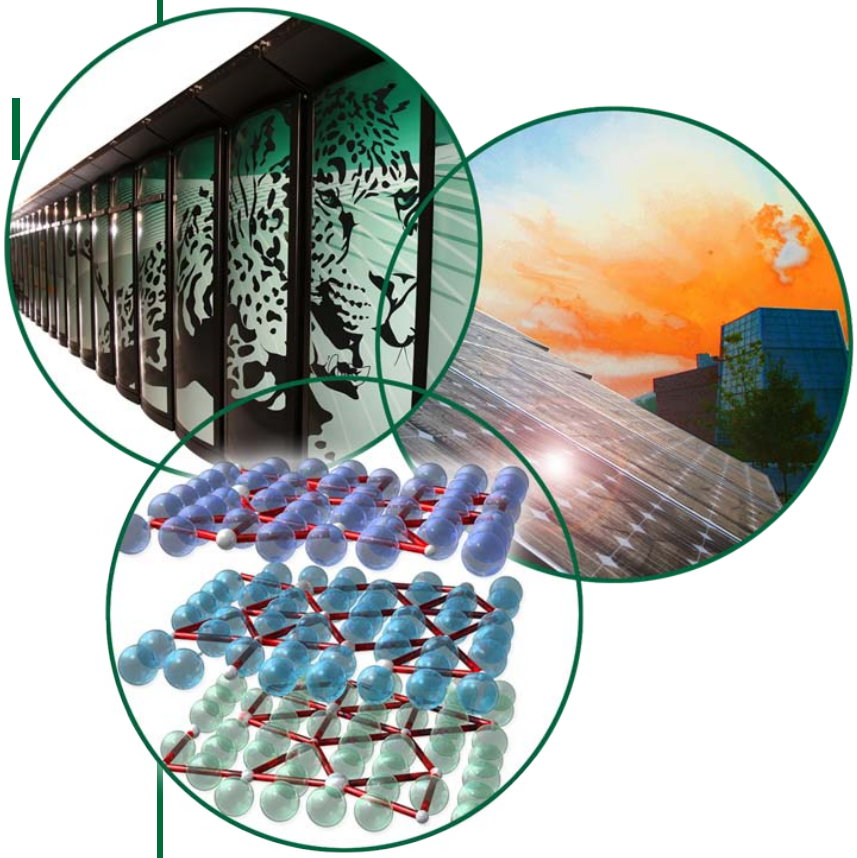
Lessons Learned:

Commercial/Industrial Building Retrofits for Energy Savings



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Exploratory investigation at Oak Ridge National Laboratory (ORNL) of a particular set of efforts to upgrade facilities, saving energy and water

- **ORNL's facilities**
- **Energy Savings Performance Contract (ESPC) mechanism, structure, and implementation**
- **Interim findings from interviews**

ORNL is DOE's largest science and energy laboratory

- $1.4B annual budget
- 4,600 employees
- 3,000 guest researchers annually
- 17,000 short-term visitors annually

- Nation's most diverse energy portfolio
- World's most powerful open scientific computing facility
- Operating the world's most intense pulsed neutron source

- 4.25 million ft^2 of facilities, on 4400 acres
- 34,000-acre Reservation
- Extensive utilities—centralized and distributed systems
- $350 million invested in modernization

ORNL's campus has experienced tremendous growth

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ORNL East Campus Today

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- 1 million ft^2 LEED-certified campus
- A first for DOE and Tennessee

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ORNL East Campus Today

But, old buildings and infrastructure remain

TEAM* Initiative: DOE's plan to transform dramatically its energy, environmental, & transportation management

Goals established for:

- Energy efficiency & water conservation
- Renewable energy generation & consumption
- Petroleum reduction & alternative fuel use
- New construction & major renovations
- Current buildings
- Environmental management
- Third party financing
- Data centers, electronics stewardship

* Transformational Energy Action Management

TEAM ESPCs are embedded in current* legislative and regulatory context

- **Exec. Order 13423,** Strengthening Federal Environmental, Energy, and Transportation Management, January 26, 2007
  - Reinforces the legislative goals for use of renewable energy and resources
- **Energy Policy Act of 2005 (EPACT 2005, P.L. 109–58)**
  - Sets goals for Federal government purchases of its electrical energy from renewable sources
- **Energy Independence and Security Act (EISA 2007, P.L. 110 140)**
  - New requirements for Fed. building; changes to process of setting up long-term ESPCs
- **DOE Order 430.2B,** Departmental Energy, Renewable Energy, and Transportation Management, February 2, 2008
  - Encourages maximum utilization of private sector, third-part financing (ESPCs; Utility Energy Services Contracts)
- **Exec. Order 13514,** Federal Leadership in Environmental, Energy, and Economic Performance, October 5, 2009
  - Requires Fed. agencies to set GHG emission reduction standards and take additional measures to meet energy, water, and waste reduction targets

***ESPCs have been used for a generation**

DOE signed an $88.1M TEAM ESPC for ORNL in Summer 2008

- **Partnership between an energy services company (ESCO) and its customer**
  - **DOE, not UT-Battelle, LLC (manages ORNL)**
- **Formed to finance and implement cost-saving energy and water-efficiency improvements**
- **ESCO finances and installs the new equipment at its expense**
  - **Customer repays ESCO over the life of the contract using the cost savings resulting from the project**

- **Project implementation cost** $88.1 M
- **Project savings** $8 million / yr
- **Simple payback** 11 yrs
- **Performance period** 18 yrs
- **Electrical Energy Savings** 12,358,000 kilowatt-hours / yr
- **Electrical Demand Savings** 17,000 kilowatts
- **Natural gas savings** 707,000 million BTUs / yr
- **Fuel oil savings** 19,000 million BTUs / yr
- **Water savings** 170 million gallons / yr
- **Construction phase:** 31 months
- **Project completion:** FY 2011

ESCO guarantees $8M in annual energy savings at ORNL, over 18-year DOE TEAM ESPC contract

Eight energy conservation measures included in the contract

1. biomass steam production
2. steam system decentralization of remote buildings
3. upgrade to building management systems
4. advanced electric metering and energy awareness training
5. mechanical equipment upgrades
6. energy-efficient lighting upgrade
7. domestic water conservation
8. elimination of once-through cooling for air compressor

Structure of TEAM ESPCs affects the energy conservation measures (ECMs) selected

- **ESCO must secure financing**
  - **What measures and risks will lender allow?**
- **ESCO is paid out of the measured/verified energy savings**
  - **Portfolio of ECMs selected to have high-probability of payback**
    - **Strategic to select high-investment, sure return measure (biomass steam plant)**
  - **Not necessarily the 'best' measures**

Exploratory study of TEAM ESPC at ORNL as a "natural experiment"

- **Interviews with facility and building operations managers and engineers — underway, so interim results**
  - **Linked to ESCO and building occupants**
- **Focus on behavior—installation, maintenance, use of and interaction with ECMs**
- **Behavioral insights about why designed savings ≠ achieved savings**
- **Insights useful to ORNL**
  - **TEAM ESPC part of much larger Sustainable Campus Initiative**
- **Insights potentially applicable to other institutional settings**

Interviews focused on subset of ECMs

1. Biomass steam production
2. Steam system decentralization of remote buildings
3. **Upgrade to building management systems**
   - **Metasys® building automation and control systems**
4. **Advanced electric metering and energy awareness training**
5. **Mechanical equipment upgrades**
   - **HVAC, air flow (e.g., in laboratories)**
6. **Energy-efficient lighting upgrade**
   - **Fixtures and bulbs, some sensors**
7. **Domestic water conservation**
   - **Aerators, toilet flush valves, reduce once-through cooling**
8. Elimination of once-through cooling for air compressor

INTERIM FINDING #1: Interviewees consistently thought ORNL would benefit from TEAM ESPC upgrades

- **ESPC mechanism allows much-needed upgrades when budgets otherwise would not allow them**
- **Generally, in favor of efforts to enhance energy and water efficiency**
  - **Expressed personally, and as something some of "their people" care about**

INTERIM FINDING #1: Interviewees consistently thought ORNL would benefit from TEAM ESPC upgrades

- **ESPC mechanism allows much-needed upgrades when budgets otherwise would not allow them**
- **Generally, in favor of efforts to enhance energy and water efficiency**
- **However, building managers have a full set of other responsibilities**
  - **Provide effective operations & services, *regardless* of the energy & water consumed**
  - **Primary focus is *not* on energy, water, or resource savings**
  - **Helping facilitate TEAM ESPC upgrades sometimes a distraction, time sink, extra burden**

OAK RIDGE National Laboratory

INTERIM FINDING #2: Building and facility managers' most consistent criticism is inadequate communication

- **Lack of top-down communication, consultation, explanation about TEAM ESPC—wariness (and resentment?)**
  - **Important "local knowledge" not tapped**
    - **Selection of ECMs to install in particular buildings, or parts of buildings**
    - **Previous modifications or work-arounds involving old equipment**
      - **Old equipment may not conform to original design/operation specifications**
    - **Needs associated with old equipment affected by new ECMs**
      - **Old, main supply ventilation fans do not function properly when steam control valves are set at energy-conserving low temperatures**

INTERIM FINDING #2: Building and facility managers' most consistent criticism is inadequate communication

- **Lack of top-down communication, consultation, explanation about TEAM ESPC—wariness (and resentment?)**
- **Contributes to lack of communication with building occupants**
  - **What measures; why the measures/disruptions?**
  - **Hear occupants' complaints; distance themselves from ESCO**

INTERIM FINDING #3: Hard to distinguish TEAM ESPC ECMs from other measures

- **Many upgrades and retrofits at ORNL over time and associated with Sustainable Campus Initiative**
  - **Other ESPCs**
  - **LEED building and net-zero energy retrofits**
  - **Energy management efforts—F&O purchase of energy-saving equipment that helps research staff**
    - **Computers and monitors; lab refrigerators; solar concentrator and arrays**
  - **Pollution prevention and waste reduction efforts**

INTERIM FINDING #3: Hard to distinguish TEAM ESPC ECMs from other measures

- **Many upgrades and retrofits at ORNL over time and associated with Sustainable Campus Initiative**
- **Often piecemeal, and previously not presented as part of a cohesive effort**
- **In general and in particular, TEAM ESPC ECMs may go unnoticed**

INTERIM FINDING #4: Details of longer-term operation and maintenance yet to be fully developed (or communicated)

- **ESCO clearly responsible for installation, early upkeep**
  - **Installation**
    - **ORNL responsible for providing access and lock-out, tag-out (safety)**
  - **Early 'fixes' & maintenance**
    - **Especially important in light of how ESCO is paid**
    - **ESCO reportedly responsive**
      - **Some negotiation, modification when mis-matches between ESCO decisions and either occupant or equipment/system needs**

INTERIM FINDING #4: Details of longer-term operation and maintenance yet to be fully developed (or communicated)

- ESCO clearly responsible for installation, early upkeep
- Ambiguities about later operation & maintenance
  - Measurement and verification
    - How to distinguish TEAM ESPC ECMs from other ECMs?
  - ECM operation and maintenance, now and over time
    - Will control authority reside only with ESCO over time?
    - Whose responsibility, whose parts—ESCO vs. ORNL?
    - Availability, access to, and costs of replacement parts
    - Any special training needed (for ORNL staff members)?
    - Timeliness of response—emergency and normal situations
    - Responsiveness, timeliness, to what standard or whose satisfaction?
    - How do responsibilities shift as uses of buildings change over time?

INTERIM FINDING #5: Behavior and choices affect potential long-term savings in C/I retrofit settings

- **Especially, institutional and organizational choices and behavior**
  - **Measures to install**
  - **'Fit' with existing and evolving buildings/systems**
  - **Measurement, maintenance, operation — over time**

INTERIM FINDING #5: Behavior and choices affect potential long-term savings in C/I retrofit settings

- Especially, institutional and organizational choices and behavior
- Individuals' behavior and choices have less impact*
  - Most TEAM ECMs do not require behavioral change
  - Difficult to circumvent installed measures
  - Most staff members may be unaware of TEAM ESPC or why 'disruptions' happen
  - 'Culture change'
    - Not apparent at this juncture

*Interviewees mainly are in F&O organization

Next steps in our exploration…

- **Continue TEAM ESPC-related interviews**
  - **Extend to building occupants**
- **Expand to net-zero energy building retrofits at ORNL**
- **Expand to LEED retrofits at ORNL**

Thank you.

Questions?