e⁻ Lab
Electricity Innovation Lab
ROCKY MOUNTAIN INSTITUTE

ADVANCING MILITARY MICROGRIDS

CHALLENGES AND RECOMMENDATIONS BASED ON INSIGHTS FROM A TWO-DAY WORKSHOP TO SUPPORT NAVAL FACILITIES ENGINEERING COMMAND SOUTHWEST'S MICROGRID EFFORTS.

For questions about this report or the workshop, please contact:
ERIC MAURER
ROCKY MOUNTAIN INSTITUTE
EMAURER@RMI.ORG | 303-245-1003

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ABOUT THE TEAM

NAVAL FACILITIES ENGINEERING COMMAND SOUTHWEST (NAVFAC SOUTHWEST)

NAVFAC is the Navy's engineering command. It builds and maintains sustainable facilities, delivers utilities and services, and provides Navy expeditionary combat force capabilities. NAVFAC Southwest, one of ten regional commands within NAVFAC, provides these services across six states in the U.S. Southwest. Several members of the NAVFAC Southwest team worked alongside e-Lab to drive workshop preparations and carry out the workshop. For more information on NAVFAC, see http://www.navfac.navy.mil/.

ELECTRICITY INNOVATION LAB (e-Lab)

e-Lab is a state-of-the-art forum for collaborative innovation to accelerate the transformation of the U.S. electricity system to a more efficient, renewable, and affordable future. The workshop was an e-Lab project that was driven by e-Lab's convening partner, Rocky Mountain Institute, and the workshop was attended by several participating e-Lab member organizations. For more on e-Lab, see www.rmi.org/elab.

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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

The electricity sector is under great pressure to respond to a powerful set of drivers that could fundamentally alter the business of selling power and the underlying architecture of the system. One of those technological drivers is the microgrid.

A microgrid is an interconnected set of electricity loads and supply sources that can operate parallel to the electric grid or as an island—disconnected from the grid. The microgrid represents an opportunity for customers to improve the reliability of their electricity and adopt and integrate more distributed renewable energy such as solar PV.

The U.S. Navy is leading the way in the technical and economic testing and validation of microgrid technology as it looks for new ways to bolster the energy security on Naval bases. Much of the Navy's leadership in this area will emanate from demonstrations happening on its U.S. bases located in the Southwest. As these bases begin to experiment with the technology, they face several major questions around microgrid design, evaluation, economics, and operation.

To begin to address these questions, NAVFAC Southwest worked with e⁻Lab on the design and execution of a two-day workshop April 16–17, 2013. Drawing on key stakeholders from inside the Navy and experts from outside, the workshop team identified five findings:

- NAVFAC Southwest is still developing a strategy to implement energy security goals stated by the Department of the Navy
- Current approaches to renewable energy procurement place emphasis on utility-scale resources, which may not support efforts to bolster energy security through microgrids
- Investment in expanding controls presents a near-term opportunity to begin to build toward microgrids while mitigating price risk
- Microgrids connected at the distribution level are likely to incur high transaction costs to enable participation in electricity markets
- Several entrenched barriers must be addressed to enable microgrid adoption across the Navy

These findings, although specific to the Navy's situation in the Southwest, inform our set of recommendations that are applicable to the Navy and other large customers, to grid operators and/or utilities, and to regulators. Our recommendations fall into three categories focused on understanding the need and motivation for a move toward microgrids, evaluating the economics, and taking action to test different microgrid solutions and models.

BACKGROUND

03

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WHAT IS A MICROGRID?

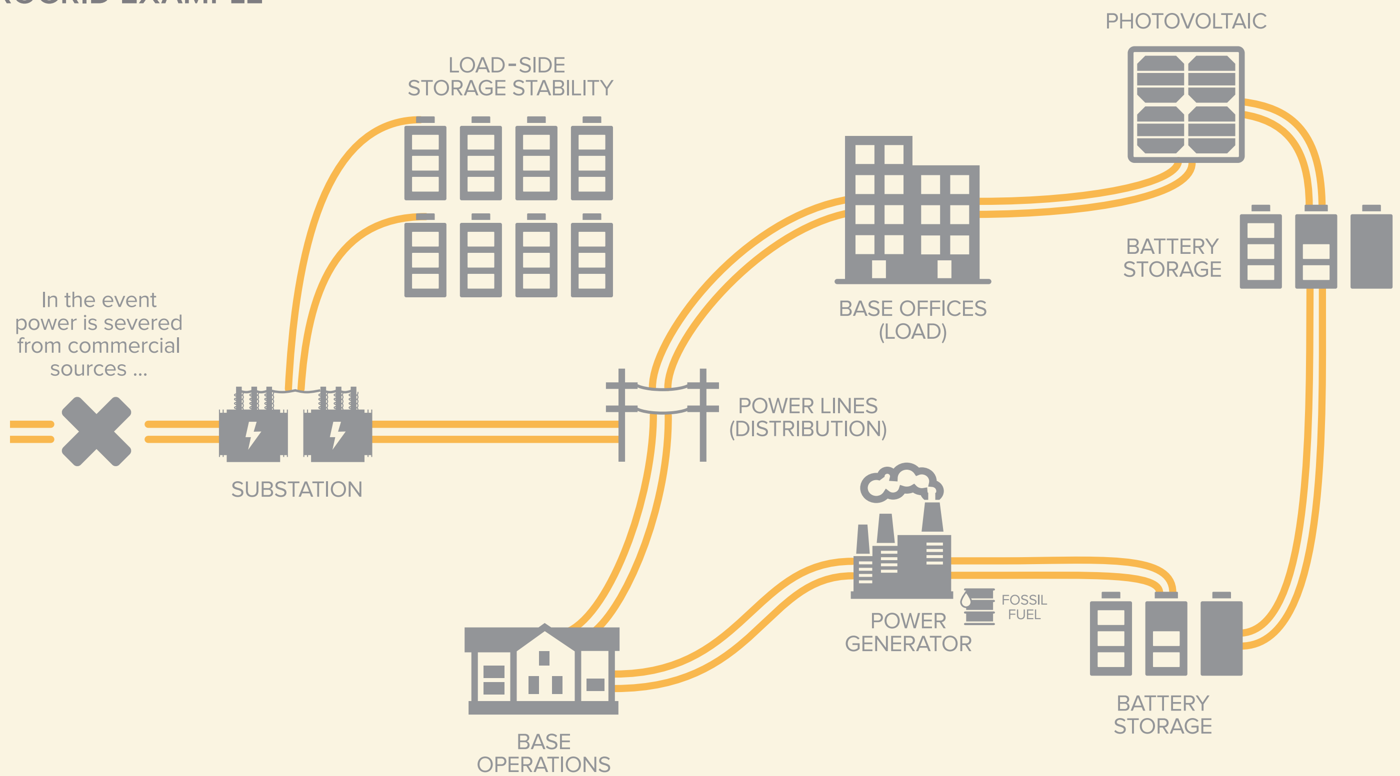
There are many definitions of a microgrid, but most definitions center on two elements:

> ***Interconnected Load & Supply:*** Multiple energy uses and supplies are connected within the microgrid boundary.
>
> ***Islandability:*** The system is capable of operating while either connected to or disconnected from the central power grid.

The U.S. Department of Energy's Microgrid Exchange Group weaves these two elements into the following definition of a microgrid: "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode."[1]

[1] http://energy.gov/sites/prod/files/Microgrid%20Workshop%20Report%20August%202011.pdf

MILITARY MICROGRID EXAMPLE



Graphic adapted from image courtesy of Sandia National Laboratories

WHY ARE MICROGRIDS IMPORTANT?

Microgrids enable the U.S. to achieve a reliable and clean electricity system—two elements society values highly.

Reliable: Electricity outages cost the U.S. over $100 billion in estimated economic losses.[2] Moreover, when the lights go off for an extended period it represents a major inconvenience for citizens and jeopardizes our safety and security.

The current electricity system relies on large, centralized power plants located far from where electricity is consumed. The energy generated in these facilities is carried through a radial network to the end users consuming the power. This system is susceptible to cascading failures that can happen in the blink of an eye. And it is not very resilient—it can take many hours or even days to bring large segments of the electricity system back online.

A microgrid changes this situation. The ability for local microgrids to connect and disconnect mean individual customers or groups of customers can choose to customize their level of reliability and resilience by enabling islanding capability.

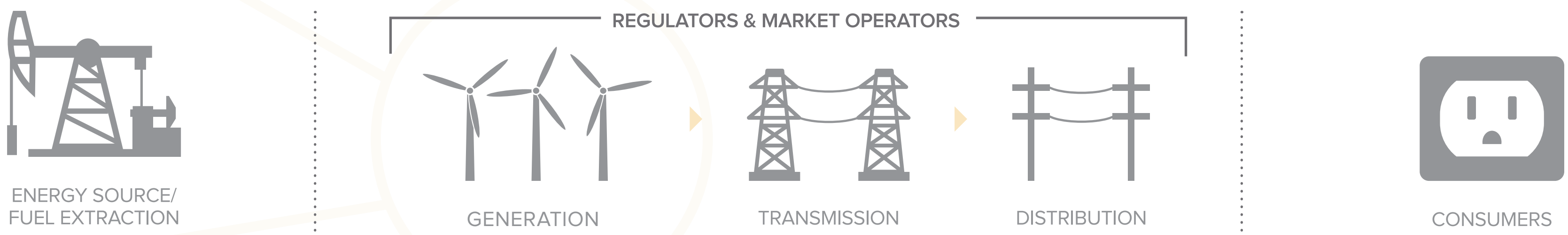
Clean: The U.S. electricity system generates 33 percent of the country's carbon emissions and is responsible for a large share of the mercury, sulfur dioxide, and nitrogen oxide emissions that create chronic health problems like asthma.[3] Microgrids enable the adoption of high levels of local, renewable energy such as solar PV. In addition, microgrids that burn fossil fuels often capture the waste heat from combustion and put it to use for things like building heating. This makes fossil fuel use far more efficient than what often happens in large power plants where vast amounts of useful heat are wasted.

Image courtesy of Shutterstock

[2] http://certs.lbl.gov/pdf/55718.pdf
[3] http://www.epa.gov/climatechange/ghgemissions/sources/electricity.html

WHOM DO MICROGRIDS AFFECT?

THE POTENTIAL EMERGENCE OF MICROGRIDS CREATE IMPORTANT QUESTIONS FOR EVERY PLAYER IN THE ELECTRICITY VALUE CHAIN AND FOR THE REGULATORS THAT DETERMINE THE RULES THAT THESE PLAYERS MUST FOLLOW.



ENERGY SOURCE/FUEL EXTRACTION

- Will microgrids lead to faster and larger adoption of certain types of energy resources?
- How will that affect different fuel extraction or energy technology manufacturing industries?

GENERATION, TRANSMISSION, DISTRIBUTION

- What do microgrids mean for the role and value of existing generators and transmission and distribution assets?
- What risks and opportunities does the emergence of microgrids present for my business, both now and in the future?

REGULATORS

- Do current regulations impede or encourage microgrids?
- How does regulation need to change to support microgrid deployment? And how can non-participant customers be insulated from any cost effects?

MARKET MAKERS

- What types of services can microgrids provide?
- How do markets need to change to support the provision of these services?

CONSUMERS

- What potential value can a microgrid bring?
- What do the microgrid economics look like and at what point does it make sense to invest in this technology?
- Will microgrids change the way my facilities are managed?

E-LAB’S ROLE AND APPROACH

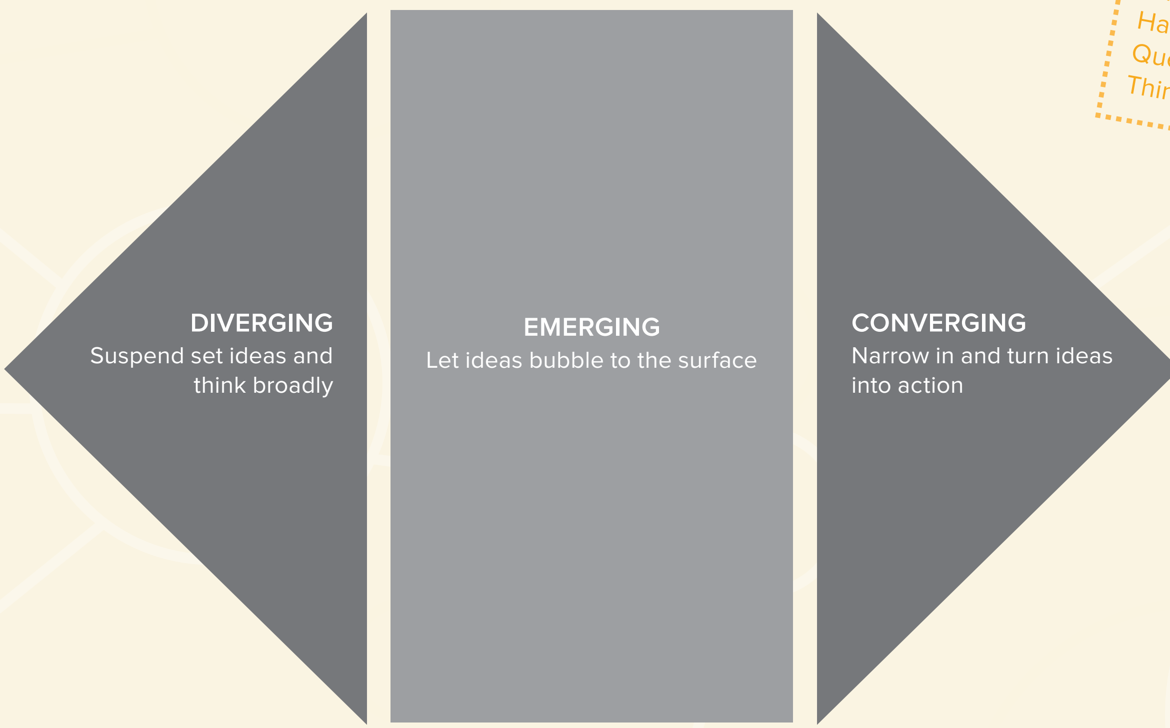
The Electricity Innovation Lab partnered with NAVFAC Southwest, the systems command leading the exploration of microgrids in the Southwest, to help further its microgrid efforts and identify challenges and opportunities where other members of the electricity value chain could play a role in advancing microgrids.

To accomplish these objectives, the team designed and carried out a two-day workshop bringing together NAVFAC personnel and microgrid experts.

WORKSHOP METHODOLOGY: EMERGE, DIVERGE, CONVERGE

The workshop process includes three phases.

Workshop Ground Rules:
Think broadly
Have a beginner’s mind
Question assumptions
Think across disciplines



WORKSHOP PARTICIPANTS

OTHER MILITARY

Marine Corps Installations West: Bob Gilleskie

Marine Corps Air Station Miramar: Mick Wasco

Naval Base San Diego: Commander Alexander Kohnen

ADVOCATES

Environmental Defense Fund*: Raya Salter

MARKETS

PJM Interconnection*: Scott Baker

California Independent System Operator*: Peter Klauer, Steve Keehn

UTILITIES

San Diego Gas & Electric*: Neal Bartek

Fort Collins Utilities*: Steve Catanach

NAVFAC SOUTHWEST*

Capt. Clifford Maurer, Bernie Lindsey, Vernon Hunt, Chris Parry, John Thomas, Dan Tokatlian

MARKET PARTICIPANTS

Shell Energy Trading: Linda Willoughby

ANALYSTS

Homer Energy: John Glassmire

Rocky Mountain Institute*: Leia Guccione, Ned Harvey, Eric Maurer, James Newcomb

MICROGRID EXPERTS

Power Analytics: Kevin Meagher, Tisha Trites

Spirae*: Sunil Cherian

National Renewable Energy Laboratory: Julieta Giraldez

Independent Consultant: Jim Reilly

**denotes eLab members*

KEY FINDINGS

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Image courtesy of Navy.mil

INTRODUCTION

During the workshop, participants developed ideas and solutions to improve the microgrid design process, establish the approach and data needs to quantify the microgrid business case, and outline an evolutionary path for microgrid participation in markets. The work in each of these solutions areas, which is detailed in the Appendix, led to the emergence of five findings. This section highlights each finding.

FIVE FINDINGS:

01 MICROGRID DESIGN REQUIREMENTS

NAVFAC Southwest is still developing a strategy to implement energy security goals stated by the Department of the Navy.

02 ENERGY SECURITY & RENEWABLE ENERGY STRATEGY

Current approaches to renewable energy procurement place emphasis on utility-scale resources, which may not support efforts to bolster energy security through microgrids.

03 NEAR-TERM MICROGRID OPPORTUNITY

Investment in expanding controls presents a near-term opportunity to begin to build toward microgrids while mitigating price risk.

04 ELECTRICITY MARKETS & MICROGRIDS

Microgrids connected at the distribution level are likely to incur high transaction costs to enable participation in electricity markets.

05 INTERNAL NAVY BARRIERS TO MICROGRIDS

Several entrenched barriers must be addressed to enable microgrid adoption across the Navy.

FINDING ONE

MICROGRID DESIGN REQUIREMENTS

NAVFAC Southwest has a tiered rating system that rates the criticality of different buildings on an installation.

This information is used to inform where to site back-up generators, the size of back-up generators, and the need and size of on-site fuel stores.

While this information has proved sufficient in the installation of hundreds of back-up generators across the Navy's bases, it falls short of providing the necessary design guidance when creating a microgrid.

A microgrid provides a unique set of capabilities. It can service critical loads that may shift in time, space, and size, and it can provide the ability to meet loads for longer durations without a corresponding increase in fuel storage.

To take advantage of these capabilities, the Navy needs to better understand its energy security needs. The following pieces of information are just some of the data points that are key to designing a microgrid:

- Duration of time that loads should be able to island
- How critical loads may shift throughout the course of an outage event and the resultant flexibility needed in an islanding solution
- Which loads within a building are critical and thus how granular the microgrid controls should be

QUESTIONS:

1. Should these data needs or design requirements be standardized across the Department of the Navy or Department of Defense?
2. What are the other key design requirements the Navy should understand?
3. How should NAVFAC Southwest collect this data?
4. How can the development of this list of requirements inform any microgrid testing and validation efforts happening in DoN and throughout other military branches?

FINDING TWO

ENERGY SECURITY & RENEWABLE ENERGY STRATEGY

The Navy has launched the 1 GW Task Force to identify the renewable projects that will allow it to meet its 2020 renewables goals. This task force places emphasis on large, utility-scale projects.

> ***The core of the 1 GW strategy focuses on developing large projects (greater than 20 MW capacity) in the Navy's RE resource-rich areas to achieve significant progress toward the 1 GW total.[4]***
>
> *—U.S. Navy, Currents*

But projects at utility scale don't take advantage of microgrid capability to integrate many small-scale renewables. Moreover, large-scale projects don't bolster energy security as much as a set of smaller, distributed renewables projects do because large projects create major vulnerability/choke points that don't exist with many small projects.

QUESTIONS:

1. Are energy security needs being accounted for in renewable project selection?
2. How big are the energy security benefits of having a set of small distributed renewables versus one large renewable asset? Are there additional costs/risks associated with investing in many small assets?
3. Could many small projects be built as fast or faster than one large project?

[4] http://greenfleet.dodlive.mil/files/2012/12/Win13_Strategy_Renewable_Energy.pdf

FINDING THREE

NEAR-TERM MICROGRID OPPORTUNITY

Microgrids present an opportunity to reduce energy costs through lowering demand or shifting demand to times when electricity prices are lower. However, it doesn't require a fully functional microgrid to take advantage of this opportunity.

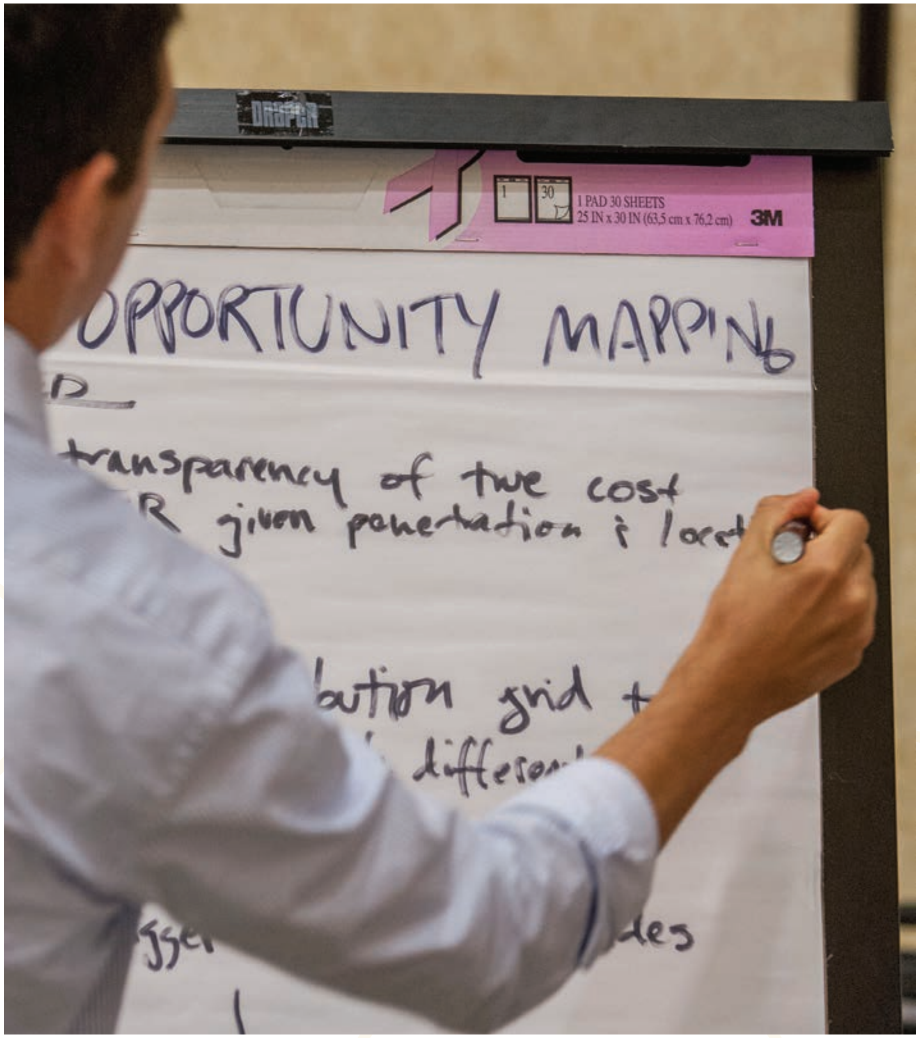
While these actions can be taken by making manual changes to the system, NAVFAC Southwest can greatly enhance its ability to reduce energy costs in this way by developing enhanced control over energy demand and the supply resources on a base.

CASE STUDY: DREXEL UNIVERSITY PHILADELPHIA, PA (2010)

Drexel University partnered with Viridity Energy to combat rising energy costs and low utilization of distributed energy resources. Together, automated demand response capabilities were implemented in select campus buildings using building automation hardware and Viridity's VPower software. With dynamic controls over its building loads and distributed energy assets, Drexel has lowered total energy costs by participating in a variety of energy markets and minimizing non-critical, peak load consumption—saving 10% of its annual electricity bill or more than $50,000.[5]

The university's newly developed demand response capabilities enable it to:

- Optimize energy consumption and production
- Sell excess capacity and energy into wholesale markets
- Minimize costs through automated responses to price spikes[6]



[5] http://www.greentechmedia.com/articles/read/viridity-coned-solutions-take-on-demand-response-2.0

[6] http://viridityenergy.com/wp-content/uploads/2012/02/Viridity-Case-Study-Drexel-University.pdf

FINDING THREE

NEAR-TERM MICROGRID OPPORTUNITY (CONT'D)

Developing control systems across Navy bases has two very important knock-on benefits. First, these control systems form the foundation for a microgrid. Advanced microgrid designs provide optimized dispatching of demand and supply-side resources in response to factors like market prices. To enable this type of functionality, more granular controls at the load, generator, and building level are required. Developing and using these more granular controls thus builds the foundation—the physical and experiential basis for operating a microgrid.

Second, these control systems will become even more valuable as NAVFAC Southwest shifts the purchase of more of its electricity to the spot market. In the next two years, NAVFAC Southwest is planning to make a wholesale change from purchasing electricity by futures procurement contracts (two years in advance), to procuring its electricity on California's spot market. A shift to spot market procurement increases price risk; however, greater control over its demand provides NAVFAC Southwest the tools to mitigate some of this risk.

QUESTIONS:

1. How many resources should NAVFAC Southwest devote to testing and validating early stage microgrid technology versus building the controls that provide near-term value and building the foundation for an evolution toward microgrids?
2. What set of controls are economic today and how close does that take you to having the controls required to operate a microgrid?
3. Do existing and planned control investments align with the types of controls that are essential for a microgrid?
4. When distributed energy resources are installed, are microgrid capable controls installed as well?
5. What level of granularity in control should NAVFAC Southwest strive for—control at the building, at the circuit breaker, etc?

FINDING FOUR

ELECTRICITY MARKETS & MICROGRIDS

A large part of the microgrid value proposition is the microgrid's ability to support and enable participation in electricity markets. Market participation comes in two forms: strategies that reduce costs and strategies that generate revenues.

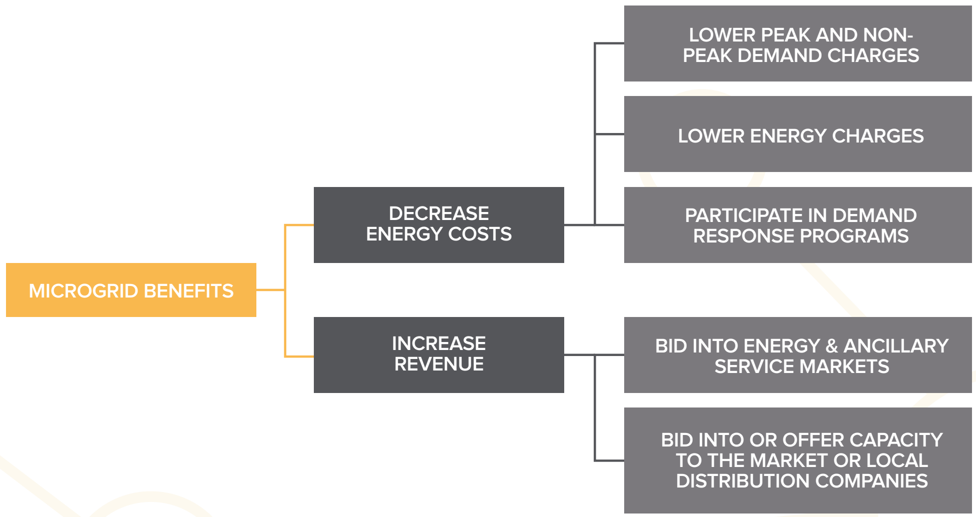
The ease and ability for microgrids to enable these two types of strategies varies across U.S. electricity markets. Below we discuss the microgrid opportunity in the California electricity market.

THE SITUATION IN CALIFORNIA

Decreased Energy Costs

Only direct access customers can procure power from a retailer of their choice or from the California electricity market. All other customers must purchase power through their local utility. NAVFAC Southwest is a direct-access customer, and in the next several years it is shifting to purchase its electricity in the spot market.

As a direct-access customer NAVFAC Southwest can lower its energy charges by changing its energy use in response to market prices. Moreover, the timing and size of these changes can reduce (or increase) demand charges NAVFAC Southwest pays to its distribution utility. For customers that are not direct access in California, a microgrid could reduce demand charges and energy charges, but the size of these cost reductions would be driven by the rate structures of their utility as opposed to being directly driven by electricity market prices.



FINDING FOUR

ELECTRICITY MARKETS & MICROGRIDS (CONT'D)

Increased Revenue

The California Independent System Operator (CAISO) has the capability to incorporate microgrid services into the markets and compensate microgrids for these services. But microgrids must take several steps to become eligible to participate in the California electricity markets.

First, a microgrid must go through an interconnection process. Microgrids connected to the distribution system that seek to provide services to the wholesale market must apply for interconnection through their distribution utility under the wholesale distribution access tariff (WDAT).

Second, a microgrid must understand and select its market designation, which determines eligibility in day-ahead and real-time energy and ancillary services markets. There are a variety of market designations, but the two most pertinent for microgrids are proxy demand response (PDR) and non-generating resource. Since many microgrids may—during some part of their lifetime—export power beyond the point of common coupling, the non-generating resource designation is most relevant. It allows the microgrid to provide both energy and ancillary services. In contrast, the PDR designation is for load-based participation—meaning the microgrid cannot export power beyond the point of common coupling but can participate in energy and non-spinning reserve markets.

Third, a microgrid must follow the CAISO new resource implementation process that prepares the microgrid for participation and includes ISO-customer agreements, metering, telemetry, testing, and certification.

As a microgrid considers providing services to the markets, it must weigh the additional responsibilities that this type of participation requires. Market rules entail higher transaction costs to become eligible to bid into markets, demand faster response times, and penalize a participant that cannot meet stipulations, such as response time. Microgrid owners like the military must carefully weigh the intended objectives and uses of their microgrid with the new responsibilities that come into play when choosing to bid services into markets.

QUESTIONS:

1. What is the full suite of services that microgrids can offer markets? And can microgrids offer these services at cost-competitive prices?
2. Will microgrids represent a large provider of these services in the future?
3. How do markets need to change to support microgrid adoption? What are the barriers to these changes?

FINDING FIVE

INTERNAL NAVY BARRIERS TO MICROGRIDS

Over the course of the workshop, participants identified a number of internal Navy barriers that will likely impede significant progress in microgrids. These barriers include:

*Split incentives—*There are multiple layers of the organization that provide or use energy, and their objectives regarding energy costs and benefits are not necessarily aligned. As a result, the stakeholder that will receive the benefits of microgrids is not necessarily the stakeholder that has to fund it.

*Acquisition Process—*The acquisition process requires formal vendor selection anytime NAVFAC Southwest wants to tap into outside expertise. This limits the ability of NAVFAC Southwest to informally engage with outside organizations to advance its microgrid work.

*Unified Facilities Criteria—*There are design specifications that contractors follow when designing a facility for any of the Tri-Services, including the Navy. UFC 2-000-05N, Facility Planning Criteria for Navy/Marine Corps Shore Installations, dictates that the most likely backup system to be employed will be a diesel generator or gas turbine connected to the critical load. Even if a microgrid is in place, a diesel genset system may also be installed for UFC compliance.

Although these barriers are not likely to prevent testing of microgrids or to impede initial investments that might put NAVFAC Southwest on the microgrid path, over time they are likely to slow or stop more concentrated efforts to move toward this technology.

RECOMMENDATIONS + CONCLUSION

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RECOMMENDATIONS + CONCLUSION

The microgrid represents a new paradigm for organizing the power system. It enables the integration of large amounts of renewable energy, and does so locally.

The Navy is leading the charge to test and validate this technology. After a two-day workshop convening a diverse group of experts and stakeholders, Naval Facilities Engineering Command Southwest has a clearer grasp on the microgrid opportunity. Based on our learnings from this workshop, the table below provides a set of recommended priority areas of action for three groups: 1.) NAVFAC Southwest and the rest of the Navy or any customer closely looking at reliability or renewable energy, 2.) for a grid operator, whether an independent system operator or a distribution utility, and 3.) for electric system regulators. Making progress in these areas can unlock the microgrid opportunity and bring benefits to the customer and the grid.

	NAVFAC SOUTHWEST/LARGE CUSTOMER	GRID OPERATOR	REGULATOR
UNDERSTAND THE NEED	Initiate a process to determine base/site reliability needs	Explore needs of early microgrid adopters, both why they are considering the technology and the challenges they need help overcoming to make the investment (e.g., finance)	Seek out early adopters such as the Navy to identify regulatory barriers to microgrids
STUDY THE ECONOMICS	Understand the economic case, starting with elements that are readily quantifiable	Build out the economics from customer perspective and evaluate potential grid conditions that might call for microgrid solutions	Understand both customer and grid economics of the microgrid solution
TAKE ACTION	Ensure current investment in renewables and other equipment central to microgrid operation, such as controls, is microgrid compliant	Pilot a potential microgrid business model with an eager customer	Start by defining microgrids and how current regulations apply to them. Begin ticking down the list of barriers identified as part of understanding the need. For a comprehensive list of guiding principles that should shape regulatory action in this area, see “Microgrids and ‘Micro-municipalization’”[7]

[7] http://blog.rmi.org/blog_2013_07_23_microgrids_and_municipalization

APPENDIX

ADDITIONAL BACKGROUND

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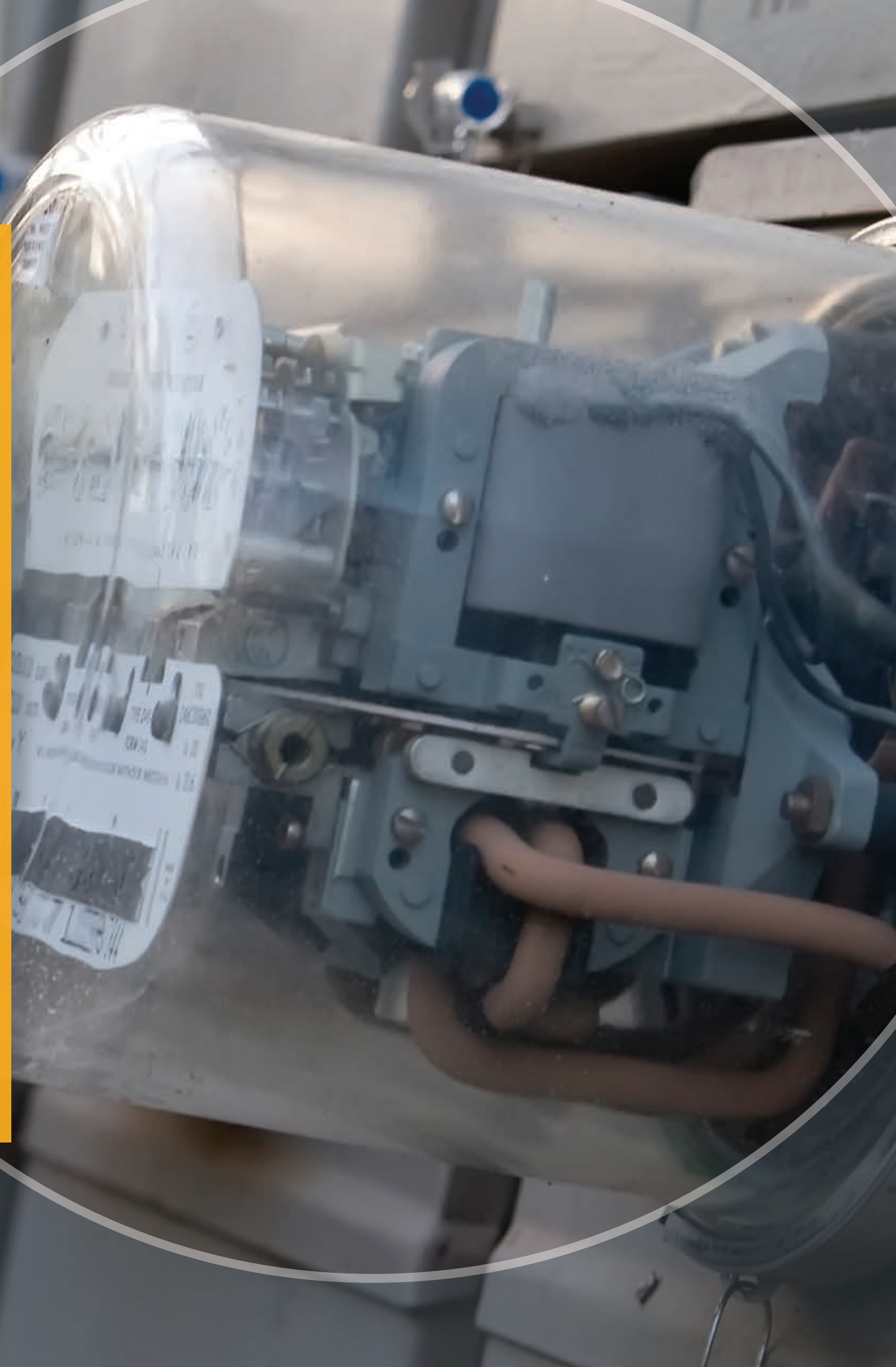


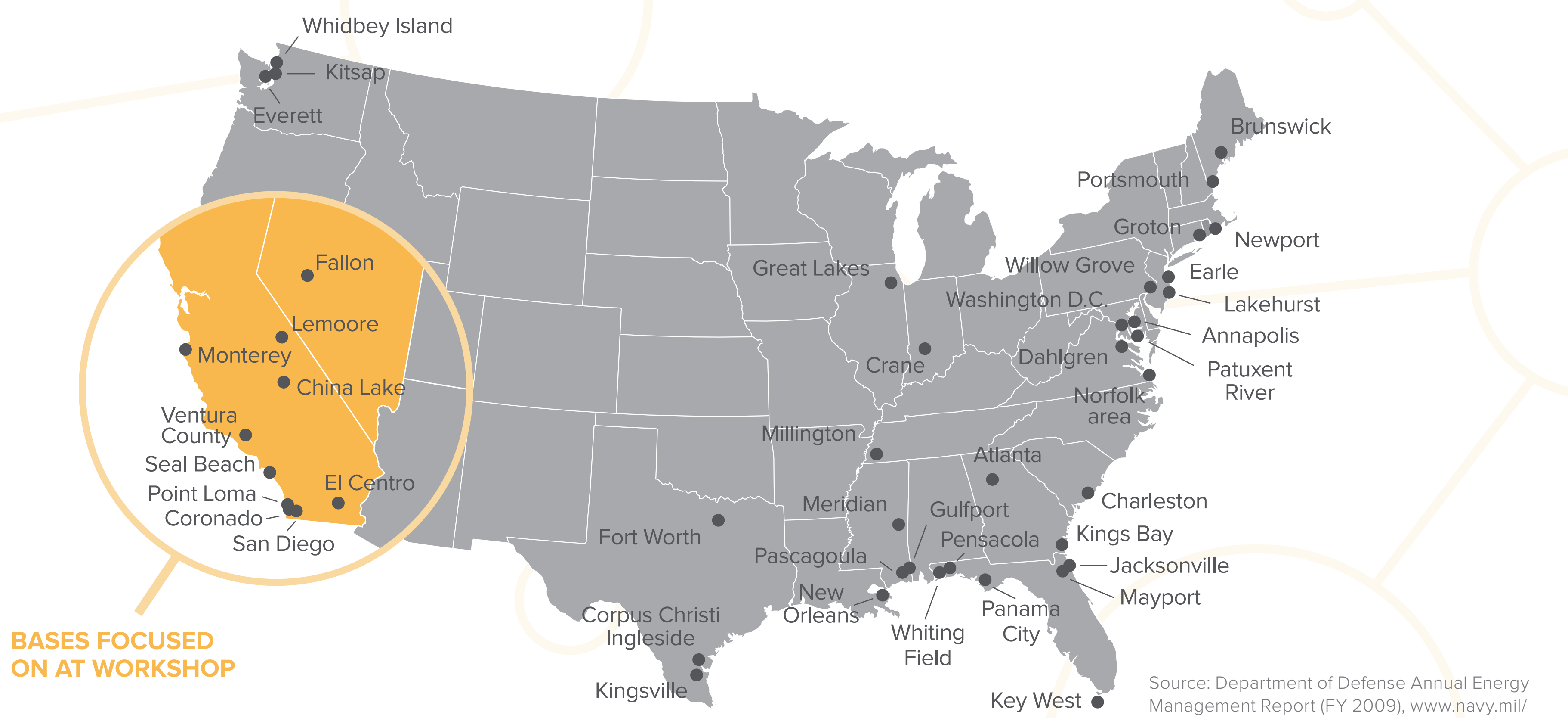
ABOUT NAVY BASES

The Department of the Navy operates bases across the United States to support its tactical forces. The Southwest, the focus of the workshop summarized in this report, contains 10 major installations.

The installations house a number of functions for Navy personnel, including:

- Facilities for the repair of machinery and electronics
- Communication centers
- Training areas and simulators
- Ship and aircraft repair
- Intelligence and meteorological support
- Storage areas for repair parts, fuel, and munitions
- Medical and dental facilities
- Air bases

In recent years, the Department of Defense has consolidated its bases across all services branches to streamline costs and increase efficiency. Consequently, the bases remaining in operation have assumed expanded roles and greater strategic importance.



Source: Department of Defense Annual Energy Management Report (FY 2009), www.navy.mil/navydata/organization/org-shor.asp.

ENERGY USE ON NAVY BASES

In the Southwest Region for fiscal year 2012, annual shore electricity demand exceeded 1,000 GWh. Total energy costs (Gas & Electricity) in the region exceeded $100 million, with Shore electricity consumption accounting for approximately 90% of that total cost.

In the Southwest, most of the electricity consumed comes from the commercial power grid.

INSTALLATION	ENERGY			COST		TOTAL ENERGY COST
	ELECTRIC (MWH)	NATURAL GAS (MBTU)	CONSUMED (MBTU)	ELECTRIC ($)	NATURAL GAS ($)	($)
Naval Base SAN DIEGO	372,200	529,300	1,799,700	36,031,100	4,258,400	40, 289,500
Naval Base CORONADO	227,700	161,200	938,400	24,009,800	1,297,000	25,306,800
Naval Base POINT LOMA	130,600	62,700	508,500	14,552,600	489,200	15,041,800
Naval Base VENTURA COUNTY	93,200	172,600	490,700	10,122,500	1,604,000	11,726,500
Naval Air Station LEMOORE	85,900	180,600	473,800	4,379,500	1,430,600	5,810,100
Naval Air Weapons Station CHINA LAKE	97,600	254,100	587,300	11,275,600	1,235,100	12,510,700
Naval Air Station FALLON	37,000	141,100	267,400	3,203,500	1,376,100	4,579,600
Naval Support Activity MONTEREY	27,600	80,100	174,300	3,588,400	468,300	4,056,700
Naval Air Station EL CENTRO	16,600	14,700	71,400	2,014,700	101,400	2,116,100
Naval Weapons Station SEAL BEACH	21,800	33,000	107,500	2,888,800	220,700	3,109,500
TOTAL CONSUMPTION	**1,110,200**	**1,629,400**	**5,419,000**	**112,066,500**	**12,480,800**	**124,547,300**

Source: U.S. Navy

GRID RELIANCE CREATES MISSION RISK

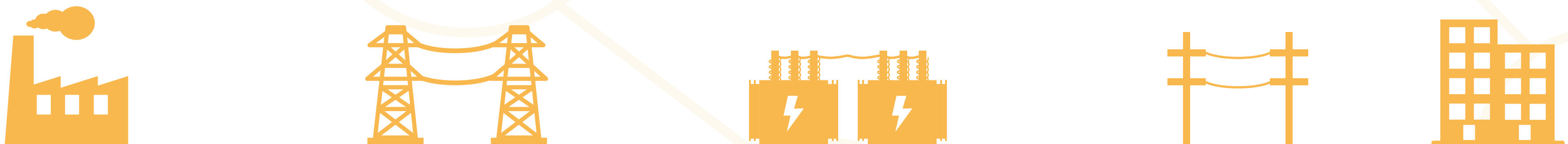
The Navy's reliance on grid-sourced electricity exposes it to significant operational risks. An outage in the grid puts important on-base services such as intelligence and communication centers (which require continuous and reliable power) at risk and thus jeopardizes combat readiness.

Any component in the highly interdependent electric grid can cause an outage. Power plants, transmission lines, substations, and distribution lines—the main cogs in the electric grid—each have a set of factors that could result in local or regional loss of power. Weather, human error, and equipment failure are among the most common causes.

"ENERGY IS CRITICAL TO EVERY MISSION, AND AS SUCH IT WILL ALWAYS PRESENT A SIGNIFICANT VULNERABILITY"

—DON STRATEGY FOR RENEWABLE ENERGY (2012)[8]

[8] http://www.secnav.navy.mil/eie/asn%20eie%20policy/Dasn_energystratplan_Finalv3.pdf



POWER PLANTS

- Equipment failure
- Sabotage (physical & cyber)
- Fuel shortages
- Automated emergency shutdowns

TRANSMISSION LINES

- Regional transmission organization human and software errors
- Fire, wind, and extreme weather
- Cascading outages
- Sabotage (physical & cyber)

SUBSTATIONS

- Equipment failure
- Fire
- Sabotage (physical)
- Extended replacement

DISTRIBUTION LINES

- Operator errors
- Animals, fire, wind, and extreme weather
- Cascading outage

NAVY FACILITIES

Sources: http://www.fas.org/sgp/crs/homesec/R42795.pdf; http://www.energy.ca.gov/sitingcases/palomar/compliance/news/2011-08-04_Palomar_Fire_Report.pdf; http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1687814, http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1052&context=vpctheen&sei-redir=1; http://www.gao.gov/assets/600/592508.pdf; http://web.merage.uci.edu/~navarro/Vita05/JA%207%20Aftershocks.pdf.

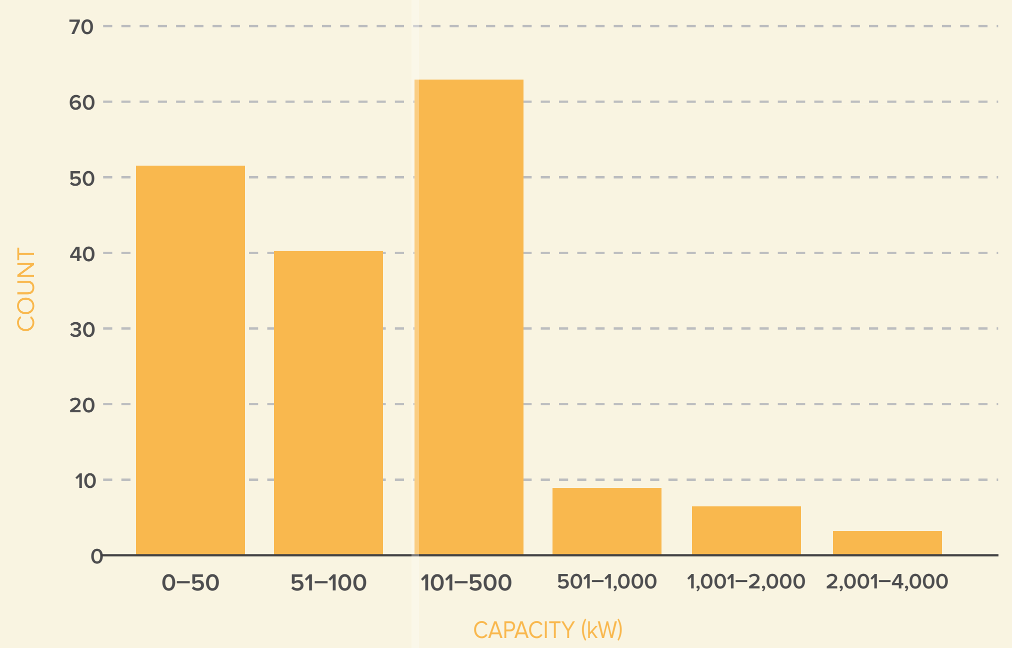
AN IMPERFECT SOLUTION

Navy installations currently rely on back up generators that provide interim power to critical sites if the grid goes down. For example, in the Southwest, there are over 150 generators. When power is lost, emergency generators (powered by diesel or natural gas) start automatically. This solution has proven capable of providing sufficient power and reliability to support operations during outage events experienced by NAVFAC Southwest. However, these experiences have also pointed to some of the shortfalls in this system.

In past outage events, generators have occasionally failed to start or have broken down mid-way through operation.[9] In 2010, Sandia National Laboratories reported that military back up generators only start 60% of the time due to inadequate maintenance or system understanding.[10] Even well-maintained generators in nuclear power plants, which cool reactors during grid outages, were found to fail at a rate of 2–3% over an 8-hour period.[11]

[9] Dan Tokatlian, personal communication, 2013
[10] US Navy;http://events.energetics.com/SmartGridPeerReview2010/pdfs/presentations/day2/am/16_Energy_Surety_Micrograms_and_SPIDERS_NEW.pdf
[11] http://www.cbsnews.com/2100-201_162-20118118.html

NAVFAC-SOUTHWEST EMERGENCY GENERATORS (BY CAPACITY)



LIMITATIONS OF BACK-UP GENERATORS

Outside of immediate experience with the use of generators during the events experienced in the Southwest, which have typically been less than one day in duration, relying on back up generators suffers from several other limitations:

- ***Fuel issues.*** The success of back up generators to meet emergency energy demands is dependent on the amount of on-site fuel stocks and the ability to dispatch fuel from storage sites to individual generators. On-site sources typically only supply between one to three days of operation, and reliance on fuel deliveries present added risk in a true emergency situation.

- ***Static energy controls.*** In a campus or base setting, back up generators are typically connected to loads at the building level. Thus, the facilities operator does not have the capability to reroute power to a specific part of a building or even to a different building in the event that one back up generator doesn't work or a load previously thought of as non-critical becomes critical.

- ***Discontinuous power.*** Despite automatic-start capabilities, back up generators require up to 30 seconds to "warm up" before delivering power.[12] Systems which need continuous power flow may be interrupted or require additional equipment such as a battery.

- ***Routine maintenance and testing.*** Back up generators must be consistently maintained and tested to ensure maximum reliability. Without routine maintenance and proper upkeep, generators become much more susceptible to failure. Common generator problems include:

    1. Battery failure
    2. Low coolant levels
    3. Oil, fuel, or coolant leaks
    4. Disabled automatic controls
    5. Air in the fuel system
    6. Insufficient fuel
    7. Tripped breakers[13]

[12] http://www.pse.com/savingsandenergycenter/ForHomes/Documents/1233_ResidentialGenerators.pdf
[13] http://ecmweb.com/ops-amp-maintenance/top-nine-reasons-generators-fail-start

THE NAVY ENERGY VISION

ADDRESSING OUTAGE RISK AND BROADER ENERGY SECURITY GOALS

In order to mitigate energy security risk from its reliance on the commercial power grid, the Navy is developing a new vision for how it supplies and uses energy on its installations. The Navy's vision integrates highly efficient and responsive end uses with distributed renewable supplies using microgrid technology.

Such a system would bolster energy security on Navy bases by allowing the Navy to produce power independent from the commercial electric grid for longer periods of time and to dynamically shift what end uses receive power. In addition, it may offer a more economic solution for providing energy security because many of the assets can contribute cost savings or create revenue opportunities by also operating when the grid is fully functioning.

In a step toward achieving this vision, the Department of the Navy has committed to:

- Procuring at least 50% of on-shore energy from alternative sources
- Achieving 50% net-zero facilities by 2020

In addition, the Navy has signaled the importance of microgrids:

> ***In parallel with deploying renewable generation, DoN must also continue the effort to pursue development of smart microgrids on our installations. Being able to generate power independently is of strategic importance, but will not significantly improve an installation's security unless the power is available during blackouts or other incidents affecting grid reliability… To improve energy security, DoN must evolve beyond simply providing emergency generators for individual buildings to being able to provide reliable, sustained power to designated substations with the capability to match sources to critical loads…***
>
> ***—DoN Strategy for Renewable Energy (2012)[14]***

[14] http://www.secnav.navy.mil/eie/ASN%20EIE%20Policy/DASN_EnergyStratPlan_Finalv3.pdf

PROJECTS IN THE SOUTHWEST

THE NAVY IS DRIVING MICROGRID DEVELOPMENT THROUGH SEVERAL LARGE PROJECTS IN THE SOUTHWEST

2012 | 2013 | 2014 | 2015 | 2016 | 2017+

FOUNDATIONAL SYSTEMS INTEGRATION

UTILITIES AND ENERGY OPERATIONS CENTER (UEOC)

COMMUNICATIONS INFRASTRUCTURE EXPANSION
Copper and fiber for energy management systems

ICS PLATFORM NETWORK
IT infrastructure expansion, software configuration, cybersecurity, and training

Concept Validated for DoN-Wide Application

ADVANCED UTILITY SYSTEMS FOR SECURITY & EFFICIENCY

AUTOMATED DEMAND RESPONSE CAPABILITY EXPANSION (DLLR)

MICROGRID
- Regional integration of microgrid technology with existing industrial control systems, critical loads, and generation assets
- Environmental Security Technology Certification Program microgrid at 29 Palms
- Expeditionary Warfare Center TECHVAL energy storage pilot at San Nicholas Island
- Environmental Security Technology Certification Program for metro San Diego microgrid cluster
- Silver Strand Training Complex coastal campus opportunity to integrate microgrid technology into planning of brand new complex

FACILITATE INDUSTRY ENGAGEMENT

REGULATORY (ONGOING)
Proactive engagement in regulatory environment to advance Department of the Navy energy initiatives

PARTNERSHIPS (ONGOING)
Building influence and expertise through relationships with private, local, state, and federal entities in support of Department of the Navy energy initiatives
- Western, San Diego Gas & Electric, Southern California Edison, California Independent System Operator
- University of California San Diego, Department of Energy, Department of Interior, Smart Power Infrastructure Demonstration for Energy Reliability and Security, Marine Corps Installations West

Source: U.S. Navy

APPENDIX
WORKSHOP IDEAS

07

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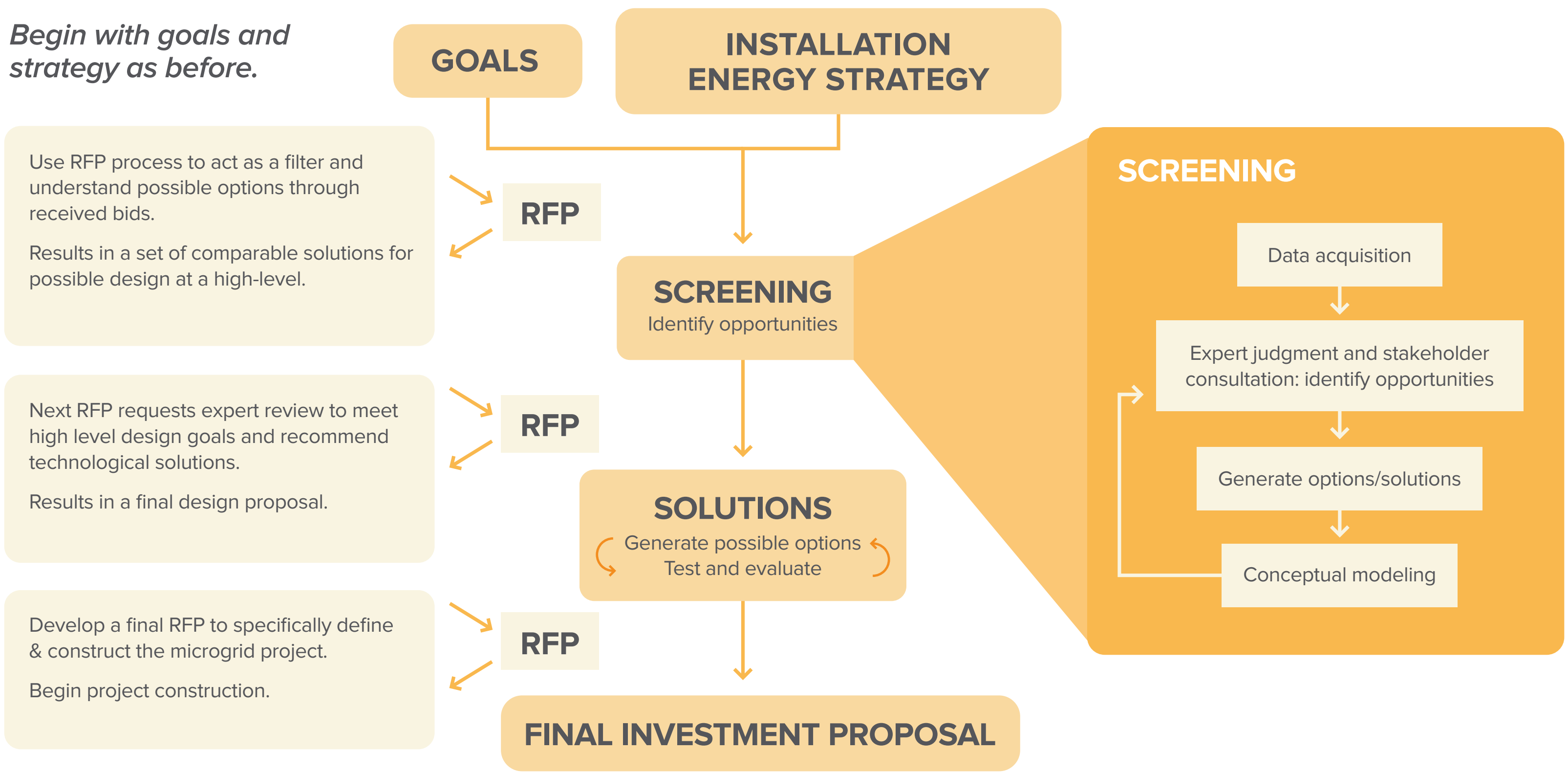
END-TO-END MICROGRID DESIGN

Recognizing that the development of design requirements fits into a larger, and yet undefined, design process, the workshop team developed recommendations and a suggested approach to Naval microgrid design. The approach relies heavily on harnessing the best solutions from external contractors through the RFP process.

RECOMMENDATIONS

- Empower energy managers to work with commanding officers to expand the specificity of energy security requirements to a specific facility and specific buildings and assets on a facility
- Build on and test the standard process for microgrid project evaluation developed during the workshop
- Evaluate the performance and costs of alternatives to microgrids to facilitate comparisons



EVOLVE MARKET PARTICIPATION OVER TIME

Workshop participants developed an evolutionary approach to market participation and microgrid development. This approach adds critical microgrid components over time with each component enabling greater market participation.

TECHNOLOGY	MARKET PARTICIPATION
1. Add facility energy management systems	• Supports more energy efficiency, traditional demand response, peak load reduction, and price responsive demand • Enables greater bidding of demand resources into markets
2. Add networking of supply through micro-controllers	• Provides supply-side optimization and control to enable supply to respond to price signals
3. Add micro-energy management system	• Delivers optimization and dispatch of entire system, as micro-EMS connects and controls facility EMS and micro-controllers • Allows optimized energy market bid strategy that considers supply and demand across microgrid

To support this evolutionary approach, the team developed a set of near-term recommendations for the Navy.

1. Control Navy use for savings on energy bill
    - Engage in utility demand response programs
    - Reduce demand charge through better control of demand and optimization of underutilized assets
    - Perform load shifting in response to market prices
    - Invest in additional energy efficiency measures
2. Analyze opportunity to participate in California Independent System Operator (CAISO) market as proxy demand response or non-generating resource
3. Add controls that optimize energy usage and enable response to real-time price signals
4. Evaluate potential for Secure Automated Microgrid Energy Management System to demonstrate microgrid market participation through partnership with San Diego Gas & Electric and CAISO

CREATE TOOLS TO QUANTIFY MICROGRID BUSINESS CASE

VALUE STREAMS:

APPROACHES TO QUANTIFY VALUE STREAMS:

VALUE STREAM	HIGH-LEVEL APPROACH TO SIZE VALUE STREAMS
Size opportunity to optimize energy use against costs/rates (energy efficiency, peak shave, peak shift, etc.)	**Model the plant (beyond Homer energy model):** • Gather historical data at building level **To evaluate demand response opportunity:** • Determine rate structure • Collect billing data • Measure headroom to respond with load and on-site generation • Use existing efforts with Power Analytics to gather more comprehensive system data • Evaluate costs and benefits of different levels of control (manual vs. auto) • Run vs. scenarios
Evaluate Operations & Maintenance Effects	**Model O&M implications in the following areas:** • New O&M requirements • Eliminated O&M requirements • IT/cyber security demands • Staff/training needs • Network benefits
Value Revenue Opportunities	• Consider California Independent System Operator (CAISO) markets that support microgrid participation (both energy and ancillary services) • Model ability of on-site generation and load to provide market services
Energy Security	• Define cost of an outage at each base • Begin by applying the methodology used at MCAS Miramar (see Giraldez et al., 2012. "Valuing Energy Security: Customer Damage Function Methodology & Case Studies at DoD Installations")

1820 FOLSOM STREET | BOULDER, CO 80302 | RMI.ORG

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