration is developing a common Fusion Energy Data Repository with common data and metadata standards, including integrated workflows using advanced simulation toolkits that address needs in both the IFE and MFE space.

- **SC/HEP: AI/ML for Particle Physics Data Analysis and Simulation:** AI/ML is used to extract rare particle signatures from high volumes of data, operate accelerators and detectors in real-time, and create more realistic and accurate simulations of complex physical processes in High Energy Physics.
- **NE:** Office of Nuclear Energy (NE) recognizes AI as a transformative technology to accelerate the demonstration and deployment of new reactors, enhance operation and reduce costs for existing reactors, and drive innovation across nuclear energy technologies. The following use cases – separated by key focus areas – highlight current and planned activities across NE to advance American nuclear energy through AI.
- **NE:** Powering Data Centers: NE aims to leverage AI to accelerate the deployment, enhance operation, and expand research of nuclear energy technologies, thereby addressing the growing energy demands driven by AI and data center needs. The Department has designated four sites, Idaho National Laboratory, Oak Ridge Reservation, Paducah Gaseous Diffusion Plant, and the Savannah River Site, as locations to invite private sector partners to develop cutting edge AI data center and energy generation projects, including nuclear energy. Most recently, DOE issued a Request for Application (RFA) to seek proposals from U.S. companies to build and power AI data centers at Idaho National Laboratory.
- **NE: Autonomous Nuclear Reactor Development and Licensing:** Streamline and expedite the nuclear permitting and licensing application processes by integrating industry frontier AI tools and regulatory systems (e.g., https://inl.gov/news-release/idaho-national-laboratory-collaborates-with-microsoft-to-streamline-nuclear-licensing)
- **NE: Reduce Nuclear Energy Operating and Maintenance Costs:** Application of AI solutions to reduce operating and maintenance costs for existing U.S. nuclear power plants (e.g., https://www.energy.gov/ne/articles/new-ai-tools-could-save-constellation-reactor-fleet-millions, https://www.anl.gov/nse/ai-ml/proaid); Utilizing AI to identify and diagnose equipment degradation to enhance and optimize predictive maintenance activities for nuclear reactor plants (e.g., https://lwrs.inl.gov/content/uploads/11/2024/03/ExplainableArtificialIntelligenceTechnology.pdf); Integration of AI/ML into existing commercial nuclear reactor plants as part of the Integrated Operations for Nuclear business model to advance work reduction opportunities (e.g., https://lwrs.inl.gov/content/uploads/11/2024/03/ION_CrossPathway.pdf)

- **NE: Increase Autonomous Operation of Reactors:** Development of autonomous nuclear reactors and acceleration of the deployment of nuclear energy systems using advanced cloud infrastructure and AI technologies that could power future data centers (e.g., https://inl.gov/news-release/idaho-national-laboratory-accelerates-nuclear-energy-projects-with-amazon-web-services-cloud-and-ai-technologies/); Creating AI digital twins for real-time simulations and predictive models of nuclear reactors (https://www.energy.gov/ne/articles/idaho-national-laboratory-demonstrates-first-digital-twin-simulated-microreactor)
- **NE: Crosscutting Nuclear Energy Technology:** Applying AI tools and exploring semi-autonomous irradiation testing laboratory operations with the goal of reducing the time and cost to qualify materials needed for nuclear energy deployment. Recent examples include utilizing AI to rapidly inspect advanced manufacturing test components including radiological materials (https://www.energy.gov/ne/articles/new-national-lab-algorithm-enables-faster-safer-inspection-nuclear-materials);
- **NE:** Applying AI to advanced X-ray technology to measure concrete strength and aging demonstrates AI technology use in the long-term operation of nuclear reactor plants (https://lwrs.inl.gov/content/uploads/11/2025/01/10-GA50624-40_R14-Article02.pdf); The US has been looking for a deep geological repository for over 50 years. A huge amount of geological site characterization has been collected from numerous sources and hundreds of millions of dollars spent on modeling generic repositories. The opportunity exists to use AI to manage this huge amount of data to quickly screen sites being considered as part of a collaborative based siting process.
- **NE:** Leveraging AI/ML to develop closure models for high-fidelity computational fluid dynamics simulations to improve the accuracy of nuclear reactor heat transfer and fluid flow modeling. (https://doi.org/10.1016/j.nucengdes.2025.113879) ;
- **NE:** Creating reduced-order models that translate atomistic-scale phenomena such as aging and irradiation to practical, engineering-scale behaviors without significant computational cost. This enables material lifetime prediction and high-fidelity digital twin types of applications. (https://doi.org/10.1038/s41524-024-01488-z);
- **NE:** Improving predictive models of advanced nuclear fuel pellet deformation to reduce model uncertainty through inference from separate effects experiments in advanced pellet-clad mechanical interaction models. By using a neural network surrogate, the advanced model can be integrated into the BISON fuel

performance code, with retained fidelity but much cheaper computational cost, to analyze pellet behavior under relevant conditions.

- **PermitAI:** The PermitAI tool, developed and maintained by DOE contractors, enhances and expedites document analysis for environmental reviews. Federal experts can now summarize past reviews or categorical exclusions under the National Environmental Policy Act (NEPA) for new permits in hours, not weeks. EERE and OP are collaborating to expand the project beyond original scope to include broadening the scope to include a permit application AI across multiple technologies.
- **NNSA:** NNSA is working to accelerate and improve nuclear technology export licensing processes (known as "Part 810" licensing) using AI/ML tools to meet Executive Order #14299's directive on deploying advanced nuclear technologies for national security. These capabilities will help NNSA manage large amounts of sensitive data, complete legally mandated reviews with multiple agencies more efficiently, and improve the user interface experience for exporters. AI/ML tools will also augment staff analysis of nonproliferation, technology, economic and political risks while maintaining an agile process to support responsible and efficient export of American nuclear
- **EERE: Energy Efficiency Scaling for Two Decades (EES2):** This partnership—which now counts most DOE national labs and 70 other external organizations as partners, it focused on R&D cooperation to improve efficiency of semiconductor industry applications—such as computing—1000-fold by 2043. Since AI is a major user of energy, as part of its analysis to support its R&D Roadmap, DOE developed techniques to measure the full compute-stack energy efficiency AI models. (see Figure 1)
- **EERE:** In 2025, DOE is setting up measurements and doing research on about 40 AI/ML algorithms ranging from matrix multiplication (GEMM) to algebraic multigrid (AMG), K-means clustering, Transformer/inference (BERT/GPT) and training (LLM). And proposes to work with NIST at DOC, NSF, and other Federal science agencies to publicize its results and cooperate to further the science of measuring and evaluating AI model performance
- **SC/FES: International Collaborations Leveraging AI in Fusion:** DOE participates in international collaborations that exploit long-pulse facilities, where multi-institutional teams apply advanced diagnostic systems and leverage data sharing, implicitly including AI-driven analysis, to accelerate fusion research globally.
- **SC/ASCR: AI for HPC Efficiency and Performance:** Enhancements to hardware and engineering methodologies, particularly for accelerated computing

systems at exascale, funded by programs like PathForward (a partnership with NNSA), directly improve performance for AI by leading to higher speed, larger models, and better training efficiency on advanced GPU systems, demonstrating the interconnection of efficient computing and AI.

- **SC/S&S: AI for Critical Infrastructure Monitoring:** AI is utilized in critical infrastructure maintenance, such as the FNAL Chilled Water Plant, where vibration monitoring of chillers, cooling towers, and pumps is integrated with AI/ML predictive analytics to monitor utilities and predict failures.
- **PM: Project Assessment and Reporting System (PARS) Portfolio of AI tools:**
  - **AI Assistant Walt:** Walt is an AI assistant operated within the PARS Azure Government environment using Azure OpenAI's GPT-4o to read PARS Data and support all users with real-time insights.
  - **AI Powered Document Management System Search:** In development: Leverages AI for advanced document indexing, categorization, chunking, and retrieval, incorporating agentic AI and RAG principles for powerful search capabilities.
  - **Environment and Maturity Program Assessment and Control Tool's Integrated Project/Program Management Maturity and Environment Total Risk Rating (IP2M METRR), EMPACT's IP2M METRR, Assessment AI Analysis:** In development: Utilizes AI for sentiment analysis, SWOT analysis, root cause analysis, and mapping environmental factors to maturity attributes, aiding in the development of corrective action plans.
  - **Compliance Readiness Checklist AI Review:** In development: Uses AI to assess contractor EVMS System Descriptions against nearly 200 criteria in a compliance checklist.
  - **Framework for Unified Security Integration with OSCAL and NIST (FUSION)**

AI-Enabling Infrastructure

- **FE's Energy Data eXchange (EDX):** EDX is an AI enabling R&D infrastructure developed by NETL to support public access/technology transfer through secure, private, multi-institution collaboration for ongoing research projects. One feature of EDX is the hosting of spatial products that include hydrocarbon resources (oil & natural gas), coal, critical minerals, energy production and transportation infrastructure, and other related assets. NETL also has AI-enhanced sub-platforms for technology communities of practice. For example, EDX ClaiMM is a

dedicated critical materials and minerals digital platform that is incorporating AI-enhanced capabilities for DOE program.

- **Nanoscale Science Research Centers (NSRCs):** NSRCs are evolving their capabilities, including unique AI/ML and data science analytical capabilities, to address national needs in QIS and next-generation microelectronics through flexible infrastructure for materials synthesis, device fabrication, metrology, modeling, and simulation.
- **Integrated Research Infrastructure (IRI) and American Science Cloud (AmSC):** IRI and AmSC aim to seamlessly and securely connect DOE's unique data, user facilities, and advanced computing resources, forming a foundational ecosystem for DOE's broader AI research goals and enabling novel workflows for AI. ARIES in the Flatirons campus at NREL, which combines digital infrastructure with hardware-in-the-loop capabilities that can be used to test solutions across the full energy system—spanning energy generation, storage, and end uses such as transportation, industry, and buildings, and the electric grid that connects them—with applications to high priority areas like resilience and cybersecurity.
- **NNSA Nuclear Security Platform (NSP):** provides access to a common, high-performance and scalable set of AI services and capabilities for NNSA national laboratories, production plants, and national security sites.
- **NNSA's Vanguard Advanced Architecture Prototype Systems (AAPS) Project:** allows the NNSA to develop and test complex national security workflows which blend advanced AI with traditional high-performance computing-based simulations.**SC/ASCR:** ASCR's ACT program provides testbeds and research centers for the design and development of emerging computing technologies, including AI-focused hardware and microelectronics, fostering a national laboratory ecosystem of automated labs, edge sensors, and data resources to accelerate AI innovation.
- **SC/BER: Microbial Molecular Phenotyping Capability (M2PC) and Autonomous Laboratory Frameworks:** M2PC will provide a fully connected, end-to-end phenotyping platform that, in combination with AI, allows for autonomous biological experimentation, serving as a testbed for AI-driven discovery and data generation. Expanding investments in autonomous laboratories and AI-guided design workflows will accelerate advances in protein engineering, high resolution plant phenotyping and creation of novel biological functions.
- **SC/APPL:** Advanced Plant Phenotyping Laboratory, developing AI-driven and automated plant phenotyping workflow and models.

- **SC/HEP: Accelerator Control Systems (ACORN):** The ACORN MIE project replaces outdated accelerator control systems with modern, AI/ML-capable ones, demonstrating the deployment of AI for high-performance operation and control of critical scientific infrastructure.
- **SC/S&S: AI-Based Physical Security Monitoring:** Continued use of AI-based technologies for detecting, identifying, tracking, and classifying physical security threats (e.g., AI-based video analytics) at sites like Argonne and LBNL exemplifies continuous monitoring for operational security.
- **SC: AI/ML Predictive Analytics for Infrastructure:** AI/ML predictive analytics are integrated for continuous monitoring of critical utility infrastructure, such as the FNAL Chilled Water Plant, to predict failures and ensure sustained reliability.
- **Maximum impact for AI-enabling infrastructure will be achieved by:** Integrating HPC, hybrid-cloud, and novel computing (e.g., quantum, neuromorphic, etc.) resources to support standardized ModelOps, federated testbeds, and automated data pipelines, enabling interoperable, secure, and reproducible AI workflows that accelerate innovation across science, energy, and national security missions; Establishing continuous performance monitoring to enable real-time tracking of model behavior, data drift, system reliability, and resource utilization across development, deployment, and operations, supporting scalable oversight, adaptive model management, tools for continual learning and sustained performance in mission-critical applications; Integrating AI into all aspects of scientific facilities, including design, operation, data acquisition, and analysis; Leveraging AI tools for efficient and effective operational support (e.g., business, facility, and human resources) for accelerated accomplishment of national security, energy, and science missions; Providing clear Federal guidance and timely approvals (e.g., operational authorizations) to move at the pace of industry with advance approvals and protocols the preferred approach (e.g., FedRamp).

Data

- **DOE's Open Data Plan**, created in July 2025, aligns with the Office of Management and Budget (OMB) Memorandum M-25-05 and the Foundations for Evidence-Based Policy Making Act of 2018 (Evidence Act), and the OPEN Government Data Act (OGDA), demonstrating our commitment to transparent and accessible government data. We aim to make DOE's extensive data assets (over 3,700 on Data.gov) more findable, accessible, interoperable, and reusable, empowering data-driven decisions across our vital energy, science, and security missions.

- **EERE:** EERE has funded the Open Energy Data Initiative (OEDI) which provides free access to data generated from efforts funded by the U.S. Department of Energy (DOE) and supporting projects and partnerships. OEDI follows FAIR (Findable, Accessible, Interoperable, Reusable) and FARR (FAIR, AI Readiness & Reproducibility) guiding principles. To ensure AI readiness the OEDI curation team is reviewing metadata for universal accessibility and machine readability, as well as accuracy, completeness, and relevance.
- **EERE:** EERE has created the Livewire Data Platform collects, preserves, curates, and disseminates a catalog of transportation and mobility-related projects. It allows transportation researchers, industry, and academic partners to increase the visibility of their projects within the research community, securely share and preserve data, and leverage datasets from other projects.
- **OE: Grid Signature Library:** The Grid Event Signature Library (GESL) is an OE-led initiative in partnership with ORNL and LLNL. The library serves as a valuable resource for researchers, power companies, and grid planners to analyze and predict electric grid behaviors, enhance reliability, and ensure safety. The library captures data on voltage, current, frequency, and more, collected by operating equipment, and is accessible to the public. It supports machine learning models to forecast and mitigate grid malfunctions, contributing to the overall enhancements of grid performance.
- **OE:** Open-source power system model for AI development: Constructed publicly open models and data sets of power systems that are coherent across multiple time scales and modeling resolutions, with accompanying solution data and relevant qualitative labels, to facilitate the application of artificial intelligence methodologies for coherent power grid studies. The project Open Extendable Coherent Models-Datasets for Cognitive Power Grid (OPEN COG GRID) was developed by LLNL and NREL under OE leadership.
- **SC/BES: Physics-Guided AI for Materials Databases:** BES supports the development of large materials databases and computational tools that leverage them, emphasizing innovative physics-guided AI approaches to accelerate discovery, which inherently requires and improves data quality and traceability.
- **SC/BER: AI-Centric Genomic Data Infrastructure (JGI):** The Joint Genome Institute (JGI) user facility is reorganizing its data infrastructure to be more AI-centric, for enabling seamless integration, analysis, and interoperability across advanced analytics and AI workflows generating actionable knowledge and insights that drive discovery and accelerate innovation. This fosters seamless aggregation and harmonization of genomic data, promoting data sharing and reuse,

- **SC/BER:** Integrating among data systems with common APIs at the Joint Genome Institute (JGI), Environmental Molecular Sciences Laboratory (EMSL), Systems Biology Knowledgebase (KBase), National Microbiome Data Collaborative (NMDC) and Earth System Sciences Deep Insight for Earth Science Data (ESS-DIVE). This will serve as a basis for easier AI access for training datasets and tool development.
- **SC/NP: U.S. Nuclear Data Program (USNDP):** USNDP curates reliable, accurate nuclear data, maintaining public access to extensive nuclear physics databases (e.g., NNDC as a PuRe Data Resource), ensuring long-term availability, quality, and accessibility for both fundamental and applied research, and promoting data sharing and reuse through a standardized catalog.
- **SC/OSTI: Public Access to Research Outputs:** The Office of Scientific and Technical Information (OSTI) ensures public access to unclassified research outputs (journal articles, reports, data, software) and promotes wide adoption of persistent identifiers (PIDs). This enhances data sharing, accessibility, and traceability, directly supporting data lineage and validation for AI models.
- **SC/ASCR: Integrated Research Infrastructure (IRI), and more broadly, the American Science Cloud (AmSC):** IRI and AmSC aim to integrate DOE's unique data, user facilities, and computing resources, fostering a cohesive ecosystem where large multi-dimensional datasets are readily accessible and utilized for AI development and application. This promotes systematic reuse and sharing of scientific data assets.
- **SC/ASCR: ASCR Research on Foundational Models:** ASCR supports basic research in applied mathematics and computer science to develop tools for building and understanding foundation models for leading AI capabilities. This includes developing scalable algorithms and methods for efficient data analysis, with an emphasis on protecting privacy and enabling new algorithms for edge computing.

AI-Ready Workforce

- **EERE:** EERE will roll out a series of seminars to equip EERE staff with a practical, working understanding of AI across various domains. The series will launch in September 2025 and conclude in FY26.
- **NNSA:** Through Project Alexandria, NNSA is integrating robust training and efficient processes into its nonproliferation research data management platform to facilitate adoption of good data governance practices, a key enabler of leveraging AI at scale for mission applications.
- **Partnering with Academia**

  - **NNSA:** Starting in FY 2026, the NNSA Predictive Science Academic Alliance Program (PSAAP) will be expanded to include a new activity focusing on AI workforce development, tentatively called PSAAP-AI, and designed to respond to the workforce needs within the AI field. Two to four PSAAP-AI Centers will be established to focus on AI topics such as adversarial machine learning methods, Generative AI, and data science.
  - **SC/ASCR and NNSA/ASC: Computational Sciences Graduate Fellowship (CSGF):** ASCR partners with NNSA to support the CSGF program, increasing the availability and breadth of a trained workforce in exascale computing, AI, and QIS.

- **Fostering Talent at the National Laboratories**
  - **SC: Microelectronics Science Research Centers:** These centers foster a workforce skilled in microelectronics relevant to AI through multidisciplinary teams from universities, national laboratories, and industry.
  - **SC/WDTS: WDTS Pathway Programs:** WDTS develops innovative pathway programs (e.g., Summer Schools, Institutes) focused on AI, ML, and Data Science to provide hands-on research experience and expose K-12 students and undergraduates to scientific and technical careers at DOE national laboratories.
- **SC/HEP: Broadening Engagement in HEP (EPSCoR, SAGE Journey, VALOR):** HEP supports initiatives to expand participation in research, including AI/ML applications, by reaching new communities and fostering a diverse talent pipeline through internships and retraining programs.
- **Merging Subject Matter Expertise and AI Workforce Training**
  - **SC/IP: Isotope R&D and Production Workforce:** IRP supports training and development for a vibrant workforce in isotope production, with a specific focus on AI/ML to enhance process effectiveness.
  - **SC/BES: AI/ML for Materials and Chemical Sciences:** BES increases funding for AI/ML research to accelerate fundamental discoveries, enhance user facility operations, and advance interpretation of massive datasets in materials sciences and chemistry, requiring skilled personnel in AI/ML and data science techniques.
  - **SC/BER: AI-Driven Biodesign Research:** BER pivots towards integrated, AI-driven automated laboratory experimental and data systems (e.g., JGI and EMSL), accelerating biodesign capabilities with AI methods for *de novo* design of biological syntheses, requiring a workforce skilled in AI and automation for biological research.

- **SC/FES: Fusion Workforce Pathways:** This program prepares a skilled talent base for the growing needs of the fusion energy sector, emphasizing research experience, specialized training, and career development in AI-relevant areas for fusion.
- **SC/S&S: Cybersecurity Workforce Development:** The Safeguards and Security program actively supports cyber workforce development to enable mission and science, aligning cyber funding for risk reduction and strengthening security posture, particularly in safeguarding critical research intellectual property in AI.

Research and Development

- **NETL** is driving AI innovation for fossil energy and critical minerals, from subsurface resources to secure supply chains. The multi-lab Minerals to Materials Supply Chain Research Facility (METALLIC), led by NETL, leverages AI to accelerate technology development, testing, and validation across feedstock beneficiation, extractions & separations, refining, and alloy development & advanced manufacturing.
- **Accelerating nuclear fuel qualification timeframes:** AI/ML tools are being developed and used by NE's Nuclear Energy Advanced Modeling and Simulation (NEAMS) program to improve predictive models of advanced nuclear fuels, such as inclusion of dopants, to enable more efficient operation of existing light water reactors. Generating complex salt properties for molten salt reactors: The properties of molten salts in a nuclear reactor evolve over time due to fission, absorption, and corrosion. The NEAMS program, in collaboration with the Advanced Reactor Technologies program, utilizes AI/ML techniques to predict key properties that are essential inputs to molten salt reactor simulations.
- **NNSA** has developed and published the Trust Calibration Maturity Model (TCMM) to evaluate AI system reliability within high consequence domains like nuclear security. The TCMM assesses five key areas: performance, bias and robustness, transparency, safety and security, and usability. This framework helps users make informed decisions about AI systems, track development progress, and identify areas needing further research.
- Across advanced manufacturing and industrial technology offices, **EERE** has invested in integrating foundational research in AI methods with advanced and autonomous laboratory infrastructure to accelerate device manufacturing, advanced characterization, and study of durability and degradation.
- **NE** has invested in the application of AI tools to rapidly inspect advanced manufacturing components for nuclear energy applications to accelerate

qualification times and reduce inspection costs. NE has also optimized reactor plants by incorporating AI tools and methods, including AI capabilities of computer vision, time series, and text analysis, into all facets of reactor plant activities for existing and future plants to leverage technology solutions to a labor-centric model which improve efficiency, enhance energy output, optimize the workforce, and incorporates modernization and automation.

- **ASCR** funds critical basic research in applied mathematics and computer science to merge the power of AI with exascale computing, developing tools for building foundation models useful for basic and applied science while emphasizing precision and trustworthiness for high-consequence applications. Leadership Computing Facilities (LCFs) and NERSC Operations: LCFs (Leadership Computing Facilities) like Frontier/Aurora and NERSC (Perlmutter) provide the nation's most powerful scientific-computing platforms, optimized for AI-enabled science and serving as testbeds for novel AI hardware and QIS technologies, offering essential capacity for AI R&D.
- **SC Computational Partnerships (SciDAC):** SciDAC fosters collaborations between discipline scientists, applied mathematicians, and computer scientists, including partnerships with industry, academia, and other agencies, to build and use foundation models that support new applications in science, energy, and national security through advanced computing.
- **Trained AI emulators** can run 1,000-5,000x faster than conventional physics-based simulations; language models trained on specialized scientific data hold promise as skilled research assistants capable of suggesting experimental approaches and connecting insights across disciplines; AI will help run experiments, interpret data, and decide on next steps; and AI models ‘at the edge’ can help manage and curate the flow of data.
- **Differentiable Predictive Control – Elexity product Integration** (PNNL, funded by the Building Technologies Office). Many AI-based building controls promise big savings but stall on robustness, affordability, and real-world integration. PNNL developed a differentiable predictive control model, prototypes, domain-tailored tutorials, and a ChatGPT-based assistant. In a cooperative research and development agreement that emerged from a competitive lab call (2022), Elexity integrated parts of PNNL’s AI controls toolbox into their cloud infrastructure within days and validated performance gains on their own customer data. The tight collaboration has already led Elexity down a clear path to product integration, giving them competitive, AI-enhanced capabilities they couldn’t develop alone and laying groundwork for broader impact open-source impact.

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