US Army ERDC Energy Program Overview

ERDC
Engineer Research and Development Center

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US Army Corps of Engineers
BUILDING STRONG®

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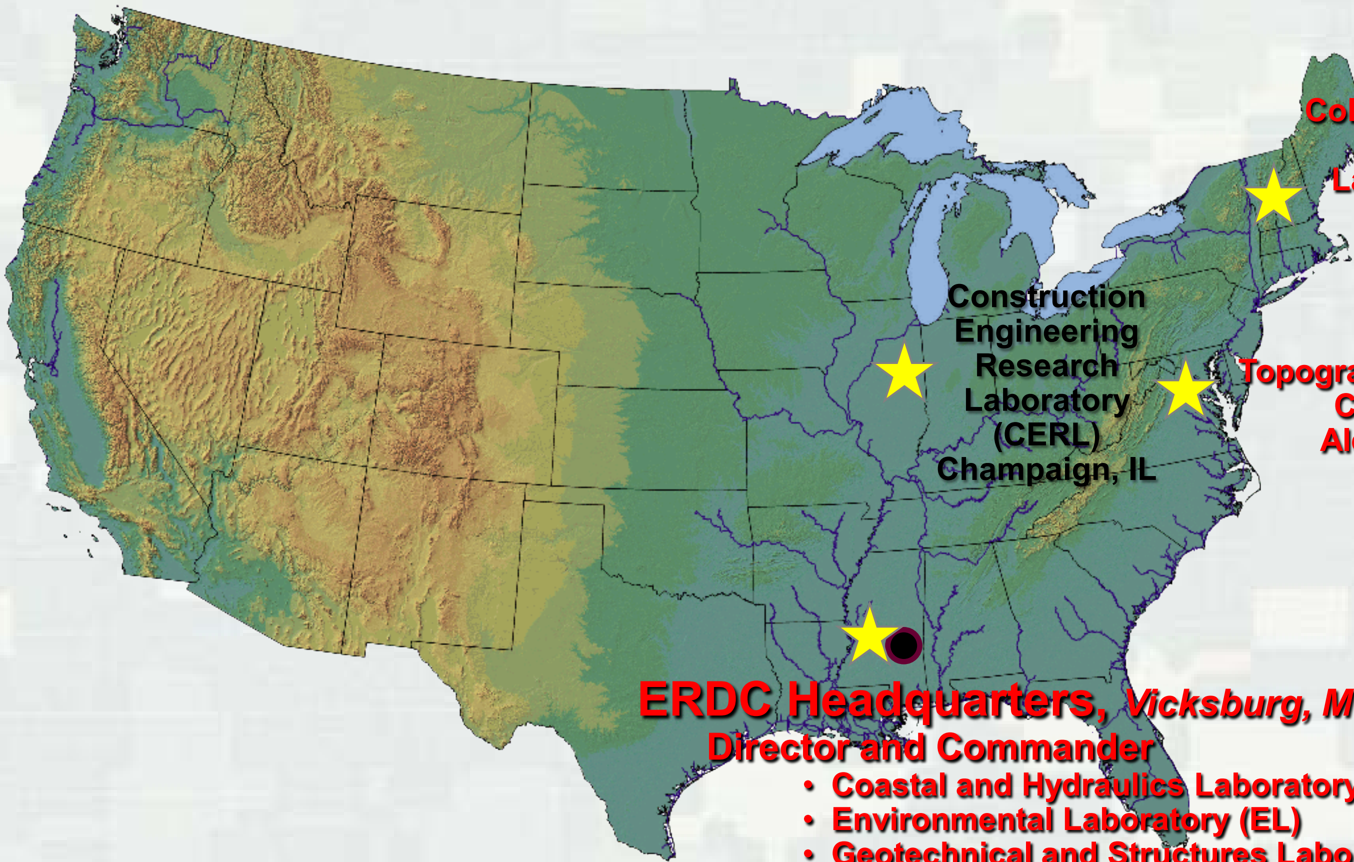
ERDC Energy Program - Outline

- Background / Drivers
- Towards Net Zero Installations – Energy
- Applied Research (6.2) Projects
- Demonstration Projects and Tech Transfer
- Operational Environment Support
- Conclusions

Engineer Research and Development Center (ERDC)

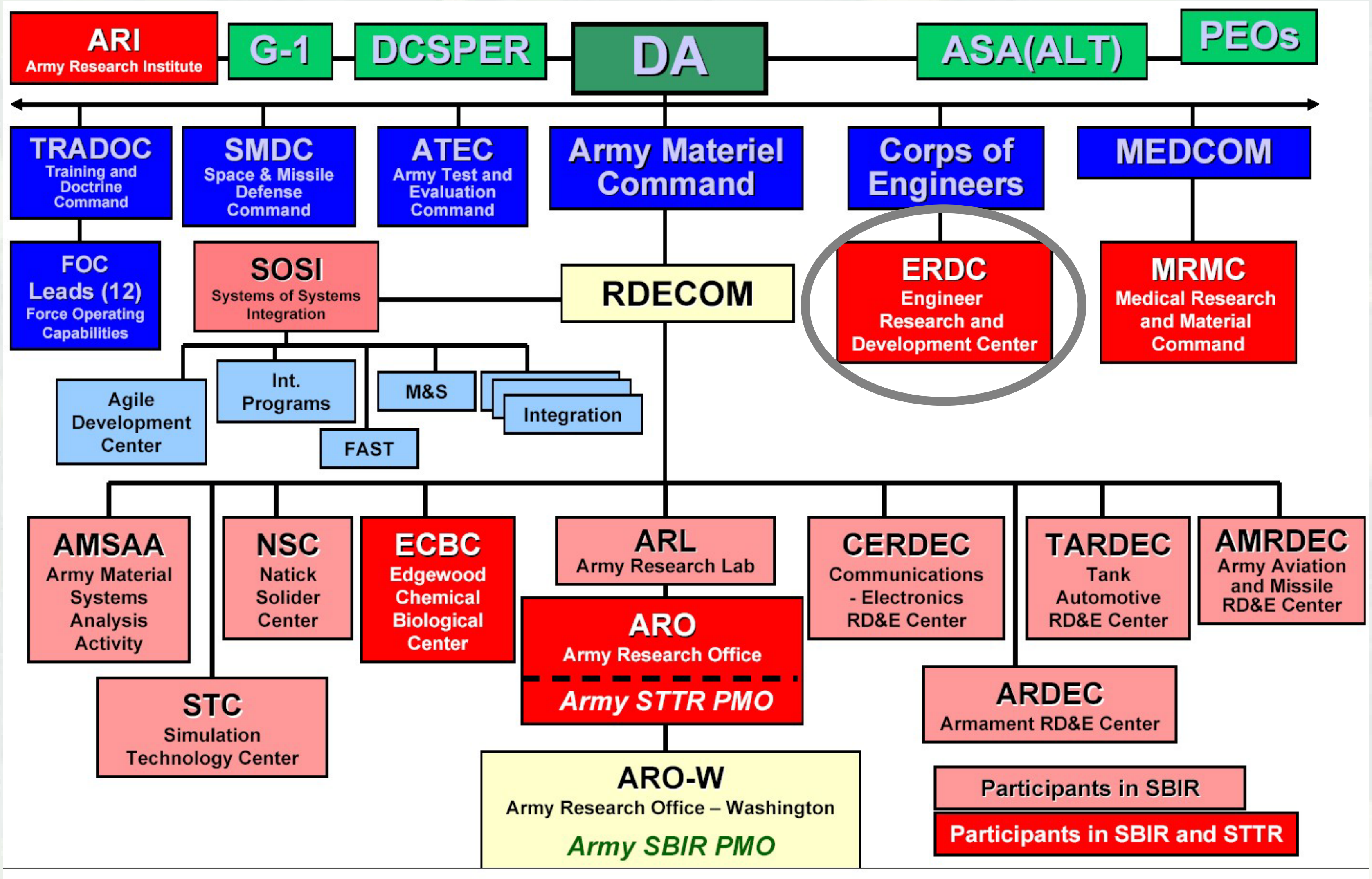


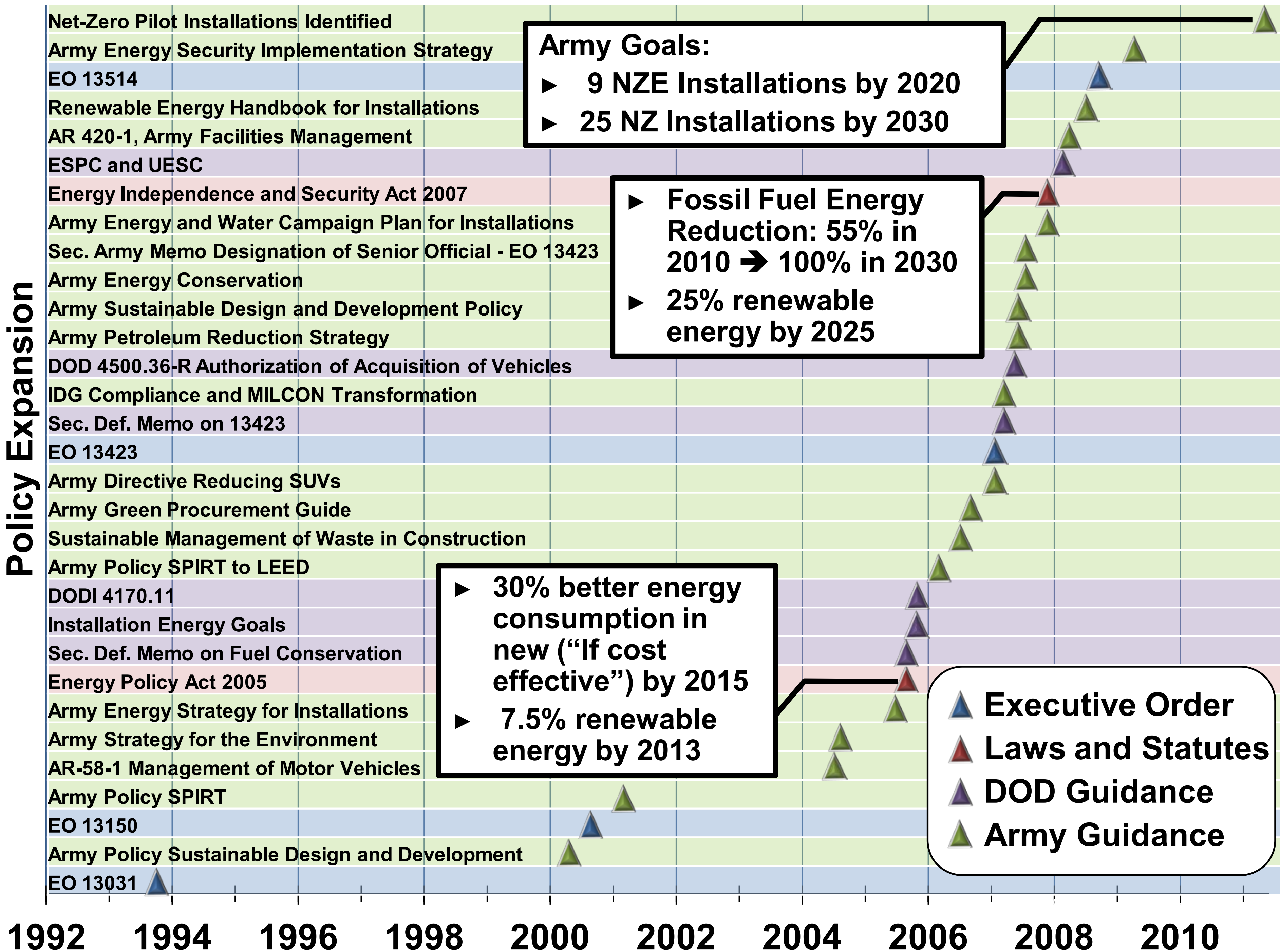
ERDC Headquarters, ***Vicksburg, MS***

Director and Commander

- **Coastal and Hydraulics Laboratory (CHL)**
- **Environmental Laboratory (EL)**
- **Geotechnical and Structures Laboratory (GSL)**
- **Information Technology Laboratory (ITL)**

Army R&D Organizations




Policy Expansion
Net-Zero Pilot Installations Identified
Army Energy Security Implementation Strategy
EO 13514
Renewable Energy Handbook for Installations
AR 420-1, Army Facilities Management
ESPC and UESC
Energy Independence and Security Act 2007
Army Energy and Water Campaign Plan for Installations
Sec. Army Memo Designation of Senior Official - EO 13423
Army Energy Conservation
Army Sustainable Design and Development Policy
Army Petroleum Reduction Strategy
DOD 4500.36-R Authorization of Acquisition of Vehicles
IDG Compliance and MILCON Transformation
Sec. Def. Memo on 13423
EO 13423
Army Directive Reducing SUVs
Army Green Procurement Guide
Sustainable Management of Waste in Construction
Army Policy SPIRT to LEED
DODI 4170.11
Installation Energy Goals
Sec. Def. Memo on Fuel Conservation
Energy Policy Act 2005
Army Energy Strategy for Installations
Army Strategy for the Environment
AR-58-1 Management of Motor Vehicles
Army Policy SPIRT
EO 13150
Army Policy Sustainable Design and Development
EO 13031
Army Goals:
► 9 NZE Installations by 2020
► 25 NZ Installations by 2030
► Fossil Fuel Energy Reduction: 55% in 2010 ➔ 100% in 2030
► 25% renewable energy by 2025
► 30% better energy consumption in new ("If cost effective") by 2015
► 7.5% renewable energy by 2013
Executive Order
Laws and Statutes
DOD Guidance
Army Guidance
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

Net Zero Hierarchy

- **A Net Zero ENERGY Installation** produces as much energy on site as it uses, over the course of a year.
- **A Net Zero WATER Installation** limits the consumption of freshwater resources and returns water back to the same watershed so not to deplete the groundwater and surface water resources of that region in quantity or quality.
- **A Net Zero WASTE Installation** reduces, reuses, and recovers waste streams, converting them to resource values with zero landfill.

A Net ZERO INSTALLATION applies an integrated approach to management of energy, water, and waste to capture and commercialize the resource value and/or enhance the ecological productivity of land, water, and air.

Net Zero Pilot Installations

18 sites announced - 19 April 2011

NET ZERO ENERGY PILOT SITES:
Fort Detrick, MD
Fort Hunter Liggett, CA
Kwajalein Atoll, Republic of the Marshall Islands
Parks Reserve Forces Training Area, CA
Sierra Army Depot, CA
West Point, NY

NET ZERO WATER PILOT SITES:
Aberdeen Proving Ground, MD
Camp Rilea, OR
Fort Buchanan, PR
Fort Riley, KS
Joint Base Lewis-McChord WA
Tobyhanna Army Depot, PA

NET ZERO WASTE PILOT SITES:
Fort Detrick, MD
Fort Hood, TX
Fort Hunter Liggett, CA
Fort Polk, LA
Joint Base Lewis-McChord WA
U.S. Army Garrison, Grafenwoehr, Germany

NET ZERO OVER-ALL PILOT SITES:
Fort Bliss, TX
Fort Carson, CO

STATE-WIDE ENERGY INITIATIVE:
Oregon Army National Guard

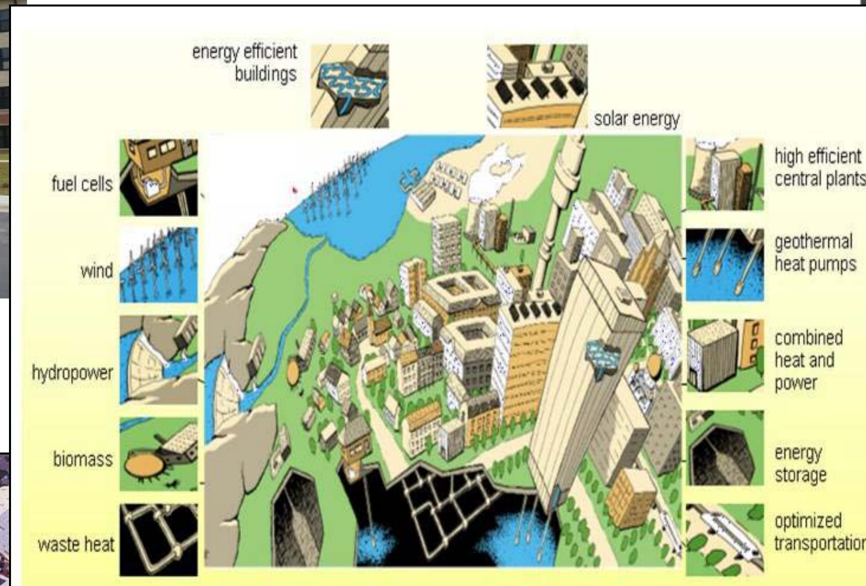
The Army is piloting six installations to be Net Zero Energy, six installations to be Net Zero Waste, six installations to be Net Zero Water, and two installations to be all three by 2020. The Army goal is to have 25 Net Zero Installations by 2030.

Net Zero Pilot Installations

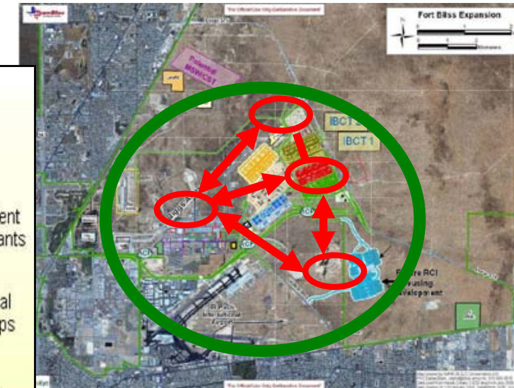
18 sites announced - 19 April 2011

ERDC Net Zero Installation Focus Areas

Energy Conservation (New & Existing Facilities)



Holistic Net Zero Installation

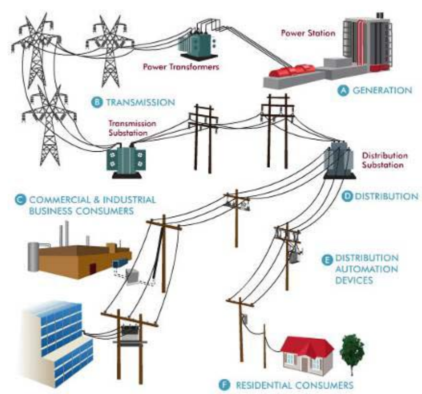


Modeling & Simulation

Renewable Power Production

Technology Demonstrations

Training / Workshops

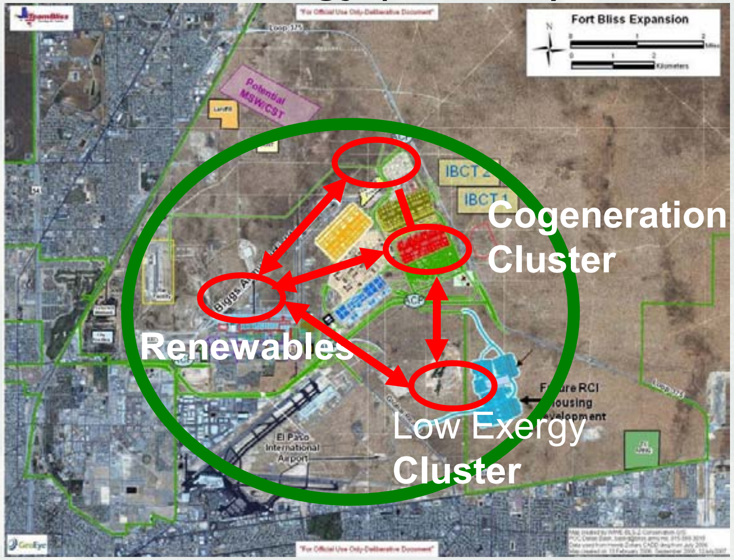


Power & Energy Architecture & Controls

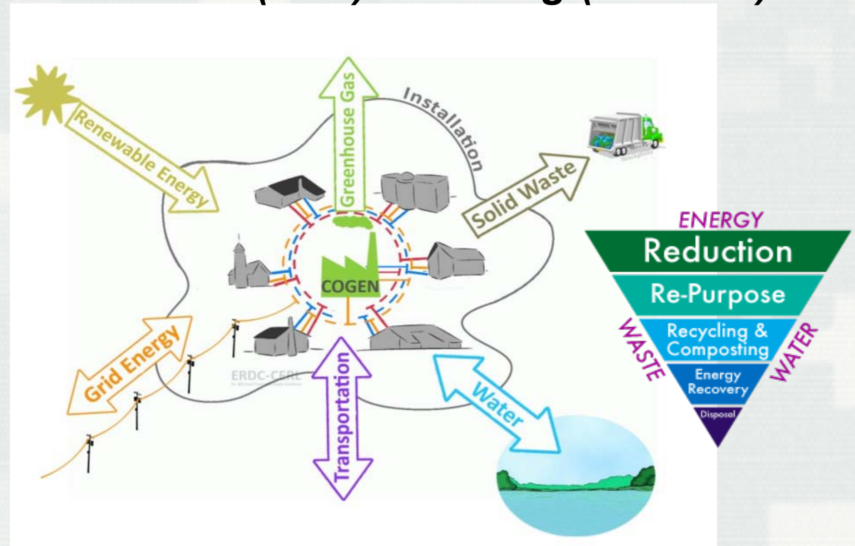
Commissioning / Operational Issues Humidity & Mold

ERDC Fixed Installation R&D Initiatives

Modeling Net Zero Installations – Energy (FY10-13)

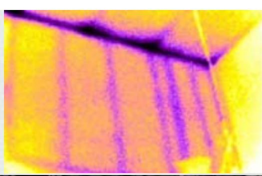


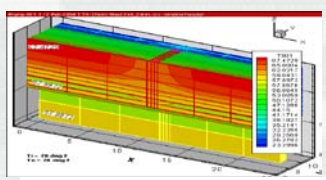
Integrated Installation Energy, Water and Waste (EW²) Modeling (FY12-15)



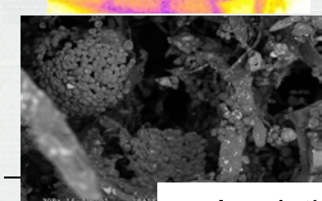
Modeling and Mitigation of Energy Losses in Building Envelopes (FY11-14)

Thermal bridges



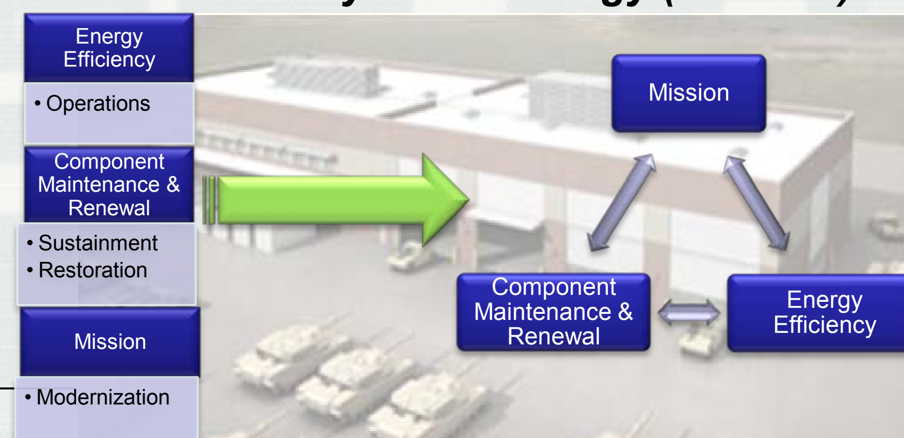


Heat transfer models



Insulating Nano-Materials & Aerogels

High Performance Building Operations – Decision Analysis for Energy (FY12-15)



Installation Technology Transition Program (ITTP)

MISSION: Demonstrate, validate and implement new technology to reduce SRM requirements for facilities, lower energy requirements and provide appropriate functionality within a facility; Evaluate existing technologies as potential Army Standards; and Move towards a more sustainable installation *The Installation Technology Transition Program (ITTP) is a sustaining, OMA funded, ACSIM centrally directed initiative to showcase and fast track the infusion of new technologies and innovative practices into routine Army installation operations*

Status: *Funding 17 work packages in FY11*

Funding 7 new and 4 continuing in FY12

FY12 Slated Projects

- High-throughput Energy diagnostic System for Building Envelopes
- Roofing Thermal Performance Analysis
- Demonstration of Rapid Assessment Analysis for Energy using Enhanced Benchmark Screening Techniques
- Integrating of Metal Roofing Inventory and Condition Assessment Procedures into Web-Based ROOFER and Application Shortfall Repairs
- Building-Scale Off-Grid Renewable Energy System
- Small Administration Facility Net Zero Energy Prototype
- Demonstration of Building Energy Storage, Heating, and Cooling with Renewable Near Solar Thermal Energy (CST) Input

Continued Projects from FY11:

- Using Frozen Soil Barriers to Prevent Contaminant Migration to Groundwater (Ph. II)
- Modular Wetlands
- Greenwall
- Integrated Water Planning through Building Level Cascade of Water Use

ERDC POC:

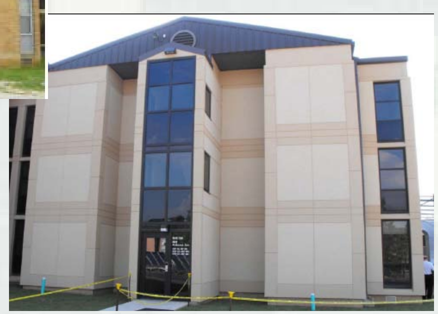
Debbie Lawrence, 217-373-7274

Example Installation Technology Transition Program (ITTP) Demonstrations

<u>Building Integrated Photovoltaic Roof (BIPV),</u> Ft Huachuca AZ

Integrate photovoltaic material with conventional membrane roofing system for a solar roof that provides both a long lasting, well-sealed flat roof and also generates electricity

Before



After

<u>VOLAR Barracks Renovation,</u> Ft Polk LA

Renovate barracks buildings to improve energy efficiency and prevent mold and moisture problems. Tightened building envelope by installing air and moisture barrier, enclosing exterior stairways, and installing non operable, insulated, low-e windows. Installed dedicated outdoor air system and energy recovery ventilator. 46% energy savings documented.

OSD Environmental Security Technology Certification Program (ESTCP), Energy & Water Focus

- FY11, $28.8M Program
- FY12, $30M Program
- Mr. Paul Volkman (DASA E&S), Mr. Qaiser Toor (HQIMCOM), and Mr. Frank Holcomb (ERDC) Army Technical Reviewers
- ~$6M Total FY11 ERDC Selected Demonstration Projects (6 projects out of 23 total selected)
  - Water Conservation & Reuse Technologies
  - Barracks Radiant Cooling Technology
  - Phase Change Materials (PCM) Insulation
  - PCM Slurry as Heat Transfer Fluid
  - HVAC Constant to Variable Air Volume (VAV) Conversion
  - Dining Hall Exhaust Hood Retrofit
- ~$3M Total FY12 ERDC Selected Demonstration Projects (2 out of 52 total selected)
  - Demonstrate Energy Component of the Installation Master Plan using Net Zero Installation Virtual Testbed Tool
  - Kinetic Super-Resolution Long-Wave Infrared (LWIR) Thermography Diagnostic for Building Envelopes

Army Leads U.S. in 1st Building Air Tightness Requirement

Required for new buildings since 2007 and major renovations in 2010

- Reduces energy ~ 5-45%
- Reduces moisture/mold
- 1st cost ~ $0.50/sqft
- Pay-back ~2-10 yrs

Joint collaboration among USACE, IMCOM and industry

US Army Corps of Engineers

ENGINEERING AND CONSTRUCTION BULLETIN

No. 2009-29 | Issuing Office: CECW-CE | Issued: 30 October 2009

Subject: Building Air Tightness Requirements

Applicability: Directive

1. **References:**

   a. ASTM E 2178 (2003) Standard Test Method for Air Permeance of Building Materials

   b. ASTM E 779 (2003) Standard Test Method for Determining Air Leakage Rate by Fan Pressurization

   c. ASTM E 1827 (1996; R 2007) Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door

   d. ISO 6781 (1983) Thermal Insulation - Qualitative Detection of Thermal Irregularities in Building Envelopes - Infrared Method First Edition

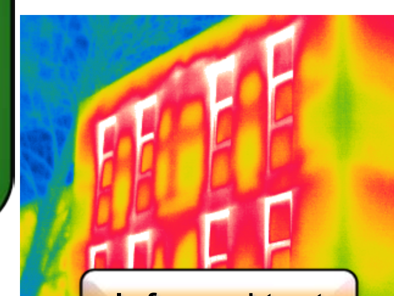
   e. ASTM C 1060 (1990; R 2003) Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings

   f. ASTM E 1186 (2003; R 2009) Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

   f. US Army Corps of Engineers Air Leakage Testing Protocol for Measuring Air Leakage in Buildings

Air barrier

Air leakage test (blower door)



Infra-red test

1st Major U.S. Building Owner to Require:

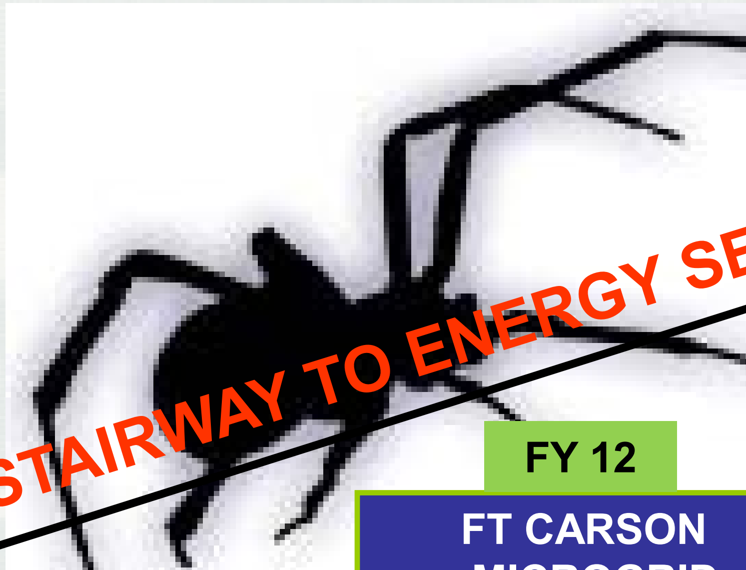
- ✓ Continuous air barrier for conditioned spaces
- ✓ Air leakage at <= 0.25CFM/sqft (envelope)
- ✓ Infra-red test for construction quality control

Currently, over 400 buildings have met or exceeded this requirement !!!

Energy Analysis Tools and Best Practices Guidance for IMCOM Garrisons

Development of Energy Conservation Measures (ECM, includes lighting) Spreadsheet
Energy Efficient Appliances and Management of Plug Loads for Army Facilities
An Evaluation of Energy Usage of Historic Properties
Best Practices for Installation Lighting During Hours of Darkness
UMCS/BAS Policy/Report
Facility Retro Commissioning and Training

Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) JCTD Implementation Plan



STAIRWAY TO ENERGY SECURE INSTALLATIONS

FY 11

HICKAM AFB CIRCUIT LEVEL DEMO

- Renewables
- Hydrogen Storage
- Hydrogen Fuel Cell
- Energy Management
- VSE SCADA Test at Idaho National Lab

FY 12

FT CARSON MICROGRID

- Large Scale Renewables
- Vehicle-to-Grid
- Smart Micro-Grid
- Critical Assets
- CONUS Homeland Defense Demo
- COOP Exercise

FY 13

CAMP SMITH ENERGY ISLAND

- Entire Installation Smart Micro-Grid
- Islanded Installation
- High Penetration of Renewables
- Demand-Side Management
- Redundant Backup Power
- Makana Pahili Hurricane Exercise

TRANSITION

- Template for DoD-wide implementation
- CONOPS
- TTPs
- Training Plans
- DoD Adds Specs to GSA Schedule
- Transition to Commercial Sector
- Transition Cyber-Security to Federal Sector and Utilities

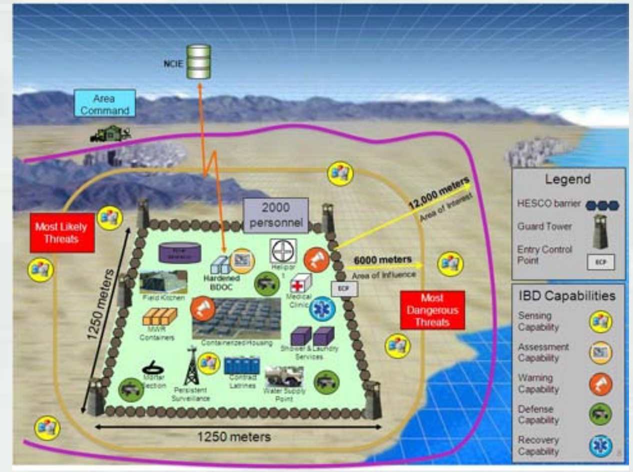
VIRTUAL SECURE ENCLAVE (VSE) CYBER-SECURITY

RIGOROUS ASSESSMENT WITH RED TEAMING IN EACH PHASE

Operational Environment Support

Renewable Energy Project - Afghan National Army (ANA) 22 Bunkers Complex (FY10-11)

Operational Energy Expeditionary Review (FY11)

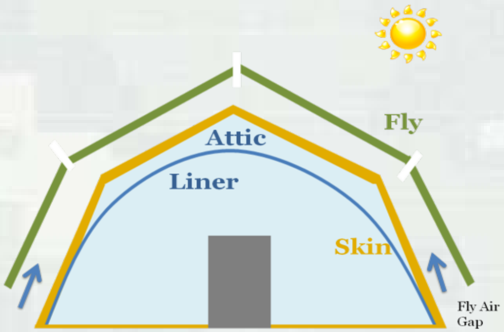


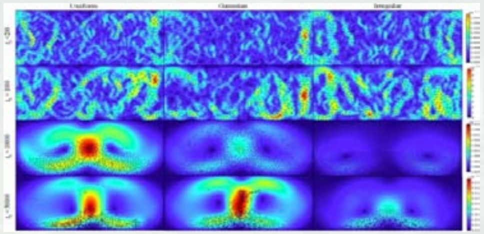
Design Concepts for Renewable Technologies at ANSU (FY10-11)

Contingency Basing Integration Technology Evaluation Center (CBITEC)

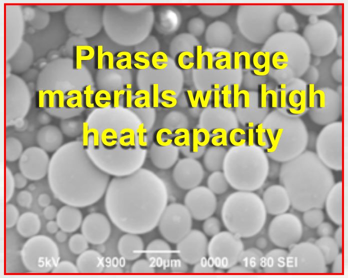
Advanced, Energy Efficient Shelter Systems for Contingency Basing and Other Applications- M&S and Advanced Insulation with Phase Change Materials

OECIF





Thermal and Fluid Computational Modeling of Shelters



Micro-encapsulated PCM in fabric

Insulating Aerogels

Purpose: *To develop and demonstrate technologies that mitigate energy loss in shelters by using validated thermal and fluid computational modeling and simulation (M&S) for optimized advanced insulation in combination with phase change materials (PCM)*

Results:

- *Develop and verify the thermal and fluid computational model of the shelter layers*
- *Fly, skin, and liners with improved thermal resistance based on M&S and optimized design of energy efficient shelters*
- *Performance models for phase change and insulation materials*
- *Demonstrate aerogel insulation integrated with PCM for rigid-wall shelters*
- *Demonstrate flexible fabric insulation integrated with PCM for soft-wall shelters*

Payoff:

Estimated 50% reduction in fuel consumption for field shelters used in Contingency Bases

Conclusions / Closing Thoughts

- **Holistic Approaches to Energy (and Water & Waste)**
- **Enterprise Level Solutions**
- **Modeling & Simulation for Planning and "Strategic" Implementation**
- **Technology Demonstrations / Validation**
- **Training and other Technology Transfer**

Back-up Slides

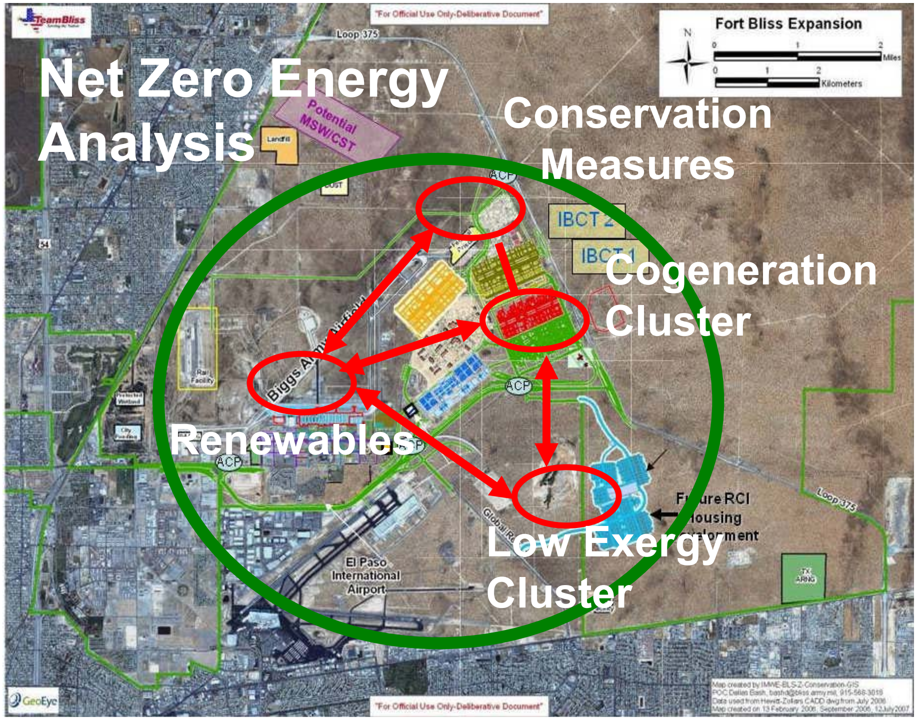
Research Problem

- Army Planners and their consultants do not have the concepts, analysis methodology, or tools to do the analysis necessary to meet Net Zero Energy goals in a <u>cost effective</u> way.

- No capability exists to integrate and resolve static, dynamic, and non-linear models of energy supply, demand, and storage over an installation scale for Army relevant facilities and climate zones.

- EISA 2007 study showed that Army cannot meet EISA goals without utilizing building “clusters.”

Modeling Net Zero Installations - Energy



Schedule and Cost

Milestones	FY10	FY11	FY12	FY13
Virtual Test Bed	3			5
Parametric facility models	3	5		
Energy clustering algorithms	3		5	
Computational framework for non-linear spatial, thermal, hydraulic, and electric power network simulation		4	5	
Total $4.3M Army				

Purpose:

Provide installation planners a capability for integrated energy analysis and optimization.

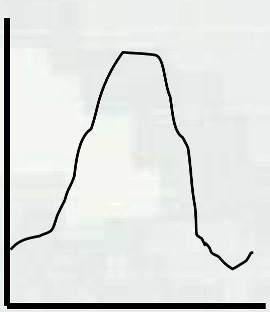
Results:

- ***A Virtual Test Bed for energy analysis that generates optimal, life-cycle effective system configurations***
- ***Parametric models of most effective energy measures for high demand Army facilities***
- ***Algorithms to identify high value clusters of facilities with complementary spatial, thermal, hydraulic, and electric power characteristics.***
- ***Computational framework for non-linear network simulation to predict performance and optimize integration of installation energy systems***

Payoff:

- ***Provide an enterprise solution for the Army***
- ***Installations meet net-zero energy requirement by 2030***
- ***Net savings in installation energy consumption of 1%/yr ($13M/yr)***
- ***Improved energy security and independence***

Building Cluster Analysis



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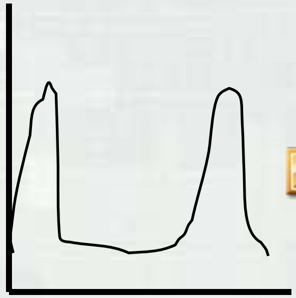

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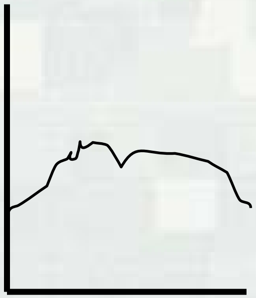

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Office Buildings

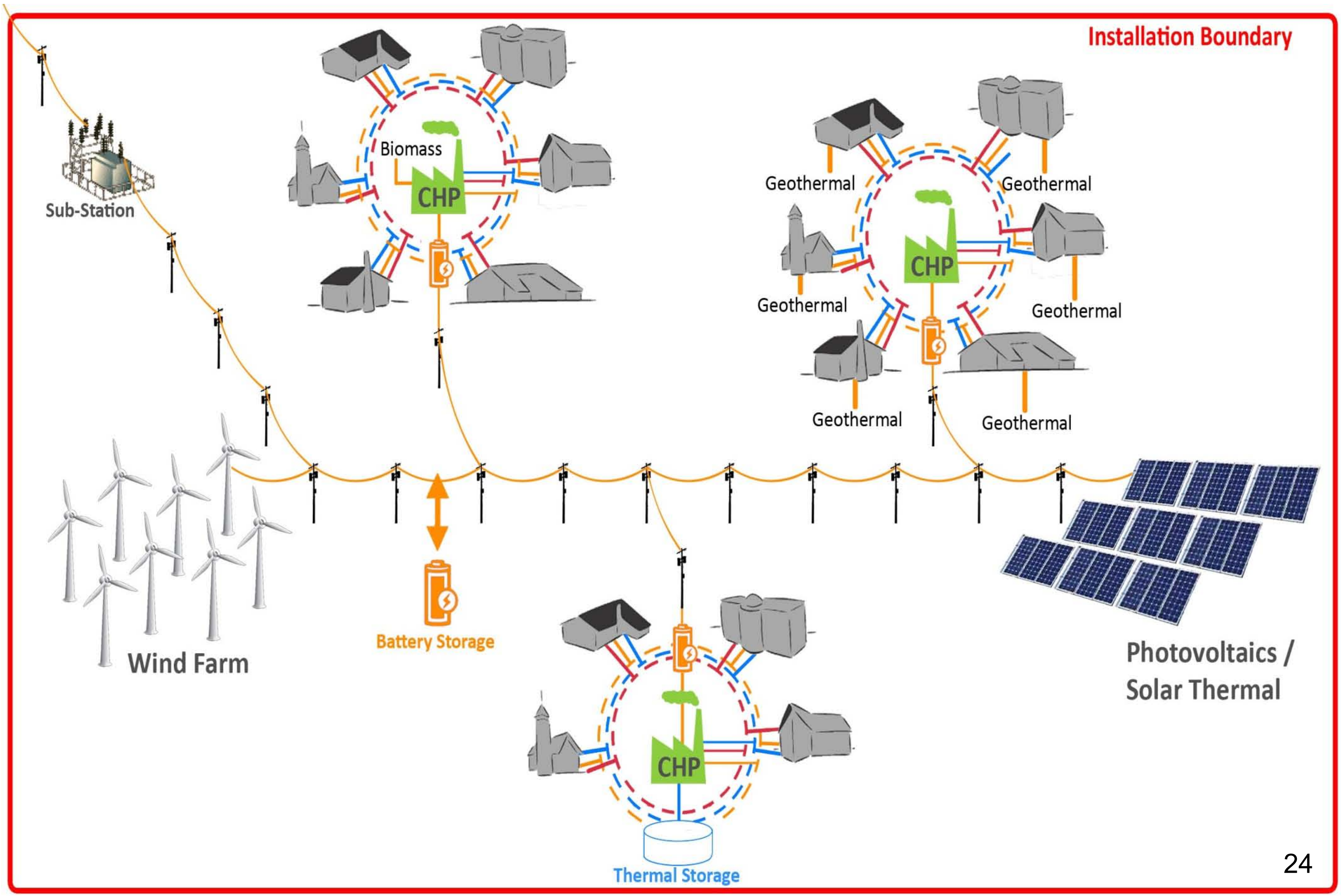
Barracks

Maintenance Facility

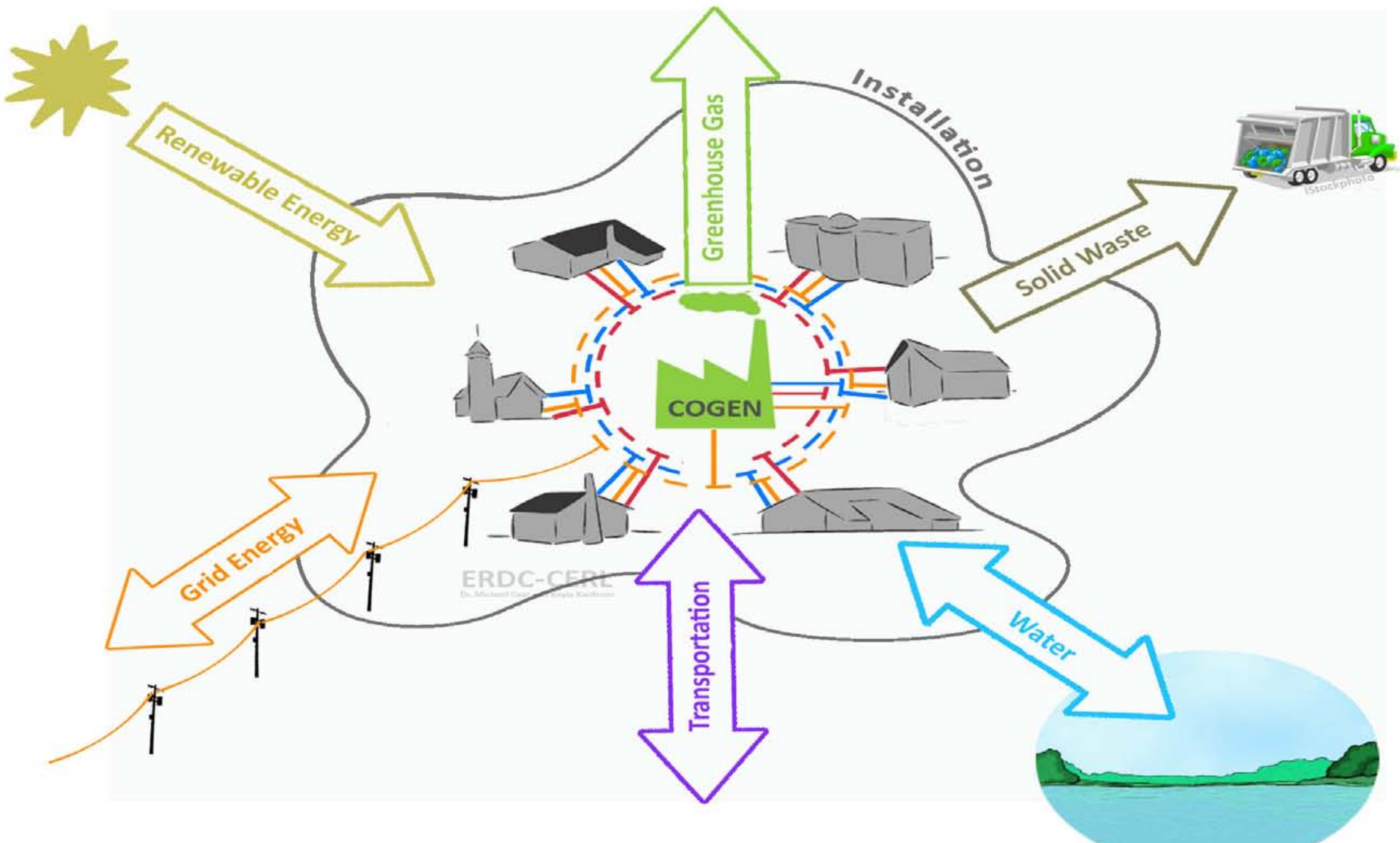
?

Other Facilities

Installation Cluster Analysis



FY12 – Energy, Water, and Waste Integrated Model - EW2

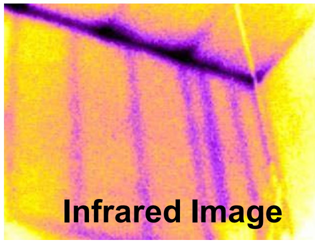


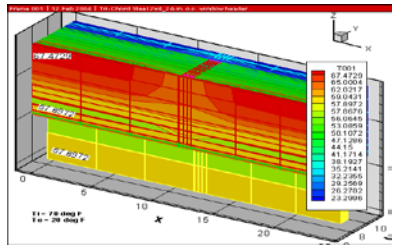
PE 0602784A

Military Engineering Technology

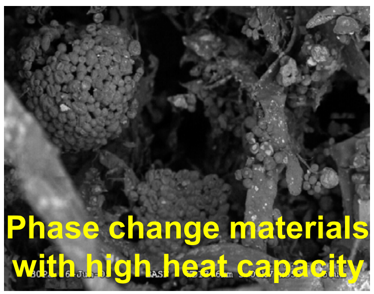
Modeling and Mitigation of Energy Losses in Building Envelopes

Thermal bridges (dark areas) caused by studs

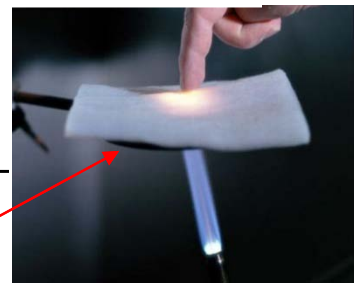




Heat transfer models



Insulating Nano-Materials & Aerogels



Milestones	FY11	FY12	FY13	FY14
Identify high energy losses in standard Army buildings	3 → 5			
Predict thermal performance and durability of phase change materials (PCM), aerogels, and nanomaterials	3 →	→	→ 5	
Develop3D Models and algorithms to characterize energy losses in building envelopes and develop dynamic models for PCM		3 →	→ 5	
Validate multidimensional models for energy-loss mitigation strategies and transition.				4 → 5
Total $6.4M Army				

Purpose:

Develop capability to characterize energy losses through building envelopes and potential mitigation strategies using advanced materials to meet mandated energy reduction goals

Results (6.2):

- *Models and algorithms to quantify energy losses in building envelopes*
- *Prediction of the long term thermal performance and durability of advanced materials for building envelope systems*
- *3D modeling of thermal bridges in building envelopes*
- *Dynamic heat transfer models for phase change materials*
- *Capability to model mitigation strategies to reduce energy losses in building envelopes*

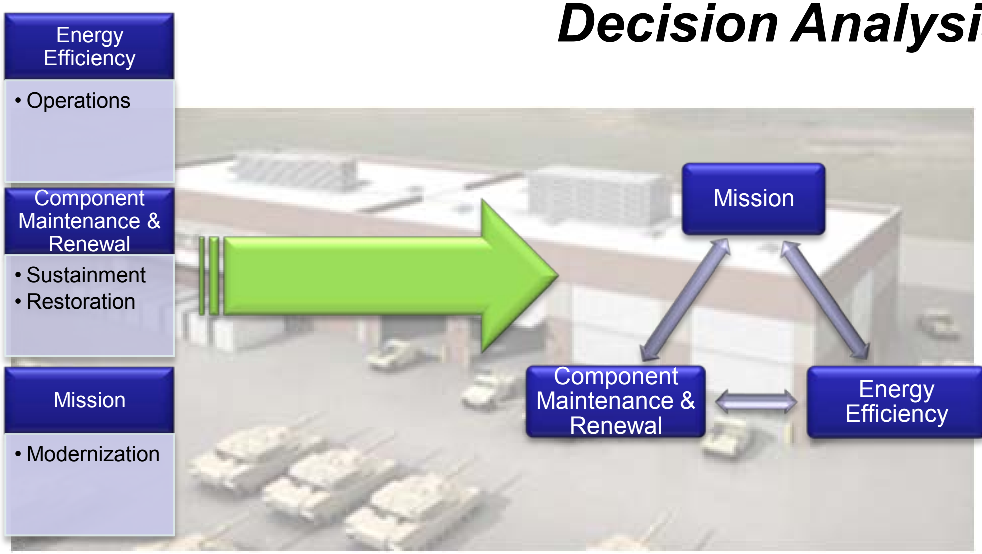
Payoff:

- *Energy Independence and Security Act of 2007 (EISA) compliance*
- *Net savings in heating/cooling energy intensity overall of 1.6 Trillion BTU annually or $26M/year*

ASTMIS WP #

Status: New

High Performance Building Operations – Decision Analysis for Energy



Traditional Requirements Stovepipes

Integrating Mission, Engineering and Sustainability Requirements for Maximum Efficiency

Purpose: Develop an intelligent framework that describes interrelationships and synergies among energy efficiency, component maintenance and renewal, and mission requirements for an integrated investment strategy that minimizes Total Cost of Ownership (TCO).

Results (6.2):

- Sustainment, Restoration and Modernization (SRM) decision models that maximize effectiveness of facility retrofits, specifically for energy performance.
- Information Fusion Model to identify energy costs attributable to improper occupancy behavior, operations and component degradation
- Performance benchmarking algorithms to identify facility energy use exceptions.

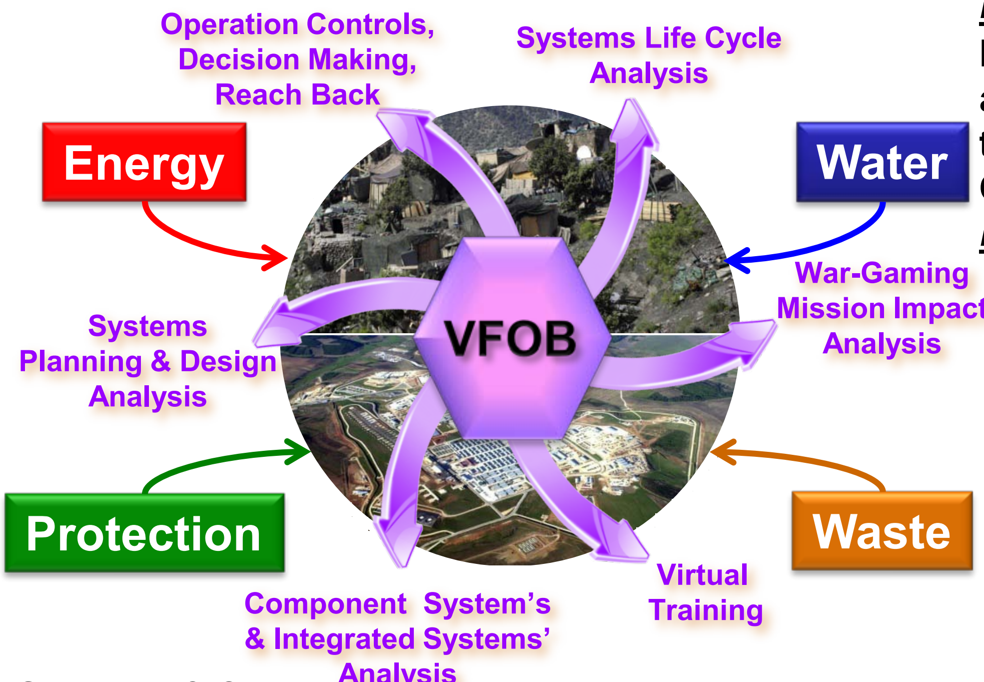
Payoff:

- Integrated approach to SRM decisions to minimize energy use and TCO.
- Reduced energy consumption by identifying facility operations that use excessive energy.
- Improved benchmarking & analysis of existing buildings to measure and achieve high energy efficiency.

Schedule and Cost

Milestones	FY12	FY13	FY14	FY15
Integrated SRM Decision Models	2			5
Facility Operations Information Fusion Model		2		4
Benchmarking algorithms for Army facility performance	3	5		
Total $M Army				

Virtual Forward Operating Base (VFOB)



Schedule & Cost

Milestones	FY11	FY12	FY13	FY14	FY15
Data & Systems Analysis	3	4	5		
Systems Algorithm development & validation	3	4	5		
Initial Integrated Complex Adaptive Systems		3		4	

Purpose:

Develop the complex adaptive system algorithms and their interrelationships necessary to represent the dynamic operating systems of a Forward Operating Base (FOB).

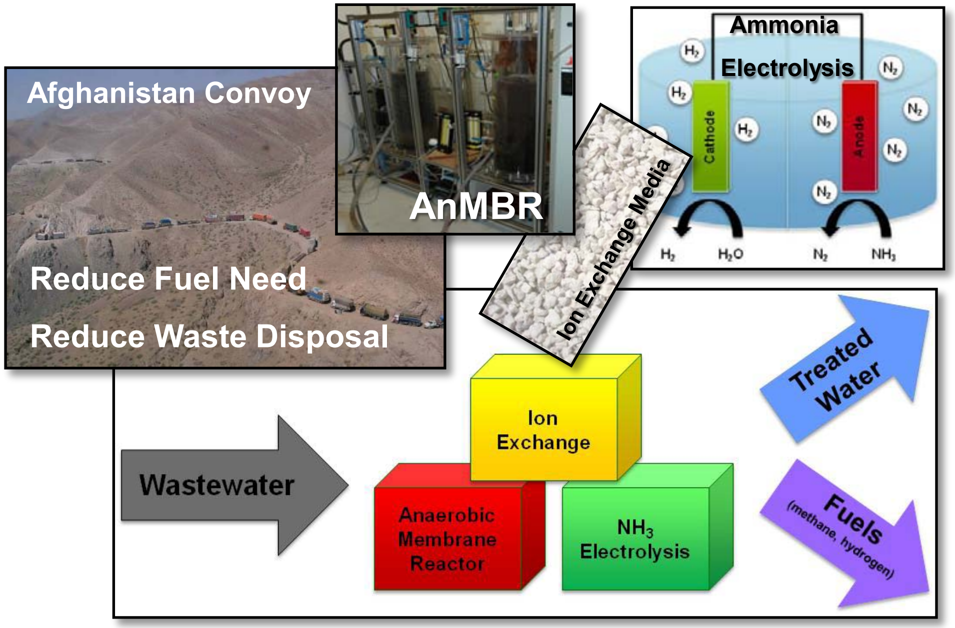
Results (6.2):

- **Data & systems analysis of the complex and unique energy, water, waste, and protection systems in FOBs.**
- **Algorithms and models that represent the complex adaptive systems for energy, water, waste, and protection in FOBs**
- **The algorithm(s) and or model that integrates the complex adaptive systems for use in a real time predicative and analytical manner.**

Payoff:

- **Reduces casualties (reduced resupply opns)**
- **Combat and force multiplication (less convoy escort required)**
- **Improved mission dynamics (Integration of FOB planning, opns, mgmt, construction)**
- **Improved OPSEC(reduced movement across fence line)**
- **Improves efficiency and effectiveness of operations (material, equipment, personnel, costs)**

Novel Anaerobic Wastewater Treatment System for Energy Generation at Forward Operating Bases (FOBs)



Purpose:

Develop a sustainable wastewater treatment system to convert wastewater contaminants into harvestable products for energy production by synergistically combining three embryonic technologies.

Results :

- **Development of an integrated wastewater system that reduces energy consumption at a FOB while producing fuels that can integrate into net-zero energy solutions**
- **Optimized AnMBR, ammonia sequestration via ion exchange, and ammonia electrolysis technologies for FOB applications**
- **Incorporation of system performance model into a utility within ASPEN*plus*, a process engineering optimization modeling software package**

Payoff:

- **Scalable, robust, and sustainable wastewater treatment system with decreased operational energy costs compared to aerobic treatment systems resulting in an estimated $145k/yr savings for a 500 person FOB**
- **Production of methane and hydrogen fuels that can be combined with microturbines or fuel cells for energy generation resulting in a net-energy positive system**
- **Reduced disposal volumes due to on-site treatment of wastewater with low sludge production**

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