From Smart Buildings to Smart Grid

**Smart grid**: Bi-directional flows of energy, remote control/automation of power, integrated distributed energy...

**Smart city**: Complex system of interconnected infrastructures and services...

**Smart Campus**: A collection of buildings managed by the same facility manager...

**Smart buildings**: Intelligent building automation systems, smart devices, productive users, grid integration...

Supported by ICT and distributed networks of intelligent sensors, data centers/clouds
Develop an open source, low cost, low power consumption platform that can monitor and control majority of loads in buildings to **improve energy efficiency** and **facilitate demand response** implementation.

Three major loads in buildings:
- HVAC
- Lighting loads
- Plug loads

### Electricity Usage in Buildings

Source: EIA - Commercial Building Energy Consumption Survey (CBECS)

### What makes a Building Smart

A single platform for monitoring and control of HVAC, lighting, water supply, sensor networks, security camera & fire emergency

Smart Building Savings

- 40% of energy usage
- 30% of water usage
- 10% to 30% of building maintenance cost

Energy Efficiency
Energy Conservation

Occupancy Sensor for controlling lights

Affordable Energy Management

With Internet of Things (IoT) technology, stand-alone systems can be connected, resulting in clear insights that reduce energy consumption and improve building performance.

BEMOSS can automatically discover and control...
BEMOSS Laboratory Setup

BEMOSS

Thermostat

Power Meters

Plug load Controller
Can control (ON/OFF) individual plug loads

Lighting load Controller
Can control (0-50%-100%) individual ballasts

Lighting/Plug Load Controllers & VAV/RTU Controllers

Network Controller
Modbus RTU -> Ethernet

Wattstopper plug load controller
Can control (ON/OFF) two plug load circuits

Wattstopper lighting load controller
Can control (ON/OFF/0-10V dimming) two lighting load circuits

Prolon VAV controller
Adjust airflow

Prolon RTU controller
HVAC control
BEMOSS Deployment in Four Buildings

Building 1 – Virginia Tech Architecture Building
- Location: Alexandria, VA
- Demonstration: HVAC, plug load control

Building 2 – Equipment Bureau
- Location: Arlington, VA
- Demonstration: Lighting control

Building 3 – Virginia Tech building
- Location: Blacksburg, VA
- Demonstration: HVAC control

Building 4 – PG County building
- Location: Camp Springs, MD
- Demonstration: HVAC control

Building 1 – VT Building in Alexandria, VA

Area: 25,000 SF
Energy: 14-25 MWh/mo.
Peak load: 61 kW
June 2016–high temperature33°C
June 1, 2016 vs. June 22, 2016

25,000 sqft building (Alexandria, VA)

Raising set point 1.6°F saves 17% in HVAC load.

Raising set point by 1°C from 6am-6pm demonstrates 17% energy savings in HVAC load.

Outdoor temperature profiles:

Indoor temperature set-points:

HVAC load (5-compressors):

Building 2 – Office Building, Arlington, VA

Arlington, Virginia

Office building size: 5,000 sqft
**BEMOSS for Lighting Control**

**Energy Savings by controlling light intensity**

<table>
<thead>
<tr>
<th>Month</th>
<th>Total Measured Energy Consumption (kWh)</th>
<th>Total Calculated Energy Consumption without Dimming (kWh)</th>
<th>Energy Savings by Dimming (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2016</td>
<td>264.37</td>
<td>399.90</td>
<td>33.89%</td>
</tr>
<tr>
<td>November 2016</td>
<td>278.13</td>
<td>423.78</td>
<td>34.37%</td>
</tr>
<tr>
<td>December 2016</td>
<td>280.76</td>
<td>426.40</td>
<td>34.16%</td>
</tr>
<tr>
<td>Total (October-December)</td>
<td>823.26</td>
<td>1250.08</td>
<td>34.14%</td>
</tr>
</tbody>
</table>

*Note: Scheduled dimming level from 6:30am to 9:00pm. Open office area A: 50%; Open office area B: 45%; Chief office’s desk area: 60%; Chief office’s meeting area: 50%; Conference room A: 50%; Conference room B: 45%. Lights are off after 9:00pm.*
Bldg 3 – Office Building in Blacksburg, VA

Blackburg, Virginia

Retailed building: ~50,000 sqft  
Peak demand: ~160kW  
Electricity consumption: 46-65MWh/month

Building 3: Energy Savings

<table>
<thead>
<tr>
<th>Dates</th>
<th>Cool set-point</th>
<th>Total daily energy usage</th>
<th>Energy saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 6, 2016</td>
<td>21</td>
<td>52.1 kWh</td>
<td>7.4 kWh (14.2%)</td>
</tr>
<tr>
<td>May 27, 2016</td>
<td>24</td>
<td>44.7 kWh</td>
<td></td>
</tr>
</tbody>
</table>
Solar PV System on BEMOSS Platform

Solar PV and Smart Inverter Integration (Cont'd)
WiseBldg Platform Built by BEM Controls

Utility/DR Aggregator
- DR Event
- Pricing
- Billing

Customers/Operators

Buildings

Internet

- HVAC
- Lighting loads
- Plug loads
- Sensors/power meters
- Water meters
- PV & storage
- Security camera

Occ. comfort
Demand response
Energy savings (kWh)
Peak demand (kW) reduction
Alarm & notifications
Building energy management

Transitioning from a Research Project to a Commercial Enterprise
What can be done at Jamia

- Identify buildings with highest electricity consumptions
- Analyze the possible reasons
- Identify conservation opportunities – plugging the leaks
- Select a building for deploying efficient technologies
- Monitor the performance
- Plan for broader deployments

Source: www.indiatoday.in (c) Saifur Rahman
You have a **GREEN** campus

Make it a **SMART** campus

Thank You

Professor Saifur Rahman
www.bemcontrols.com
www.saifurrahman.org