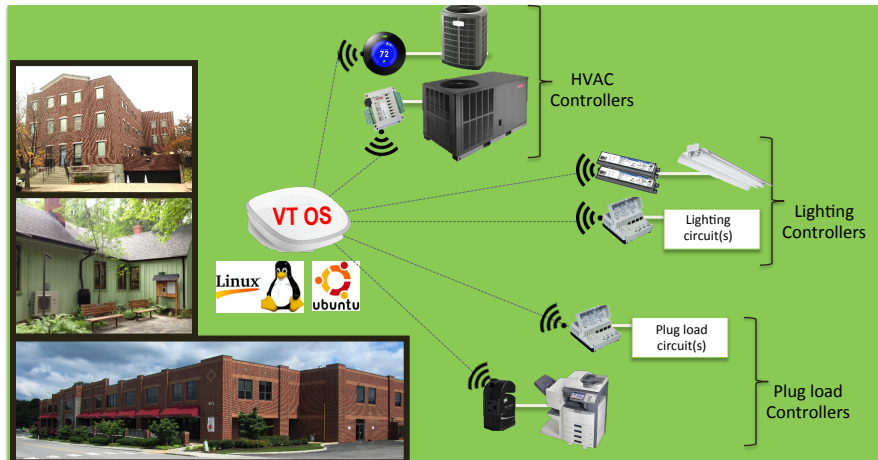


Partnership for Innovation

An Open-source Hardware/Software Solution



South Asian University
New Delhi, INDIA, 21 Aug 2014

Prof. Saifur Rahman
Virginia Tech, USA

Virginia Tech Research Center Arlington, Virginia, USA



PPT slides will be available at

www.saifurrahman.org

INNOVATION: Why it is needed

- Problem is not easily understood
- Problem is multidimensional
- Problem requires many resources

- Solution needs to be multidisciplinary
- Solution requires university-industry collaboration
- Solution requires end-user participation

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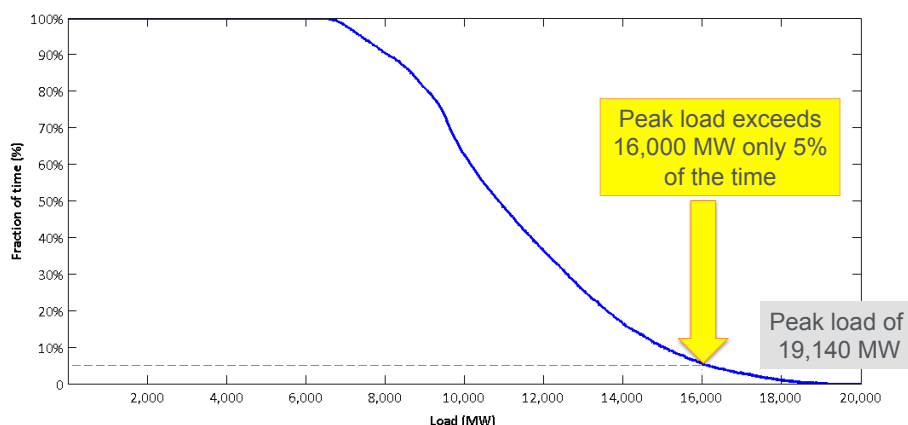
Electric Power Sector Challenges

Peak Load Reduction

Energy Efficiency

4

Inefficiency in Electricity Consumption



5

Peak Load and its Duration

- In the **US** 20% of the load happens only **5%** of the time
- In **Australia** 15% of the load happens less than **1%** of the time
- In **Egypt** 15% of the load happens only **1%** of the time

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How is the peak load managed in the US today

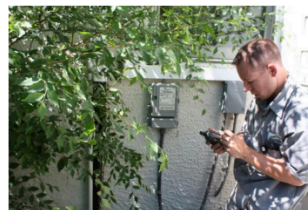
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Electric Utility – Smart Cooling Rewards (\$40/year)

Utility installs **an A/C cycling switch** on home outdoor cooling system



AC Cycling Switch



Testing the AC Cycling Switch



Installing the AC Cycling Switch



AC Cycling Switch Installed

U.S. DEPARTMENT OF **ENERGY** | Energy Efficiency & Renewable Energy

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Drawback of the Current Approach

- Air conditioning is turned off when needed the most
- Homeowner has no control after the initial consent

Proposed Solution

- Electric utility sends a signal through the smart meter or home internet gateway
- Home Energy Management (HEM) system optimizes appliance/equipment operation to provide the peak load reduction requested, but maintains customer comfort
- The homeowner gives the utility the peak load saving it wants, but on his/her own terms





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Virginia Tech Solution

Control multiple non-critical loads

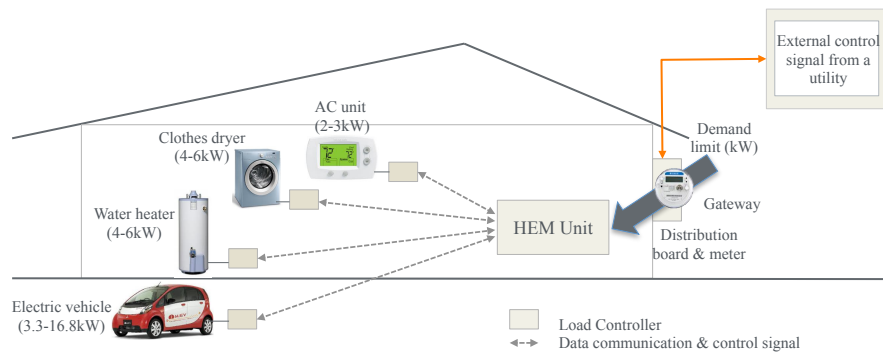
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Example of Load Priority and Preference Settings

	Load			
	Water Heater (WH)	Space cooling (AC)	Clothes Dryer (CD)	Electric Vehicle (EV)
#1. Priority setting	1 	2 	3 	4 
#2. Preference setting	110-120°F	76°F (±2°F) Not to exceed 85°F	Finish the job by midnight	Fully charged by 8AM

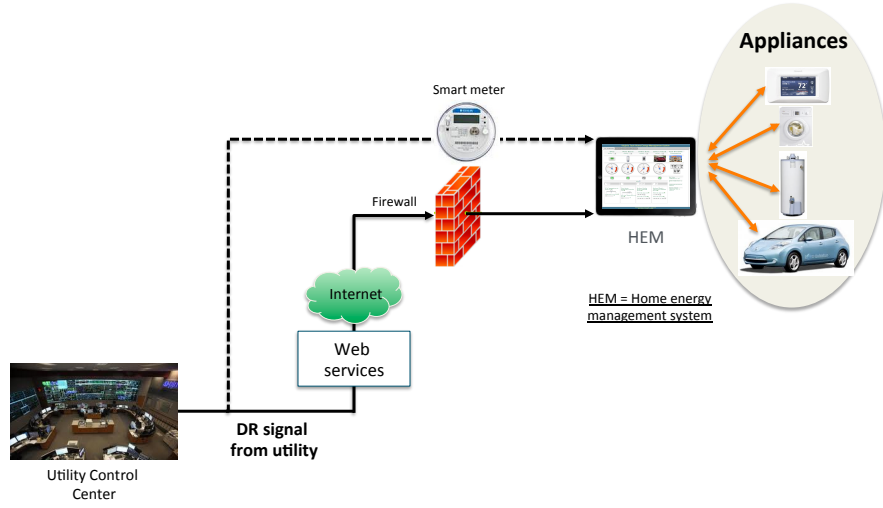
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Home Energy Management Unit Setup



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Web Services for Demand Response Applications



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HEM User Interface

Seen on an iPad

Virginia Tech Home Energy Management System

LIVE DASHBOARD | GRAPHING | DR SIMULATION | SETTINGS

HVAC	Water Heater	Clothes Dryer	Electric Vehicle	Total Household Consumption
Priority: 1	Priority: 2	Priority: 3	Priority: 4	
				10.2 kW
<p>HVAC temperature set point (°F): 76°F</p> <p>Temperature set point: 76°F</p>	<p>Water heater temperature set point (°F): 116°F</p> <p>Hot water temperature set point: 116°F</p>	<p>Preferred clothes dryer's operating period:</p> <p>Preferred start time: 09:00 PM</p> <p>Preferred end time: 01:00 PM +1 day</p>	<p>Preferred Electric Vehicle (EV) charging period:</p> <p>Preferred start time: 11:00 PM</p> <p>Preferred end time: 08:00 PM +1 day</p>	<p>Hot Water Temperature: 115 F</p> <p>Room Temperature: 73 F</p> <p>Cloth Dryer on run: 45 minutes</p> <p>Electric Vehicle remaining time: 30 minutes</p>

Advanced Research Institute (ARI) - Virginia Tech
600 W. Clarke Hall, Blacksburg, VA 22603

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Utility-Industry Partnership

Electric Utility:



Dominion Virginia Power

High-tech small manufacturers:



Advanced Manufacturing Technology, Inc. (AMTI)

EIT, LLC.

Innovative Wireless Technologies (IWT)

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From the
Residential
to the
Commercial Sector

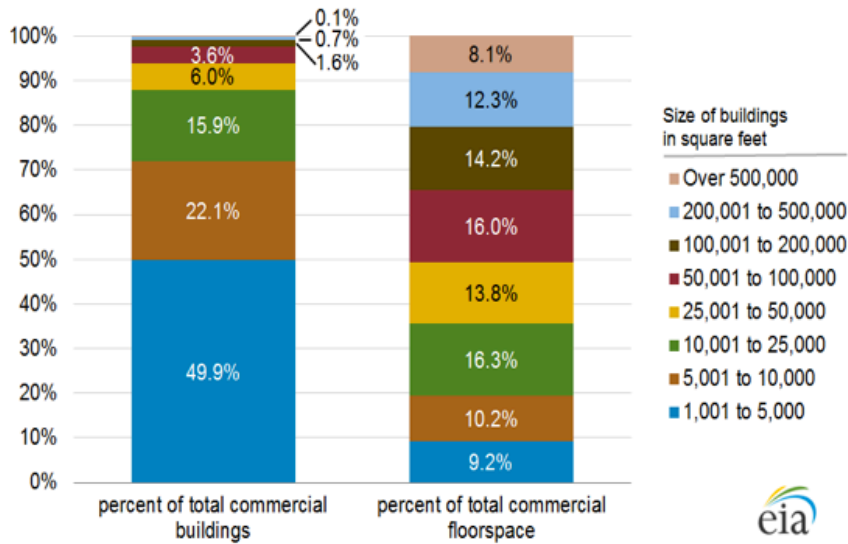
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Energy Efficiency Issues

- Buildings are responsible for over 40% of the total energy consumption in the U.S. A large majority of these have no building automation systems (BAS)

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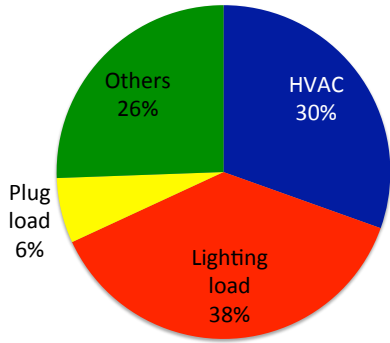
Commercial Building Sizes in the US



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Breakdown of Electricity Usage

Improve energy efficiency and facilitate demand response applications.



Electricity use in buildings

Three major loads in buildings:

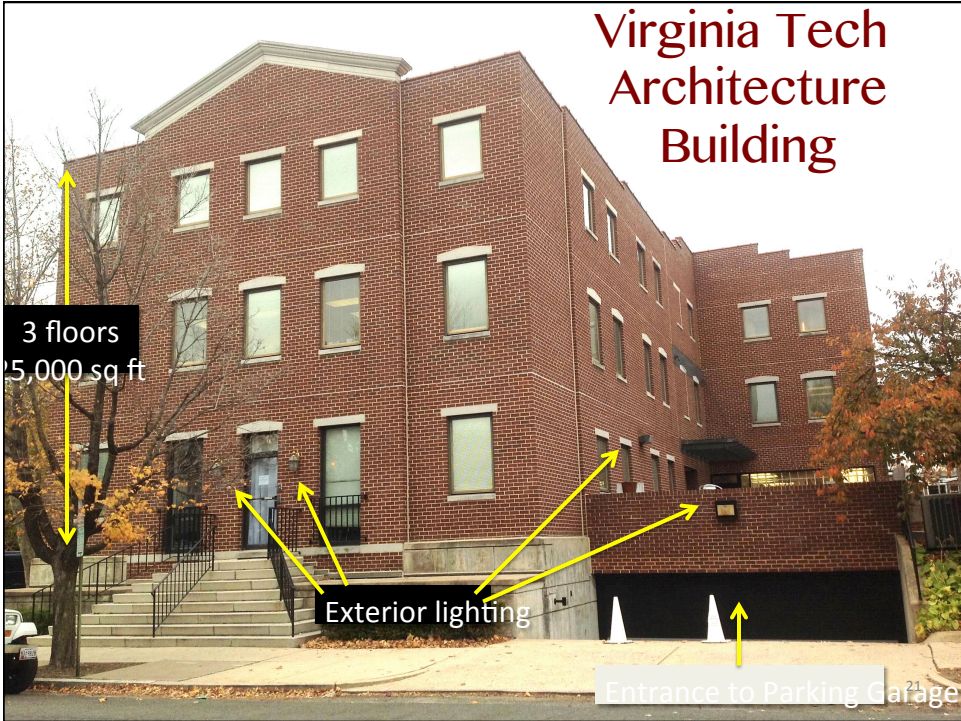
- HVAC
- Lighting loads
- Plug loads

Source: EIA - Commercial Building Energy Consumption Survey (CBECS)
<http://www.eia.gov/consumption/commercial/data/2003/index.cfm?view=consumption#e1a>

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Study Diverse Building Types





Long Branch Nature Center in Arlington



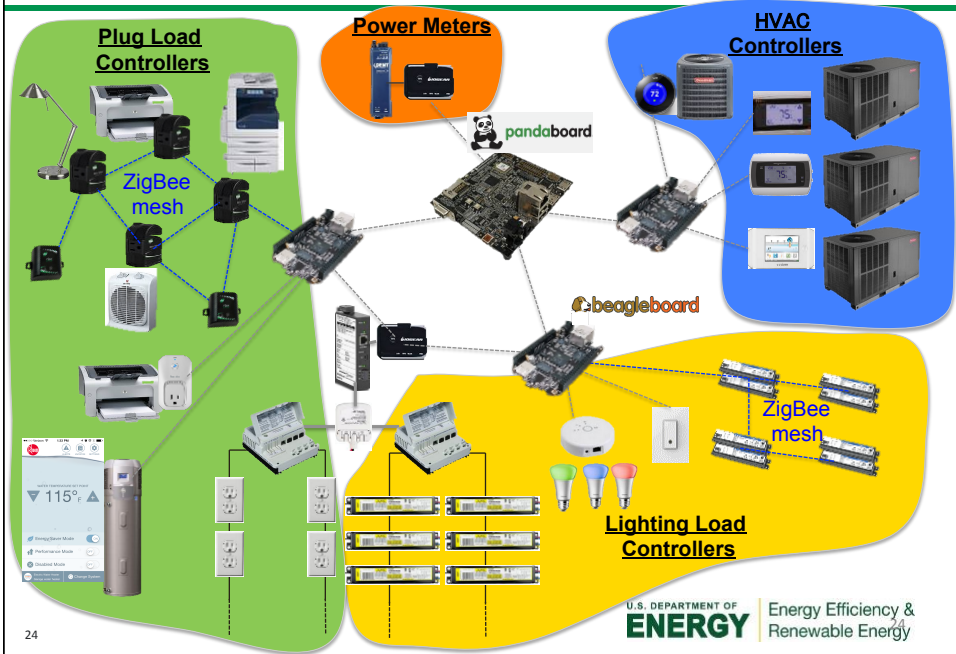
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U.S. DEPARTMENT OF ENERGY Energy Efficiency & Renewable Energy

Retail/Office Building, Blacksburg



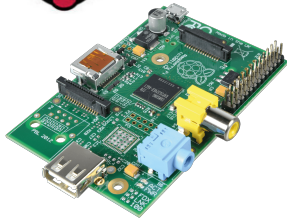
Hardware/Software Deployment for Small Buildings



Software on Various Embedded Devices



Raspberry Pi



CPU: 700 MHz ARM processor
 RAM: 512MB SD
 Ethernet: 10/100 RJ45
 USB 2.0: Available
 Price: \$35
 Size: 3.4"x2.2"

beagleboard



CPU: 1GHz ARM Cortex-A8
 RAM: 512MB SD
 Ethernet: 10/100 RJ45
 USB 2.0: Available
 Price: \$55
 Size: 3.4"x2.1"



pandaBoard



CPU: Dual core 1.2GHz ARM Cortex-A9
 RAM: 1GB SD
 Ethernet: 10/100 RJ45
 USB 2.0: Available
 Price: \$220
 Size: 4.5"x4.0"



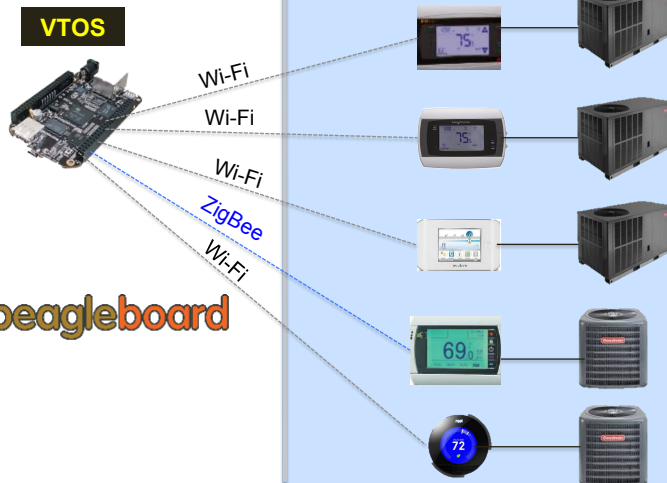
Energy Efficiency & Renewable Energy

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HVAC Controller Details



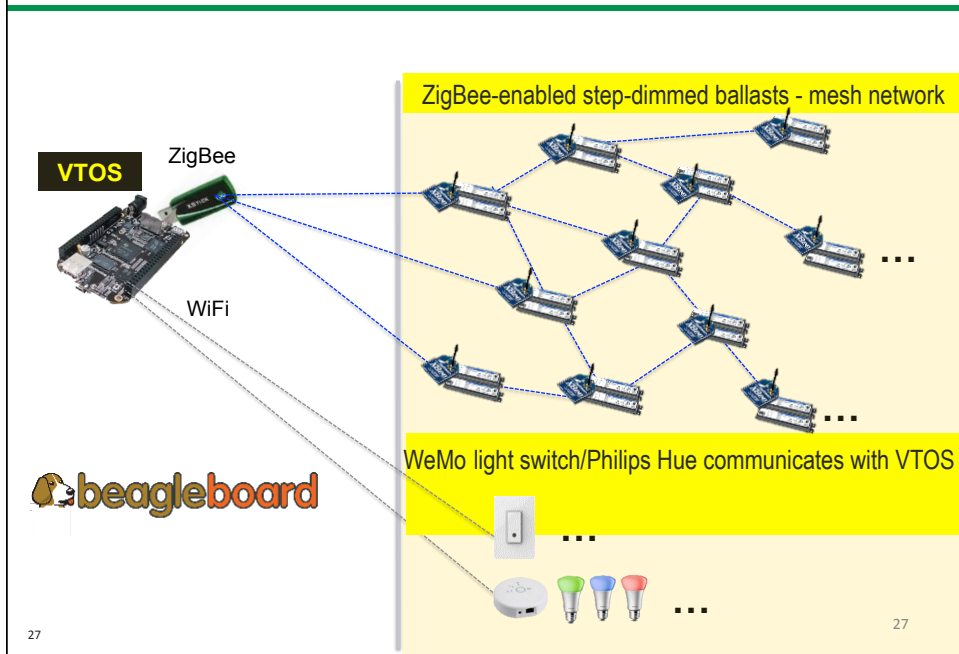
HVAC can be controlled via smart thermostat



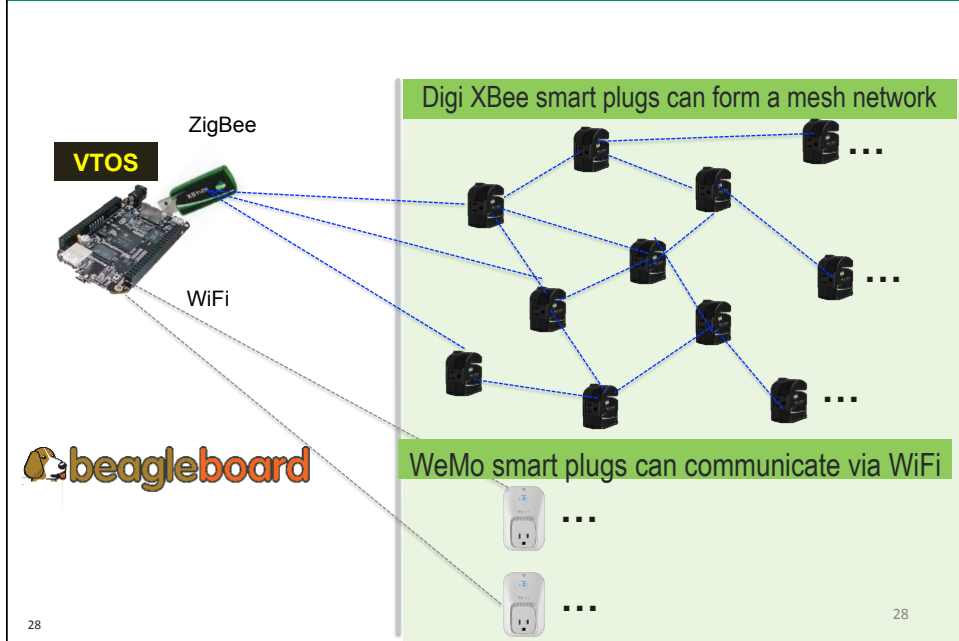
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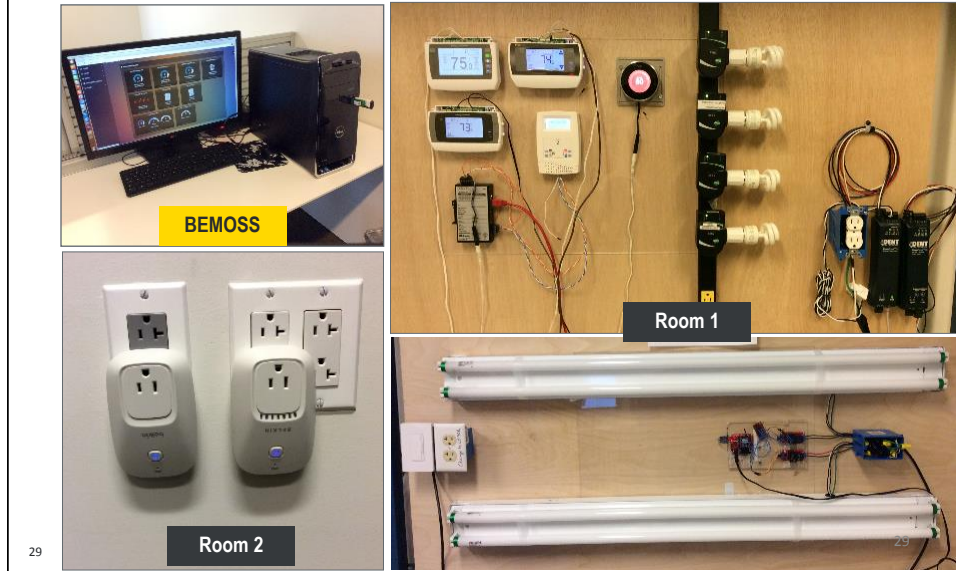
Lighting Controller Details (ZigBee/WiFi)



Plug Load Controller Details (ZigBee/WiFi)



Laboratory Setup for Device Discovery Process



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User Interface – Dashboard Page

Once the discovery agent gets device information, device discovery status is displayed in the User Interface dashboard

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Summary

- **Peak Load Reduction**
 - Simple concept, but **innovation** is in making it possible without customer discomfort
- **Energy Efficiency Applications**
 - How to attract consumer interest – **simplicity** in design and applications

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Thank You

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