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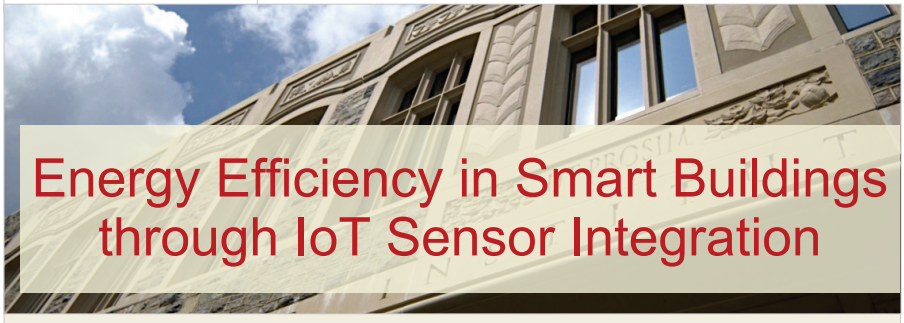

Energy Efficiency in Smart Buildings through IoT Sensor Integration

Invited Lecture

Professor Saifur Rahman
Director, Virginia Tech Advanced Research Inst., USA
President, IEEE Power & Energy Society 2018 & 2019

AEI-EI Distinguished Lecture, ASEAN, 19 February 2021

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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).

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An Open Architecture Platform for Building Energy Efficiency

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

www.bemcontrols.com

Monitoring and control:

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

Value:

Improves energy efficiency and facilitates peak load savings in buildings

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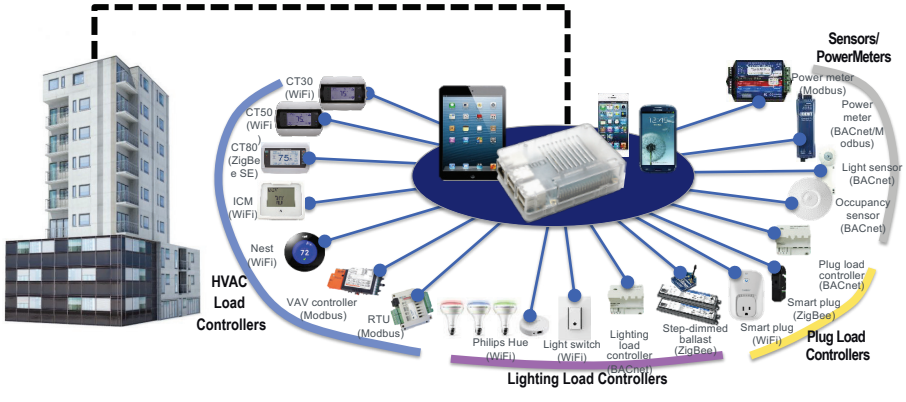
WiseBldg supports multiple IoT devices through industry standard protocols and communications technologies



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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)

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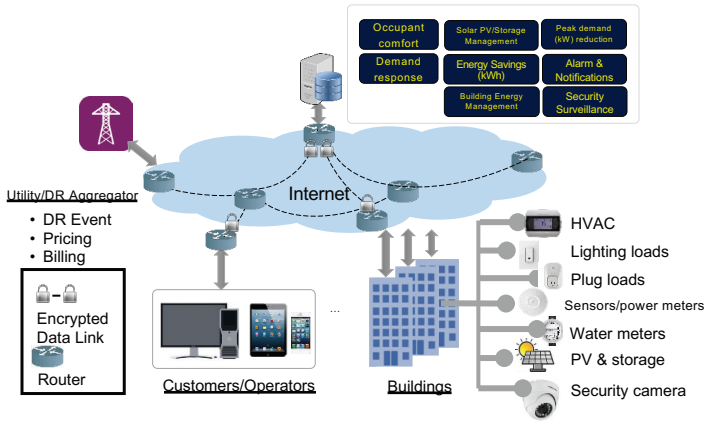
WiseBldg Platform Built by BEM Controls



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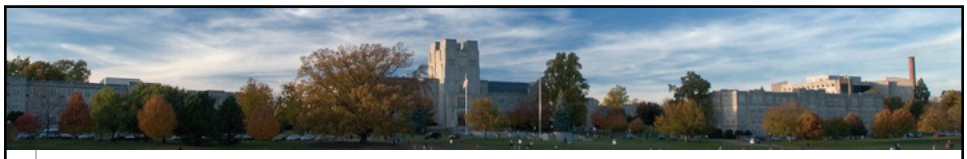

WiseBldg can make an old building smart

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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).

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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

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Building 1 – VT Building in Alexandria, VA

Alexandria, Virginia, USA

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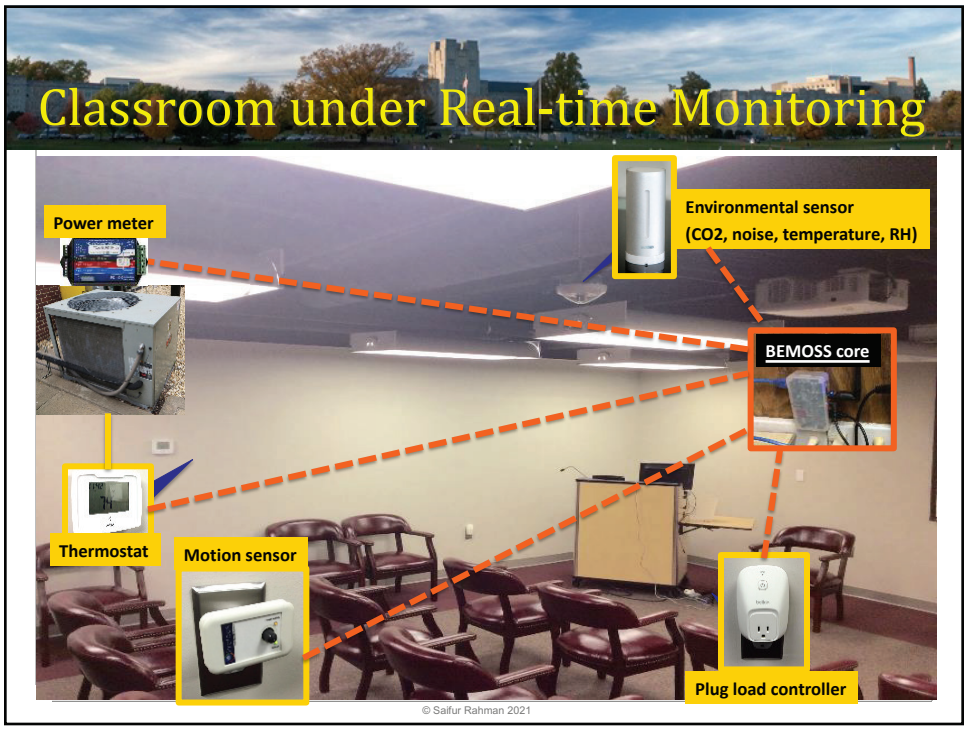
Classroom under Real-time Monitoring
Power meter
Environmental sensor
(CO2, noise, temperature, RH)
BEMOSS core
Thermostat
Motion sensor
Plug load controller
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Indoor Environmental Monitoring
BEMOSS
Admin
Log Out
HOME
DISCOVER NEW DEVICES
DISCOVER/MANAGE
NETWORK STATUS
ALARMS & NOTIFICATIONS
MANAGE USERS
MISC SETTINGS
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
Weather_Sensor21 : CO2
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Energy and Peak Savings from HVAC Control

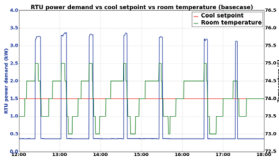
Location: Alexandria, VA
Area: 25,000 square feet
Deployed Devices
- 6 Thermostats
- 6 Power meters
- 1 Li-ion battery
- 1 Environmental sensor

Using WiseBldg, Building Operator saved 27% on HVAC consumption alone

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**

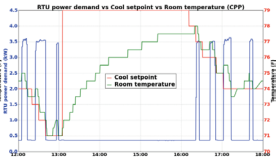



Temperature profile BEFORE WiseBldg Demand Reduction



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

Temperature profile AFTER WiseBldg Demand Reduction



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

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Office Building, Arlington, Virginia

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Energy Savings from Lighting Control

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

Oct 2016	Nov 2016	Dec 2016	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	Jun 2017	AVERAGE
33.7%	33.9%	34.4%	33.4%	35.9%	36.2%	35.0%	36.0%	36.3%	**34.5%**

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Energy Savings by controlling light intensity

Month	Total Measured Energy Consumption (kWh)	Total Calculated Energy Consumption without Dimming (kWh)	Energy Savings by Dimming (%)
October 2016	264.37	399.90	33.89%
November 2016	278.13	423.78	34.37%
December 2016	280.76	426.40	34.16%
Total (October-December)	823.26	1250.08	34.14%

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.

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Solar PV System Monitoring and Control

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WiseBldg User Interface

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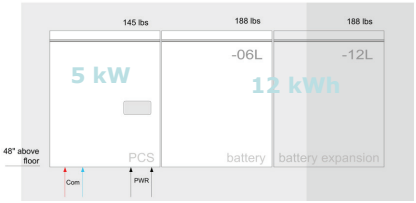
Managing Battery Storage from WiseBldg Platform

Battery Cells LG Chem



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Battery Storage Data Access from WiseBldg

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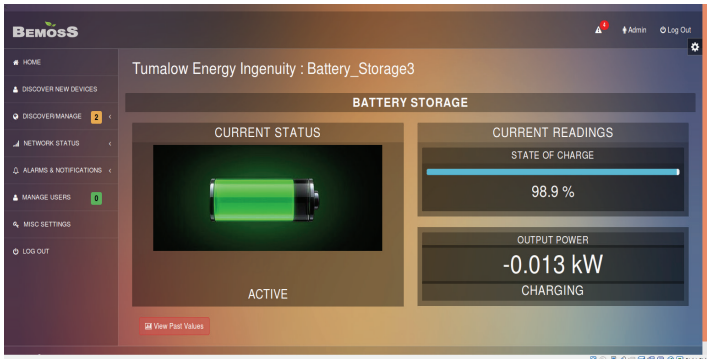
Battery Storage Monitoring & Control



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Thank you

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