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Feasibility of Deploying a Small Modular Reactor on or Near an Air Force Space Command Site

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ABSTRACT

Deploying small modular reactors (SMR) to serve Department of Defense (DoD) facilities has been the subject of significant discussion and study during the past decade. The deployment is viewed as a potential strategy to enhance energy reliability at military installations, and achieve clean energy goals, while also accelerating commercialization of United States (U.S.) SMR technology. The Small Modular Reactor Licensing Technical Support Program of the Department of Energy (DOE) Office of Nuclear Energy (DOE-NE) funded a study to further evaluate this strategy. This study took an in-depth look at the considerations and requirements relevant to deploying SMRs to serve DoD installations. It focused on the suitability of the light water SMR designs currently under development in the US, as one or more of the designs are likely to be commercially available within the next 10 years. The leadership of Air Force Space Command (AFSPC) expressed interest in the concept in 2013, and cooperated in the study by providing subject matter experts and allowing access to two of its installations for case studies. The study Team established specific criteria to evaluate the suitability of AFSPC's 12 installations in the continental U.S. using the Oak Ridge Siting Analysis for power Generation Expansion (OR-SAGE) model developed by Oak Ridge National Laboratory (ORNL). Based on the ORNL results and additional analysis, the Team built case studies using Schriever Air Force Base (AFB) in Colorado, and Clear Air Force Station (AFS) in Alaska. The study finds that the near term SMRs are a suitable source of clean, secure energy for DoD installations, with some important considerations to address the lack of sufficient water on Schriever AFB and the seismic activity in the vicinity of Clear AFS. Further, it identifies pathways the U.S. government can take to facilitate the deployment of SMRs to serve DoD installations.

This paper outlines the results of the study. Topics covered include: Economics, Federal Mandates, DoD Policies, AFSPC/DoD Desired Capabilities, Reliability, SMR Deployment Scenarios, Potential Synergies between SMRs and AFSPC sites, Aggregation of Demand, Non-Electric Applications, Commercial Sales, Public Perceptions, and Recommendations for Realizing Deployment.

This paper has been derived from the Final Report for the study that is described herein.[1] References for any statements in this paper that are not taken from this document have been included in the References section.

BACKGROUND

In 2012, the DOE-NE began the SMR Licensing Technical Support (LTS) program. This program has worked to advance the certification, licensing, and siting of domestic SMR designs and to reduce the economic, technical, and regulatory barriers to their deployment.[2]

LTS program management was interested in the possibility of placing an SMR on or near DoD facilities. Therefore, DOE-NE funded a team (Team) from Sandia National Laboratories (SNL) and Scitor Corporation (Scitor) to assess the feasibility of placing an SMR on or near an AFSPC site. The decision to assess AFSPC sites was greatly aided by a cooperative agreement between Commander, AFSPC and SNL. The agreement gave the SNL/Scitor Team access to AFSPC sites and to expertise from AFSPC personnel. The study began in April, 2015 and concluded in March, 2016.[1]

INRODUCTION

The federal government is the largest user of energy in the United States (US), accounting for approximately 950 Trillion BTUs of energy in 2014. This translates to about 31.8 gigawatt-years (GW-yr), or the equivalent of the electricity produced by 32 large nuclear reactors operating at full power for an entire year.[3] The DoD is responsible for about 80% of this energy consumption. About 30% of DoD total energy consumption is classified as facility energy; facility energy is defined as energy required to power fixed installations and non-tactical vehicles.[4]

In 2015, there were two major regulatory documents issued that are expected to have significant impacts on the use of energy at federal facilities. The most recent of these is Executive Order (EO) 13693, *Planning or Federal Sustainability in the Next Decade*, issued in March, 2015. This EO requires all federal agencies to receive 25% of their electric and thermal energy from renewable and clean, alternative sources by 2015. The EO also designates SMRs as an "alternative" power source. The second major regulatory document issued in 2015 is the Environmental Protection Agency's (EPA) Clean Power Plan (CPP). This document state-by-state targets for reducing carbon emissions.[1]

With the understanding that such forthcoming documents were inevitable, DOE-NE began discussions with SNL in 2012 about the possibility of assessing the feasibility of placing an SMR on a DoD site. SNL began working to find the best options to facilitate such a study. In May, 2013, General William Shelton, Commander, Air Force Space Command agreed to a collaboration with SNL whereby AFSPC would provide access to AFSPC sites and personnel to facilitate a study to assess the feasibility of siting an SMR on an AFSPC site.[1]

In April, 2015, the study was kicked off with a meeting held at the Scitor facility in Colorado Springs, CO. This paper addresses the major results of the study, focusing on the following areas:

- Site Selection,
- DoD Policies,
- AFSPC/DoD Desired Capabilities,
- Reliability,
- Economics,
- Potential Synergies between SMRs and AFSPC sites,
- Aggregation of Demand,
- Non-Electric Applications,
- SMR Deployment Scenarios,
- Commercial Sales,
- Public Perceptions, and
- Recommendations for Realizing Deployment.

SITE SELECTION

AFSPC has twelve sites. It was impossible to analyze all of these sites, so two of these sites were selected.[5]

To determine which sites should be used in case studies, the SNL/Scitor team used a three-step process. In the first step, the team worked with Oak Ridge National Laboratory (ORNL) and utilized the Oak Ridge Siting Analysis for power Generation Expansion (OR-SAGE) tool. OR-SAGE uses US Nuclear Regulatory Commission (NRC) standards to develop criteria for screening reactor sites. It employs Geographic Information Systems (GIS) data sources to identify candidate areas through development of exclusionary, avoidance, and suitability criteria. This tool allowed the number of sites to be reduced to four.

The second step was to apply AFSPC-related criteria to rank the four remaining sites. The four remaining sites were ranked in the following order:

1. Schriever AFB,
2. Buckley AFB,
3. Clear AFS, and
4. New Boston AFS.

The third step in the selection involved the application of use-case assessment. Schriever AFB and Buckley AFB are similar in size and operation, whereas Clear AFS and New Boston AFS are both smaller with more limited operations. It was decided that a broader understanding of AFSPC needs would be achieved by choosing one of the AFBs and one of the AFSs. Schriever AFB is just outside Colorado Springs, CO, which is the location of the Scitor portion of the study team, so this was the logical AFB to study. Clear AFS was selected because it lies outside the contiguous US and would provide a perspective that could not be obtained by visiting New Boston AFS.[5]

DOD POLICIES

The U.S. government has written policies that inhibit DoD's ability to use SMRs to provide its installations with energy. The DoD has stated clearly that it will not own or operate SMRs, or other generating resources, except in unique situations. In fact, at installations such as Clear AFS, DoD is transitioning from producing its own energy to purchasing commercial power off the grid. This policy prohibits DoD from supporting the capital cost of an SMR developed to provide it with clean, reliable power. Federal policy also prohibits DoD from purchasing power for more than the current and forecasted market rate. Solar and wind project developers have been able to keep the price of power at or below market as a result of their access to financial incentives. Unfortunately, there is no mechanism that allows DoD to place a value on the "always-on" availability of SMR power, the improved reliability from synergies between the SMR and the installation, or the ability of the SMR to meet the installation's EO goals for clean energy.[1]

AFSPC/DOD DESIRED CAPABILITIES

The DoD, and AFSPC, have major priorities that drive energy requirements. Key among these are mission assurance, energy security, safety, security, reduced energy costs, and attainment of clean energy and greenhouse gas goals. DoD's desired capabilities for an SMR could include a black start capability, island mode operations, smartgrid compatibility, non-electric applications, independence from the commercial grid, integration with renewable energy resources, mobility, forward-deployed site operations, and offsite storage and disposition of spent fuel.[1]

RELIABILITY

DoD installations are part of a larger class of installation defined as those sites that maintain "mission critical" facilities. As such, DoD installations must maintain a highly reliable supply of energy that is critical for sustaining their missions. In particular, AFSPC's reliability requirements range from 99.9% to 99.999% (3 nines to 5 nines). When commercial power goes out, mission critical functions immediately switch to uninterruptable power supplies (UPSs), and then transition to backup generators, mostly powered by diesel. [1]

Many AFSPC sites operate as their own microgrid. For example, Schriever AFB has a single connection to the utility provider. If there is a problem with the grid, Schriever has the ability to isolate itself, relying on a backup plant with seven diesel generators. Clear AFS, on the other hand, was entirely self-sufficient prior to 2015, with electrical and thermal energy produced at an on-site, coal-fired, combined heat and power plant (CHPP). In 2015, Clear transitioned to receiving electrical service from its local cooperative utility and uses diesel-fired boilers on site to produce thermal energy.[1]

One aspect of reliability that is difficult to address in detail is the availability of fuel for backup generators. On select AFSPC sites, the on-site storage tank for backup generators is sized to hold enough fuel for 72 hours of operation. Table 1 provides the AFSPC required backup configurations. Availability of a 7-day fuel capacity is required from either on-site storage or from a confirmed delivery source.[1] Some discussions have been had concerning lengthening the availability of on-site fuel storage. These discussions have included fuel availability up to six months or more. This would make the use of diesel difficult, if not prohibitive. On the other hand, SMRs would have multiple years of fuel available at almost any time.[4]

DoD installations – and critical infrastructures in general – would benefit from the ability to operate their power supplies in "island mode", which allows them to provide power to the installation's microgrid and to a larger microgrid encompassing the surrounding community. The four leading US SMR vendors have all been designed to operate in island mode.

Table 1 AFSPC Backup Power Configurations

Backup Configuration	Assumed Availability Provided
Minimum mission-required backup generators, single UPS	0.999
Minimum mission-required backup generators with parallel-redundant UPS	0.9999
Minimum mission-required backup generators with two sets of parallel-redundant with a hot-tie UPS	0.99999

Another consideration related to reliability is black start capability. Black start capability is the ability to start a power plant without aid from the external grid. All four of the US vendors that were considered in this study have explicitly designed black start capability into their products.

Capacity factor is probably the most widely used data to compare reliability among various technologies. Nuclear power has the highest capacity factor of all electricity generating power plants, by far. In 2015, nuclear power plants in the US had an average capacity factor of 92.2%; the next closest technology was geothermal power, at 71.7%. By comparison, the averages for coal, wind, and solar were 54.6%, 32.5%, and 22.7%, respectively. Table 2 lists the various capacity factors by source, as provided by the US Energy Information Administration for 2015.[6] It is expected that SMRs will have capacity factors that equal or exceed the capacity factors of currently operating nuclear reactors.

The conclusion of the study was that placing an SMR on or near an AFSPC site has the potential to have a large impact on energy reliability for the site. One factor that would have to be considered in a quantitative study is the grid configuration, including the use of smart grid technology and how it is tied to the larger, external grid.

Table 2 Capacity Factors for Various US Electricity Generating Plants During 2015

Energy Source	Specific Technology	Capacity Factor (%)
Nuclear		92.2
Coal		54.6
Natural Gas (NG)	NG Combined Cycle	56.3
	NG Combustion Turbine	6.7
	Steam Turbine	11.7
	Internal Combustion	NA
Petroleum	Steam Turbine	14.7
	Petroleum Liquids Fired Combustion	1.3
	Internal Combustion Engine	7.5
Conventional Hydropower		35.9
Wind		32.5
Solar Photovoltaic		28.6
Solar Thermal		22.7
Landfill Gas and Municipal Solid Waste		67.6
Other Biomass		52.9
Geothermal		71.1

ECONOMICS

There have been multiple studies by various groups that have attempted to forecast the levelized cost of energy (LCOE) for the light water SMRs that are under development in the US. The studies include those performed by the University of Chicago, the Center for Strategic and International Studies, the Energy Information Agency, the National Energy Technology Laboratory, utility Integrated Resource Plans, and the various SMR technology vendors. These models project LCOEs that range from $0.07/kwh to $0.12/kwh.

Due to federal regulations, the DoD has taken the position that the cost of renewable and clean energy that it purchases cannot exceed the current and projected future cost of energy.[7,8] This could make the LCOEs projected by previous studies problematic for SMR technology, especially in the contiguous US. For example, Schriever AFB currently pays Mountain View Electric Association (MVEA) a retail rate of $0.077/kwh. This power is then melded with low-cost federal power marketed by the Western Area Power Administration (WAPA), lowering the average cost of power to Schriever.[9] Outside the contiguous US, the situation is quite different. Clear AFS pays a commercial rate of $0.13/kwh since its connection to Golden Valley Electric Association (GVEA) at the end of 2015. GVEA's residential customers pay about $0.19/kwh.[10]

There are multiple factors that affect the LCOE of SMRs. Some ways to reduce the LCOE of SMRs are:

- **Lowering the overnight capital cost**. Nuclear plants are notoriously capital-intensive. The most comprehensive cost estimate to date for SMRs was completed by NuScale Power in 2015. The estimate forecasted an overnight capital cost of $5,078/kWe installed for NuScale's 12-unit, 570 MWe power plant, resulting in a total overnight capital cost of $2.9 Billion. This would result in an LCOE of $0.078/kwh if the plant is owned by a cooperative or municipal utility and $0.096/kwh if the plant is owned by an investor-owned utility (IOU). The largest contributor to this difference comes from the fact that a cooperative utility does not pay income taxes, whereas an IOU has an average income tax rate of 39%.

Solar, wind, and other sources of clean energy receive investment tax credits (ITCs) that are not currently available to SMRs, although Executive Order (EO) 13693 classifies SMRs as alternative energy. The most generous of these ITCs effectively reduces the eligible portion of the solar plant capital cost by 30%. Providing this same ITC to SMRs would reduce the LCOE of an SMR owned by an IOU from $0.096/kwh to $0.083/kwh.

The first of a kind (FOAK) cost to bring an SMR to market – exclusive of capital cost – is estimated at about $1 Billion. This includes licensing, testing, detailed design and engineering, and attorneys' fees. [11] The DOE is currently supporting the efforts of NuScale Power and some utilities by sharing up to 50% of the costs associated with the NRC licensing process. An assessment provided by NuScale concluded that a program that provided 50% matching funds for the capital cost of the first SMR would reduce the LCOE of an SMR owned by a municipal or cooperative utility to about $0.06/kwh and for an IOU to about $0.068/kwh.

- **Lowering the cost of capital.** The cost of interest on debt borrowed and the return on equity to shareholders who help fund construction are also major factors in the LCOE. Debt historically carries a lower interest rate than equity, so the ratio of debt to equity in the overall financing of the power plant directly affects the weighted average cost of capital (WACC). Cooperatives and municipal utilities do not have shareholders and can often finance 100% of their construction projects. This contributes to lowering the cost of an SMR when compared to an SMR owned by an IOU. Another mechanism for lowering the cost of capital is *loan guarantees* from the federal government. Under the Energy Policy Act (EPAct) of 2005, the DOE received authorization to issue up to $18 Billion in loan guarantees for new nuclear power projects. Only $8.3 Billion in guarantees has been granted. Southern Company, one of three companies to participate in the program estimates that the loan guarantees that it received have a net present value to its customers of $225 Million to $250 Million. Loan guarantees are estimated to reduce the interest rate on debt by an average of 0.5%.[12]
- **Lowering the cost of power.** Production tax credits (PTCs) provide a means for lowering the cost of power. Many PTCs have been made available for a number of clean energy sources over the last decade. PTCs provide a credit on income taxes for energy produced over a given period. Because PTCs apply to income taxes, they are of no value to cooperatives and municipal utilities. However, they are of value to IOUs. The Energy Policy Act of 2005 offered a PTC of $0.018/kwh for a period of eight years for the first 6,000 MWe of new nuclear power in the US, provided they meet certain milestones. Southern Company will receive approximately $875 Million in PTCs for its share of Vogtle 3 and 4 during the first eight years of operation.
- **LCOE Comparison Summary.** The analysis by NuScale Power covered a range of LCOE variables, including ownership type, capital structure, and the effect of incentives. Key points are summarized below.
    - LCOE ranges from $78/MWh for a cooperative utility to $96/MWh for an IOU.
    - A cooperative utility can finance with low-cost, tax-exempt debt.
    - A cooperative utility does not pay income taxes (IOU average tax rate = 39%).
    - Loan guarantees lower costs for any owner by ~ $/MWh.
    - A PTC equivalent to that provided for new nuclear plants under the EPAct of 2005 would lower the LCOE for an IOU by about $8/MWH.
    - An ITC equivalent to that provided for solar power (30%) would lower the cost for an IOU by ~ $14/MWh.
    - The most significant reduction would come from a 50-50 cost sharing of FOAK capital cost, which would lower LCOE for cooperatives and municipal utilities to $60/MWh and for IOUs to $68/MWh.

POTENTIAL SYNERGIES BETWEEN SMRs AND AFSPC SITES

Siting an SMR on or near an AFSPC site would allow the SMR and the AFSPC site to share certain capabilities. Some of those include:

- **Physical security capabilities.** Security capabilities exist on an AFSPC site. It is possible that these capabilities could be extended to cover the SMR, assuming any regulatory issues could be resolved. Whether the SMR is sited on the site, near the site, or in the surrounding community would greatly affect the degree of security integration.

- **Emergency services.** Fire response and other emergency management capabilities could be shared between the AFSPC site and the SMR. As with physical security, the actual location of the SMR would affect the ability of the site to integrate with the SMR.
- **Siting data.** Many aspects of siting an SMR require specific data (hydrology, seismology, aquifer, and environmental impact) that may already exist due to siting needs for the AFSPC site. This could aid in facilitating licensing.
- **Training.** Combining training for support functions (e.g., fire, emergency response) could have potential cost savings, although the SMR and AFSPC site would have to provide separate funding.
- **Morale, Welfare, and Recreation.** Some base capabilities (shopping, gymnasium, cafeteria, child care, medical facilities) may be made available to SMR personnel, especially if sited on the AFSPC installation.

Other capabilities, such as environmental monitoring and utilities (water, sewer, communication) could be utilized for the SMR.

AGGREGATION OF DEMAND

The US light water SMRs under development are designed to produce from 50 MWe to 225 MWe. Even the smallest of these produces more power than any AFSPC installations use. One way to make SMRs attractive is to aggregate demand of multiple federal facilities. Multiple studies have addressed this in terms of determining geographic locations where facilities make this concept attractive.[13,14,15,16] However, no in-depth analysis of contracting mechanisms has been performed to date. Some contracting mechanisms that that are available include the following.

- **General Services Administration (GSA).** The GSA has the ability to establish power purchase agreements (PPAs) between federal customers and utilities.
- **Energy Savings Performance Contract.** The DoD can establish an Energy Savings Performance Contract covering multiple sites, similar to a contract placed by the Coast Guard that covers 12 sites in Florida. This eliminates the burden of establishing multiple contracts.
- **Multiple Award Task Order Contracts.** The DoD could issue a Request for Proposal (RFP) for a given amount of electrical energy. The awards could cover any length of time determined by the DoD. In 2012, the Army Corps of Engineers issued an RFP for up to $7 Billion in Renewable and Alternative Energy Power Production for DoD installations. The money is to be expended on PPAs of up to 30 years.
- **Federal Power Marketing Agency Contracting.** A federal Power Marketing Agency (PMA) can contract for power from the SMR, then act as the distributor of that power to its federal customers. WAPA, for example, provides power to Schriever AFB and most of the DoD installations in Colorado, including Cheyenne Mountain Air Station, Fort Carson, Peterson AFB, and the US Air Force Academy. WAPA also provides power to at least 15 other DoD installations.[17]

Utilizing the tools that are available to various government entities would allow SMRs to provide power to one or more aggregates throughout the US.

SMR DEPLOYMENT SCENARIOS

Six deployment scenarios were developed that would allow SMRs to be deployed by 2025. The highlights of these scenarios are discussed in this section.

1. **Site SMR on Schriever AFB to serve regional DoD/federal facilities.** In the first scenario, an SMR is sited on Schriever AFB in Colorado, with the intent of serving Schriever and other DoD and Federal facilities in the region. Land for the SMR is acquired through a 50 year Enhanced Use Lease (EUL) and Schriever is compensated for the land through a commensurate reduction in the price it pays for power. The SMR is owned by multiple public and investor-owned utilities. The GSA establishes Area-Wide Contracts with the utility-owners that facilitate PPAs with their DoD and other Federal customers. Each utility's ownership share is equal to the Federal load it will serve under the PPAs, unless the utility desires a larger ownership share to provide power to its non-Federal customers. To lower the LCOE of power, DOE provides loan guarantees to lower the cost of capital for the SMR. The SMR is operated under contract by an experienced nuclear operating utility, which may or may not be an owner of the project. In this scenario, the SMR is sited on, or immediately adjacent to, operations at Schriever in order to optimize the potential for synergies. The SMR operator and the host DoD installation achieve synergies through a services agreement included in the EUL, or as part of a separate services contract.
2. **Site SMR on Clear AFS to serve regional DoD facilities and utility load in Alaska.** In the second scenario, the SMR is sited at Clear AFS, about 75 miles southwest of Fairbanks, AK. The land is acquired through an EUL or direct lease and the installation is compensated through a reduction in its cost of power. In this scenario, the SMR is owned by the local electric cooperative, Golden Valley Electric Association (GVEA). As a publicly owned utility, GVEA has access to tax-exempt debt and does not pay income taxes, which significantly lowers the LCOE of power. GVEA establishes PPAs for SMR power with the other DoD installations in its service territory--Fort Wainwright, Fort Greely, and Eielson AFB. Current retail electric rates for GVEA customers range from $0.13 kwh to $0.19 kwh, significantly higher than the projected LCOE of power from an SMR. Rates for the

other utilities in the Alaska Railbelt (Fairbanks-Anchorage) are similar. To allow access to the lower cost power to a larger customer base, all Alaska Railbelt utilities have an opportunity to take ownership shares in the SMR and establish PPAs with their DoD customers. While the SMR is owned by GVEA, it is built and operated by an experienced nuclear utility.

3. **Site SMR on a DoD installation near Fairbanks, AK.** In a derivative of the second scenario, the SMR is sited on Fort Wainwright or Eielson AFB, which are closer to Fairbanks than Clear AFS. In addition to lower cost electricity, the SMR provides thermal energy for district heating to the host installation, customers in Fairbanks, and other DoD installations in proximity to its location. A variation of this approach could consider SMR deployment on off-shore, isolated DoD installations in a U.S. Territory such as Anderson AFB, Guam, or isolated DoD installations in non-U.S. territories such as Thule Air Base, Greenland.
4. **Aggregation of DoD demand through a Federal Power Marketing Agency.** To further facilitate the aggregation of Federal power requirements, in this scenario the SMR is sited on Schriever AFB, or another DoD installation within the territory served by the WAPA. This scenario also can be extended to other regions of the country that have Federal PMAs and large clusters of DoD and Federal installations, e.g., New Mexico: White Sands Missile Range, Kirtland AFB, SNL, Los Alamos National Laboratory, Waste Isolation Power Plant, Holloman AFB, and Cannon AFB. The SMR is owned by a generation and transmission cooperative with a broad base of publicly-owned utility members. As an alternative, DOE owns the SMR. The owner establishes a long-term PPA for power from the SMR with WAPA. WAPA establishes long-term PPAs with its current DoD and other Federal customers in the eight states that it serves. The land lease and operating structures would be similar to those in Scenario 2.
5. **Aggregation of DoD and federal demand through the Tennessee Valley Authority.** The Tennessee Valley Authority (TVA) is a stand-alone Federal agency reporting to the President. It has seven operating nuclear power plants, provides power to 155 local power distributors that serve some nine million retail customers in seven states, and directly serves several DoD and DOE facilities in four states. TVA currently intends to file a generic Early Site Permit (ESP) in 2016 as a first step in potentially siting an SMR using one of the four technologies at the Clinch River site in east Tennessee. In this scenario, the ESP provides the starting point for siting an SMR at Clinch River. TVA would build, own, and operate the SMR, and finance it using its access to low-cost debt. It would establish specific PPAs with its DoD and DOE direct-served customers that allow them to take credit for the clean power. The Clinch River site is in proximity to the ORNL, which houses a number of operations that are critical to national security and defense. TVA could enhance energy security for ORNL by establishing a microgrid between the SMR and ORNL's operations.
6. **Multiple applications of SMR energy.** Beyond electricity and heat, the energy produced by an SMR can support other applications to help DoD meet its energy requirements. An SMR sited at a DoD installation in a coal producing region, or in proximity to one, can provide the electricity and steam to support a Fischer-Tropsch process to convert coal into transportation fuels. Similarly, electricity and thermal energy from the SMR can support any of the desalination processes to produce clean water for the DoD installation and nearby communities. Further, the SMR can be used to support the production of commodities such as hydrogen, oxygen and fertilizers with market values to offset the cost of energy production.

While these scenarios are not exhaustive, they do provide a starting point for the discussion of how to kick start deployment of US light water SMRs.

RECOMMENDATIONS FOR REALIZING DEPLOYMENT

There are multiple actions that the DOE and the DoD can take to facilitate the deployment of SMRs and to aid the DoD in accessing the benefits of SMRs on or near DoD bases. These actions will help accelerate the commercialization of SMR technologies in the US and aid in placing the US at the forefront of a developing market. Some of the recommendations of the SNL/Scitor team are listed here.

1. As a starting point, DoD can remove uncertainties by clarifying policies regarding the duration of PPAs and the interim storage of used nuclear fuel on DoD installations. Congressional action would be required in some cases. At the same time, DOE can take the lead in ensuring that policies related to energy purchases are aligned and consistent across the Federal government. Again, longer duration PPAs are viewed by investors as being more favorable. This lowers the cost of capital and, ultimately, the price of energy.
2. DOE should conduct an analysis of EO 13693 and the CPP to identify and quantify the potential role of SMRs in meeting the goals these mandates establish. As a second step, DOE should establish a strategy for the use of SMRs to assist both Federal agencies and the states in achieving their EO and CPP goals.
3. DOE can accelerate the commercialization of U.S. SMR technology by providing Federal funding for licensing, First of a Kind design and engineering, and the capital costs of the initial projects. Validating SMR technology is

of strategic importance to the US. domestically and internationally. Establishing an industry that supports the deployment of SMRs here and abroad will have long-term economic, environmental, and socio-political benefits to the US.

4. DOE and DoD should take the next step and, as a test case, establish the framework for deploying an SMR to serve a DoD installation. This would include evaluating potential locations using siting criteria and previously identified Federal clusters (e.g., in Colorado and New Mexico) as well as high cost markets (e.g., Alaska, Hawaii, Guam) and taking the first steps toward Nuclear Regulatory Commission licensing and a services agreement and land lease.
5. DOE should implement a deliberate, integrated communications plan focused on key stakeholders, to foster understanding and obtain feedback, advocacy, and support for a decision on the use of SMRs to provide energy to DoD installations. Additionally, DOE and DoD should convene a forum that includes representatives from key Federal departments and agencies, and other principal stakeholders, to determine how SMRs can best be used to meet Federal/DoD energy needs. The deployment scenarios outlined in this study could facilitate this discussion. Results of the forum would form the basis for a leadership decision on an SMR deployment test case and viable funding mechanisms.
6. When evaluating the potential deployment of SMRs at DoD installations, DoD and DOE should look for applications for SMR energy to provide value beyond electricity. The use of energy from an SMR for district heating, desalination, the conversion of coal to liquids such as transportation fuels, and production of hydrogen and oxygen all offer potential value to DoD.

CONCLUSIONS

In summary, there are no insurmountable impediments to the deployment of SMRs on or near DoD bases. There are multiple ways in which the deployment can be achieved, as evidenced by the Aggregation of Demand and SMR Deployment Scenarios discussed in this paper. There are also multiple benefits from an initiative by the DoD, the DOE, and the federal government to pursue the deployment of an SMR on or adjacent to a DoD installation. Electrical and thermal energy from the SMR can be used at multiple DoD installations and other federal facilities to aid in achieving mandates for clean energy. Energy from an SMR can also be used for non-electric applications, such as the production of transportation fuels and desalination. In some of the more remote locations, these added benefits can have great value to the DoD installation.

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