Energy Resilience and Conservation Report

Pursuant to House Report 117-88, page 106, accompanying H.R. 4432, the Department of Defense Appropriations Bill for Fiscal Year 2022

Assistant Secretary of Defense for Energy, Installations, and Environment

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Introduction

The Department of Defense (DoD or the Department) Energy Resilience and Conservation Report ("report") satisfies the reporting requirement in House Report 117-88, page 106, accompanying H.R. 4432, the Department of Defense Appropriations Bill for Fiscal Year 2022. Therein, the committee directed the Department to study the implications of applying federal energy management requirements to both its installation energy operations and its operational energy operations and to create a report containing the findings from this study. The Department also studied the implications of requiring the Department to establish energy security and resilience metrics to evaluate Department energy consumption, carbon footprints, and progress towards energy conservation. Findings for this investigation are also included in the report.

Consistent with the committee's request, this report is organized according to the energy management requirements outlined in 42 U.S.C. § 8253[1] and the development of energy security and resilience metrics identified in 10 U.S.C. § 2920.[2] As the application of these requirements and metrics to installation energy is a well documented and reported process (see Appendix A), this report will focus on the implications of applying 42 U.S.C. § 8253 and 10 U.S.C. § 2920 to operational energy.

Mostly in the form of liquid fuel, operational energy is defined in 10 U.S.C. § 2924 as the energy required for training, moving, and sustaining military forces and weapons platforms for military operations. In Fiscal Year 2022, the Department consumed 628,590 billion British Thermal Units (BBtus), costing a total of $14.5 billion, to support operations and training across a worldwide set of installations with thousands of energy consuming platforms. Nearly 70 percent of this total DoD energy use was for operational energy.[3]

The FY 2024 President's Budget Request of $3.5 billion for operational energy requirements of the Department, reflects the need to decrease energy demand and increase energy supportability. The 2022 *National Defense Strategy* directs the Department to "make reducing energy demand a priority" and "adopt more efficient and clean-energy technologies that reduce logistics requirements in contested or austere environments."[4] Likewise, the Deputy Secretary of Defense directed that the "Department's capability development activities, from requirements to acquisition to sustainment, must increase energy supportability and must reduce energy demand across all capability solutions."[5]

This guidance informed the development of the Department's revised *Operational Energy Strategy*, which was signed by the USD(A&S) in May 2023. The *Operational Energy Strategy* will ensure that Joint Forces have the energy needed to fight and win in contested environments through four lines of effort, including:

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[1] 42 U.S.C. § 8253
[2] 10 U.S.C. § 2920
[3] Department of Defense, Fiscal Year 2022 Annual Energy Performance, Resilience, and Readiness Report
[4] Department of Defense, National Defense Strategy, October 2022.
[5] Kathleen Hicks, Deputy Secretary of Defense, Energy Supportability and Demand Reduction in Capability Development, April 21, 2022.

- Energy Demand Reduction;
- Energy Substitution and Diversification;
- Supply Chain Resilience; and
- Enterprise-wide Energy Visibility.[6]

Energy Intensity Performance Targets

42 U.S.C. § 8253(a) required all Federal agencies, including DoD, to reduce energy use in buildings (measured in energy consumption per gross square feet) by 30 percent over a 10 year period from 2005-2015. The recent Executive Order 14057 requires agencies to establish targets for reductions through 2030 using industry benchmarks. The hypothetical application of this approach to energy use in platforms led to the following findings:

- **Department-wide Operational Energy Use**. In combination with changing operations tempo and force structure, the Department applied a range of upgrades and technological innovations to increase the range, endurance, payload, time on station, and other performance attributes of platforms to reduce the demand for operational energy. Likewise, changes in how the Department operates its equipment have also led to improvements in total operational energy use. As depicted in Figure 1[7], total Department energy consumption (including fossil fuel and renewable energy sources) has decreased year over year since FY 2012. Although the reduction from 2012 to 2022 for installations is seven percent, the installation energy reduction measures began in earnest in 2005 with EPACT 05. DoD currently has reported a 33 percent reduction since the statutory 2003 baseline for energy intensity reduction was established. Operational energy decreased by over 28 percent.

[6] Department of Defense, Operational Energy Strategy, May 2023.
[7] Figure 1 includes all energy (including both renewable and fossil fuel energy) consumed by the DoD over the time period.

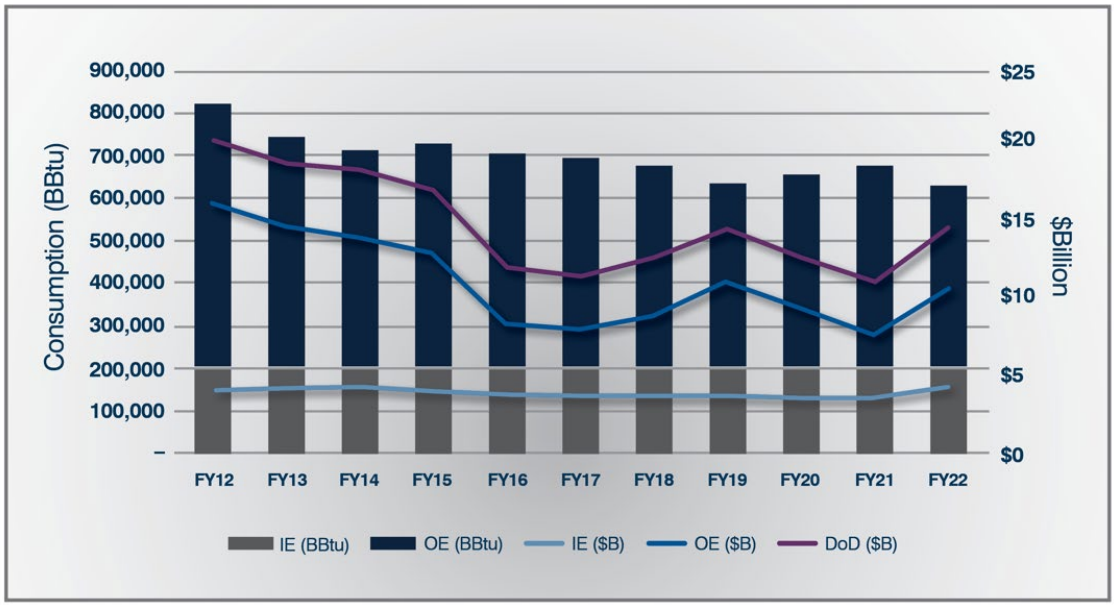

Figure 1. DoD Energy Consumption

- **Complexity of Metrics for Operational Energy Use**. While energy use per square foot is a useful metric for buildings with various sizes and purposes, the development of a single metric able to capture the rates of energy use across, to name a few, tactical generators, wheeled and tracked vehicles, rotary winged aircraft, fixed wing aircraft, surface ships, and unmanned systems, is a significant challenge. For instance, a training mission by a C-17 airlift aircraft will have dramatically different fuel use per unit of activity compared to a DDG-51 class destroyer maneuvering in the Red Sea or an unmanned aerial system conducting surveillance for a Combatant Command. Not only do the varying sizes of these platforms affect their energy use, but there is tremendous variation across the missions of a single platform. A tactical fighter aircraft energy use will vary across take off, climb, cruise, maneuver, and landing. Applying the requirement for reduced energy intensity would require the development of a range of metrics tailored to the specific kind of platforms and reflect the large variations in energy use. While Service operation tempo programs provide a broad set of activity metrics to consider (flying hour, steaming hour or day, or vehicle miles driven), further analysis would be needed to confirm the suitability of these activity metrics for measuring energy intensity across the whole force.

- **Steady State vs Wartime Energy Use**. Current energy metrics for buildings typically reflect the actual energy consumed while the building is performing its intended mission (e.g., operations center, dormitory, warehouse storage) across a given fiscal year and suggest a more narrow operating envelope compared to combat platforms. Not only do combat platforms consume energy at varying rates, but peacetime energy use may or may not be similar to energy use in wartime. As a result, while improvements in steady state energy efficiency may translate into lower emissions and/or costs, such improvements may not increase combat effectiveness. For instance, DoD operational energy use is dominated by a larger airlift and refueling aircraft. While improvements in mobility aircraft offer significant savings in fuel consumption and cost, the effects of those energy

improvements in supporting a specific operation plan or other warfighting scenario could be substantially different. The prioritization on peacetime energy performance may sub-optimize the application of energy improvements for platforms that consume less energy in peacetime, but play a more significant role in the Department's primary role of deterring, defending, and prevailing in competition and conflict.

Use of Energy Conservation and Efficiency Measures

Applying 42 U.S.C. § 8253(b) and § 8253(f) to the use of operational energy combat platforms would mean, to the maximum extent practicable, the use of energy conservation measures determined by the Secretary to be life cycle cost-effective. As reflected in the FY 2024 President's Budget and multiple reports to Congress, the Department already is implementing a broad portfolio of investments to reduce energy use by combat platforms.[8] Organized by component, these initiatives include:

- **Office of the Secretary of Defense**. Within the Office of the Secretary of Defense, the Operational Energy Capability Improvement Fund **(OECIF; PB2024, $172M)** is a defense-wide, advanced technology development program that matures operational energy technologies from Technology Readiness Level (TRL) 3, characterized by analytical and laboratory studies, to TRL 6, characterized by a model or prototype system tested in a relevant environment. In line with Congressional direction, the Department also established the Operational Energy Prototyping Fund **(OEPF; PB2024, $54M)** to enhance the transition of operational energy technologies to programs of record through prototyping. OEPF will demonstrate the most promising, innovative, cost-effective joint technologies, with the goal of minimizing the "valley of death" regarding transition to programs of record. The priorities of OECIF and OEPF include reducing the risk of energy distribution in contested environments, enabling the electrification of weapons, platforms, and unmanned systems, and improving the Joint's ability to command and control energy in operations.

- **Department of the Army**. The Army is investing in several programs to improve the effectiveness and efficiency of current and future forces.

  For rotary wing aircraft, the Army is investing in the Improved Turbine Engine Program **(PB2024, $201M)** to improve performance of the medium-lift fleet by increasing performance at full payload in high/hot conditions, lowering the fuel and maintenance requirements, and improving overall reliability. The Army expects 13 to 25 percent reduction in fuel consumption compared to the current Blackhawk and Apache engines.

  The Army is also planning upgrades for the current tactical wheeled-vehicle fleets to enhance range, endurance, and silent watch capabilities. These improvements include the development of anti-idle capabilities that will reduce fuel consumption by 20-25 percent

[8] See Department of Defense, FY22 Annual Energy Performance, Resilience and Readiness Report; Department of Defense, FY22 Operational Energy Architectures Report; and Department of Defense, Increased Resilience and Lethality Report, January 2022.

and engine runtime by 50 percent, additional electrical power productions, and software upgrades to transmissions **(PB2024, $146M)**.

Hybridization of the vehicle fleet offers another way of reducing fuel consumption by increasing efficiency. Current estimates are that hybrid-electric vehicles may reduce the fuel consumption of a vehicle by 35 percent. The Army is investing in a range of programs to support the fielding of hybridized tactical vehicles by 2035 and electrified tactical vehicles by 2050 in support of reducing fuel consumption of existing platforms. These include research and development of hybrid electric drivetrains, energy storage, and other power and thermal management systems for the XM30, the replacement for the Bradley Fighting Vehicle **(PB2024, $359M)**.

The Army's investments in wheeled-vehicle hybridization for the Joint Light Tactical Vehicle, Family of Medium Tactical Vehicles, and the High Mobility Multi-purpose Vehicle focus on hybrid-electric technology demonstrators with the goal of increasing mobility and improving acceleration, extending silent watch, reducing fuel consumption and providing limited silent mobility, thereby extending mission duration and effectiveness **(PB2024, $67M)**. The additional electrical power available can also support emerging capabilities like power export/import while being positioned to support future capabilities such as directed energy weapons and novel protection systems.

- **Department of the Air Force**. The Air Force is pursuing more fuel-efficient operations and capabilities through a variety of initiatives including mission planning, optimization of current aircraft and engines, and the development of all new propulsion and airframe designs. To optimize air operations (**PB2024, $48.4M)**, the Air Force is investing in software that coordinates with digitized scheduling programs to pair assets (aircraft and crews) against mission, reducing unproductive fuel use. The Jigsaw Tanker Planning Tool (Pythagoras) which can achieve a 10 percent+ efficiency improvement and deliver estimated savings of 6.4M gallons per year and a greenhouse gas (GHG) reduction of approximately 65K metric tons per year. The Mobility Aircraft Allocation and Planning (Magellan) Program can achieve a 1 percent efficiency improvement, estimated savings for 8.8M gallons per year and a GHG reduction of approximately 89K metric tons per year. The Puckboard Aircrew Scheduling Tool provides a 1 percent efficiency improvement, estimated savings of 2.7M gallons per year, and a GHG reduction of approximately 27K metric tons per year. The Cargo Load Planning Optimization initiative provides 3 percent efficiency improvement, estimate savings of 10.2M gallons per year, and a GHG reduction of approximately 100K metric tons per year.

  The Air Force also is pursuing a range of low-cost, high payoff initiatives (**PB2024, $33.7M)** to increase to reduce the drag and increase efficiency of current airlift and aerial refueling aircraft. The Engine Wash Program aims to improve energy efficiency by removing debris and contaminants ingested by jet engines during operations that reduce their time-on-wing and decreases engine efficiency and power. This causes increased fuel burn and exhaust gas temperature, leading to higher maintenance costs and decreased aircraft availability. Detergent engine washes reach deep into the engine core and apply full coverage to engine parts, removing buildup of contaminants. Detergent washing is

expected to improve performance, reduce engine temperatures, and decrease fuel burn. The Air Force is also investing in the Engine Compressor Blade Initiative that will reduce blade wear, significantly improving engine performance up to 3 percent for expected savings of 6.1M gallons to 18.3M gallons per year.

Additionally, the Air Force is developing and fielding a range of advanced engines that will improve the range, endurance, and power generation capabilities of current and future aircraft. The B-52 Commercial Engine Replacement Program (**PB2024, $576M)** replaces the aging B-52s with a new commercial-based engine that will be 20 percent more efficient, enables upgrades to various mission systems, and yields substantial improvements in both maintainability and readiness. The Adaptive Engine Transition Program and Next-Generation Adaptive Propulsion Program (**PB2024, $595M)** will focus on development and maturation of engines for 5th- and 6th-generation fighter aircraft, respectively. Recent prototype engine tests validated that adaptive engines achieve 10 percent higher thrust response, reduce fuel consumption by 25 percent, increase efficiency during cruise, and significantly enhance power and thermal management capabilities when compared to current 5th-generation fighter engines.

Taking advantage of possible step changes in range and endurance, the Air Force is developing a Blended Wing Body (BWB) prototype (**PB2024, $88M)** in collaboration with Federal agencies and private industry. Cargo, tanker, and non-stealth bomber aircraft account for approximately 40 percent of the DOD's total annual operational energy consumption: about 1.2B gallons per year. Reducing this number reduces energy logistics risks, a significant challenge in vast theaters such as the Pacific. Shifting cargo, tanker, and non-stealth bomber aircraft from tube-and-wing designs to BWB designs, via a demonstrator aircraft, would yield a minimum 30 percent increase in range and payload capabilities from current Air Force capabilities, and a corresponding 30 percent reduction in emissions.

- **Department of the Navy**. The Navy is prioritizing reduction of fuel consumption in existing and future systems. The Integrated Power and Energy Systems Program **(PB2024, $73M)** will support the development of Next Generation Integrated Power and Energy System technology aboard Navy ships to enable current and future weapons systems and to enable the sharing of power between propulsion and systems loads resulting in significant efficiencies in fuel consumption.

  The Navy continues investment in energy command and control and planning tools, including the Global Energy Information System (GENISYS) for the Navy's combatant and expeditionary forces and Replenishment at Sea Planner (RASP) for logistics and fuel distribution planning **(PB2024, $4M)**. The Navy Logistics Enterprise is integrating all Navy LOG IT systems, including GENISYS and RASP, to establish capabilities for optimizing energy and logistics supply and demand for distributed operations in contested environments. NAVSEA is also exploring additional energy performance improvements of DDG51 propulsion as well as classes of ships **(PB2024, $7.4M)**.

Focusing on improving the range and endurance, the Navy is developing the first CVN-based organic mission and recovery tanker. The MQ-25 Program **(PB2024, $798M)** will extend the range and increase lethality of the Carrier Aircraft Wing, and will contribute to F/A-18EF shortfall by relieving tanker duties and returning a/c to the strike fighter role. MQ-25 will also have a secondary ISR capability.

Marine Corps investments in energy conservation and efficiency measures include the Advance Mobile Medium Power Sources Program **(PB2024, $32M)**. The goal of this program is to continuously procure, update, and replenish approximately 19,000 pieces of Mobile Tactical Power Generation and Distribution Equipment, which is procured and fielded to provide electricity on the battlefield. Combat, combat support, and combat service support units all require tactical power to operate weapons systems, C4I systems, medical and messing facilities, environmental control equipment, and water purification systems. Investment in these systems will eliminate or reduce the need for fuel resupply, reduce weight, and enable silent operations.

To improve future equipment performance, Marine Corps continues to invest in the Fuel Efficient Medium Tactical Vehicle Replacement Program **(PB2024, $7M)** to develop, optimize, integrate, and demonstrate at least 15 percent fuel efficiency improvement across a set of driving cycles representative of likely operational conditions, while maintaining MTVR affordability, current mobility, transportability, and survivability capabilities. The Marine Corps is also investing in examination of hybrid options to replace the Medium Tactical Truck; research and development starts in FY24.

Through investments like these, the Department already is implementing a range of cost effective energy improvements that improve warfighting capability.

Energy Metering

42 U.S.C. § 8253(e) requires the use of advanced meters or advanced metering devices that provide data at least daily and measure at least hourly consumption of energy of energy used in Federal buildings. The Department recognizes that energy demand reduction and related increases in capability are contingent on the ability to understand the scope, scale, and distribution of energy use and availability across a worldwide battlespace, and to make that information accessible to commanders and decisionmakers. Currently, the Department has an incomplete ability to identify the type of equipment that consumes operational energy. While strongest for air and sea forces, the Department has limited visibility regarding the use of energy by wheeled and tracked vehicles, mobile electric power systems, and other tactical equipment.

Reflecting Department shortfalls in this area, the *2023 Operational Energy Strategy* includes a line of effort focusing on enhancing energy command and control capabilities to improve its understanding of the energy required to create the desired effects. In the near-term, the Department will focus on enhancing enterprise-wide planning for energy supply and demand by updating all relevant equipment-level usage characteristics and rates to ensure accurate and timely assessments (e.g., logistic factor files). These efforts will enhance the quality of Joint planning and improve energy resilience in contested operating environments. In the mid-term,

the Department will assess existing metering, monitoring, and other analytical capabilities to support these requirements – including all operational activities from home station training to expeditionary operations – and prioritize investments to support integration of energy information in predictive decision-making. In the long-term, the Department will seek real-time and enterprise-wide energy visibility for the full spectrum of military activities, to include peacetime competition and offensive and defensive planning for contingency operations.

Evaluation of Energy Use for Capital Investments

As outlined in 42 U.S.C. § 8253(g), agencies are required to employ the most efficient designs, systems, equipment and controls that are life-cycle cost effective, for any large capital energy investments in Federal buildings. Applying this statute to the use of operational energy would mean ensuring that sub-systems and overall systems reflect the most efficient cost effective designs and technologies.

10 U.S.C. § 2911 notes, *Consideration of Fuel Logistics Support Requirements in Planning, Requirements Development, and Acquisition Process*, already mandates the use of a fuel efficiency key performance parameter in the requirements development process for the modification of existing or development of new fuel consuming systems. The Department is implementing this statutory requirement through the energy key performance parameter (KPP), which is designed to "affordably manage energy demand and related energy logistics and security risks without degrading mission effectiveness of the capability solution" and "ensure combat capability of the force by balancing the energy performance of systems and the provisioning of energy to sustain required systems/forces by the operational commander in relevant threat environments."[9] As this description suggests, the KPP is designed to support the development of cost effective capabilities that also reduce logistics risks. Within the context of capability development, the use of the most efficient designs and technologies is balanced against other warfighting performance attributes that support the overall purpose of the capability.

However, a Department review found an inconsistent application of the energy KPP and uneven prioritization of energy supportability across joint programs. In response, the Deputy Secretary of Defense directed that the "Department's capability development activities, from requirements to acquisition to sustainment, must increase energy supportability and must reduce energy demand across all capability solutions."[10] As part of this effort, the Department initiated changes to Military Department requirements and acquisition decision-making, and the establishment of a recurring reporting framework on the role of energy in specific programs to inform Department-wide decisions and resourcing.

In addition, 10 U.S.C. § 2911 notes, *Consideration of Fuel Logistics Support Requirements in Planning, Requirements Development, and Acquisition Process* requires the use of the fully burdened cost of fuel during analysis of alternatives. DoD Instruction 5000.84,

[9] Department of Defense, Manual for the Operation of the Joint Capabilities Integration and Development System, 30 Oct 2021, pp B-G-E-1-2

[10] Dr. Kathleen Hicks, Deputy Secretary of Defense. *Energy Supportability and Demand Reduction in Capability Development*. 21 April 2022.

Analysis of Alternatives (AOA), specifically requires a "life-cycle cost analysis that includes the fully burdened cost of fuel," and the Director of Cost Assessment and Program Evaluation (DCAPE) is ensuring that AOAs support the development of capabilities that increase energy supportability and reduce energy demand.

Energy Security and Resilience Metrics

10 U.S.C. § 2920 specifies a series of metrics and standards for installations and states that the Secretary of Defense shall:

- "By the end of fiscal year 2030, provide that 100 percent of the energy load required to maintain the critical missions of each installation have a minimum level of availability of 99.9 percent per fiscal year…,"
- "…Issue standards establishing levels of availability relative to specific critical missions, with such standards providing a range of not less than 99.9 percent availability per fiscal year and not more than 99.9999 percent availability per fiscal year, depending on the criticality of the mission;" and
- "require that black start exercises be conducted to assess the energy resilience and energy security of installations."

The application of the energy availability standards to the use of energy in combat platforms raises challenges similar to the installation energy performance standards noted earlier. Rather than a narrow or singular mission profile typical of installations, operational energy use cases are characterized by the employment of substantially different capabilities in actual peacetime consumption and the analytically-grounded, postulated use of these capabilities in operation plans or warfighting scenarios. As a result, unless there is a contingency, there are no data on the actual availability of energy in wartime, which is the most significant and appropriate mission set to apply these standards and metrics.

The Department does have a similar set of standards related to Petroleum War Reserve Requirements (PWRR) for operation plans. The Inventory Management Plan, developed annually by DLA Energy in coordination with the Joint Staff, Services and Combatant Commands, details worldwide bulk PWRR and storage availability by location. The quantities of required fuel are informed by the number of days of operation ("days of supply") that on-hand fuel supply can support until resupply is available through normal lines of communication. Measured against the days of supply requirements and the overall PWRR, the Department continuously monitors the sufficiency of petroleum war reserve stocks to meet the needs of contingency plans.

Regarding black start exercises, the Office of the Secretary of Defense, Joint Staff, Military Departments, and the Combatant Commands, with support of industry, have developed a Black Start Exercise Framework and mathematical models for evaluating the risks to installations. Originally developed under the auspices of adverse weather events affecting electrical infrastructure supplying power to Departmental installations, the scope of the framework has expanded to account for adversarial actions (attributable and non-attributable) linked to energy disruption. However, operational energy has no direct corollary to installation

energy black start exercises. Instead, the Department account for the operational implications of energy disruptions in contested logistics environments through wargames, exercises, and campaign analyses. Under this concept, planners identify the likelihood and operational significance of any energy disruptions, namely liquid fuels, and seek a variety of alternatives to mitigate these risks. The alternatives include:

- Obtaining fuels from allies and partners;
- Working with commercial fuel companies to source fuels during operations;
- Dispersing, hardening, or defending DoD fuel storage and distribution capabilities;
- Acquiring additional DoD fuel distribution assets;
- Reducing energy demand through changes in equipment and operations; and
- Adopting alternatives to petroleum that reduce logistical burdens.

Conclusion

The application of energy management requirements outlined in 42 U.S.C. § 8253 and energy security and resilience metrics identified in 10 U.S.C. § 2920 to operational energy would have varying implications for the Department. In the case of energy intensity performance targets and energy availability standards, further analyses are required to confirm the suitability of these metrics for use in a diverse fleet of operational energy consuming platforms that use energy at varying rates and intensities. The Department is already pursuing conservation and efficiency measures to reduce energy use by combat platforms, but balances energy efficiency against the resulting reduction of logistics burdens and the warfighting performance attributes required of the capability. Energy metering and the evaluation of energy use for capital investments in operational energy are two areas where the Department has recently issued new guidance in the form of strategy and policy, and has launched new efforts to apply these practices to operational energy.

Appendix A

Subsection		Description of application to installation energy
42 U.S.C. § 8253	(a) Energy Performance Requirements for Federal Buildings	DoD continuously strives to reduce its energy consumption and energy use intensity through the implementation of energy conservation measures while ensuring reliable, resilient energy to meet mission requirements.
	(b) Energy Management requirement for Federal Agencies	DoD continues to install energy and water conservation measures to the maximum extent practicable.
	(d) Implementation Steps	DoD has established a robust installation energy management program to implement energy management requirements.
	(e) Metering of Energy Use	DoD currently meters the electricity, natural gas, steam and water consumption of all installations, using advanced meters to the maximum extent practicable.
	(f) Use of energy and water efficiency measures in Federal buildings	DoD designates energy managers at each installation to implement energy program requirements, including facility evaluations, recommissioning, retrocommissioning and implementation of energy conservation measures.
	(g) Large capital investments	DoD has implemented a process for reviewing large capital investments.
	(h) Federal implementation strategy for energy-efficient and energy-saving information technologies	DoD has implemented a strategy for the maintenance, purchase, and use of energy-efficient and energy-saving information technologies.
10 U.S.C. § 2920	(a) Energy Resilience Measures	DoD is working towards providing a minimum level of availability of 99.9 percent for 100 percent of the energy load required to maintain critical missions of each installation by 2030.
	(b) Planning	DoD requires installation energy plans for each installation which assess current energy resilience and energy security posture, focusing on critical missions, and identifying gaps and measures to close gaps in energy resilience and energy security.
	(c) Development of information	DoD installation energy plans contain required information for each installation.
	(d) Testing and Measuring	DoD requires monitoring, measuring and testing of installation energy systems, to include no fewer than five Black Start Exercises per Military Department per year.

	(e) Contract Requirements	DoD ensures that contracts for energy services and utilities include energy resilience and energy security standards.