AN IOT PLATFORM FOR BUILDING ENERGY EFFICIENCY APPLICATIONS

Invited Lecture

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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.

Monitoring and control:

Value:

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

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 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

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

Bemoss Core: Weather_Sensor21

Indoor Environment Status
- Temperature: 71.4°F
- Humidity: 22.0%
- Pressure: 30.65 Pa
- CO2: 484.0 ppm
- Noise: 47.0 db

Outdoor Environment Status
- Temperature: 74.3°F
- Humidity: 49.0%
- Maximum Recorded Temperature: 74.3°F
- Minimum Recorded Temperature: 74.3°F

CO2 Graph:
- Date Recorded: Wed, 15 Jun 2016, 16:25

Graph shows CO2 concentration over time.
Using WiseBldg, Building Operator saved 27% on HVAC consumption alone

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

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>Compressor consumption 2014 (Before WiseBldg)</td>
<td>8,340 kWh</td>
</tr>
<tr>
<td>Compressor consumption 2016 (After WiseBldg)</td>
<td>6,071 kWh</td>
</tr>
<tr>
<td>Average savings</td>
<td>26.8% savings</td>
</tr>
</tbody>
</table>

**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
**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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<tr>
<td></td>
<td>33.7%</td>
<td>33.9%</td>
<td>34.4%</td>
<td>33.4%</td>
<td>35.9%</td>
<td>36.2%</td>
<td>35.0%</td>
<td>36.0%</td>
<td>36.3%</td>
<td>34.5%</td>
</tr>
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</table>
### 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>
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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>
</tr>
<tr>
<td>Total (October-December)</td>
<td>823.26</td>
<td>1250.08</td>
<td>34.14%</td>
</tr>
</tbody>
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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

Node1: Der1

Power
- Incident: 35361.2 W
- DC: 5140.15 W
- AC: 4958.0 W

Efficiency
- Inverter: 14.54%
- TOTAL: 14.03%

Voltage
- DC: 357.7 V
- AC: 212.3 V

Current
- DC: 14.37 A
- AC: 23.51 A

Energy
- TOTAL: 6.52 MWh
- TODAY: 14.41 kWh

Iradiance
- ARRAY: 865.0 W/m²
- HORIZONTAL: W/m²
- AMBIENT: 84.0 °F
- MODULE: 93.0 °F

Wind Velocity: 0.0 m/s
CO2 Saved: 10105.01 lbs

Smart inverter control

REAL POWER CONTROL

POWER FACTOR

Power limit value: 100%
Power factor limit: 100%
Managing Battery Storage from WiseBldg Platform

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Weight</th>
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<tbody>
<tr>
<td>5 kW</td>
<td>145 lbs</td>
</tr>
<tr>
<td>12 kWh</td>
<td>188 lbs</td>
</tr>
</tbody>
</table>

**Battery Cells**

- **LG Chem**

**Diagram:**

- **5 kW**
- **12 kWh**
- System Certified
- Battery Expansion

**Technical Specifications:**

- BATTERY READY
- COMMAND READY
- SYSTEM CERTIFIED

**System Layout:**

- 48" above floor
- PCS
- Battery
- Battery Expansion
Battery Storage Monitoring & Control

Tumalow Energy Ingenuity: Battery Storage

**BATTERY STORAGE**

**CURRENT STATUS**

**CURRENT READINGS**

STATE OF CHARGE

98.9%

OUTPUT POWER

-0.013 kW

CHARGING
All Buildings should be Smart Buildings

Building Automation Systems (BAS) can slash power consumption and energy bills significantly, but they are too expensive for most buildings.

*BEM Controls breaks through this barrier.*

Our Wise Building (WiseBldg) platform is affordable and works with any existing loads to make any building smart, no matter the size or age.

www.bemcontrols.com
Prof. Saifur Rahman

Past-President of IEEE Power & Energy Society
Past-Chair, IEEE Publication Services & Products Board

PES accomplishments:
• PES University
• PES Corporate Engagement Program
• PES Chapters’ Councils in China, India, Africa and Latin America

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Thank You

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