Project Summary

Timeline:
Start date: Oct 2012; Planned end date: Sep 2017

Key Milestones
1. Pilot lighting system deployment with open control interface (Fall 2014)
2. Transactional Network Volttron integration (Spring 2016)
3. Demonstrate transaction-based controls for constrained-resource buildings in Indian office building (Summer 2017)

Budget:
Total DOE $ to date: $375K (FY13-FY15; $250k spent)
Total future DOE $: $250 K (FY16-FY17)

Target Market/Audience:
Commercial building owners and system innovators

Key Partners:

<table>
<thead>
<tr>
<th>Institutional</th>
<th>Industry</th>
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<tbody>
<tr>
<td>International Institute of Information Technology Hyderabad (IIIT-H)</td>
<td>enLighted</td>
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</table>

Project Goals:
Develop and demonstrate:
• Transaction-based controls to manage constrained energy resources,
• Open software interfaces to allow communication and control across diverse building systems.
Purpose and Objectives

Problem Statement:
• Lack of coordination among building systems wastes energy (e.g., lighting system might turn off when space is unoccupied, but HVAC system unaware).
• Loads in buildings do not adjust to constrained energy resources in a coordinated, cost-effective way.

Solving this problem requires:
• Communications and integration across end-uses,
• New control paradigms for buildings using software-driven tools and services like Transactional Energy frameworks.

Target Market and Audience:
• Commercial building owners and system innovators.
• Small/medium buildings with inadequate controls consume ~3 Quads source energy annually in US; ~0.5 Quad savings potential.

Impact of Project: This project will:
• Demonstrate an integrated workstation control system (lighting, plug loads, HVAC) in an Indian office building
• Release open-source software tools enabling unified, transaction-based control
Are Constrained Energy Resources a Problem?

NYC: Cell phone charging after Hurricane Sandy
(source: FEMA)

Bangalore: 5x1.5MW backup generators at Magna office complex
(source: Powerica)
Approach

Integrate commercial control systems using open-source tools

- Develop and use open data interfaces to allow communication and control across diverse building systems.
- Adapt and demonstrate integration platforms that enable new control paradigms for buildings using open-source, software driven tools.
- Demonstrate advanced plug-load management capabilities as part of platform.

Extend Volttron transaction-based control system

- Hierarchical architecture with distributed control at workstation level, loosely coupled to neighboring workstations, aggregated to zone and building.
- Use transactional-energy principles to allocate scarce energy resources within each control realm.

Key Issues:

- Can we integrate control of several end-uses into one, easy-to-use platform?
- Can transactional-energy principles be applied to individual workstation?
Approach: Data Integration Platform Overview

New Control Applications

Data Exchange Layer (VOLTTRON, sMAP)

- Lighting
  - Occupancy
  - Switches
  - Light levels
  - Schedules

- HVAC
  - Schedules
  - Temperature
  - Air flows

- Plugs
  - Power mgmt.
  - Occupancy
  - Load ID
Results: Integrated commercial lighting system with open-source communication and control platform

Fixture dimming data show energy savings during unoccupied times

Occupancy data now available in platform for controlling HVAC, other systems
Baseline Commercial Lighting System:
Fixtures are commissioned and controlled via a web-accessible GUI where user can:
• Set lighting schedules.
• Group fixtures and set group behaviors based on integrated occupancy sensor data.
• View current projected power consumption and cumulative savings attributable to efficient behaviors.

Integration Platform adds:
• Lighting behaviors are determined by software, which is highly customizable.
• Integration with other (third party) sensors and controls is enabled.
• Fixtures can respond to whole-building schedules and other external data.
Project Integration and Collaboration

Project Integration:
• Regular calls with Indian research partners
• Joint US-India work on data exchange platform
• Collaborative work with Enlighted on lighting interface

Partners, Subcontractors, and Collaborators:
• Project is a task in the CBERD Program
• Vishal Garg, International Institute of Information Technology, Hyderabad, India
• Tanuj Mohan, Enlighted Systems, California, USA (Development Partner)

Communications: CBERD Industry Forum
Next Steps and Future Plans

Transaction-based Controls: tools are being developed for U.S. grid-integration ... but have not been applied to “resource constrained” settings, such as islanded buildings during power outage

Approach:Extend Volttron transaction-based control system

• Builds on work for BTO that uses Volttron to manage military microgrids.
• Demonstrate Volttron-based system in Indian office building

Key R&D questions:

• Can Volttron be used to manage energy and load in grid-islanded, “resource constrained” buildings?
• Is the Volttron system robust enough to handle intermittency and instability of the Indian grid?
• Demonstrate that control of many workstation-level loads can have an effect on zone and whole building.

• Volttron is a key component of DOE’s grid-integration research agenda.
• Advanced communication and control technologies are essential to BTO’s 50% energy savings goal.
• This project will extend transaction-based controls to resource-constrained grids.
Next Steps: BTO Transactive-Energy Microgrid Control Concept

- Developed to manage military microgrid; can be applied to islanded building
- Price of electricity is used to manage energy, balance supply & demand
- Supply assets (generators, battery) publish prices based on energy scarcity
- Grid controller publishes system-wide price to balance available supply & expected demand
- End-use devices adjust load based on system price & device-specific demand elasticity curves
Future Plans: Integrated Workstation Demo

• Challenge:
  - Manage loads at workstation, zone, and building level, while still giving individual occupants control.
  - Demonstrate that control of many workstation-level loads can have an effect on the zone and whole building.

• Approach:
  – Hierarchical architecture with tightly controlled “microgrid” at workstation level, loosely coupled to neighboring workstation microgrids, aggregated up to zone and building.
  – Control loads (e.g., lighting, person comfort) and laptop batteries to conduct transactions between microgrids; use findings from RPI lighting task.
  – Use power price as control mechanism, influenced by availability of grid power and local resources.
  – Volttron system used for communication and transactions.
  – Infosys very interested in workstation-level control on their campuses.
Each workstation controlled independently using transational-energy methods.

Volttron manages each workstation “microgrid.”

Independent workstations are coordinated at the zone level using price-based transactions.
REFERENCE SLIDES
**Project Budget**

- **Project Budget**: $125K per year
- **Variances**: None.
- **Cost to Date**: $250K
- **Additional Funding**: $300K cost share

### Budget History

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# Project Plan and Schedule

## Project Schedule

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<tr>
<th>Task</th>
<th>FY2013</th>
<th>FY2014</th>
<th>FY2015</th>
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<tbody>
<tr>
<td>Q1 Milestone: Kick Off meetings, Documents finalized</td>
<td>Q1 (Oct-Dec)</td>
<td>Q2 (Jan-Mar)</td>
<td>Q3 (Apr-Jun)</td>
</tr>
<tr>
<td>Q2 Milestone: Develop prototype smart lighting controller</td>
<td>Q1 (Oct-Dec)</td>
<td>Q2 (Jan-Mar)</td>
<td>Q3 (Apr-Jun)</td>
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<tr>
<td>Q3 Milestone: Smart Lighting Controller Documentation</td>
<td>Q1 (Oct-Dec)</td>
<td>Q2 (Jan-Mar)</td>
<td>Q3 (Apr-Jun)</td>
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<td>Q4 Milestone: Review luminaire, HVAC technologies available in market</td>
<td>Q1 (Oct-Dec)</td>
<td>Q2 (Jan-Mar)</td>
<td>Q3 (Apr-Jun)</td>
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<td>Q1 Milestone: Development of data exchange system between building system and integrated controls</td>
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<td>Q2 (Jan-Mar)</td>
<td>Q3 (Apr-Jun)</td>
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<td>Q2 Milestone: Data exchange system documentation</td>
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<td>Q2 (Jan-Mar)</td>
<td>Q3 (Apr-Jun)</td>
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<td>Q3 Milestone: Pilot study of fluorescent lighting control</td>
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## Past Work

- Q1 Milestone: Kick Off meetings, Documents finalized
- Q2 Milestone: Develop prototype smart lighting controller
- Q3 Milestone: Smart Lighting Controller Documentation
- Q4 Milestone: Review luminaire, HVAC technologies available in market
- Q1 Milestone: Development of data exchange system between building system and integrated controls
- Q2 Milestone: Data exchange system documentation
- Q3 Milestone: Pilot study of fluorescent lighting control
Progress: Laboratory Scale Lighting Demo

Dimmable LED Lamp

Wireless Gateway

Networking Support (all IP)

Enlighted Energy Manager

LBNL Controller & Open Software Interface