Energy Efficiency in Smart Buildings through IoT Sensor Integration

Keynote Speech
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President, IEEE Power & Energy Society 2018 & 2019

ICACCP, SMIT Sikkim, India, 22 March 2021
Recent Keynote Speeches and Invited Talks

Purpose and Objectives

• Buildings consume over 40% of the total energy consumption in the U.S. Over 90% of the buildings in the U.S. are either small-sized (<5,000 square feet) or medium-sized (between 5,000 sf and 50,000 sf). These buildings typically do not use Building Automation Systems (BAS) to monitor and control their building systems from a central location.

• **WiseBldg platform** facilitates energy efficiency applications in commercial buildings using a very simple and scalable building automation system (BAS).
WiseBldg is a Building Energy Management Open Architecture Software solution that is engineered to improve sensing and control of all IoT-enabled equipment in commercial buildings.

Three major loads in buildings:
- Heating, Ventilation, AC
- Lighting loads
- Plug loads

Monitoring and control:

Value:
Improves energy efficiency and facilitates peak load savings in buildings.

WiseBldg supports multiple IoT devices through industry standard protocols and communications technologies.
Multiple-protocol Interoperability

Communication Technologies
- Ethernet (IEEE 802.3)
- Serial Interface (RS-485)
- ZigBee (IEEE 802.15.4)
- WiFi (IEEE 802.11)

Data Exchange Protocols
- BACnet (IP and MS/TP)
- Modbus (RTU and TCP)
- Web (e.g., XML, JSON, RSS/Atom)
- ZigBee API
- Smart Energy (SE)
- OpenADR (Open Automated Demand Response)

WiseBldg Platform for a Campus-type Environment
- Customers/Operators
- HVAC
- Lighting loads
- Plug loads
- Sensors/power meters
- Water meters
- PV & storage
- Security camera
WiseBldg can make an old building smart

Customers controlling buildings optimized for savings

Measured energy savings across deployments

20% HVAC Energy Savings
25% Lighting Energy Savings

Improved operations and maintenance: WiseBldg analytical platform enables operators to detect faults when devices operate outside standard thresholds enabling building operators to investigate prior to device failure.

Occupant satisfaction: spaces controlled by WiseBldg have been more comfortable due to more consistent temperature profiles and healthier air quality through consistent monitoring of environmental factors (CO2 levels, PM 2.5).
WiseBldg Deployments in Four Buildings

Building 1 – VT Classroom Building
- Location: Alexandria, VA
- Demonstration: HVAC, plug load control

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

Building 3 – VT Lab Building
- Location: Blacksburg, VA
- Demonstration: HVAC control

Building 4 – PG County Community 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

Alexandria, Virginia, USA
Classroom under Real-time Monitoring

- Environmental sensor (CO₂, noise, temperature, RH)
- BEMOSS core
- Plug load controller
- Motion sensor
- Thermostat
- Power meter

Indoor Environmental Monitoring

- Bemoss Core: Weather_Sensor21
  - Indoor Environmental Status
    - Temperature: 71.4°F
    - Humidity: 22.0%
    - Pressure: 30.65 Pa
    - CO₂: 484 ppm
    - Noise: 47.0 dB

- Outdoor Environmental Status
  - Temperature: 74.3°F
  - Humidity: 49.0%

- Weather_Sensor21: CO₂
Using WiseBldg, Building Operator saved 27% on HVAC consumption alone

<table>
<thead>
<tr>
<th>Location: Alexandria, VA</th>
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<tbody>
<tr>
<td>Area: 25,000 square feet</td>
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Deployed Devices
- 6 Thermostats
- 6 Power meters
- 1 Li-ion battery
- 1 Environmental sensor

**Summer Months (June-July-August)**

| Compressor consumption 2014 (Before WiseBldg) | 8,340 kWh |
| Compressor consumption 2016 (After WiseBldg) | 6,071 kWh |

Average savings 26.8% savings

Base case (w/o WiseBldg)
- Setpoint: 74 deg F
- Energy usage = 2.72kWh
- Max demand = 3.98kW

Managed by WiseBldg
- Setpoint: 77 deg F
- Energy usage = 1.42kWh
- Max demand = 0.5kW

Office Building, Arlington, Virginia

Office building size: 5,000 sqft
Using WiseBldg the building operator reduced HVAC consumption by 27%

Location: Arlington, VA
Area: 5,000 sq ft

Deployed Devices
• 3 Lighting controllers
• 1 Power meter

An average energy savings of 35% was achieved through dimming control

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<tbody>
<tr>
<td>Savings</td>
<td>33.7%</td>
<td>33.9%</td>
<td>34.4%</td>
<td>33.4%</td>
<td>35.9%</td>
<td>36.0%</td>
<td>36.2%</td>
<td>35.0%</td>
<td>36.3%</td>
<td>34.5%</td>
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Energy Savings by controlling light intensity

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<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>
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<tr>
<td>October 2016</td>
<td>264.37</td>
<td>399.90</td>
<td>33.89%</td>
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<tr>
<td>November 2016</td>
<td>278.13</td>
<td>423.78</td>
<td>34.37%</td>
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<tr>
<td>December 2016</td>
<td>280.76</td>
<td>426.40</td>
<td>34.16%</td>
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<tr>
<td>Total (October-December)</td>
<td>823.26</td>
<td>1250.08</td>
<td>34.14%</td>
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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.
Solar PV System Monitoring and Control

WiseBldg User Interface
Managing Battery Storage from WiseBldg Platform

Battery Storage Data Access from WiseBldg
Battery Storage Monitoring & Control

All Buildings Can Be Smart Buildings

Need sensors and controllers

An open-architecture platform to monitor and control IoT devices for Energy Efficiency applications can make it possible

www.bemcontrols.com
Thank You
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IEEE President-elect Candidate