Demonstrating Energy, Waste, and Wastewater Technologies to Reduce the Footprint of Contingency Bases




The NDCEE is supporting the Department of Defense (DoD) in its efforts to reduce the environmental, logistical, and personnel burden of Outside of the Continental United States (OCONUS) contingency bases by demonstrating and validating technologies to address energy, solid waste, and wastewater issues.

Problem Statement

OCONUS contingency bases are highly dependent on outside resources and generate large amounts of waste.

- **Reducing energy usage:** Base services and operational support, especially at contingency bases, require outside power and energy resources. Fuel for vehicles and equipment must be shipped or air dropped in at high security and operational risk and at a high cost. This threatens operational effectiveness and endurance.
- **Managing waste:** Solid, nonhazardous waste generated at contingency bases is either buried, burned in open pits, or incinerated, creating environmental, health and safety risks, and adding to the management burden of the base.
- **Managing wastewater:** Improperly managed wastewater poses health risks to soldiers and the surrounding communities, as pollutants can be released to surface and ground water.

Approach

Reducing the logistical and environmental burden of OCONUS contingency bases requires a holistic, system-based perspective that involves all aspects of doctrine, organization, training, materiel, leadership, personnel, and facilities. The NDCEE is addressing this need to reduce the contingency base footprint within the domain of its competence – technology transfer in environment and energy – through a System of Systems (SOS) framework.

The SOS framework recognizes that solutions pursued in one component of the system will have an impact on the other components and that this collection of impacts must be weighed against the benefits. For instance, proposed solutions to improving wastewater or solid waste management at contingency bases may impact the energy requirements for the bases and therefore increase the overall logistics burden. A holistic perspective is needed to recognize the interdependencies of each aspect of contingency base construction, operation, and closure as a complex system that changes over time. The proposed solutions must consider the impacts to the other functions of the base. Furthermore, mobility, scalability, and durability are other important considerations for any contingency-based solution.

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Technology Demonstrations: Renewable Energy Sources

Validating the applicability of PV arrays to reduce electricity costs at remote locations, particularly locations with adequate daily periods of sunshine, may allow the technology to be used to reduce the environmental footprint of contingency bases.

The WTE technology includes a gasifier, gas engine, and generator that are synchronized and governed by a digital controller.

A small-scale WTE system powers lights using wood chips and refuse-derived fuel, representative of solid waste generated in theater.

PV arrays are mounted on the conex once it is deployed on site.

A wide range of renewable energy technologies are available as commercial-off-the-shelf (COTS) solutions, but these have not been validated for use at OCONUS contingency bases. Many of these involve photovoltaic (PV) solar cell systems that convert the light of the sun directly into electricity. Others convert waste material into energy through gasification. Gasification transforms organic materials such as biomass or municipal solid waste (MSW) into a synthesis gas that can be burned directly in internal combustion engines. The NDCEE executed three demonstrations to examine the applicability of solar PV arrays and biomass gasification for renewable energy generation at contingency bases; two demonstrations focused on the individual technologies and the third demonstrated an integrated system of solar, a biomass gasifier, and energy storage. These demonstrations focused on reducing the energy footprint of OCONUS bases using a SOS perspective.

The NDCEE teamed with Pacific Command and the A/249th Engineering Battalion (EB) to demonstrate a PV System at Camp Katuu, Palau. The solar panels and system components for a grid-connected system were installed by soldiers from the Camp Katuu Civic Action Team and the A/249th EB in August 2011. The NDCEE monitored performance for a 6-month time period. Performance data indicated the system met or exceeded performance expectations in energy production, cost savings, system reliability, and sustainability.

The NDCEE, in coordination with United States Army Central (ARCENT), evaluated the ability of a small-scale, mobile Waste-to-Energy (WTE) technology to generate electrical power and process mixed waste steams typical of a contingency base. The 20 kilowatt (kW) gasification system that was demonstrated is designed to use shredded biomass, so it was necessary to test its ability to handle other waste streams. The demonstration also documented the labor time and skills required to successfully mobilize, demobilize, and operate a small-scale WTE system and identified capability and robustness issues that must be addressed to meet military requirements. The system was transferred to United States Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory in July 2012 for additional testing.

Leveraging a unique biomass source – coconut shells – the NDCEE designed, constructed, and demonstrated an expeditionary Renewable Energy Suite in coordination with the Headquarters United States Southern Command (USSOUTHCOM) and the Cooperative Security Location (CSL) Comalapa, El Salvador. This system was designed to fit in a 20 foot ISO container and operate independent of the national or local power infrastructure. It integrates a biomass gasifier (designed and developed by the State University of New York), generator set, photovoltaic panels, and lithium iron magnesium phosphate batteries. The biomass gasifier supplies syngas to a conventional diesel generator using readily available biomass. PV panels capable of generating 22.4 kilowatt hours (kWh) per day of electricity were designed for easy mounting onto the shipping container and are stored inside the container for secure transport. Preliminary testing of the system indicated it was capable of providing 80 kWh of electricity per day, meeting demand of the CSL host site facility.

- **Environmental, Safety, Occupational Health, and Energy (ESOHE) and Cost Benefits:** Renewable Energy systems can reduce electricity use, costs and associated logistics burden, increase energy security, reduce greenhouse gases, and improve living environments. PV systems often have low labor and maintenance requirements (location-dependent).
- **Technology Limitations:** Power production from renewable systems is very dependent upon the geographic location and readily-available energy sources. Solar panels can take up significant land areas if there are not buildings that can support the panels. Mobility is also a concern, as many renewable systems are long-term infrastructure investments. WTE systems and gasifiers have additional material handling and maintenance requirements.

Technology Demonstrations: Solid Waste Management

Waste management technologies are needed that reduce the volume of solid waste at contingency bases safely, efficiently, and effectively. In-vessel composting systems and mobile two-stage burn incinerators are COTS solutions to enhance solid waste reduction, but these have not been validated for use at contingency bases. Composting itself is a natural process where micro-organisms, macro-organisms like worms and beetles, and fungi aerobically decompose organic solids. Composting with aerated static piles requires a large physical footprint and long periods of time, so in-vessel and containerized composting technologies have been developed to enhance the natural processes and lower maintenance requirements. Incinerators are designed to promote combustion by operating at higher temperatures with a constant supply of oxygen. Although large-scale incinerators are in use at contingency bases, small-scale, mobile incinerators have yet to be validated. The NDCEE executed three demonstrations to examine the applicability of in-vessel composting technology and mobile, small-scale two-stage incinerators for reducing non-hazardous solid waste at contingency bases.

The NDCEE, in coordination with ARCENT and Joint Base Meyer-Henderson Hall (JBM-HH), demonstrated an in-vessel composting technology. The 3rd U.S. Infantry (The Old Guard), the Army's official ceremonial unit and security force in the Washington metropolitan area, is based at JBM-HH. As part of their sustainability efforts, JBM-HH developed a proposal to compost manure and food waste and reduce the amount of manure sent to landfills. The overlap between desired in-vessel technologies for rapid composting at JBM-HH and contingency bases provided a unique opportunity for demonstration and validation. Two essentially different mixes were tested; one mix that included horse manure generated by JBM-HH and another mix based on solid waste characterization data from theater that excluded horse manure. Based on a cost analysis, composting manure will significantly reduce JBM-HH's landfill disposal costs since collecting and landfilling the manure and stable waste costs approximately $120,000 per year. The composting technology was transitioned to JBM-HH at the end of the demonstration.

Working with the Naval Facilities Engineering Support Center, the NDCEE evaluated in-vessel composting technology for potential use at Camp Lemonnier, Djibouti, Horn of Africa. Camp Lemonnier faces challenges with effective operation of its existing solid waste incinerators due to the high quantity of food in the camp's waste stream. The NDCEE identified alternative waste management practices including waste sorting to remove organic materials and pre-processing prior to composting. Recommendations for consideration were also prepared for the camp's leadership.

The NDCEE demonstrated two small-scale, mobile incinerators in coordination with ARCENT, Product Manager, Force Sustainment Systems, Army Public Health Command, and Army Operational Test Command. The demonstration collected the necessary information to determine if incinerators are a safe and viable option for handling waste at forward contingency bases. The primary objectives of the demonstration were to: 1) validate vendor's claims for solid waste incineration capacity; 2) evaluate operational requirements and functionality of the incinerators; 3) identify, monitor, and document the potential for adverse human health impacts during mobilization, operation, and demobilization; and 4) quantify the impacts to the environment by analyzing the concentrations of emissions released from the stack. The demonstration was conducted using MSW collected and sorted to resemble the characteristics of waste typical to contingency bases.

- **ESOHE and Cost Benefits:** In-vessel composting allows closer process control and faster composting and therefore may be a viable complement to incineration by removing organic materials from the waste stream. Incineration reduces soldier exposure to emissions from open pit burning, and increased combustion efficiency may reduce fuel costs for waste disposal. Combining incineration with composting may provide an overall solid waste management approach with a significantly lower energy and land area footprint.

The in-vessel composting system was demonstrated at JBM-HH.

A biofilter distributes composter discharge air into a manifold and up through pine bark nuggets.

Burn boxes are used to incinerate trash in theater.

NDCEE evaluated physical hazards and ergonomic issues associated with operating the incinerators.

Ash generated from the trial burns was sampled and analyzed for toxicity.

The NDCEE will collect performance data during the demonstration.

The AX-Mobile system features textile sheets in a packed bed media filter.

The wastewater treatment system is containerized for easy transport.

- **Technology Limitations:** Composting and incineration will require more operator training than open burning. Both technologies will require regular maintenance. Effective waste sorting and pre-processing equipment will also be needed.

Technology Demonstrations: Wastewater Treatment

Multiple wastewater treatment package plants are available as COTS technologies for rapid mobilization and treatment of wastewater. These systems often have high energy and maintenance requirements, limiting their applicability to contingency bases. Mobile wastewater treatment plants use a variety of technology approaches to treatment, and demonstration and validation is needed to identify technologies that can effectively reduce wastewater contamination with the lowest energy footprint possible.

The NDCEE demonstrated a mobile wastewater treatment plant at Fort Leonard Wood, Missouri, in coordination with ARCENT and the Army Engineer School. The treatment technology is a multi-stage unit incorporated into two 20 foot ISO containers for convenient transportation. Solids settle in the primary tank and the secondary container is a multiple-pass, packed bed, textile media filter capable of treating wastewater to a level that exceeds secondary treatment standards. In addition, the secondary treatment unit includes a UV component for eliminating pathogens in the treated wastewater. The system includes wireless cellular telemetry which provides performance information and remote operation and notifies the user of alarms. During the demonstration, the unit was powered with a 5 kW military tactical quiet generator. The demonstration, conducted from February through May 2012, confirmed the technology could treat wastewater to acceptable standards. Proposed modifications would enable simpler and quicker commissioning and decommissioning, increase the ease of operation, provide additional protection of electrical components, and prevent overflows and spills.

- **ESOHE and Cost Benefits:** Wastewater treatment technologies reduce pollution of surface and groundwater and may allow water reuse for non-potable purposes such as dust suppression or vehicle washing. Plants may be quickly decommissioned and located to another contingency base.
- **Technology Limitations:** Wastewater package plants have a high capital cost and are more applicable to smaller contingency bases. Lack of continuity of personnel at contingency bases becomes a challenge for operation of the systems based on the differing levels of expertise with each staff rotation.

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