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Enhancing Energy Resilience in Navy Region Southwest: Bridging Capability and Capacity Gaps with Modern Technologies and Utility Acquisition Approaches

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Enhancing Energy Resilience in Navy Region Southwest: Bridging Capability and Capacity Gaps with Modern Technologies and Utility Acquisition Approaches

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Abstract

Naval installations and defense communities are Centers of Gravity (COGs), enabling missions across warfare enterprises. However, they're susceptible to interruptions due to vulnerable, deteriorating energy infrastructure, lack of distributed energy resources, rapidly growing demand for power, and reliance on the existing utilities' central "macro-grid" that cannot meet surging demands for high quality electric power. These difficulties underscore the need for prompt and innovative energy solutions that are secure, affordable, and acceptable. This paper explores the multifaceted challenges and opportunities faced by defense energy managers and public works professionals in understanding predominant capability and capacity gaps and the planning and acquisition of utilities from integrated defense community energy systems to address them. This study combines guidelines from Commander, Navy Installations Command, to create educational content for energy managers and a thorough framework for installation energy and utility gap identification and mitigation, incorporating modern applications of technologies such as interconnected microgrids and Digital Twins (DTs). This study offers focused solutions inspired by effective deployments of Integrated Community Energy Systems (ICES). It also introduces a four-level engineering and institutional planning and project delivery methodology. For wider use across Navy installations, the conclusions seek to ensure operational resilience and scalability at selected installations.

Introduction

The U.S. Southwest region hosts several critically important Navy and Marine Corps installations. This is obvious in San Diego, but also is true in areas outside San Diego, within Southern California Edison (SCE) electric utility service territory, as well as other areas. Key installations in SCE territory include Naval Weapons Station Seal Beach, responsible for loading, storing, and maintaining Navy weapons, and its detachments across California. Naval

Base Ventura County serves as a major aviation shore command and mobilization base for Naval construction forces, providing airfield, seaport, and base support services. Additionally, Marine Corps Air Ground Combat Center (MCAGCC) at Twentynine Palms focuses on large-scale live-fire training and operational readiness. These installations collectively support missions such as fleet logistics, weapons maintenance, aviation operations, and advanced combat training, ensuring operational readiness and strategic capabilities for the Navy and Marine Corps in the region (MilitaryBases.com, n.d.).

These installations, their critical missions, the surrounding defense communities that support them, and the utilities that are their critical enablers make up a complex socio-technical system that can be considered a COG. From a strategic military perspective, a COG is a primary source of strength, balance, or stability that enables a force to maintain its freedom of action, physical strength, or will to act. It can be physical, moral, or both, and exists at strategic, operational, and tactical levels of war. The concept, introduced by Carl von Clausewitz, emphasizes targeting the “hub of all power and movement” to disrupt an adversary’s ability to achieve objectives. Analyzing COG using frameworks, such as Joseph Strange’s critical capabilities, requirements, and vulnerabilities, is not the primary focus of this paper. However, it underscores the importance of recognizing COGs and how they might be exploited effectively by an enemy (Clausewitz, 2009; Joint Chiefs of Staff [JCS], 2020; Strange, 1996). Hence, it is of paramount importance for defense energy managers to understand the vulnerabilities of utility systems (particularly electric utilities) in the context of capability and capacity gaps and how to address them with timely and appropriate acquisition and procurement approaches like what is presented in this paper.

Aging and Vulnerable Energy Infrastructure

Many large central electric utilities in the United States (e.g., SCE) are characterized by aging utility “macro-grids,” sprawling networks of power plants, transmission lines, and substations. They also face mounting challenges in delivering reliable power due to physical, cyber, and environmental threats. Built largely in the 1960s and 1970s, these grids are reaching or exceeding their 50- to 80-year lifespans (Smart Electric Power Alliance [SEPA], 2024). Electromechanical substations, critical nodes for voltage transformation, are estimated to be beyond their peak age, with an estimated 70% of U.S. transformers and transmission lines that are over 25 years old (SEPA, 2024; U.S. Department of Energy [DOE], 2021).

Physical threats, such as vandalism and terrorism, have surged, with 95 human-related electric disturbances reported in the first half of 2023 alone (American Society of Civil Engineers [ASCE], 2025). Cyberattacks, like ransomware or state-sponsored hacks, target substations’ automation systems, risking widespread outages costing up to $1 trillion in economic damage (Lloyd’s, 2015, as cited in Power Grid International, 2016). Environmental threats include wildfires and storms that damage infrastructure, with weather-related outages doubling from 2000–2009 to 2014–2023 (ASCE, 2025).

Replacement of aging substation components, such as high-voltage transformers, has lead times of at least 18–36 months due to supply chain constraints and manufacturing delays (National Academies Press, 2012). These delays exacerbate downtime risks, with U.S. utilities reporting a 20% increase in outage duration (System Average Interruption Duration Index) from 2006 to 2023, partly due to equipment failures (Lawrence Berkeley National Laboratory [LBNL], 2012; SEPA, 2024). Prolonged outages disrupt critical services, increasing public health and economic risks, with costs of reliability events estimated at billions annually (LBNL, 2012).

Peak energy demands could escalate as much as 40% by 2045 in SCE’s service territory (Castaneda & Ioan, 2024). As energy demands escalate and threats to critical infrastructure persist, U.S. Navy installations in the Southwest, such as Naval Base Ventura

County (NBVC), face significant challenges in maintaining mission-critical operations. Deferred maintenance on SCE transmission lines heightens fire hazards and grid instability, exacerbating risks for installations in their service territory, while widespread Public Safety Power Shutoffs (PSPS) to mitigate wildfire risks mean widespread outages. Recent grid failures in SCE's service territory highlight these vulnerabilities. In February 2025, SCE reported at least 530,000 customers were without power for days from wildfire-related damage. The wildfire itself may be attributable to SCE equipment as an ignition source. Restoration was delayed in some areas for weeks (Southern California Edison, 2025).

At the outer edges of SCE's network in Port Hueneme, Ventura, and Oxnard, a severe storm in late December 2023 destroyed the Port of Hueneme's shoreside power substation, a critical system enabling docked vessels to use electricity from shore. Flooding from the storm inundated the substation, necessitating its replacement, which in the case of typical electromechanical substation technology requires several years. This long-term outage has forced vessels to rely on their engines, increasing emissions and disrupting compliance with California Air Resources Board (CARB) regulations.

The Port of Hueneme's critical role in regional logistics, handling well over $10 billion worth of goods annually, and its proximity to NBVC amplify the operational risks of such grid failures. However, critical issues prevent widespread adoption of Distributed Energy Resources (DER) that are needed now to provide more reliable, resilient, high quality power, while also deferring expensive and long-lead-time central utility distribution system upgrades. Backup power systems alone are not a profitable venture for attracting third party financing, and they are typically unable to seamlessly sustain critical loads without interruption, threatening mission readiness. Poor shore power quality, exacerbated by events like the 2023 substation destruction, damages ship equipment and forces reliance on shipboard engines, contributing to port emissions. These challenges underscore the need for innovative energy projects that can provide secure energy solutions, accepted by the surrounding community, and aligned with the Navy's Shore Energy Program. This starts at a fundamental level with addressing the critical issues preventing widespread DER adoption.

Gaps Due to Critical Issues With DER Adoption

Widespread DER adoption could defer the immediate need for expensive and slow-to-deliver central utility distribution system upgrades. However, there are three critical issues that prevent the widespread adoption of DER. These are:

1. Hosting capacity limitations
2. The difficulty of solving centralized control and optimization algorithms and
3. The reluctance of customers to adopt large-scale distributed energy resources even where the technical and economic designs seem favorable to them.

Hosting more DER can supply the increased peak demand growth SCE predicts, beyond the capacity limits of the current distribution network. This capability is known as a "dynamic hosting capacity" (Castaneda & Ioan, 2024). Such capability can help utilities manage the forecasted growth in electricity demand for things like data centers, electrified ports, and increasing shipyard production capacity. A DT model of a substation is needed to simulate real-time environments and validate control architecture use-cases to ensure interoperability between all control architecture systems prior to field deployment using actual customer DER.

It is critical that a Distribution System Operator (DSO) has the capability for control and optimization in the dispatch of large numbers of customer inverters independently. However, simulations of large numbers (~10,000) of DER have demonstrated that it is not possible to individually optimize them all using a centralized control approach. Furthermore, despite the coming peak demand increases, critical infrastructure operators are reluctant to invest in DER. This is likely attributable to inconsistencies between what existing central utilities say is needed to meet the demand in terms of DER adoption versus what they will actually allow to interconnect. Therefore, SCE (and other central utilities), along with the installations they serve, face both a capability and capacity gap with respect to hosting a large amount of DER.

Because of these persistent DER adoption issues, critical defense infrastructure operators like installation public works officers and the energy managers that advise them continue to remain dependent on external central utilities. It also can cause them to self-limit their thinking of the solution space for resilience to only things like demand management (e.g., efficiency projects to reduce their reliance on the utility macro-grid) and backup power (e.g., microgrids for “islanding” in the event of utility macro-grid failure). They are less aware of how modern Integrated Community Energy Systems (ICES) microgrids operated internally or locally with distributed utility business approaches address the critical issues of DER adoption and can meet significant expected demand growth reliably, affordably, and acceptably.

Understanding ICES

ICES is not a new concept. It broadly refers to localized energy systems integrating DER to meet community needs (electricity, heat, cooling, mobility) with goals of efficiency, sustainability, and resilience. The ICES concept has evolved over decades, shaped by technological, policy, and social shifts, with microgrids playing a significant role in modern iterations. Post–World War II energy scarcity and Denmark’s cooperative tradition originally spurred these kinds of decentralized energy solutions. Early district heating systems (1940s–1950s) used waste heat from small coal/oil plants (1–5 MW) to serve towns, laying ICES groundwork. In response to the oil crisis in the 1970s, the DOE’s Community Systems Program aimed to reduce U.S. energy imports and sponsored a 1977 financial overview of ICES. This study formalized ICES as integrated DER systems (solar, combined heat and power [CHP], storage) for self-sufficiency. There were several U.S. examples of ICES projects using distributed CHP plants to serve areas like Starrett City in New York City which includes residential towers, commercial spaces, and community facilities. European implementations of ICES from the 1980s–2010s in rural applications (e.g., Wildpoldsried and co-ops) integrated renewables and modern technologies including some power electronics. Modern urban ICES implementation (2010–2015) leverage microgrid technology and medium voltage power electronics interconnection. When these are developed as primary power projects and operated by regulated distributed utilities, they can offer higher rates of return than microgrid projects developed for energy savings or power backup only. The evolved distributed energy business models developed at 36 European ICES have been detailed in Reis et al. (2021). Similarly, business models for numerous ICES energy cooperatives have been detailed in Kubli (2023).

Beginning in early 1992, electric power experts at Pacific Gas Electric Company (PG&E) began collaborating with their counterparts at the DOE’s National Renewable Energy Laboratory (NREL), the Electric Power Research Institute (EPRI), and the Pacific Northwest National Laboratory (PNNL) on the Distributed Utility Valuation Project (Pupp,1993). The research about the mutual benefits of the distributed utility business model culminated in 1997 with a special issue of *The Energy Journal*. From numerous articles therein about applied technologies, institutional innovations and regulatory reforms, it became clear that distributed energy resources could compete with the utility macro-grid by offering less expensive power with higher levels of quality, reliability and environmental sustainability (Smeers et al., 1997).

The 1992 Distributed Utility Valuation Project demonstrated the value of "non-synchronous" interconnection using AC to DC to AC power conversion at a PG&E distributed generation system. The conclusion by 1993 was that

> Modern solid-state inverters have very reliable, fast, and sophisticated protective devices built in, are digitally controlled and hence flexibly programmable, and produce very clean waveforms. This experience and others like it confirm that "most interfacing issues are resolved or resolvable with state-of-the-art hardware and design," …and that the literature "does not reveal any unsolvable technical problems," so "In the near-term, it appears that there are no technical constraints that impede the integration of intermittent renewable technologies into...utility systems."…Distributed generators that feed the grid through appropriately designed DC-to-AC inverters can provide the desired real-time mixture of real and reactive power to maximize value. (Lovins, 2002, quoting from Wan, 1993)

PNNL researchers on the 1993 PG&E Distributed Utility Valuation Project had concluded by 1996 that the self-commutating inverter was the "technology of choice" for interconnecting large amounts of storage to the utility grid (Donnelly et al., 1996).

In the face of increasing congestion on the wide-area transmission and distribution network and surging demand for power to support artificial intelligence and the electrification of transportation, heating and cooling, SCE has accepted the need for DER as a faster, more affordable alternative to expanding the wide-area SCE transmission and distribution network (Castaneda, 2022). In 2022, SCE advised that

> The market size for DERs have grown exponentially over recent years and is projected to continue growing due to benefit awareness and realization of societal benefits, evolving rates & tariffs, decreased cost of equipment, and government incentives & policies" and that "In the future, DER aggregators … will be incentivized to compete with bulk-system energy supplied through substations and play a critical role in managing most of the DER customers on the network. (Castaneda, 2022)

Later, SCE also confirmed through testing the superior affordability and reliability of "non-synchronous" (DC link) power electronics interconnection and control (SCE, 2023).

It's important to note that "non-synchronous" (DC link) interconnection can result in dramatic cost savings. A federally funded <u>synchronous</u> control system for the 14 MW of combined heat and power at Naval Shipyard Portsmouth cost <u>$4.14 per watt</u> (Environmental Security Technology Certification Program [ESTCP], 2017). <u>"Non-synchronous" (DC link) power electronics</u> control systems are being offered at <u>$1.20 per watt</u> and, if funded by a third party, could earn an investment tax credit that results in a net price of $0.72 per KW. Moreover, the non-synchronous interconnection can earn more than the synchronous interconnection in sales of voltage and frequency regulation to support the utility-owned macro-grid. The $0.72 investment can usually be recouped in less than two years from such revenue (Pareto Energy, 2023).

Three implementations of federally funded microgrids at Naval Shipyard Portsmouth, Naval Shipyard Norfolk and the Naval Research Lab in the District of Columbia cost between $5.50 and $11.10 per watt. A third party funded microgrid to serve a hospital and federal offices in the District of Columbia cost $0.66 per watt after federal tax credits and a grant, a price that reduced cost of power by 40% as compared to power from the utility grid (Pareto Energy, 2023).

In conclusion, SCE's acknowledgement of the critical need for more DER customer adoption and acceptance of a power electronics control platform make the organization of ICES to serve installations and the community of critical infrastructure and labor that support installations a timely and affordable option for energy resilience and reliability. However, before energy managers can understand how modern ICES address DER adoption issues, they must understand ICES and key related technologies and theory. There's key terminology that's particularly relevant to understanding modern ICES.

Multi Agent Systems (MAS): MAS consist of multiple decision-making agents which interact in a shared environment to achieve common or conflicting goals. An ICES is a MAS where the energy producing or using devices and energy distribution networks are the agents and interconnected with one another. To optimize its operations, an ICES must provide near instantaneous balancing of voltage and frequency as consumer demand for power continuously changes. It is important to note here that SCE has admitted that they cannot centrally control multiple agents fast enough to respond to demand without a $400 million investment in computing technology. However, Naval Postgraduate School (NPS) and their Cooperative Research and Development Agreement (CRADA) partner, Pareto Energy, have recommended that SCE implement a more affordable and effective distributed control and optimization framework that has been developed and tested on numerous ICES. For a summary of the advantages of distributed versus centralized ICES control, see Cheng et al. (2018).

Common Pool Resource (CPR): A CPR is a framework in which MAS decision-making is made more by active consumers that use the MAS and the labor that builds the MAS, and less by governments or markets. The value of organizing an ICES as a CPR is that it enables decentralized optimization algorithms fast enough to balance the ICES. Currently, centralized optimization by a utility company cannot optimize an ICES fast enough, as noted in the DER adoption issues. Fortunately, Nobel Prize winning economist Elinor Ostrom developed a practical method for designing a CPR that she applied successfully to numerous MAS in the field. It is known as the Institutional Analysis and Development framework (IAD). Professor Ostrom (2005, 2010) summarized the benefits of consumer collective self-governance of a CPR:

> Public policies based on the notion that all CPR consumers are helpless and must have rules imposed on them by either markets or the government can destroy institutional capital that has been accumulated during years of experience in particular locations. An in-depth analysis of their experience can deepen one's appreciation of human artisanship in shaping and reshaping the very situations within which individuals must make decisions and bear the consequences of CPR use on a day-to-day basis. Success in starting small-scale initial institutions enables a group of individuals to build on the social capital thus created to solve larger problems.

Digital Twin (DT): An ICES DT is a virtual representation of a MAS that spans its life cycle, it's updated from real-time data, and it uses simulation, machine learning and decentralized optimization and reasoning to help decision making. In the life cycle of MAS development from design to construction to operation, the fidelity of an ICES DT in terms of accurately representing the operations of the eventual "real twin" will increase as more elements of the MAS get installed and provide data streams to the DT. At the very beginning or design stage of a MAS, it is possible to gain high-fidelity results by using data streams from small table-top or small laboratory-scale replicas of the eventual hardware to be installed. Such replicas are often referred to as hardware-in-the-loop (HIL.) If you have seen the movie Apollo 13, you will remember that the astronauts trained on a "digital twin" consisting of a laboratory-scale replica of the command module and simulation software. Besides being a training aide, the Apollo DT uplinked to the mission operations (i.e., the real twin) to compare data between the ideally simulated operations and the actual data streams from the mission. When an explosion destroyed a piece of hardware during the mission, the less-than-ideal operating conditions of the real twin could be replicated on the digital twin to find a solution and save the mission. So, by the operating stage of the MAS life cycle, the DT becomes part of the operating system for the real twin. It is important to note here that SCE began using digital twin technology in 2022 to consider the optimal way to increase customer adoption of DER (Castaneda & Ioan, 2022).

Addressing DER Adoption Issues With Modern ICES

Addressing the first issue of hosting capacity limitations involves energy managers' knowledge of commercially available medium voltage power electronics. These have long been used at customer sites in Europe but have not commonly been used in North America, particularly not with their software capabilities enabled. However, this approach was reviewed and had gained acceptance among SCE engineers in 2012. Addressing the second issue of the difficulty of solving centralized control and optimization algorithms involves energy managers' knowledge and potential use of an open-source decentralized control and optimization approach utilizing a DT platform called Dynamic Monitoring and Decision Support (DyMonDS) invented by MIT Professor Maria Ilic.

The DyMonDS DT platform uses price signals and hierarchical communications to simulate a modern ICES project consisting of customer-owned DER such as on-site power, energy storage and demand-side management organized into the local-area distribution networks (i.e., microgrids) that interconnect with each other, the wide-area utility-owned transmission and distribution network, and certain transportation carriers (i.e., vehicle-to-grid, ship-to-grid and rail-to-grid power).

DyMonDS simplifies the simulation of an ICES global equilibrium for the simultaneous objectives of affordability, reliability, and environmental sustainability by requiring each DER to only communicate their amount and rate of real and reactive power with their most immediate neighbor. Such simulations enable training and cybersecurity exercises during the design phase of the complex system. At this stage, data streams from working DER at the Massachusetts Institute of Technology Lincoln Lab (MIT LL) provide a high degree of fidelity in terms of simulations accurately reflecting actual ICES operations. Thereafter, the DyMonDS DT acts as the operating system for the actual installed ICES (i.e., the real twin) by conducting day ahead simulations, exchanging data with the real twin during real time operations, and making any error corrections between the two.

Addressing the third issue involves energy managers integrating knowledge of power electronics and DT as previously described into a methodology for planning and delivering actual ICES projects. This methodology was inspired by ICES researchers at TU Delft and organized into a four-level engineering and institutional design methodology (Warner, 2023). See Figure 1.

GridLink Engineering and Institutional Design Methodology					
Level		**Engineering Design**		**Institutional Design**	
Access	1A	Engineering Feasibility	Technology Availability & Feasibility	Institutional Feasibility	Customs, Traditions & Norms
			Permit & Regulation Requirements		Legal Feasibility & Government Support
			Utility Interconnection Requirements		Analysis of Utility Competition
			Electrical & Thermal Demand Forecast		Discounted Cash Flow Model
	1B	Systematic Environment	Basic System Architecture	Institutional Environment	Stakeholder Memorandum of Understanding
			Preliminary Design (30%)		Design-Build-Operate Supplier Subcontracts
			Conditional Interconnection Approval		Real Options Model
Responsibility	2	Design Principles	Complete IEEE Standard Design	Governance	Energy Purchase & Use Contracts
			Engineering Procurement & Construction		Construction Loan Agreement
			UL Certification		Dispute Resolution Procedures
			Final Interconnection Approval		Game Theoretic Profit Sharing Model
Control	3	Control Mechanisms	ISO Registration & Bidding Rules	Organization	ISO-ICES Agreements
			O&M Rules & Procedures		Permanent Financing Agreement
			Other Operational Decision Rules		Day-Ahead Optimal Power Flow Model
Operation	4	Operations	Monitoring & Control Systems	Administration	Accounting & Reporting System
			Information & Communications Systems		Membership Meetings & Support
			Asset Management Plan		Error-Corrected Optimal Power Flow Model

Figure 1. GridLink Engineering and Institutional Design Methodology (Pareto Energy, LTD)

This innovative methodology differs from microgrid planning and project development efforts that only address engineering. It includes four stages of simultaneous engineering and institutional design. It has been developed by Pareto Energy as a standard open-source framework of governance contracts, legal enabling, and decision support software whereby an ICES of integrated local-area microgrids, collectively planned and governed by consumers as infrastructural commons, can enjoy fair competition and equitable profit sharing with the wide-area utility-owned grid.

This approach is developed to ensure money is not wasted doing engineering design that has no social or institutional feasibility, nor is money wasted doing institutional feasibility that doesn't have any engineering aspect. The first level deals with access to the microgrid, the utility grid, and to transportation carriers as applicable. The second level is about assigning responsibilities to the agents that manage that, so the cost of benefits is shared in a way that key stakeholders (labor, communities, and users themselves) can agree to and support. The third level is control which deals with setting up the rules before the start of operations to control the power flows (i.e., the optimal power flows within the microgrid). The fourth (and last) is operations. On the left-hand side, the power electronics engineering design is done by IEEE standards with UL certification.

Educating Energy Managers for ICES Project Development

Energy managers must be able to integrate modern ICES knowledge into the overall Shore Energy Program corporate knowledge. The image shown in Figure 2 captures the broad spectrum of challenges energy managers face that are associated with supporting the development and execution of their overall energy program for their respective chains of command. It is a Navy perspective, distilled from the past seven years of energy program management for the Navy’s 70 installations across 10 Navy regional commands.

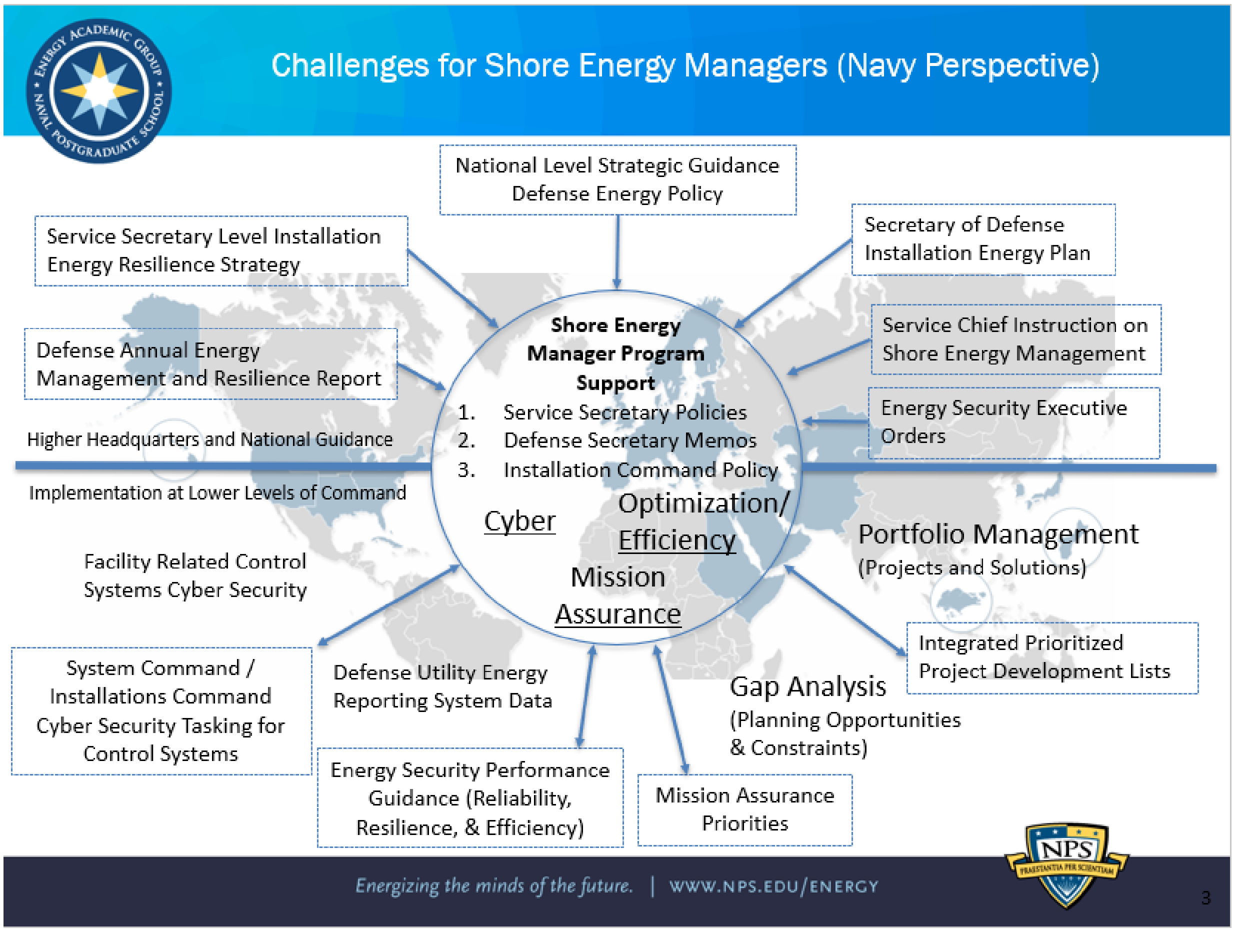

Figure 2. The Challenges Shore Energy Managers Face Managing Their Respective Shore Energy Programs

The challenges shore energy managers face can have both highly technical engineering aspects as well as complex institutional aspects to them. Energy managers therefore need continuous training and education to be able to maintain a common understanding of the current energy program and policies as implemented in their respective services and to maintain knowledge of and proficiency in the use of the latest tools and techniques to aid them in supporting a yearly plan of action and milestones that inform energy project selection. In the Navy, this process consists of four phases aligned with the four quarters of the fiscal year. Phase one is gap analysis across each of the installations that is performed at the installation level with technical assistance (in the case of the Navy) provided by the Navy's facilities engineering Systems-Command (a SYSCOM called NAVFAC).[1] In phase two, alternatives to address the gaps are studied and analyzed. Phase three is where planning and project development occur along with the vetting of different acquisition strategies across the teams, installations, and regions. Other SYSCOMs as well as the Navy regional commands get more involved in this phase as mission assurance is assessed and relative prioritization is worked. The planning and development of viable projects that can really be executed is among the most challenging things an energy manager supports.

Phase four is the coordination of all the energy project requirements developed in phase three, up through the chain of command to Commander, Navy Installations Command (CNIC),

[1] In the Navy, SYSCOMs like NAVFAC are execution agents and *materiel* solution providers for TYCOMs like CNIC that man, train, and equip warfighters.

who is the Chief of Naval Operations (CNO) designated Shore Type-Command (TYCOM) for final review and approval. All energy project submissions from each installation are historically due by September 30 every single year. It's expected that the submissions from each installation are vetted through leadership at the installation level through the installation and regional staff and commands for coordination and prioritization of effort.

Education for shore energy managers must reinforce official Shore TYCOM guidance and process while simultaneously integrating essential knowledge in planning and development of modern ICES projects for defense communities. This can be done through a four-course graduate certificate program for entry to mid-level energy managers. The graduate certificate courses can be organized as follows:

1. Shore TYCOM Energy Requirements Development and Project Feasibility Assessments
2. Analysis, Design Principles, and Governance of Shore TYCOM Energy Projects
3. Planning, Development, Control, and Organizational Considerations of Shore TYCOM Energy Projects
4. Coordination, Execution, Operations, and Administration of Shore TYCOM Energy Projects

A corresponding four-day-long condensed senior managerial level short-course for public works officers, regional energy program managers, and other defense community stakeholders (e.g., union or community leadership, mayoral staff, utility company managers) can also be offered. A Coherent Resilient Tabletop Exercise (CORE TTX) alternative to the short course can also be offered to focus on specific locations, scenarios, and specific energy resilience project planning. The four course certificate, senior manager short course, and CORE TTX can all leverage practical exercises and game-based learning.

The objectives of the Shore TYCOM Energy Certificate Program and Corresponding Senior Manager Short Course are to educate installation and regional energy managers, public works professionals, and other key defense community stakeholders on the key modern energy technologies, systems, and business approaches that are critical to ensuring reliable, affordable, and sustainable power for the shore enterprise, and to certify they have the combination of fundamental engineering and institutional knowledge for effective shore energy planning and management. The coursework and instructional content will be informed by official guidance as promulgated by CNIC, as well as ICES research from the "Applied Microgrid Design and Digital Twins Research and Education for Municipal, Port and Military Energy Planners" effort under the CRADA between NPS and Pareto Energy LTD, led by the Energy Academic Group.

The governance of Shore TYCOM projects in the second course will cover the Installation Energy Program Summary (IEPS); for projects, the Energy Project Selection Process (EPSP); etc. For background, CNIC under the authority as the Shore TYCOM partners with NPS to build out the TYCOM roles and responsibilities, partnerships, and the definition of "manning, training and equipping" energy managers around the globe.

Through the four-course sequence and corresponding short course, the content and instruction are envisioned to foster the knowledge of energy managers during the four phases of installation energy management efforts each year and improve understanding of the simultaneous engineering and institutional aspects of ICES planning and development. An existing case study of the Puerto Rican power grid using DyMonDS, that has shown how Puerto Rico's electricity cost and resilience could be improved through a modern ICES project using key technologies, may be explored in more detail in the four-quarter graduate certificate course. This MIT LL case study is motivated by the recognition that serving highly distributed electric power loads during extreme events requires innovative methods (Ilic et al., 2019). To do this, the type and locations of the most critical equipment, innovative methods, and software for operating the electrical system most effectively must be determined. Existing systems must be both hardened and further enhanced by deploying DER and local reconfigurable microgrids to manage these newly deployed DER. A key learning outcome of the instruction, practical exercise, and game-based learning is achieving a fundamental understanding of how to scope, plan, design, and deliver, operate, and procure power from modern ICES projects in a way that effectively hosts DER for use during both normal operations and grid-failure situations. Traditionally, utility companies rely on excessive amounts of centralized reserve generation to mitigate failures. This increases the cost of normal operations and nullifies the potential of DER to improve reliability by meeting loads during grid failures. Innovative distributed utility business approaches that overcome these limitations are going to be in demand. Innovative public private partnership distributed utilities can use the open source DyMonDS DT platform to do so. Energy managers will need to understand DyMonDS and how to leverage it for training, exercises, and independent government estimation and verification.

Prototype ICES DT Reference Case With SCE

As a first Navy installation DT reference case, Commander Navy Region Southwest (CNRSW) has expressed interest in potential collaboration between NPS and SCE on a prototype DT reference case simulation of a modern ICES to serve NBVC and the Port of Hueneme. This initiative supports the Navy's commitment to developing resilient microgrid projects capable of sustaining operations for at least 21 days during central grid outages, as mandated by the Department of Defense's March 2024 Unified Facilities Criteria for Resilient Installation Microgrid Design. The modern ICES DT will model decentralized control and distributed optimal power flow, enabling microgrids to act as primary power sources for installations and surrounding communities, rather than serving solely as backup systems. By leveraging federal grants, tax credits, and third-party financing, the prospective project would aim to ensure affordability and reliability while fostering energy resilience.

The ICES DT will also serve as a critical tool for workforce development, addressing concerns about skilled labor availability for designing, building, and operating ICES microgrids. It will provide training for electricians, engineers, and optimization specialists, equipping them to meet the needs of critical infrastructure operators. Additionally, the DT will simulate responses to natural disasters and cyber or physical attacks, enhancing preparedness and operational resilience. This effort aligns with SCE's Grid Technology and Innovation (GTI) group's objectives to increase DER adoption and defer transmission and distribution investments.

The project will support the integration of proven technologies, including a power electronic interconnection platform widely used in Europe and the DyMonDS platform, which offers decentralized control and optimization capabilities. Institutional innovations would ensure long-term governance and stakeholder alignment. Union labor pension funds will initially own the ICES and transition ownership to the community through stock purchasing plans. The project would also address regulatory requirements for distributing ICES power to multiple consumers, including obtaining a Certificate of Public Convenience and Necessity (CPCN).

To support education and research, the reference case ICES DT will inform certificate and short course content, fostering knowledge transfer and practical application. Stakeholders will participate in a structured pathway that includes earning a seminar digital badge for foundational training, attending an ICES short course at the CNRSW Broadway Complex for advanced skills development, and/or engaging in a Coherent Resilience Tabletop Exercise (CORE TTX) to apply learned concepts through an ICES planning charrette.

With SCE's support to designate the NBVC DT pilot project as a GTI demonstration initiative, this collaboration will address barriers to DER adoption, secure funding opportunities, and establish a pathway for ICES implementation. By leveraging proven technologies, institutional models, and educational frameworks, the reference case DT pilot project aims to enhance energy resilience, foster innovation, and support the Navy's energy resilience goals.

Prototype ICES Project Delivery

Following a prototype ICES DT reference case, and assuming favorable outcomes, a modern ICES prototype project will aim to enhance energy resilience for both the Port of Hueneme and NBVC. Inspired by Kirk Phillips' (2023) innovative geothermal prototyping approach, this prototype project will leverage Other Transaction Authority (OTA) under 10 U.S.C. § 4022 to bypass lengthy traditional DoD acquisition processes, perhaps enabling other rapid 2-year pilot ICES projects to further de-risk modern ICES implementation. This flexible approach aligns with the DoD's 99.9% resilience mandate and would establish a baseline for other Naval ICES initiatives.

Because the utility macro-grid, responsible for wide-area power transmission and distribution, struggles to meet growing demands for energy resilience and reliability, this leads to vulnerabilities in communities supporting critical infrastructure. In response, state public utility commissions are adopting distributed utility models that can deploy microgrids within 18 months. Federal tax credits and grants covering up to 80% of capital costs make microgrids more affordable and reliable than the macro-grid while offering enhanced resilience against disasters and disruptions.

Through the CRADA led by the EAG at NPS, the prototype project will refine best practices for third-party financing of modern ICES projects to serve defense installations and their surrounding communities. Using OTA, the project will prototype a distributed utility company and a non-Federal Acquisition Regulation contracting vehicle to standardize third-party financing for installation energy infrastructure. The OTA structure will resemble a Utility Energy Service Contract (UESC) and be executed by CRADA partners or incumbent utility companies.

The ICES prototype project will integrate key technologies and innovations, including:

- **Power Electronics Interconnection and Control**: Off-the-shelf power electronics and optimal power flow software to enable reliable transactions between microgrids, the utility macro-grid, and transportation carriers as applicable.
- **Digital Twin Technology**: Model-based design using NPS's test bed and MIT's open-source software for optimization, training, and cybersecurity testing, aligning with DoD energy goals.
- **Institutional Innovations**: A municipal corporation framework for consumer governance of microgrids, supported by optimization software and regulations to ensure equitable benefits and fair competition.
- **Workforce Development**: Labor pension funds will finance microgrids, enabling unions to establish training programs for skilled labor. NPS will collaborate with university think tanks to train engineers and electricians while developing curricula for Naval and other defense personnel.

This modern ICES prototype project will represent a transformative approach to energy resilience, fostering innovation, affordability, and reliability for defense installations and their supporting communities.

Conclusion

Enhancing energy resilience in Navy Region Southwest requires a paradigm shift in how installations and their surrounding defense communities approach energy planning, acquisition, and infrastructure development. The vulnerabilities of aging macro-grids, escalating energy demands, and persistent challenges in DER adoption underscore the urgency for innovative solutions. This paper has demonstrated that modern ICES, supported by technologies such as DT and decentralized optimization platforms, offer a viable pathway to bridge capability and capacity gaps while ensuring operational resilience.

By integrating modern ICES planning and development into the Navy's Shore Energy Program, energy managers can address hosting capacity limitations, overcome centralized control challenges, and foster DER adoption through institutional and technological innovations. The proposed four-level engineering and institutional design methodology provides a structured framework for planning and delivering ICES projects, ensuring alignment with mission-critical requirements and stakeholder priorities. Furthermore, the educational initiatives outlined—ranging from graduate certificate programs to tabletop exercises—will equip energy managers and public works professionals with the knowledge and skills needed to navigate the complexities of modern energy systems.

The prototype ICES DT reference case for NBVC and the Port of Hueneme exemplifies the transformative potential of these systems. By leveraging advanced technologies, institutional models, and innovative financing mechanisms, this initiative aims to enhance energy resilience, reduce reliance on vulnerable macro-grids, and support the Navy's energy security goals. The use of OTA for rapid prototype project delivery further highlights the adaptability and scalability of ICES as a solution for defense energy challenges.

In conclusion, modern ICES represent a critical evolution in energy resilience planning for Naval and other defense installations and their surrounding communities. By fostering collaboration between stakeholders, integrating cutting-edge technologies, and prioritizing education and workforce development, the Navy can achieve secure, reliable, and sustainable energy solutions. This approach not only addresses immediate capability and capacity gaps but also establishes a foundation for long-term resilience and innovation across the shore enterprise.

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