Energy has a multitude of security dimensions. From the supply perspective, these include ensuring access to energy commodities (especially oil, natural gas and coal) in spite of geopolitical, business and natural disaster risks and in ensuring the integrity of the infrastructure and transportation systems (pipelines, ports, sea lines of communication) that move commodities and refined products to end users. From the consumption side security refers to the ability to access power at an acceptable price on demand to perform routine activities. NATO-led development of standards governing military base microgrids and their interconnections with local emergency management power, to ensure the uninterrupted functioning of water and sewage systems, hospitals, traffic lights and police services, can contribute to national efforts to enhance energy security.

NATO

The North Atlantic Treaty Organization is a complex political and security organization, composed of 28 Member nations in Europe and North America. NATO not only runs operations in Afghanistan, Kosovo, the Mediterranean (recently completing Operation Unified Protector in Libya) and off the Horn of Africa, it also participates in a wide network of partnerships. These include the Mediterranean Dialogue with countries in the Mediterranean littoral; the Istanbul Cooperation Initiative which includes countries in the Middle East; the Partnership for Peace; and bilateral relationships with regional organizations (the European Union, Untied Nations and African Union) and with countries like Australia and Japan.

NATO as an Alliance of Nations makes decisions on the basis of consensus. NATO cannot compel a Nation to do anything. However, NATO does provide a forum for discussion, for the cross fertilization of ideas between many different sectors, and to develop mechanisms for interoperable approaches to common challenges. By establishing common standards for nations, a NATO Standardization Agreement on an issue simplifies the capability development process across the full range of capability elements (doctrine or policy, organization, training, materiel, leadership, personnel, and facilities). No less importantly, these standards provide insight for industry, making it possible to develop technologies, such as those associated with microgrids to meet standards adopted by NATO Members that can influence standards for partners around the globe.

NATO member militaries are already engaged in efforts to increase energy efficiency and to reduce military operational energy requirements in accordance with normal activities associated with increasing energy efficiency. For a discussion of some of these see Energy Security: Tough Lessons of Afghanistan by Mehmet Kinaci .

NATO and energy vulnerabilities

As a security organization, NATO is interested in reducing energy related vulnerabilities to which its Members and Partners are exposed. Energy vulnerabilities emerge from sources both inside and outside NATO Member nations. Vulnerabilities from outside NATO, such as the interruption of petroleum or natural gas supplies from external suppliers as a result of natural disasters, political disputes, armed conflicts or asymmetric hybrid attacks on NATO Member countries often get the most attention. For example, blockages of major oil a transit point, like the Straits of Hormuz, pirate or terrorist attacks against liquified natural gas (LNG), oil tankers or pipelines would have a dramatic effect on energy security. Less obviously, hypothetical European Union objections to human rights abuses or the imprisonment of political protestors in a large country to the east could theoretically lead to interruptions in natural gas deliveries by ostensibly taking down a pipeline for "maintenance" purposes.

Suboptimal condition of physical infrastructure

Yet threats which emerge from the internal condition of our energy systems demand attention as well. The suboptimal condition of much of the physical infrastructure of which our energy, especially electricity grids, consist makes these system vulnerable to mechanical component failure, forcing energy consumers to invest in their own backup systems in order to ensure 24/7 power reliability. In addition, commendable efforts to increase the efficiency and intelligence of the grid have had serious unintended consequences – they have made the grid less resilient in two ways. One, a "smarter" grid enables optimization of power generation resources, reducing the need for additional generation capacity. Without spare capacity we are overly reliant on the optimized (remaining) power stations. In the event of failure, nations no longer have idle capacity standing by to bring online to seamlessly meet energy demand. The vulnerability created by this optimization through intelligence is compounded by cost optimization, the continuing effort to conserve financial and personnel resources. Second, adding intelligence to the power system has created vulnerabilities from cyber attack. "Intelligent" internet connected generators capable of autonomously adjusting run times in response to local demand are also open to hacker attacks. For example, malware like the Stuxnet virus or logic bombs in pipeline or generator control software could have devastating effects on energy production and distribution systems.

Looking at the energy security challenges from a NATO perspective provides a unique angle from which to view the challenges and opportunities associated with increasing energy security. NATO's Smart Defense initiative and efforts to operationalize the Comprehensive Approach provide frameworks within which NATO, in close cooperation with industry, can take additional practical steps to enhance overall energy system resilience through contributing to the development of military facility based microgrids.

The Comprehensive Approach refers to working more effectively with a wide variety of governmental, non-governmental, military and commercial organizations to accomplish complex objectives. We can define it as inter-organizational interaction that reduces the transaction costs among the actors working to generate effects in the engagement space.

Experts at the US Institute of National Strategic Studies have done some excellent work on this issue. NATO has three major strengths making it a valuable partner with industry and governmental organizations in North America and European Union dealing with energy security related issues.

First, NATO as a vehicle for mufti-organizational cooperation can aggregate the contributions of multiple national military forces to various energy related deliberations, simplifying the coordination challenge of groups like the US's National Institute of Standards and Technology (NIST) and European Union standardization organizations. These deliberations generate real world effects through the creation of NATO wide standards. These standards facilitate development not only of the technical pieces of equipment necessary for widespread microgrid deployment, (the hardware) but also software. These guidelines govern construction and use of that equipment and the training required for operators.

Second, NATO provides the "gold standard" for military capability interoperability. Through its Standardization Agreement development process, NATO nations develop standards to enhance the interoperability of their militaries. While originally NATO standardization efforts focused on interoperability of military hardware (sizes of bullets, designations of fuel oil) standardization agreements also exist in areas like environmental protection e.g. NATO Standardization Agreement 7141 Joint NATO Doctrine for Environmental Protection during NATO led military activities. Similar standards should be developed in the areas of smart grids, distributed energy and microgrid use.

Third, NATO has a robust concept development and experimentation (CD&E) process with some of these events open to industry. Through the CD&E process NATO engages in collaborative capability development (from the earliest stages of exploring a potential need to final deployment of a capability in the field) with Member and Partner nations, academia and industry.

Energy security is, like most contemporary complex issues, embedded in a dynamic system of systems involving infrastructure, personnel and emerging issues like cyber security. NATO possesses the organizational infrastructure necessary to bring together broad sets of stakeholders to contribute, along with government standards organizations and other major intergovernmental organizations, to energy security standard creation. In addition, NATO has a robust lessons learned system to inform the capability development process as its moves forward.

Microgrids: an energy system resilience increasing tool

Microgrids provide a useful focal point through which we can examine the utility of NATO's contribution to energy security. A microgrid can be defined, according to Peter Asmus as "an integrated energy system consisting of distributed energy resources and multiple electrical loads operating as a single, autonomous grid either in parallel to or 'islanded' from the existing utility power grid." Microgrids have two important overlapping capabilities from the military perspective: increased multi-source (natural gas, diesel, oil, wind, solar, methane, etc.) power generation capability for bases (both in home countries and in expeditionary operations in austere environments) and in providing continuity of service separate from the main power grid.

Enhanced power generation utilization efficiency

Reliance on fossil fuel to power generators in expeditionary contexts imposes huge costs on the military, not only in fuel but much more importantly in lives lost to attacks on logistics systems. NATO militaries have therefore in many cases been enthusiastic early adopters of alternative power generation technologies based on wind and solar sources because multiple power source capability both increases resilience and reduces operating costs. Every kilowatt produced by a solar or wind system reduces the amount of fuel, and convoys or air drops to deliver that fuel, a remote forward operating base requires.

Yet managing diverse power sources is extremely complicated. For example, integrating a solar array into a base power supply infrastructure requires not only knowledge of the microclimate effecting the array and the projected loads but also requires conventional power generation resources on standby to cover the possible shortfalls from the solar generation. Microgirds can help manage this challenge. The small size and focus on key customers of microgrids makes more efficient use of multiple distributed energy resources, like landfill methane, wind, solar and small scale natural gas and co-generation facilities and a variety of storage technologies easier. The microgrid operator can more efficiently manage its loads within the microgrid because the operator can quickly, and without considering possible disruption to other loads, adjust to changes in wind speed or cloud cover by shifting its standby power generation sources or (when available) simply drawing more power from the grid.

Microgrids thus provide two important energy security advantages from a military perspective. First, by providing a flexible set of sockets and the intelligent control of distribution systems into which multiple energy generation sources and storage devices can plug, microgrids simplify the base power management task. Second, the use of multiple power generating technology increases the resilience of a base – when power is unavailable (no wind, the convoy of fuel trucks is late, etc.) another power source can fill the gap and preserve continuity of service. The extra costs associated with creating a microgrid able to utilize multiple power generating and storage systems pales into insignificance when compared to the costs of mission failure. Alternative generating technologies provide faster and more visible savings when the financial evaluation is taking place in a context in which the fully burdened costs of fuel (as seen in resupply by air drop or hundred mile truck convoys over hostile terrain) are brought to the forefront of decision making.

Island living

The resilience enhancing effect of microgrids is further amplified by the killer application of microgrids – the ability to disconnect from the grid and run independently – as an "island". Several NATO militaries are developing this capability for their bases both to make better use of their renewable and alternative energy resources and to provide continuity of service for warfighters. Faced with a crisis interrupting grid services (such as an ice storm), a base microgrid can shift into island mode, using its own organic power generation and storage resources to continue operations.

This capability makes significant contributions to energy security in response to both unintended (natural disaster) and intentionally caused crises. If military forces are reliant solely on the grid and backup generators (with limited reserve fuel supplies) an enemy could dramatically reduce the military capability of an opponent through hybrid (such as a cyber attack on generator motor controllers in conjunction with using construction equipment to “accidentally” cut a power bus or topple a transmission tower) attacks on its power system in ways that fail to breach traditional definitions of aggression and thus provide little scope for effective reaction by the attacked party. An island operations capability reduces this vulnerability.

Smart Defense and microgrids

In accordance with NATO’s Smart Defense initiative, which emphasizes multinational, collaborative capability to reduce costs, the island operating capability provides two important opportunities. First, it provides a venue for military cooperation to meet a major energy security need both at home and in expeditionary operations abroad. Second, it is an opportunity for the military forces to add additional value to the broader community in which they are located. This need not be limited to communities within a single nation. Military microgrids, depending on their location, can benefit citizens in more than one nation. NATO Smart Defense thus provides a framework within which to enhance regional, not only national, energy security.

This idea of military capabilities contributing to continuity of service for civilian emergency capabilities is based on a logic that moves beyond Smart Defense to the broader concept of Smarter Security; the military, within the Smarter Security framework, does not simply defend the country from external aggression but contributes to providing security constituted by the rule of law and a safe domestic environment. How would microgrids add this value?

With the appropriate infrastructure investment, during a crisis the military base “island” can power not only it own required services, but local community vital loads. Continued power supply to vital loads like the emergency management center, hospital, airport and street lighting, increases the overall resilience of the community. Electricity provided by the military microgrid (taking advantage of its power storage and renewable power generation resources to maintain service through the crisis) can enable the local medical and emergency service facilities to remain operational even when their own emergency generators run out of fuel after a day or two.

Therefore as a result of its islanding capability, the military base can serve as a super-resilient node of the national energy network, dramatically multiplying the return on investment in base infrastructure and providing additional high value service from the military to broader community. How would this work? The benefits of money spent on the military are often invisible. For example, it is difficult to precisely point out the deterrent effect of military capabilities, giving the impression that they are a waste of money unless the nation goes to war. Money spent on the development of military microgrids, interconnected with local emergency capabilities, visibly demonstrates the utility of the military infrastructure enhancements (when continuity of emergency services is maintained even during an energy crisis) that would otherwise seldom become obvious to taxpayers.

The microgrid logic as security enhancing tool could apply not only to NATO national facilities in Member countries but also to military facilities in Partner nations. The expertise NATO develops advising nations on creating islanding capable microgrids in operations and at home could be applied as an integral component of a NATO's defense institution building advice and support capability activities with Partner and other countries with whom NATO is working. NATO advice on making base infrastructures both island- capable and interconnected with the local civilian emergency service electrical system would enable the country to simultaneously, and at very little added cost, increase both their military and civil emergency response capabilities.

Microgrids and the Comprehensive Approach

This multidimensional use of microgrids also serves as an example of operating in accordance with a Comprehensive Approach. Viewed through the Comprehensive Approach capability development lens the NATO Alliance organizational structures can add value to member and partner nations by providing a framework within which development of each of the island operation's capability elements (e.g. interoperability, training, organization, personnel, leadership, facilities, policy and materiel). This will require NATO support to national, intergovernmental and private sector actors to develop the capability elements through the formulation of interconnection standards, emergency response exercises, training programs, creation of facility management guidelines, sharing good practices and lessons identified on microgrids, and creating personal qualification standards. Such cooperative engagement will reduce costs and increase the capability development velocity for commercial, governmental and military organizations and agencies.

Implications

Well-designed capabilities serve functions beyond a single category – they must be multidimensional to adequately deal with the complexity of the 21st century threat environment. Microgrids are one such capability. However, when making the case for investment in capabilities it is useful to speak to specific concerns of particular stakeholders.

Military implications

So what are the implications of these activity sets in NATO Member and Partner countries from the strategic military perspective? For if there are not significant security domain gains, then NATO involvement, and the additional costs imposed on defense budgets already under stress, will not provide adequate return on investment. Better to directly invest in civilian power generation and storage capabilities.

Deterrent effect of increased resilience

Microgrids on military installations constitute a capability that will both enhance NATO's ability to respond to crises in the security dimension and, through interconnection with local community load capacity, increasing the overall resilience of the nation. This increased resilience is not only useful in itself, but also contributes to NATO's ability to deter adversaries. Extremely resilient power systems in NATO countries, consisting of combinations of large scale power generation, distributed generation and storage, and microgrids mutually supporting one another through a regional power transmission grid will affect the decision making calculus of potential enemies in two ways. One, the challenges associated with creating disruption will increase due to the need to not simply degrade the main power grid, but degrade multiple well protected energy network nodes. Two, the negative effects resulting from a successful attack on a single node in the power generation or supply network will decrease. As a result, the costs of developing such system degrading capabilities increase while the negative effects decrease, (the disruption cost curve moves up to the left while the resilience cost curve moves down) making such attacks less worth the investment of enemy resources. Military microgrids connected to civil emergency service provider facilities can thus directly help the nation meet its most fundamental obligation – preserving citizen's security.

Implications for local government

From the government perspective, the experimentation enabled by developing microgrids to service military bases and local emergency services has two primary implications for broader development of microgrids as a component of smart grids: informing decision making and more efficient technology development.

<u>Informing decision making through pilot projects</u>

Creation of military base microgrids, tied into local emergency management systems, can serve as pilot projects to demonstrate not only the technologies but the return on investment various technological systems make, or fail to make, possible. Deploying microgrids to meet the high demands of military and emergency services customers who can justify the cost in terms of increasing security system resilience provides an opportunity to evaluate the costs and benefits to inform broader public decision making about microgrids as a component of the wider development of smart grid technology by providing insight into the cost effectiveness of microgrids. This will speak not only to the issues of microgrid use, but of the utility of larger investments in the infrastructure necessary to benefit more comprehensively from smart grid technology deployment.

<u>More efficient technology development</u>

The development of military microgrids, interoperable with emergency management systems, provide a way to discover requirements and test capabilities that will help meet energy security needs for a wide variety of customers. Cooperation between NATO and other standardization organizations worldwide will enable significant cost savings. Industry will be freed to develop technologies based not on the organizational affiliation (civilian or military) of the customer, but the required functions of the devices, thus obviating the need to develop separate product lines to meet military or civilian specifications. This is a natural extension of the shift in military procurement from designing to meet specific military requirements to delivery of commercial off the shelf (COTS) products that may or may not require additional modification to meet military needs.

Conclusion

Looking at energy security through the lenses provide by NATO’s Smart Defense initiative and the Comprehensive Approach offers ways to think about microgrids that add an additional energy security rationale to the case the case for broader microgrid creation and use. Microgrids can provide continuity of service for military forces as well as provide power to local community vital loads. By doing so they enhance not only military resilience but national and regional civil emergency management capabilities.

Developing the microgrid islanding capability on military bases does not require a huge expenditure of additional resources. Instead, it only requires an enhancement of existing base energy infrastructure plans and programs so that the system can operate as a microgrid. For example, changes to the base power distribution system to incorporate a renewable production capability (a solar array or combined heat and power system running in conjunction with a computer server farm) could at little additional cost be expanded to create the interfaces necessary to establish a microgrid. These would include the interconnections such that when the local city, in the future, renovates its own power grid emergency service connections can easily be made. Linking this sort of planning with initiatives like those included in the European Union’s Energy Security and Solidarity Action Plan has the potential to expose even more opportunities for mutually beneficial energy related interaction to increase energy security. NATO leadership in this area, in close cooperation with partners in accordance with Smart Defense and the Comprehensive Approach, will accelerate standard development and the concept development and experimentation necessary to deploy this capability. Aggregating the results of pilot projects and experiments from throughout the 28 NATO Member nations, using the NATO Lessons Learned process and existing concept development and experimentation networks offers added value to the nations, freeing them from the cost of engaging in such efforts to increase their energy resilience enhancing options alone.

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