Technologies for Deep Reductions in Military Operational Energy Use

R. Brown[*], S. Lanzisera[*], T. Sharp[**], M. Lindsey[***], and K. Andrews[****]

[*]Lawrence Berkeley National Laboratory, 1 Cyclotron Road, B90R1121, Berkeley, CA, USA, tropec@lbl.gov
[**]Oak Ridge National Laboratory, Oak Ridge, TN, USA, tropec@ornl.gov
[***]U.S. Pacific Command, Camp H.M. Smith, HI, USA, tropec@pacom.mil
[****]Marine Forces Pacific Experimentation Center, Camp H.M. Smith, HI, USA

ABSTRACT

To improve energy security, the U.S. military is pursuing a long-term plan to improve the energy efficiency of its operations. As part of this effort, the U.S. Pacific Command (PACOM) has begun a research program for Transformative Reductions in Operational Energy Consumption (TROPEC), which will identify, refine and validate technologies to reduce energy use in expeditionary military outposts, for energy end-uses such as heating, cooling, water heating, lighting, and electronics. The program includes a multi-stage process—the Innovations Network—to identify and screen candidate technologies for testing. Technology developers, especially startups and other small businesses, can submit energy efficiency technologies for consideration. Technologies that offer military utility and are technically sound will undergo testing and further development at a Department of Energy national laboratory, then operational testing by the Marine Forces Pacific Experimentation Center.

Keywords: energy efficiency, operational testing, tactical energy, military logistics

1 INTRODUCTION

The U.S. military has embarked on an ambitious long-term plan to improve energy security by transitioning its operations away from a dependence on petroleum [1]. Our wars in Iraq and Afghanistan have especially focused attention on operational energy. Three factors—vastly increased fuel demands, significantly increased costs in the procurement and delivery of fuel, and high casualty rates associated with the fuel delivery—have distorted the battlespace in a way that creates suboptimal force structures and allocation of funds.

To date, energy efforts have mostly focused on increasing the supply of renewable and alternative fuels, but a very large potential still exists to reduce military energy use through energy efficiency technologies. To address this technology gap, the U.S. Department of Defense (DoD) in January 2012 provided $18 million to six military programs to reduce the energy demand of future expeditionary outposts[1]. One of these programs—Transformative Reductions in Operational Energy Consumption (TROPEC)—is a joint DoD and Department of Energy (DOE) team, led by U.S. Pacific Command (PACOM, the warfighting command responsible for military operations in the entire Asia/Pacific region). Due to this regional focus, TROPEC will primarily address expeditionary outposts in tropical regions. The goal is to identify, refine and validate technologies for reducing energy use in outpost operations, which include many energy end-uses traditionally found in buildings, such as heating, cooling, water heating, lighting, and electronics. The overall goal of the TROPEC program is to demonstrate technologies that can reduce operational energy consumption at PACOM expeditionary basing by 25% within three years. Operational conditions found at an expeditionary outpost are shown in Figure 1. Essentially all power is provided by diesel-fueled generators, with power costing $1.50/kWh or more (factoring in the fully burdened cost of the fuel, including transportation and security).

Figure 1: Tactical Shelters Typically Used in Expeditionary Outposts

TROPEC employs a multi-stage process to identify and test energy efficiency technologies, as shown in Figure 2. Phase I—the Innovations Network—involves outreach to a wide range of technology providers and subsequent screening of the technologies submitted to ensure they address PACOM's military requirements and appear technically capable of reducing energy use. Promising technologies move into Phase II, which involves testing in a controlled environment at one of the DOE national laboratory team members — Oak Ridge National Laboratory (ORNL) or Lawrence Berkeley National

[1] http://www.defense.gov/releases/release.aspx?releaseid=15035

Laboratory (LBNL). Candidates that successfully complete this testing move to Phase III, in which technologies will be deployed to any one of several exercises in the PACOM region. The US Marine Forces Pacific Experimentation Center (MEC) identifies the appropriate testing venue and conducts the field experiments on chosen technologies. Energy efficiency technologies and products that successfully complete this phase will be strong candidates for transition into a military acquisition program.

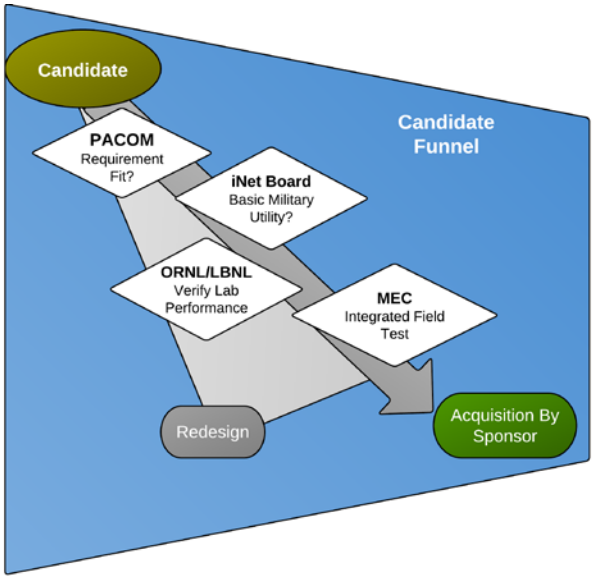

Figure 2: TROPEC technology selection process

2 INNOVATIONS NETWORK

The Innovations Network (I-NET) is both an outreach and screening process to identify energy efficiency technologies for testing in the TROPEC program. Outreach efforts include public engagement events (such as this cleantech conference), as well as a web portal for candidates to submit their technologies for review. A key goal of the I-NET is to identify technologies from startups and other small businesses that are traditionally not involved in DoD research programs, thus these communities are a prime target of the outreach activities. The following information is required from applicants to enter the TROPEC evaluation process:

- Description of the technology and identification of the end-use it addresses (Table 1 identifies the end-uses of interest to the TROPEC program and some example energy efficiency approaches that are applicable to expeditionary outposts)[2],
- Technology Readiness Level (TRL) of the technology (TRL 5 or above is desired for the TROPEC program),
- Description of energy performance testing that has been conducted on the technology,
- Whether the technology is available in a commercial or military product,
- Estimate of the energy savings in an expeditionary environment,
- Estimate of the cost and payback of the technology in an expeditionary setting,
- Any ancillary benefits the technology provides, such as reduced water use, improved reliability, or weight reductions.

Once submitted, the technology is reviewed by a joint team from PACOM, ORNL, LBNL, and MEC to determine if the technology meets PACOM's military needs and the applicant's claims of energy savings seem technically justified. Note that technologies do not need to meet military performance specifications ("MIL-Spec") in order to be considered, but must be capable of eventually meeting these specifications in future phases of development. The review team may interact with the applicant during this stage to request clarifying information. This review stage is simply a "paper review;" no hardware samples or hands-on testing are needed. Technologies that look promising in this review will be selected for laboratory testing.

3 LABORATORY TESTING

To verify energy performance claims, promising technologies are tested under controlled conditions at ORNL or LBNL. In most cases, ORNL is the lead for testing heating, cooling, and shelter technologies, while LBNL handles lighting and electronics technologies. The applicant is expected to provide samples for testing[3], as well as technical support to the national lab staff for training in proper configuration and operation of their technology. In return, the applicant receives feedback on testing results and suggestions for design changes to improve energy performance or military utility. In certain cases, ORNL and LBNL may dedicate TROPEC resources for laboratory staff to further develop the technology to improve its suitability for expeditionary outposts. These arrangements are negotiated on a case-by-case basis. Technologies that complete the laboratory testing process successfully will be selected for operational testing.

4 OPERATIONAL TESTING

Several times each year, PACOM conducts operational exercises with its military allies in the Asia/Pacific region.

[2] Note that the TROPEC program only addresses the efficient use and management of energy in expeditionary outposts. No energy supply or storage technologies will be considered.

[3] In some cases the TROPEC program may purchase items for testing, but will not fund the applicant's costs for technology research and development.

These exercices generally involve real soldiers and Marines conducting military operations and living in the type of expeditionary outposts that are the subject of the TROPEC program. One objective of these exercises is to test the effectiveness of new technologies, thus they offer a realistic setting for testing TROPEC's energy efficiency technologies.

The goal of this operational testing is to assess a technology's energy performance in a realistic tropical environment. Secondarily, the team tries to form some preliminary conclusions about the technology's suitability for military applications (including improvements that would be needed to meet durability and other requirements). Operational testing is led by the MEC, assisted by National Lab staff. Technology applicants are again expected to provide units for testing and some level of remote technical support, but are generally not expected to attend the exercise. In return, the applicant again receives feedback and suggestions for design improvements. A key goal of TROPEC is to transition into military acquisition programs all technologies that demonstrate significant potential to reduce energy use in expeditionary settings. These applicants will receive assistance from the TROPEC team in this transition process.

5 CONCLUSION

The DoD and DOE are carrying out the TROPEC research program to identify and test technologies that can significantly reduce energy use in expeditionary outposts. A key goal of the program is to identify technologies from startups and other small businesses that are traditionally not involved in DoD research programs. For this reason, the TROPEC program represents a unique opportunity for the cleantech community to have its technologies and products tested in an operational environment and considered for further development or acquisition by the armed services.

REFERENCES

[1] Assistant Secretary of Defense for Operational Energy, Plans & Programs, "Operational Energy Strategy: Energy for the Warfighter." U.S. Department of Defense, May 2011. <energy.defense.gov>.

Table 1: Example Technologies for TROPEC Testing

Energy End-Use	Technologies and Best Practices
HVAC – Heating and Cooling	• Ground-water and ground-source heat pump • Thermal energy storage and phase-change material • High-efficiency space conditioning units • Variable-refrigerant-flow systems • Condensing boilers and water heaters • Energy recovery ventilation
Shelters and Structures	• Advanced insulation for tent liners: Vacuum panels, Gas-filled panels, Aerogel, Flexible foam, Radiant barrier
Lighting	• Efficient Lighting sources: Light-emitting diodes (LEDs), organic light-emitting diodes (OLED) or polymer light-emitting diodes (PLED) • Efficient light fixtures • Lighting controls
Electronics	• Energy efficient and lightweight batteries • Energy efficient power electronics and battery chargers • Power management of electronic equipment
Data Center Power Management	• Cooling plant optimization, variable-speed pumping and chillers • Air economizers and better air management • DC power distribution • Energy efficient and high-operating temperature servers • Virtualization and improved software management
Other (Kitchens, Laundries, Showers, Latrines, grids, etc.)	• Waste heat utilization • Enhanced-efficiency modern burner units • High-efficiency appliances and refrigeration systems • Water harvesting from refrigeration cycle • Integrated heat pump water heaters (simultaneous cooling and hot water)