U.S. Department of Energy

Secretary Ernest Moniz

Cabinet Exit Memo | January 5, 2017

Overview and Summary

The Department of Energy (DOE) is responsible for advancing the energy, environmental, and nuclear security of the United States; promoting scientific and technological innovation in support of that mission; sponsoring basic research in the physical sciences; and ensuring the environmental cleanup of the nation's nuclear weapons complex. The DOE enterprise has 64 sites across 29 states and the District of Columbia, including 17 National Laboratories that form a critical part of America's research enterprise (see attachment 1).

During the eight years of the Obama Administration, DOE has delivered on its mission. The results have included dramatic growth in clean energy jobs, vital progress on securing and diminishing the amount of nuclear material globally, and major scientific and technological (S&T) discoveries.

In 2009, the President set forth goals in Prague to secure vulnerable nuclear material and reduce the nation's nuclear stockpile while maintaining our nation's security. Over the past eight years we have continued to maintain a safe, secure, and effective nuclear deterrent without nuclear explosive testing because of our innovative science-based stockpile stewardship program. Together with international partners, we have completed removals or disposition of more than 4,000 kilograms of highly enriched uranium (HEU) and plutonium from 16 countries plus Taiwan – more than enough material for 160 nuclear weapons.

The threat to the United States and our allies of Iranian nuclear weapons development has been addressed through the negotiation by the Department of State and the DOE of the Joint Comprehensive Plan of Action (JCPOA). Reaching the agreement required a unique integration of science and diplomacy. The agreement restricts some aspects of Iran's nuclear program for 15 years and other aspects for much longer, provides for indefinite monitoring and verification, and rules out critical weaponization activity in Iran. If Iran chooses to violate its commitment to a purely peaceful nuclear program, the United States and our allies will know and will have ample time to respond.

We have established technological innovation as a key element of addressing climate change and energy security. In 2008, America had installed 1.2 GW of solar and 25 GW of wind energy; today, American families, businesses and military installations are powered by 31 GW of solar and 75 GW of wind energy. In 2008, there were no photovoltaic solar plants greater than 100 MW operating in America; now, catalyzed by the DOE Loan Program's initial funding of the first five plants, there are 50, nearly all financed by the private sector and driven largely by rapidly falling costs. In the next few months, the first two coal-fired power plants in the U.S. with carbon dioxide capture and utilization are expected to come online, both with DOE support. In October, for the first time in decades, a new nuclear reactor started delivering power to American consumers. With DOE support, the first advanced nuclear power plant in the United States is planned for operation in 2018. These developments reflect the Administration's commitment to an "all of the above" clean energy future.

In 2008, U.S. dependence on foreign oil was nearly 60 percent; today, it is about 25 percent. Due to early DOE investments and the advances made by U.S. companies, domestic production of crude oil rose from 5 million barrels per day in 2008 to 9.4 million barrels per day in 2015, the highest production rate since 1972. Our natural gas production has grown by more than 7 trillion cubic feet per year over the same period. In fact, in 2009, the United States surpassed Russia to become the largest producer of natural gas

in the world. Both of these developments have materially improved energy security and our economy. The low price of natural gas has lowered consumers' bills and given American industry a competitive edge. Meanwhile, DOE will have issued about 50 energy efficiency standards that will save consumers $550 billion on their energy bills and avoid about three billion tons of carbon dioxide emissions by 2030.

Because of these efforts on domestic natural gas production, clean energy, and energy efficiency, U.S. energy-related carbon dioxide emissions in the first six months of 2016 were at their lowest levels since 1991. Since 2008, energy-related CO2 emissions in the United States have been reduced by more than 500 million metric tons annually. DOE played a key role in designing the Mission Innovation initiative that the U.S. and 19 other countries announced in Paris in November 2015, which will build on our progress by doubling federal investment in clean energy research and development (R&D) over the next five years and linking the outcomes to investors. Such an initiative has been advocated by a diverse group of major American company CEOs for several years.

DOE is fundamentally a science, technology and innovation organization. The foundation is the network of 17 National Labs, world-class capabilities like DOE's supercomputers and accelerator facilities and public-private research partnerships. National laboratory facilities support the research of more than 32,000 scientists each year from across the country, providing cutting-edge research opportunities in materials science, nuclear and particle physics, plasma and high energy density science and technology, life sciences, and other fields.

These National Lab facilities are systematically renewed so as to keep American scientists at the research frontier, such as completion of a nearly billion-dollar enhancement of the Brookhaven synchrotron light source in 2015 to provide extremely bright x-rays for basic and applied research in materials, nanoscience, biology and other fields. We continue to push the limits of high performance computing, big data analysis, and associated software development for transformative applications in energy, science, environment and security.

Advanced Photon Source
Argonne National Laboratory

DOE's National Labs contributed critical "on call" technical expertise to needs ranging from the Iran nuclear negotiations to understanding the Aliso Canyon gas storage leak to the Deepwater Horizon oil spill, delivering science-based real-world results day in and day out for the American people. They are also unique resources for providing innovative technology and analysis to the U.S. national security and homeland security communities.

DOE instituted substantial reorganization and performance and management improvements to better serve the American people and the agency. These include enhanced enterprise risk management,

enterprise data management, strengthened project management and cost controls for major projects cross-cutting initiatives that provide a multidisciplinary approach to our greatest challenges, improved stewardship of taxpayer dollars, and enhanced integration of DOE headquarters and our National Labs.

We also greatly strengthened our approach to emergency response in the energy sector. For example, following through on the lessons of Superstorm Sandy, we were much better prepared to respond to Hurricane Matthew, helping to lessen power outages and get power on more quickly. Closer, ongoing collaboration with the energy industry has been key to our heightened preparedness.

During the worst economic crisis since the Great Depression, President Obama signed the American Recovery and Reinvestment Act (ARRA), which included more than $90 billion in investment and tax credits to boost the clean energy economy. Of this, DOE invested more than $30 billion in more than 15,000 clean energy projects. These programs have created or sustained tens of thousands of quality energy sector jobs in the United States, catalyzed substantial reductions in the cost of clean energy technologies, and positioned the United States as a global leader in clean energy.

ARRA funding also accelerated the cleanup of contaminated, often hazardous, legacy sites from the Cold War nuclear weapons production efforts, reducing overall costs to taxpayers while protecting the public and the environment. During the Obama Administration, DOE reduced the cleanup footprint from 931 to 241 square miles and eliminated nearly six million square feet of contaminated facilities.

Because of the President's commitment to addressing nuclear security, investing in science and innovation, and pursuing an "all of the above" energy strategy that fights global warming through low-carbon solutions, the United States and the world are safer, our energy is cleaner, affordable and more secure, and our greenhouse gas emissions are decreasing while our economy is growing and steadily generating private sector jobs.

Establishing a New Era of Nuclear Security

Vision for the Future:

As the President set out in his Prague speech in 2009 and reiterated in Berlin in 2013, the threat of nuclear war has decreased, but the risk of nuclear attack may have increased. We are committed to reducing the role of nuclear weapons in U.S. national security strategy, strengthening the nonproliferation regime, and preventing nuclear terrorism while promoting access to peaceful proliferation-resistant uses of civil nuclear energy. At the same time, as long as nuclear weapons exist, we will maintain a safe, secure and effective nuclear arsenal to deter any adversary, and guarantee that defense to our allies.

DOE will continue to maintain our remaining nuclear weapons without a return to nuclear explosive testing, carry out nuclear weapons life extension programs (which can facilitate future additional reductions in the stockpile), monitor and implement the Iran nuclear agreement and other nuclear security and nonproliferation agreements, continue to support the nuclear propulsion needs of the U.S. Navy, and advance the cleanup of contaminated legacy sites from the Cold War nuclear weapons program.

Record of Progress:

As we worked to implement the President's Prague agenda, DOE has been one of the lead agencies to secure vulnerable nuclear and radiological material around the world, strengthen the international nonproliferation regime, and take concrete steps towards a world without nuclear weapons.

This includes the landmark nuclear deal with Iran and the E3/EU+3 (U.S., China, France, Germany, Russia, UK, and EU), negotiated by the Department of State and the Department of Energy and underpinned by the technical expertise of our National Labs and nuclear sites. The JCPOA significantly extends Iran's potential breakout time for a nuclear weapon, while committing Iran to unique and lasting verification measures for decades to come.

Working with Russia under the New START Treaty that the President and his team negotiated, we are reducing our deployed strategic warheads to the lowest level since the 1950s while safely dismantling retired warheads. The first next generation aircraft carrier, with two powerful new nuclear reactors, will sail in the next few months.

Additional progress includes:

Preventing Nuclear Terrorism: Building on the improved international collaboration generated by the four Nuclear Security Summits led by President Obama during his tenure, DOE has lessened the threat that nuclear radiological materials will be used inappropriately. Since 2009, we have removed or confirmed the disposition of more than 4,000 kilograms of HEU globally – enough for 160 nuclear weapons. In September 2016, Poland became the latest of 31 countries plus Taiwan to be declared free of HEU (16 of those plus Taiwan since 2009). We have reduced the exposure to theft of fissile material by converting or shutting down 34 research reactors and medical isotope production facilities in 18 countries since 2009. DOE has worked with 36 partner countries to install radiation detection equipment at more than 360 international ports of entry, taking concrete action to combat trafficking of nuclear and radiological materials.

Maintaining Nuclear Deterrent without Testing: As President Obama stated, so long as nuclear weapons exist, we must ensure that our nuclear arsenal is safe, secure, and reliable. We have clearly demonstrated the success of the science-based Stockpile Stewardship Program (SSP) in maintaining the stockpile without explosive nuclear testing. The SSP represented an enormous paradigm shift for our nation when it was established to support the no-testing regime started in 1992 and followed by every President since. The National Labs applied remarkable innovation to the task, from a new architecture for high performance computing to successful design, construction and operation of experimental facilities that enter new frontiers of high pressure and temperature. The year 2015 marked the 20th anniversary of the SSP, and our nuclear weapons laboratory directors can say they know more about the stockpile today than they knew with nuclear explosive testing. With the new experimental and computational capabilities, the Secretaries of Energy and Defense have successfully certified that the stockpile remains safe, secure, and reliable without testing for more than 20 years.

Cleaning Up the Cold War Nuclear Legacy: DOE's Environmental Management Office (EM) has successfully reduced the footprint of the DOE cleanup program from 931 square miles to 241 square miles while achieving more than $7 billion in life-cycle cost avoided. Other noteworthy achievements include the successful demolition of the gaseous diffusion uranium enrichment process buildings at Oak Ridge, demolition of more than 500 facilities overall and remediation of more than 1,200 waste sites at six former production reactors. This includes starting demolition of the Plutonium Finishing Plant at Hanford; deactivation and decommissioning (D&D) of more than 220 buildings and structures at the Idaho National Laboratory; construction and startup of two depleted uranium hexafluoride (DUF6) conversion plants at the Portsmouth and Paducah sites that will process a total of approximately 700,000 tons of material for final disposition; and completed construction of the Savannah River Salt Waste Processing Facility that will significantly increase the ability to treat tank waste and accelerate efforts to close underground high-level waste tanks.

Actions Needed:

- Continue to implement the Iran nuclear agreement, including the extensive monitoring and verification measures.
- Ensure a safe, secure, and effective nuclear deterrent without nuclear explosive testing through continued investment in the SSP, life extension programs, and the nuclear enterprise.
- Continue to reduce the role of nuclear weapons in U.S. national security strategy, with initiatives like the acceleration of dismantlement efforts of retired nuclear weapons.
- Build case for ratification of Comprehensive Test Ban Treaty, highlighting progress in detecting low-yield underground tests and confidence in the reliability of the U.S. deterrent without nuclear explosive testing.
- Make additional progress in reducing the threats of nuclear terrorism and proliferation through measures to identify, protect and eliminate nuclear and radiological materials worldwide and through support of the International Atomic Energy Agency.
- Continue to modernize the infrastructure for the research, development, operational training, and production activities necessary to support the full range of nuclear security requirements.
- Advance plutonium disposition strategy by transitioning from MOX approach to dilution and disposal approach, among other steps.
- Provide support to mission critical programs for naval nuclear propulsion to include the OHIO-class submarine replacement nuclear reactor, the Spent Fuel Handling recapitalization Project, and the refueling of the S8G prototype reactor.
- Further protect human health and the environment by advancing the cleanup of the small number of extremely challenging contaminated Cold War sites that remain to be completed in the coming decades.

Building a Clean Energy Revolution, Creating Jobs, and Fighting Climate Change

Vision for the Future

The accelerating threats from climate change have only made the imperative to reduce the costs and increase deployment of advanced clean energy technologies more urgent. That urgency compelled the President to set out his Climate Action Plan in 2013 and lead the charge to reach the Paris climate agreement in 2015 and the Montreal Protocol amendment this past October. A clean energy market that was already growing will now accelerate across the globe. The International Finance Corporation recently estimated a $23 trillion market in 21 emerging economies through 2030.

DOE's early and robust investments in clean energy, and technology, with similar investments by industry and research universities, have contributed to dramatic technology cost reductions and increased deployment. American companies are consequently well-positioned to lead and compete in the rapidly emerging multi-trillion-dollar market for clean energy technologies.

In order for the United States to keep our edge in the global push to increase clean energy innovation, DOE's long-term vision includes:

- A doubling of federal funding for clean energy research and development in the United States over the next five years from the FY 2016 baseline, as agreed upon with 19 other countries under the Mission Innovation initiative, to push the clean energy breakthroughs needed to achieve deeper emissions cuts at lower costs. As energy production, transmission, and use account for roughly 80 percent of overall U.S. CO2 emissions, we must pursue technological advances in each of the energy sectors: power, transportation, buildings and industry. These increased investments in next-generation clean energy technologies will include advanced nuclear energy, distributed renewable energy systems, advanced vehicle technologies and carbon capture, sequestration and utilization technologies to significantly reduce the carbon impact of fossil fuels.

- Continued work with the private sector to encourage patient investments all along the energy technology innovation pipeline, from early-stage risk capital to project finance.

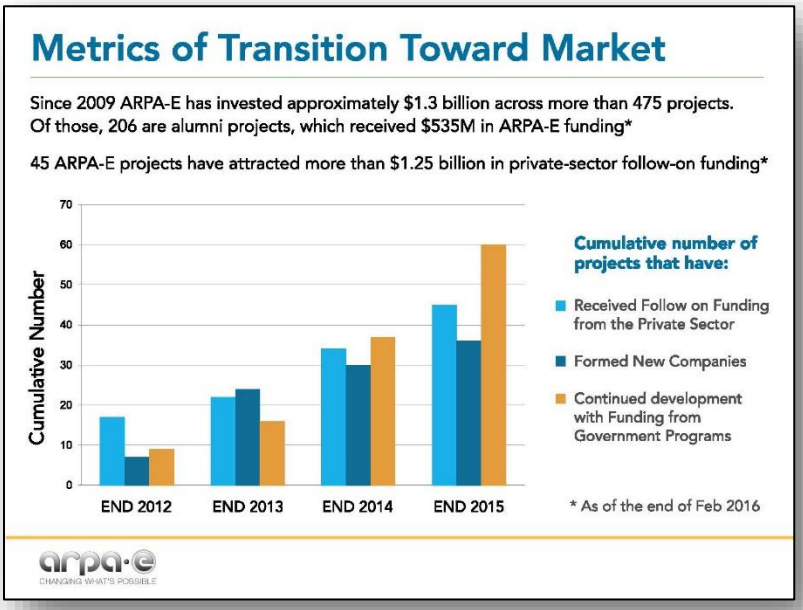
- Supporting new models for the commercialization of federally funded research, such as LabCorps, Cyclotron Road, and vouchers to small businesses to increase their use of DOE's National Laboratories.

Record of Progress

DOE's innovations and investments have helped accelerate clean energy technology deployments in recent years. Wind towers dot the landscape, utility-scale and distributed solar installations soak up more sunlight than ever, adoption of light emitting diode (LED) lights is accelerating, and the latest electric vehicle models can be seen on many neighborhood streets. Significant cost reductions in these technologies are a big part of this story. Meanwhile, we are creating more output with less energy after the most ambitious period of advancing energy efficiency in our nation's history.

In one major example of the role of innovation and technology investment driving ambition, the recent agreement to amend the Montreal Protocol to reduce hydrofluorocarbons was possible in part through R&D into alternative refrigerants by DOE, our National Labs, and industry to develop a new generation of environmentally-responsible, advanced cooling technologies. Additional commitments by DOE to work with our international partners on alternative cooling R&D assisted U.S. negotiators in securing key progress in the talks. The new agreement will avoid up to 0.5° Celsius warming by the end of the century.

The Advanced Research Projects Agency-Energy (ARPA-E) and Energy Frontier Research Centers (EFRCs) were kick-started by ARRA funding. Seven years later, they are recognized as extremely successful in advancing energy-related basic research and in developing and attracting private investment for advanced clean energy technologies.



Funding for ARPA-E, including under ARRA and in subsequent fiscal years, led to investment in more than 400 high-risk, high-reward projects. The first 200 completed projects led to the creation of 36 new companies and secured more than $1.25 billion in private sector follow-on funding. Examples of technological advances supported by ARPA-E are long-lasting, fully-rechargeable batteries for grid-scale energy storage, new semiconductor transistors, and technologies to improve the efficiency of the grid and enable renewable energy integration.

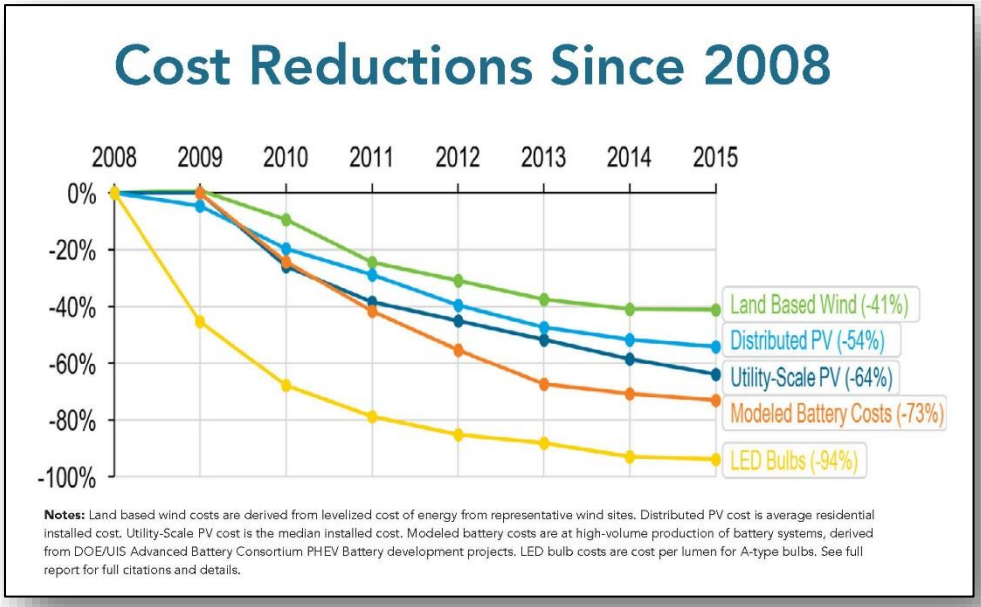
Together with the utility industry, DOE's $4.5 billion investment of ARRA funds helped modernize the electric power grid by deploying more than 16 million smart meters, more than 9,000 automated switches and more than 1,300 Phasor Measurement Units to increase the amount of energy than can be reliably transmitted over the high-voltage transmission system. The phasors help avoid major outages of the transmission system and the smart meters both provide new service options for consumers and help restore power after outages more quickly.

In 2015, DOE established a new Office of Technology Transitions, which is responsible for expanding the commercial impact of DOE's portfolio of research activities through lab-to-market engagement with American business and industry. The first awards under the Department's Technology Commercialization Fund were made to laboratories partnering with businesses that at least matched the DOE funding.

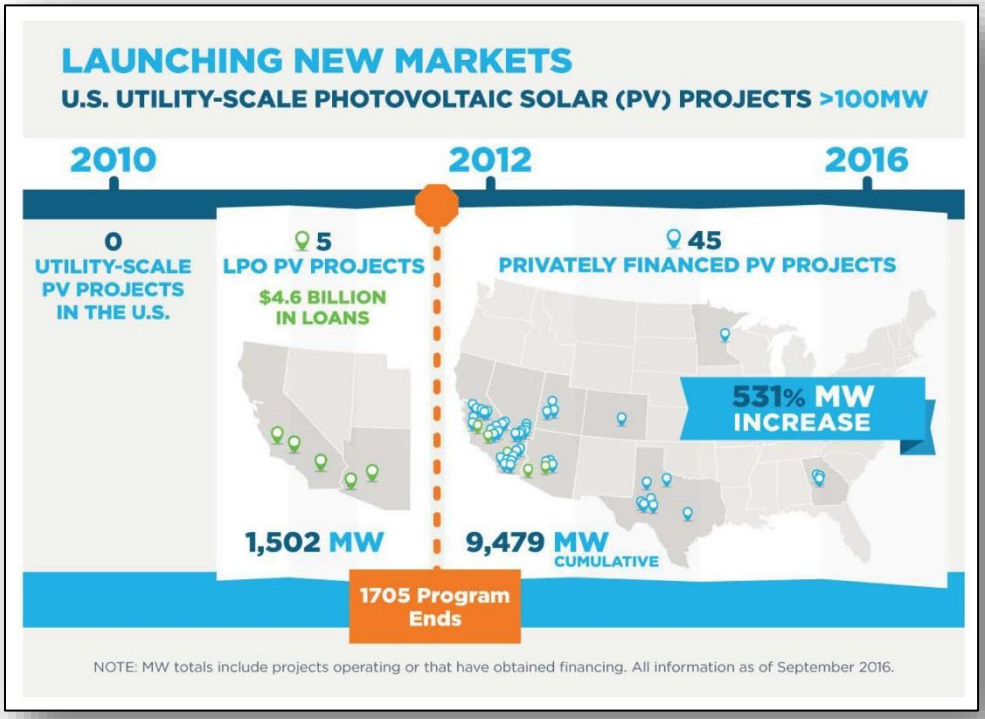
Since 2008, clean energy advancements in technology fueled by both federal and private investment have included:

Wind: Since 2008, the cost of land-based wind energy fell by 41 percent, spurring a tripling of wind capacity. In 2015, land-based wind generated enough electricity to power more than 17 million households and, in 2016, the nation's first offshore wind farm began operations.

Solar: DOE launched the SunShot Initiative in 2011 with the goal of making solar electricity cost competitive with conventionally generated electricity by 2020. Initial goals were to reduce the solar photovoltaic (PV) levelized cost of energy (LCOE) to 6¢ per kilowatt-hour (kWh) for utility-scale PV, 7¢/kWh for commercial rooftop PV, and 9¢/kWh for residential rooftop PV by 2020. Today, solar-generated electricity is increasingly being adopted and Sunshot is already 90 percent of the way towards achieving its 2020 goal. In November of this year, the SunShot Initiative announced new goals of reducing the average LCOE, by 2030, to 3¢/kWh for utility-scale solar, 4¢/kWh for commercial rooftop PV, and 5¢/kWh for residential rooftop PV. Achieving these new targets could more than double the projected amount of electricity demand that could be met by solar in 2030. One million rooftops now have installed solar panels, inspired in part by a 54 percent reduction in overall costs since 2008.



Large-scale solar: The cost of utility-scale solar PV dropped by 64 percent since 2008 and now generates enough electricity to power more than two million homes. Before the Obama administration, there were no large solar power facilities. After DOE's Loan Programs Office helped finance the first five, the private sector built an additional 45 with private funds.



LEDs: The cost of LED lightbulbs dropped by an astounding 94 percent since 2008, leading to 200 million bulbs installed in the United States through 2015. As of fall 2016, some stores now carry these bulbs for under $2 per unit. The best performing 60 watt equivalent LED bulbs available now consume 85% less energy than incandescent bulbs.

EVs: The cost of battery storage has decreased 70 percent since 2008, making it easier and cheaper to develop affordable electric vehicles. Nearly 30 electric vehicle models are available, up from only one in 2008, from more than a dozen manufacturers, giving vehicle buyers more choices of manufacturer, size, capabilities, and appearance. Total sales of electric vehicles (EVs) approached the half million mark with 490,000 EVs on the road as of August 2016. There are now more than 16,000 publically accessible charging stations, up from 500 in 2008, giving electric car owners more confidence in the range of their vehicles.

Carbon capture: DOE-supported projects have safely sequestered more than 10 million metric tons of carbon dioxide during the Obama Administration – the equivalent of the emissions from two million passenger vehicles from the nation's roads for one year. Within the next year, DOE investments will lead to the first two operating U.S. power plants with carbon capture: Petra Nova in Texas and Kemper in Mississippi, both utilizing the CO2 for enhanced oil recovery. In addition, a large ethanol plant will start operating in 2017 in Illinois with carbon capture and deep saline aquifer sequestration.

Nuclear: The Watts Bar 2 nuclear reactor in Tennessee became fully operational on October 19, 2016 after nearly 10 years of construction – the first new reactor to come online in decades. Four next generation advanced nuclear units, the first new reactors built in the U.S. in the last three decades, are expected to be completed within a few years. In February 2010, DOE offered conditional commitments for $8.33 billion in loan guarantees to two of those units, Southern Company's Vogtle Electric Generating Plant Units 3 and 4 in Georgia. Units 3 and 4 – 1100 MW Westinghouse AP1000 Generation III+ reactors – are under construction, with operations set to begin in 2019 and 2020, respectively. Once completed, the plant will produce enough electricity to power one million Georgia homes and businesses.

Energy efficiency: To achieve the Climate Action Plan target of three billion tons of carbon emissions reduced by strengthening standards to increase energy efficiency of appliances, heating/cooling equipment, lighting, and electronics, DOE accelerated the pace of issuing energy efficiency standards. DOE will, by year's end, have finalized about 50 standards during the Obama administration, more than any preceding administration. These standards will save consumers a projected $550 billion in their utility bills by 2030 and avoid three gigatons of CO2 emissions.

Energy jobs: Increases in clean energy deployment created new American jobs, from solar installers to wind energy engineers to energy efficiency construction workers. This progress was driven in part by DOE's workforce initiatives, which have trained tens of thousands of Americans to enter the clean energy economy. For example, the Solar Instructor Training Network trained 1,087 instructors at 422 community colleges, 46 labor union centers, and several technical high schools. These instructors, in turn, trained more than 37,000 students to qualify for the North American Board of Certified Energy Practitioners Entry Level Exam as a minimum requirement. According to DOE's first annual analysis of national energy employment, issued in 2015:

- 600,000 people are employed in the United States who contribute to the production of low-carbon electricity.

- 1.9 million Americans are employed, in whole or in part, in energy efficiency.

- Roughly 30 percent of the 6.8 million employees in the U.S. construction industry work on energy-related facilities or building energy efficiency projects.

National Network for Manufacturing Innovation: In support of the President's National Network for Manufacturing Innovation (NNMI), DOE manages three Institutes for Manufacturing Innovation and is about to launch two more, representing more than $700 million in federal and non-federal investments in advanced manufacturing. These institutes accelerate innovation and commercialization of a variety of manufacturing technologies: wide bandgap semiconductors, advanced composite manufacturing, smart manufacturing technologies, modular chemical process intensification, and reuse, recycling, and remanufacturing of materials. Each institute has mandated clear goals to drive U.S. manufacturing competitiveness through new technologies and innovation; reduce greenhouse gas (GHG) emissions and improve energy productivity; stimulate regional economic growth; and develop an advanced workforce in each of the focus areas.

Actions Needed:

The U.S. Nationally Determined Contribution that President Obama announced leading into the Paris climate agreement negotiations commits to reducing our greenhouse gas emissions by 26-28% below 2005 levels in 2025. With our progress in advanced clean energy technology, sharply dropping costs, and increased deployment of known technologies, we are well-positioned to achieve these targets. Yet, our analysis indicates that these advancements will not be enough to avert the worst effects of climate change.

To achieve the deep decarbonization necessary later in the century, we need an economy-wide approach that focuses on each of the major sectors that use energy: electricity, buildings, transportation, and industry, along with large scale carbon management. An approach that combines significantly increased investment in innovation with smartly-designed public policies will accelerate the transition to a clean energy economy, promote American leadership in clean energy technology development and export markets, and create new U.S. jobs.

To do this, these actions are needed:

- Fund and implement Mission Innovation by doubling U.S. investment in clean energy research and development, including increased investments in DOE's regional energy innovation partnerships, ARPA-E, the Office of Science and applied energy programs.

- Advance policies that accelerate the transition to a clean energy economy across all sectors, such as a carbon emissions charge.

- Expand a clean energy job creation strategy and increase and target job transition assistance and training for those in communities affected by changes in America's energy mix.

- Continue international engagement that promotes cooperation on climate and energy policy and competition on clean energy technology development and deployment. Build on key

international partnerships, including the Clean Energy Ministerial, North American Partnership, and projects in emerging economies, such as China and India.

- Reinvigorate the nuclear energy option by deploying advanced reactors and small modular reactors and implementing consent-based consolidated storage and geologic repositories, potentially including separate defense waste geologic isolation.

Strengthening America's Energy Security and Infrastructure

Vision for the Future:

Whether it is extreme weather from climate change, cybersecurity attacks on our electricity grid, crumbling energy infrastructure in need of modernization, or potential energy shortages originating in unstable regions of the world, threats against America's energy and economic security are rapidly evolving. The answer is to build reliable, resilient energy systems.

To best meet these threats, our vision for U.S. energy security and infrastructure includes:

- Continued diversification of America's energy supplies for fueling the American economy and for global energy markets, enhancing energy security of our allies and trading partners around the globe and economic returns to the U.S. economy.

- Expanded work with our G-7 partners and the EU to establish a new collective energy security framework, to continue shaping an emerging global natural gas market.

- Updated U.S. energy infrastructure across all sectors to allow for clean and reliable energy delivery, resilience of the entire system, and the creation of new energy construction and operating jobs across the country.

- Enhanced emergency response capabilities that address a changing threat environment that includes more extreme weather and evolving manmade threats like cyber-attacks.

Record of Progress:

Ukraine Energy Security: In the wake of Russia's annexation of Crimea in March 2014, the United States and the other G7 members worked with Ukraine to lessen its severe energy dependence on Russian energy imports. DOE, in partnership with Canada and the European Union, provided technical assistance to the Ukraine Prime Minister's office as it developed a National Energy Resiliency Plan. Successful implementation of that plan helped enable Ukrainian national oil and gas company Naftogaz to make it through the last heating season in (2015-16) without purchasing Russian natural gas for the first time in its history. DOE technical assistance to Ukraine over the last 15 years helped allow them to qualify a fuel manufactured by Westinghouse that can be used in Russian-designed VVER-1000 nuclear reactors, so that Ukraine is no longer uniquely dependent on Russia for nuclear fuel.

G-7 Energy Security: In June 2014, inspired in part by the Ukraine situation, G-7 leaders endorsed a set of seven energy security principles focused on transparent energy markets, diverse energy fuels, sources and routes, reducing greenhouse gas emissions, enhancing efficiency, promoting deployment of clean energy as well as R&D, and improving energy system resilience and emergency response systems. DOE was key to crafting these principles, which we believe the U.S. and our allies and partners need to pursue as the basis for energy security.

To develop more resilient and reliable energy infrastructure that remains stable and affordable, DOE has engaged on the following fronts:

Quadrennial Energy Review (QER): In 2015, DOE published the first installment of the multi-agency Quadrennial Energy Review report – a first-time detailed document outlining the tasks ahead for energy transmission, storage, and distribution infrastructure. The QER included 63 recommendations for action – 29 of which have been implemented and 21 more are working towards full implementation. Congress included provisions in the FAST Act to expand the Secretary of Energy's authority to respond to a "grid security emergency" by issuing orders "to protect or restore the reliability of critical electric infrastructure or of defense critical electric infrastructure".

Lessons Learned from Sandy: Following Superstorm Sandy, DOE worked with utility partners to increase communication and coordination between DOE, utilities, and federal government partners and increase investments in smart grid technologies that could better identify outages and keep power flowing. DOE also worked with the oil and natural gas industry through the National Petroleum Council to develop a report – Enhancing Emergency Preparedness for Natural Disasters – to better understand how DOE and the industry can better prepare for and respond to disasters. DOE hosted a series of exercises – the Clear Path series – to validate improvements made since Sandy and continue to find ways to close gaps in our energy sector response capabilities. In one powerful example, Florida Power & Light (FPL) said that during Hurricane Matthew, smart grid automated switches on their poles prevented more than 118,000 outages. FPL has reduced its estimates for recovery of power outages in its service areas from 10 to 15 days after past storms to 2 to 3 days this year.

Strategic Petroleum Reserve (SPR) modernization: The SPR is a critical federal energy security asset but the SPR facilities are aging. As recommended by the QER, Congress authorized $2 billion worth of oil sales from the reserves to modernize the SPR and provide new marine distribution capacity, which will extend its life for decades to come. However, the SPR is also being used by Congress to cover costs of programs not related to energy security, a shortsighted use of long-term security assets to meet short-term budget needs.

Northeast Gasoline Supply Reserve: Recent experiences, including the shortages of refined petroleum products following Superstorm Sandy in 2012, indicated the need for a reserve of refined petroleum products to ease shortages from sudden and unexpected supply interruptions. Using authority under the Energy Policy and Conservation Act in June 2014 the DOE established of a Northeast Gasoline Supply Reserve, with storage of up to one million barrels of refined petroleum product (100,000 barrels in South Portland Maine, 200,000 barrels in the Boston Harbor Area, and 700,000 barrels at two terminals in the New York Harbor area). All gasoline was delivered to the four storage terminals and available for emergency use by the end of August 2014.

Liquefied natural gas (LNG) exports: The first large-scale LNG exports from the contiguous United States began in February 2016. As of September of this year, U.S. LNG producers had exported over 100 billion cubic feet of LNG to 13 countries, providing countries with a new LNG source based on free trade principles as opposed to state-run decisions. Following DOE license approvals, one large-scale LNG export terminal is now operating and four more are under construction. As the U.S. develops into the third largest LNG exporter by the end of the decade (from no LNG exports in 2015), a more liquid global natural gas market is forming, supporting the G7/EU energy security principles.

Electricity grid construction and modernization: To deliver cleaner energy in a more reliable, flexible, and efficient way, DOE has approved more than one thousand new miles of transmission to be constructed across the United States that add 5,400 MW of new electricity capacity to the grid. DOE initiatives are helping shape the future of our nation's grid and solve the challenges of integrating conventional and renewable sources with energy storage and smart buildings, while ensuring that the grid is resilient and secure to withstand growing challenges from cybersecurity and climate change impacts.

Emergency response: In 2016, DOE restructured its emergency management program to more effectively manage and coordinate all-hazards response across the DOE complex and throughout the federal government. DOE provided emergency responders in support of the nuclear reactor crisis at Fukushima and in the aftermath of Superstorm Sandy and Hurricane Matthew, and supports National Security Special Events throughout the year. DOE successfully strengthened its emergency management partnership with the U.S. utility industry, which owns and operates 90 percent of America's electricity grid. This effort included regular meetings with the Electricity Subsector Coordinating Council (ESCC) – a group of chief executive officers from several energy companies and major industry trade associations plus the DOE – that focuses on security and resilience issues for current and emerging threats.

Federal Energy Management Program (FEMP): DOE, working with the Domestic Policy Council, provided leadership in helping the President achieve his $4B investment goal that will improve federal infrastructure through energy and water efficiency investments.

Actions Needed:

To secure and update America's energy system, the needed actions include:

- Work with Europe and other U.S. allies to advance energy security through implementing Strategic Petroleum Reserve modernization, moving forward on G7 collective energy security, and addressing climate change as a national security threat.

- Further bring DOE's energy infrastructure expertise to bear in emergency response situations to better protect America against threats, including securing resources from Congress to address DOE's growing responsibilities in this arena, and potentially reorganizing to consolidate the Department's emergency response programs.

- Invest more in grid technologies that allow for the smart, resilient and efficient delivery of clean energy.

Making Discoveries by Investing in Science

Vision for the Future:

DOE will continue to lead the federal sponsorship of research in the physical sciences, expand our contributions to life science (DOE was first to implement large-scale genomics to energy bioscience and biodefense) and develop and maintain world-class scientific user facilities at our National Laboratories that are made available to our national research community based on merit.

A recent Secretary of Energy Advisory Board report found that a strong NIH-DOE collaboration in biomedical science would significantly advance the national interest. Building from our early legacies of the Atomic Energy Commission's radiation biology efforts and our role in kicking off the human genome project, we will collaborate with the NIH on Vice President Biden's Cancer Moonshot, precision medicine, and the BRAIN initiative, applying DOE's supercomputing capacity, imaging and sensor expertise, and user facilities to support biomedical research. A Cancer Moonshot partnership with the Department of Veterans Affairs will improve veterans' health through a big data effort with DOE National Laboratories. The bipartisan CURES Act specifically supported NIH-DOE collaboration that draws upon National Laboratory unique capabilities to advance precision medicine.

Record of Progress:

Formed from strategic national investments in science during and following World War II, DOE's world-leading research in the physical, chemical, biological, environmental, and computational sciences contributes fundamental scientific discoveries and technological solutions that support the nation's primacy in research and innovation. Among the top discoveries and advances of this large and complex system are: 1) new elements and chemicals; 2) critical scientific and technical advances that strengthen our national security; and 3) fundamental and applied research that stimulated the shale gas revolution, the development of nuclear energy, photovoltaics and energy storage for the transportation industry, among other areas.

Scientists at our labs have contributed to 115 Nobel prizes to date. One went to a Lawrence Berkeley National Laboratory scientist who shared the Nobel Prize in Physics in 2011 for the discovery of the accelerating expansion of the Universe through observations of distant supernovae. DOE National Laboratory technologists won 32 of 2016's R&D 100 Awards.

Highlights in research and research capability during the Obama Administration include:

Supercomputing: A $525 million commitment to the Collaboration of Oak Ridge, Argonne, and Livermore (CORAL) in 2015 to produce, before this decade is out, super computers capable of speeds within a factor of ten of the exascale benchmark (a billion billion operations per second). We expect exascale to be reached early in the next decade. A new application at this computational scale will be to the Cancer Moonshot, unleashing the power of data and linking massive amounts of genomic information with large clinical, environmental, and public health datasets.

Creating Intense Light: In June 2015, DOE opened the most advanced storage-ring-based light source facility in the world, the NSLS-II at Brookhaven National Laboratory. The facility produces extremely

bright beams of x-rays, providing unprecedented capabilities to accelerate advances in chemistry, biology, energy, geology, physics and materials science. The Linac Coherent Light Source II (LCLS-II) project at SLAC National Accelerator Laboratory will maintain U.S. leadership in high-repetition-rate free electron laser (XFEL) facilities.

Searching for the Higgs Boson: The July 2012, discovery of the Higgs Boson particle, the final particle predicted by the Standard Model of particle physics that contributes to our understanding of the origin of mass, showed the benefits of sustained investments in basic science by governments around the world. More than 1,700 scientists, engineers, technicians, and graduate students from U.S. institutions— including 89 American universities and seven of DOE's National Laboratories— worked as key parts of the research team that helped design the Large Hadron Collider accelerator and its four particle detectors so critical to the Higgs Boson research.

Energy Frontiers: DOE's Office of Science established the Energy Frontier Research Center (EFRC) program, to accelerate transformative discovery, combining the talents and creativity of our national scientific workforce with a powerful new generation of tools for penetrating, understanding, and manipulating matter on the atomic and molecular scales. In 2009, five-year awards were made to 46 EFRCs, including 16 that were fully funded by ARRA. As of 2016, the EFRCs have produced more than 7,500 peer-reviewed publications, 490 invention disclosures, 50 issued patents, 380 U.S. Patent applications, and 100 licenses.

Nobel-recognized Science Contributions: DOE has contributed to Nobel awarded research and experiments that led to six Nobel Prize awards announced since 2009, in the fields of physics, biochemistry, and chemistry. In physics, DOE supported research that led to the discovery of the accelerating expansion of the Universe through observations of distant supernovae (2011 Nobel), for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass and subatomic particles (the theoretical prediction of the existence of the Higgs particle, later helping lead to its discovery) (2013), and for the discovery of neutrino oscillations, showing that neutrinos have mass (2015). DOE also funded Nobel-recognized research into the structure and function of the ribosome in Biochemistry (2009), G-protein-coupled receptors in Biochemistry (2012), and the development of multiscale models for complex chemical systems in Chemistry (2013).

National Robotics Initiative (NRI): In 2015, DOE joined NRI, a broad multi-agency collaboration to accelerate the development of next-generation robotics that can solve problems in areas of critical national priority, including nuclear applications and for cleanup of radioactive and toxic materials. This includes a Federal priority on machine learning and artificial intelligence.

Actions Needed:

- Increase investment in research and technical infrastructure at DOE labs and other facilities, consistent with the Mission Innovation initiative to double U.S. clean energy R&D over the next five years.

- Implement new directions as suggested by the Secretary of Energy's Advisory Board (SEAB), including recommendations from recent reports on high performance computing, biomedical research, commercial nuclear power, technology development for environmental management, nuclear nonproliferation, and CO2 utilization.

- Invest in and implement the advanced computing initiative, which is essential to our international leadership (especially vis-a-vis China), national security (including intelligence), economic competitiveness and scientific and technological research capacity. This involves redefining the next generation computing ecosystem through convergence of today's supercomputing, artificial intelligence, and big data analytics. Early engagement with critical applications (digital health, information economy, cancer, and manufacturing) will help shape the innovation strategy and accelerate the realization of transformational societal value.

- Advance DOE collaborations in Cancer Moonshot, precision medicine, and other biomedical missions using not only supercomputing but also sensor, imaging, and other technological capacity at the National Laboratories.

Improving Management and Performance at DOE

Vision for the Future:

DOE has, implemented major management reforms that have resulted in reduced cost for administrative and management services, improved security and safety across the complex, and helped strengthen the relationship with the National Laboratories.

Looking ahead, DOE must continue to:

- Focus on transparency, collaboration, and coordination across the DOE enterprise.

- Break down operational silos and develop enterprise-wide solutions that increase the efficiency and effectiveness of Department management and day-to-day operations.

- Institutionalize the key organizational reforms that have significantly strengthened the management and performance of the department.

Record of Progress:

Reorganized for Better Management and Performance: In one of my first actions, I reorganized the responsibilities of the Department under three Under Secretaries: Management and Performance, Science and Energy, and Nuclear Security. The result has been improved direction and oversight of our multi-mission agency. We also established a high-performing Energy Policy and Systems Analysis office (EPSA) within the Office of the Secretary, reinvigorated the Secretary of Energy Advisory Board, and created a number of boards and councils that help guide and focus DOE's cross-cutting work (e.g. a Cyber Council that addresses administrative data protection, energy system security, and protection of classified information). We divided the Former Office of Health, Safety and Security (HSS) into two separate organizations in 2014 – the Office of Enterprise Assessments (EA) reporting to the Secretary and

the Office of Environment, Health, Safety and Security (EHSS) in the Management and Performance organization – to allow each to better focus on their respective missions. EA is DOE's autonomous organization responsible assessments across the enterprise. They have also produced reports and initiated a process to identify and promulgate best management practices across DOE.

Added Critical New Areas of Focus: Recognizing the importance of jobs as changes occur in the energy sector, we established a new Energy Jobs Strategy Council, whose mission is to work to accelerate the growth of and access to jobs in the energy and advanced manufacturing sector. This Council issued the first annual DOE U.S. Energy and Employment Report in 2016, with a second to come shortly. We created a new Office of Technology Transitions to help expand the technological commercialization of DOE's portfolio of research activities.

Revitalized Infrastructure: Led by the National Laboratory Operations Board (LOB) that I established in 2013, DOE has engaged in enterprise-wide initiatives focused on revitalizing the aging infrastructure across the DOE complex, improving infrastructure management, managing risk at the thousands of contaminated excess facilities, and halting the growth in the deferred maintenance.

Initiated Risk Management: I named the Department's first Chief Risk Officer, initiated new policies and established a cross-department risk committee to bring project management expertise from across the DOE enterprise to better assess and address the Department's challenge of building multi-billion dollar, first-of-a-kind nuclear facilities.

Strengthened Project Management: Over the past several years, we have improved DOE's project management by revitalizing the board that provides recommendations on critical decisions related to major construction projects, strengthening the independent peer review process, and revising DOE's order governing project management to institutionalize these changes.

Reformed HR Services: We transitioned DOE's human resources servicing model from a highly decentralized model with 17 separate, independent HR offices to a hybrid approach that utilizes a blend of shared services at five service centers and on-site HR expertise to support DOE's diverse missions. This initiative has significantly increased the efficiency of HR services to our more than 13,000 federal employees.

Increased Cyber Capabilities: Developed an enterprise approach to cyber security, including the establishment of a Department-wide cyber collaboration network that works around the clock to increase cyber situational awareness across DOE and provide actionable cyber threat information. This organization showed its merit almost immediately by identifying and addressing a cyber-attack well before industry figured it out.

Actions Needed:

- Institutionalize the major organization reforms, added areas of focus, new approaches to project management and risk management, and strengthened services and capabilities described above.

- Continue to build a culture and practice of enterprise risk management with an established governance structure.

Conclusion

I have been especially privileged to lead the Department of Energy during the Obama Administration, because the President placed a very high priority on clean energy and climate change, science and innovation, and nuclear security. This set of priorities defines the core of DOE's responsibilities and opportunities for enduring service to the nation.

To get the job done, I have drawn upon an extraordinary group of public servants, both career and "transient" (like me!). They and their families deserve our collective gratitude for the long hours and days and months and years of service, too often against the tide of those advancing narrow interests. They are patriots.

Similarly, work across the Administration has been extraordinary. The Department of Energy's span of responsibilities – energy, science, security, environment – puts a premium on effective collaboration. The enhanced collaboration with the Department of Defense and the Intelligence Community has paid dividends for a secure America, as has the collaboration among twenty-two agencies to produce the Quadrennial Energy Review.

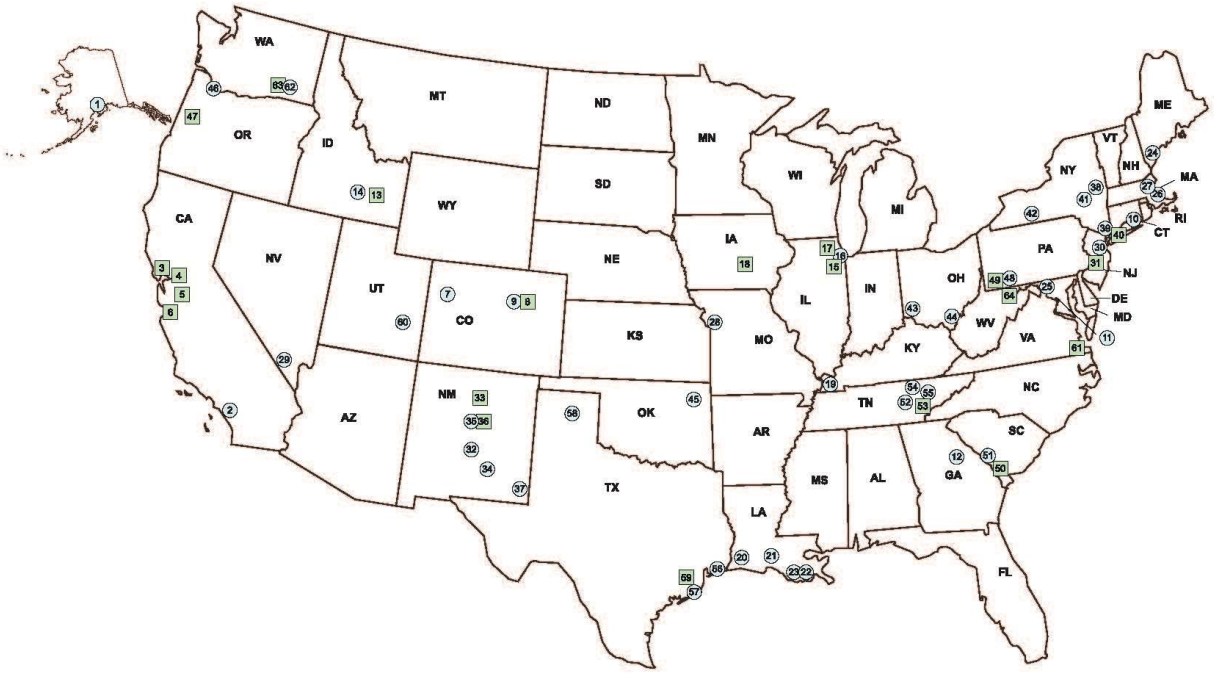
The private sector – companies, academia, nongovernmental organizations – has effectively helped steer DOE towards maximum impact, especially in the energy and science missions. In particular, public-private partnerships have shaped our evolving response to resilience needs of our 21st century energy infrastructure.

Finally, effective relationships between the executive and legislative branches and between federal agencies and states are crucial for progress, including both sides of the aisle and both chambers in Congress. The Department of Energy and I personally have benefitted from productive collaboration with members of Congress and with states in a shared spirit of advancing the prosperity and security of all of our fellow citizens.

The "business" of the Department of Energy has major consequences for America's future. I expect that the next and future Administrations and Congresses will sustain its success in addressing science, energy, security and environmental opportunities for generations of Americans.

Attachment 1

DOE Laboratories, Plants, and other Field Sites



*** Federal Field/ Site Offices are co-located with many of the DOE locations listed**
Indicates DOE National Laboratory

Alaska
1. Arctic Energy Office

California
2. Energy Technology Engineering Center
3. Lawrence Berkeley National Laboratory
4. Lawrence Livermore National Laboratory
5. Sandia National Laboratories
6. SLAC National Accelerator Laboratory

Colorado
7. Grand Junction Office
8. National Renewable Energy Laboratory
9. Western Area Power Administration

Connecticut
10. Northeast Home Heating Oil Reserves

District of Columbia
11. DOE Headquarters – Forrestal Building

Georgia
12. Southeastern Power Administration

Idaho
13. Idaho National Laboratory
14. Radiological Environmental Sciences Laboratory

Illinois
15. Argonne National Laboratory
16. Chicago Office
17. Fermi National Accelerator Laboratory

Iowa
18. Ames Laboratory

Kentucky
19. Paducah Gaseous Diffusion Plant

Louisiana
20. Strategic Petroleum Reserve - West Hackberry Site
21. Strategic Petroleum Reserve - Bayou Choctaw Site
22. Strategic Petroleum Reserve Project Management Office
23. St. James Terminal

Maine
24. Northeast Gasoline Supply Reserve

Maryland
25. DOE Headquarters – Germantown Campus

Massachusetts
26. Northeast Gasoline Supply Reserve
27. Northeast Home Heating Oil Reserve

Missouri
28. Kansas City National Security Campus

Nevada
29. Nevada National Security Site

New Jersey
30. Northeast Home Heating Oil Reserve
31. Princeton Plasma Physics Laboratory

New Mexico
32. Inhalation Toxicology Research Institute
33. Los Alamos National Laboratory
34. National Training Center
35. NNSA Albuquerque Complex
36 Sandia National Laboratory
37. Waste Isolation Pilot Plant

New York
38. Separations Process Research Unit
39. Northeast Gasoline Supply Reserve
40. Brookhaven National Laboratory
41. Knolls Atomic Power Laboratory
42. West Valley Demonstration Project

Ohio
43. EM Consolidated Business Center
44. Portsmouth Gaseous Diffusion Plant

Oklahoma
45. Southwestern Power Administration

Oregon
46. Bonneville Power Administration
47. National Energy Technology Laboratory – Albany

Pennsylvania
48. Bettis Atomic Power Laboratory
49. National Energy Technology Laboratory – Pittsburgh

South Carolina
50. Savannah River National Laboratory
51. Savannah River Operations Office

Tennessee
52. East Tennessee Technology Park
53. Oak Ridge National Laboratory
54. Office Scientific and Technical Information
55. Y-12 Plant

Texas
56. Strategic Petroleum Reserve - Big Hill Site
57. Strategic Petroleum Reserve - Bryan Mound Site
58. Pantex Plant
59. National Energy Technology Laboratory - Sugar Land

Utah
60. Moab UMTRA Project

Virginia
61. Thomas Jefferson National Accelerator Facility

Washington
62. Hanford
63. Pacific Northwest National Laboratory

West Virginia
64. National Energy Technology Laboratory – Morgantown

* EFFECTIVE DATE: NOVEMBER 2016