VirginiaTech
Invent the Future

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

IEEE PES Chapter, Egypt, 09 August 2020

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).

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 <u>all</u> IoT-enabled equipment in commercial buildings

www.bemcontrols.com
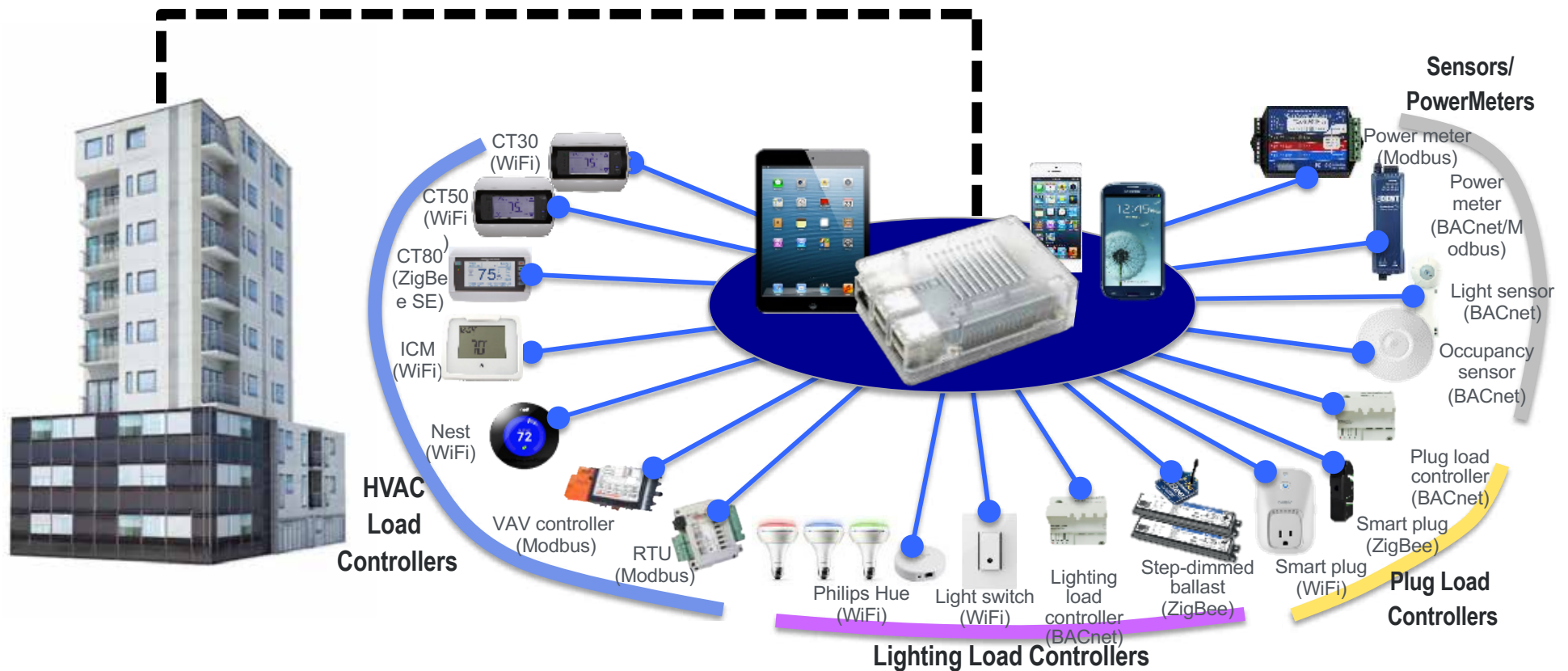
Monitoring and control:

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

Value:

Improves energy efficiency and facilitates peak load savings in buildings

VirginiaTech
Invent the Future

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

Sensors/PowerMeters

Power meter (Modbus)

Power meter (BACnet/Modbus)

Light sensor (BACnet)

Occupancy sensor (BACnet)

Plug load controller (BACnet)

Smart plug (ZigBee)

Plug Load Controllers

Smart plug (WiFi)

CT30 (WiFi)

CT50 (WiFi)

CT80 (ZigBee SE)

ICM (WiFi)

Nest (WiFi)

HVAC Load Controllers

VAV controller (Modbus)

RTU (Modbus)

Philips Hue (WiFi)

Light switch (WiFi)

Lighting load controller (BACnet)

Step-dimmed ballast (ZigBee)

Lighting Load Controllers

VirginiaTech
Invent the Future
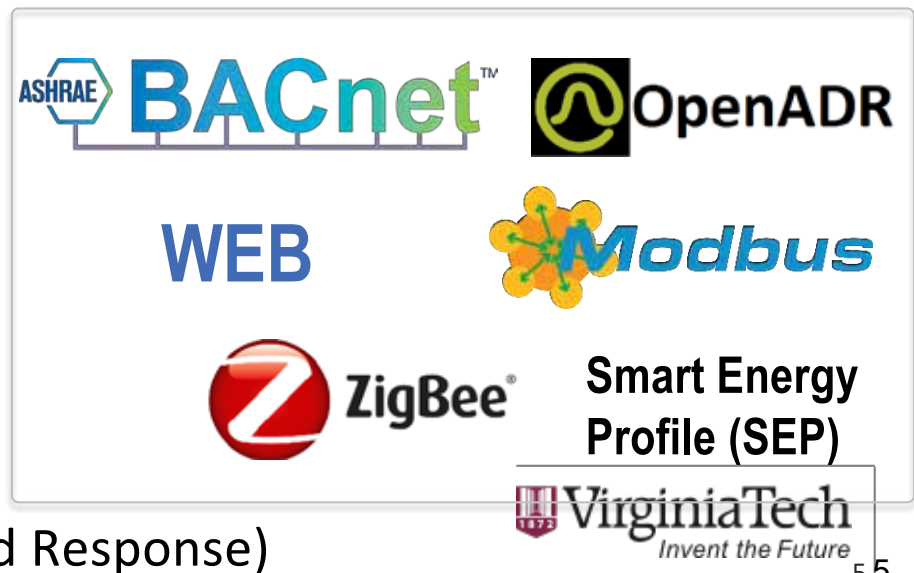
Multiple-protocol Interoperability

Communication Technologies

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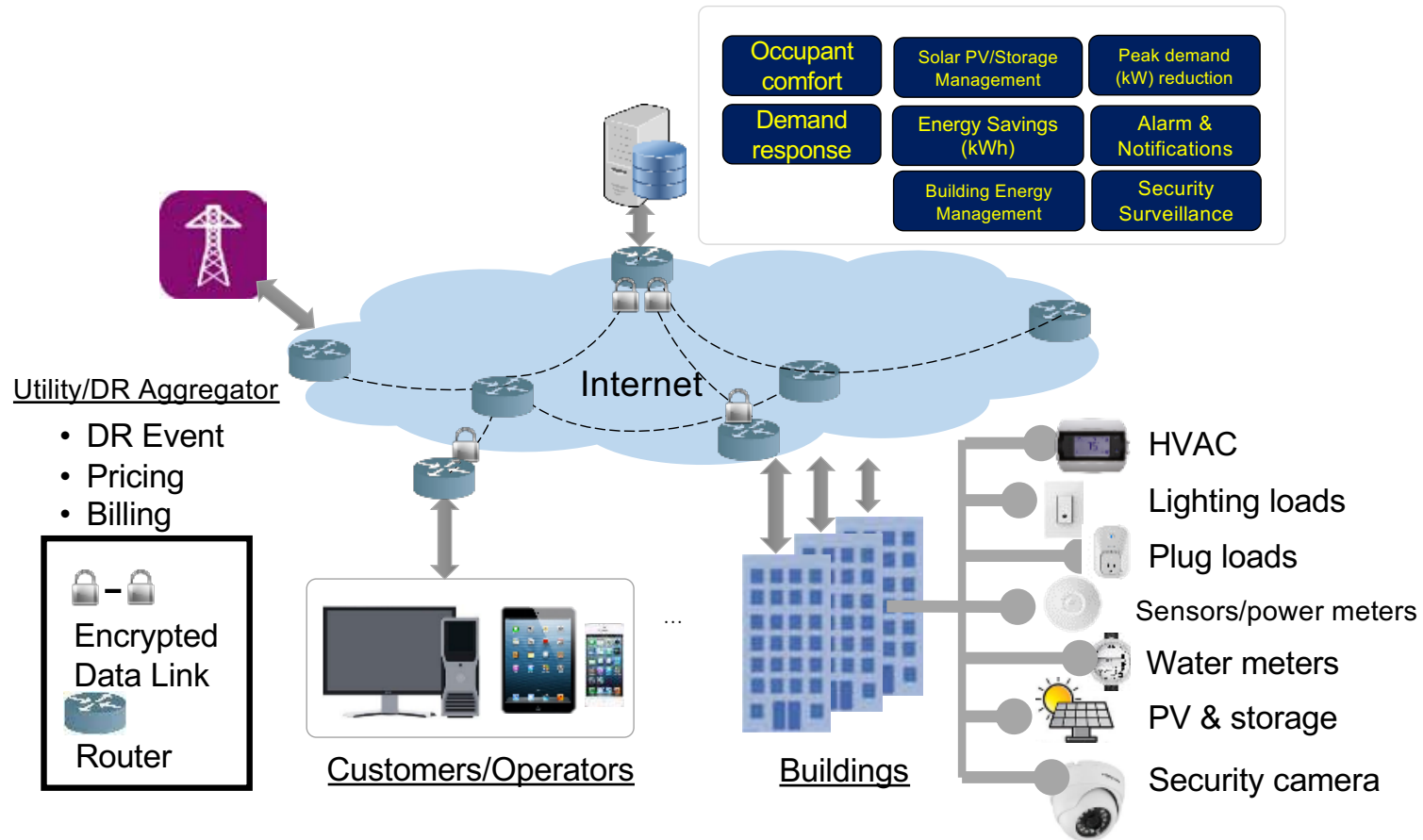- ❑ WiFi (IEEE 802.11)

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 Built by BEM Controls

Occupant comfort	Solar PV/Storage Management	Peak demand (kW) reduction
Demand response	Energy Savings (kWh)	Alarm & Notifications
	Building Energy Management	Security Surveillance

Utility/DR Aggregator

- DR Event
- Pricing
- Billing

Internet

🔒–🔒 Encrypted Data Link

Router

Customers/Operators

...

Buildings

HVAC

Lighting loads

Plug loads

Sensors/power meters

Water meters

PV & storage

Security camera

VirginiaTech
Invent the Future

6

WiseBldg can make
an old building smart

Virginia Tech
Invent the Future

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 (CO_2 levels, PM 2.5).

VirginiaTech
Invent the Future

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

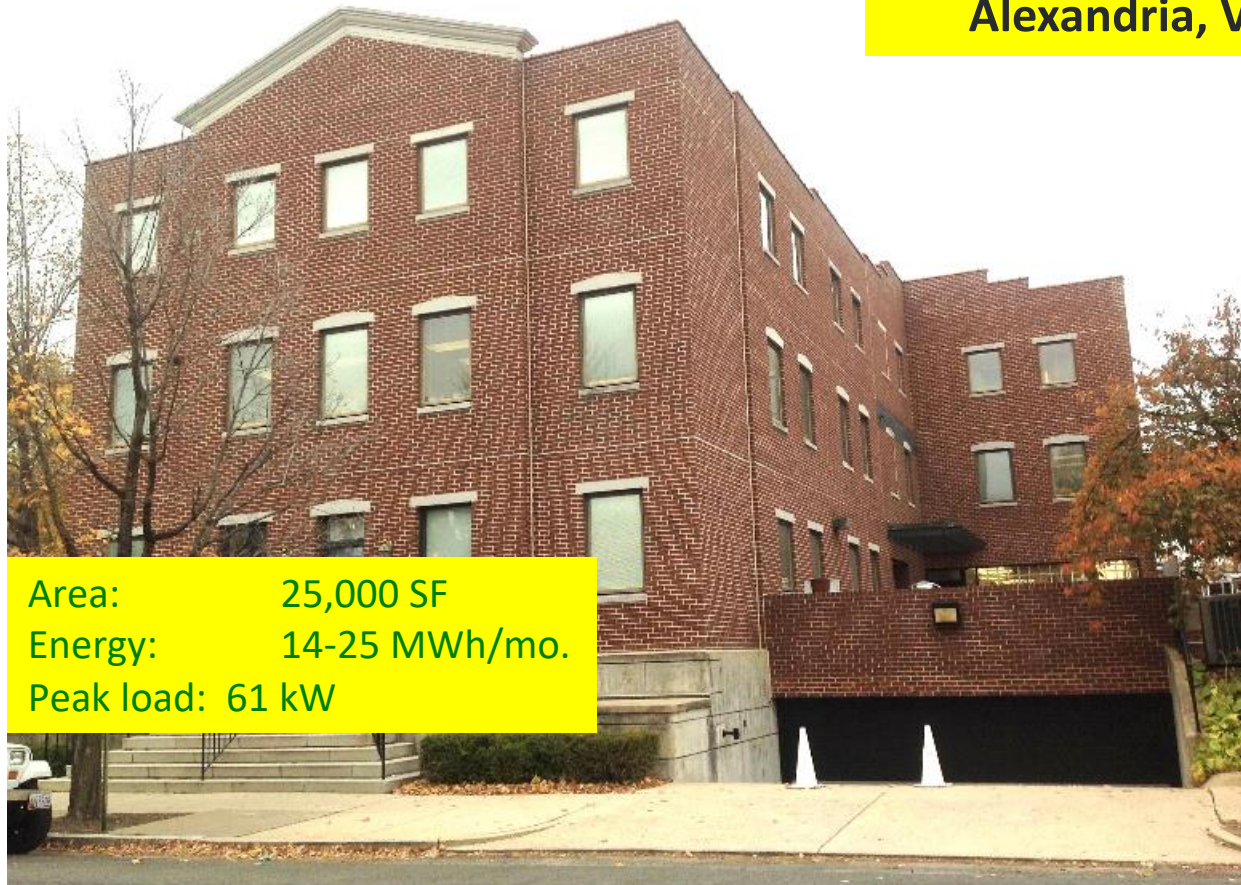- **Location: Blacksburg, VA**
- **Demonstration: HVAC control**

Building 4 – PG County Community Building

- Location: **Camp Springs**, MD
- Demonstration: HVAC control

VirginiaTech
Invent the Future

Building 1 – VT Building in Alexandria, VA

Alexandria, Virginia, USA

Area:	25,000 SF
Energy:	14-25 MWh/mo.
Peak load:	61 kW

VirginiaTech
Invent the Future

Classroom under Real-time Monitoring

Power meter

Environmental sensor (CO2, noise, temperature)

BEMOSS core

Thermostat

Motion sensor

Plug load controller
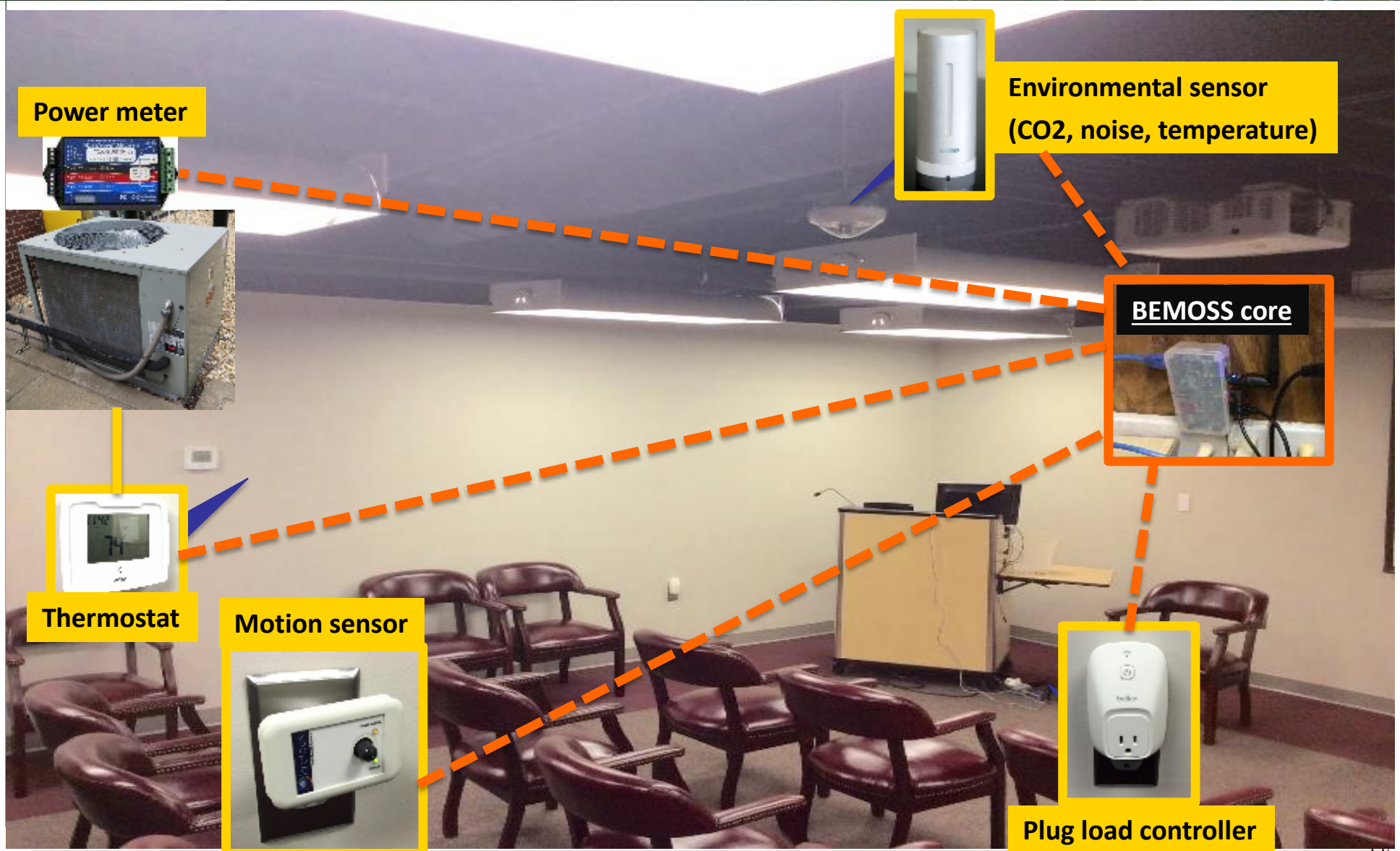
Indoor Environmental Monitoring

BEMOSS

⚠ 19   👤 Admin   ⏻ Log Out

- 🏠 HOME
- 👤 DISCOVER NEW DEVICES
- 🌐 DISCOVER/MANAGE   **6**   ‹
- 📶 NETWORK STATUS   ‹
- 🔔 ALARMS & NOTIFICATIONS   ‹
- 👤 MANAGE USERS   **1**
- 🔑 MISC SETTINGS
- 🖥 BEMOSS CORE

Bemoss Core : Weather_Sensor21

🔖 Indoor Environment Status

TEMPERATURE	HUMIDITY
71.4°F	22.0 %

PRESSURE	CO2	NOISE
30.65 Pa	484.0 ppm	47.0 db

MINIM... RECORDED TEMP...

71

e Recorded: ...
6

🔖 Outdoor Environment Status

TEMPERATURE	HUMIDITY
74.3°F	49.0 %

MAXIMUM RECORDED TEMPERATURE	MINIMUM RECORDED TEMPERATURE
74.3°F	74.3°F
Date Recorded: Wed, 15 Jun 2016, 16:25	Date Recorded: Wed, 15 Jun 2016, 16:25

📊 Weather_Sensor21 : CO2

CO2

CO2 (ppm): 400, 500, 600, 700, 800, 900, 1000, 1100, 1200

Time: 03/22, 09:21 · 03/22, 12:46 · 03/22, 16:10 · 03/22, 19:35 · 03/22, 22:59 · 03/23, 02:24 · 03/23, 05:48 · 03/23, 09:1

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
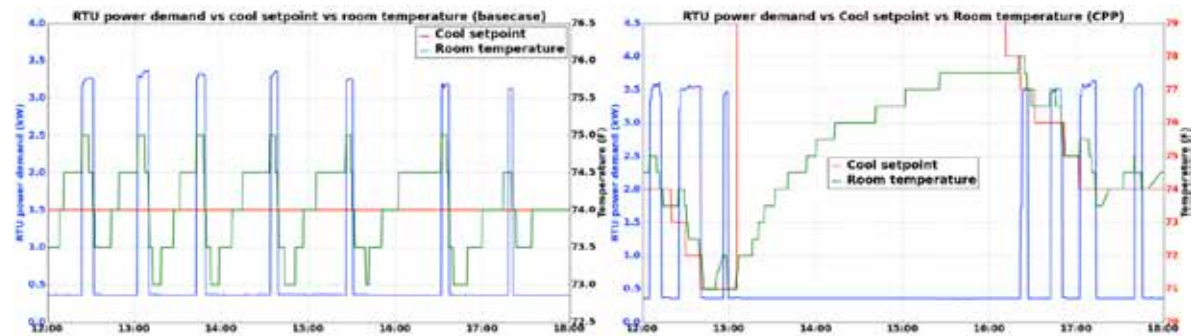- 1 Environmental sensor

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

Temperature profile AFTER WiseBldg Demand Reduction

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

VirginiaTech
Invent the Future

Office Building, Arlington, Virginia

Office building size: 5,000 sqft

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%**

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.

Solar PV System Monitoring and Control

Solar Panels in Winter

VirginiaTech
Invent the Future
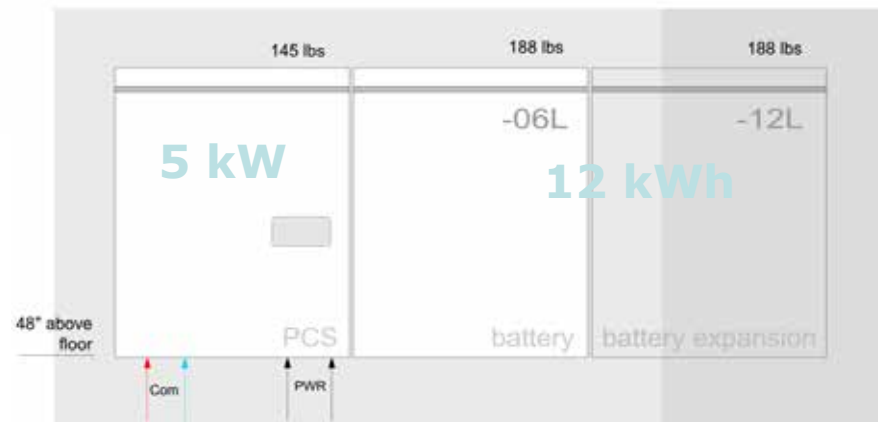
WiseBldg User Interface

Managing Battery Storage from WiseBldg Platform

Battery Cells

5 kW

12 kWh

Battery Storage Data Access from WiseBldg

VirginiaTech
Invent the Future

Battery Storage Monitoring & Control

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

I would like to see a broader IEEE

We need to ensure that we are "READY FOR RECOVERY", when we get back to the "NEW NORMAL" after COVID-19. Let us enhance cooperation, collaboration and community spirit.

For this we need to make IEEE broader so that IEEE is more relevant to the work our members do regardless where they work.

We need more participation from volunteers globally in IEEE governance. A broader based IEEE will make the Institute more relevant to technologists and academics from all parts of the world.

I would like to see more IEEE Senior Members and IEEE Fellows from Regions 8, 9 & 10

24

VirginiaTech
Invent the Future
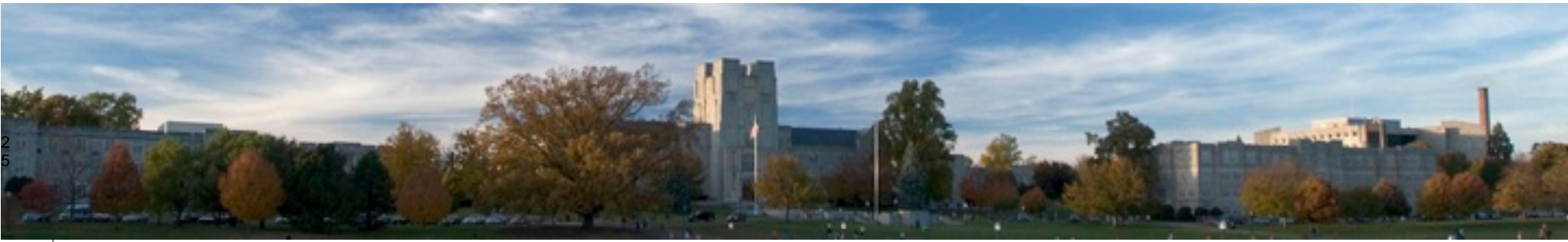
Prof. Saifur Rahman (s.rahman@ieee.org)

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

website: https://www.srahman.org.

VirginiaTech
Invent the Future