

Energy Efficiency in Smart Buildings through IoT Sensor Integration

Invited Speech

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Energy Efficiency in “Smart Buildings”

- Buildings consume over 40% of the total energy consumption in the U.S. Over 90% of the **commercial** 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.
- **Result:** Inefficient building operation, which causes excessive electricity usage and high peak demand, and compromised air quality.

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An Open Architecture IoT Platform for Building Energy Efficiency

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.bemoss.org

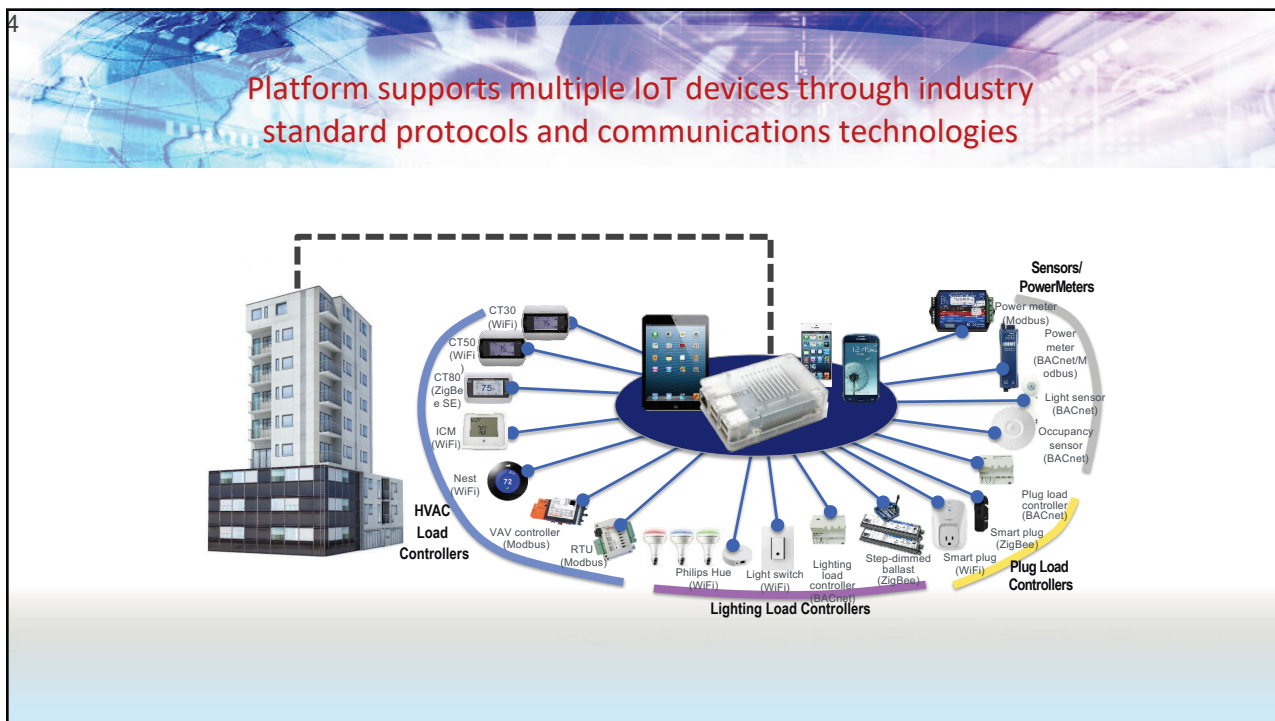
Monitoring and control:

- Heating, Ventilation, AC
- Lighting loads
- Plug loads

Value: Improves energy efficiency and indoor air quality in buildings

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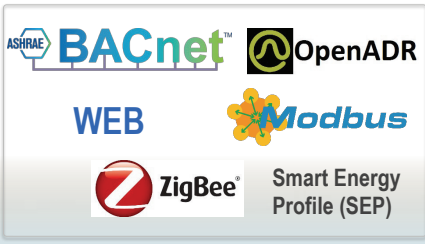
Multiple-protocol Interoperability

Communication Technologies

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

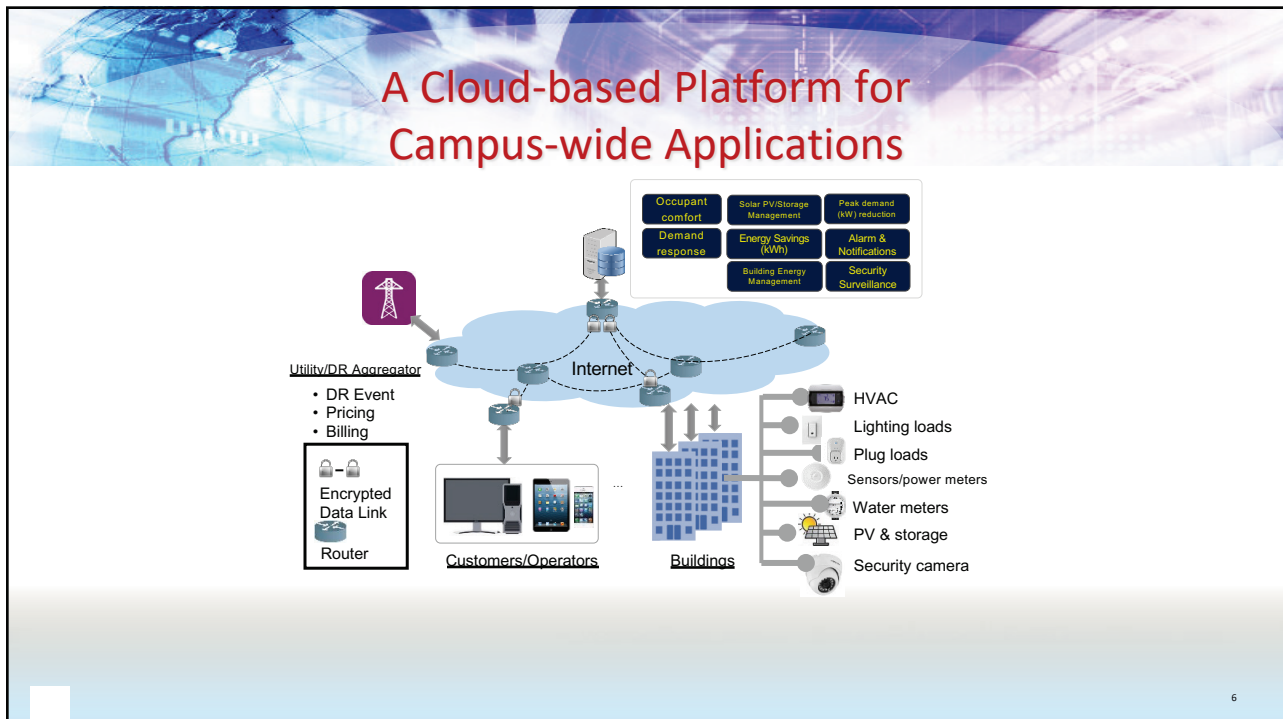
Data Exchange Protocols

- 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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Users 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, SARS Cov-2).

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IoT Platform 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



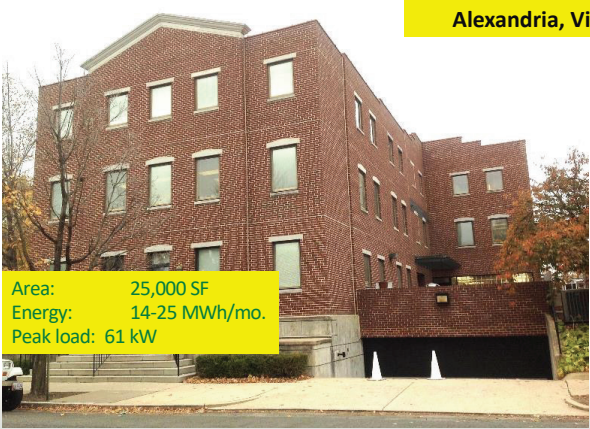
Building 4 – PG County Community Building

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

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Building 1 - VT Building in Alexandria, VA



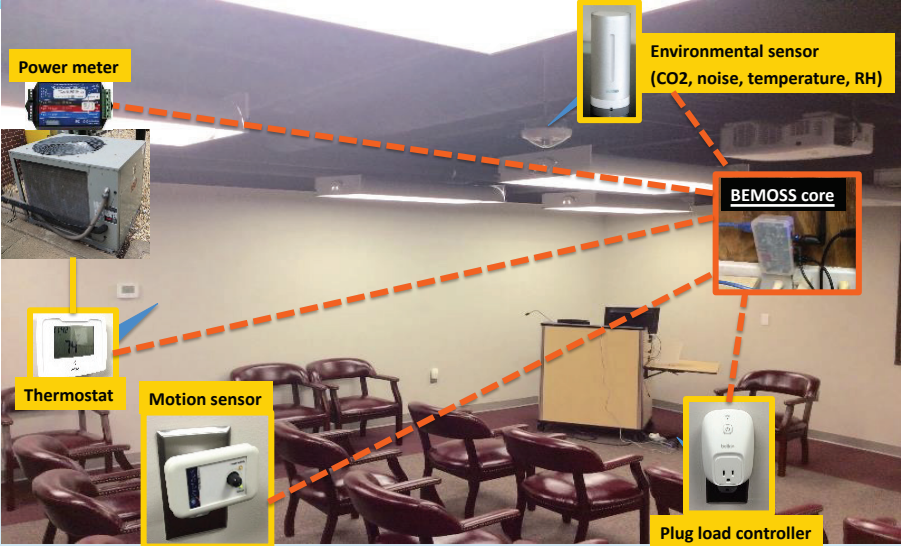
Alexandria, Virginia, USA

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

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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

The screenshot shows the BEMOSS dashboard for 'Bemoss Core : Weather_Sensor21'. It features a sidebar with navigation options: HOME, DISCOVER NEW DEVICES, DISCOVER/MANAGE (5), NETWORK STATUS, and ALARMS & NOTIFICATIONS. The main content area is divided into two sections: 'Indoor Environment Status' and 'Outdoor Environment Status'. The indoor status shows a temperature of 71.4°F and humidity of 22.0%. The outdoor status shows a temperature of 74.3°F and humidity of 49.0%. Below these, there are sections for 'NOISE', 'MAXIMUM RECORDED TEMPERATURE', and 'MINIMUM RECORDED TEMPERATURE'. A CO2 graph titled 'Weather_Sensor21 : CO2' is highlighted with a green border, showing a peak in CO2 levels around 1100 ppm. A blue arrow points from the indoor temperature display to the CO2 graph. A photograph of a brick building is also visible on the left side of the dashboard.

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Commercial Building Ventilation Improvements Possible

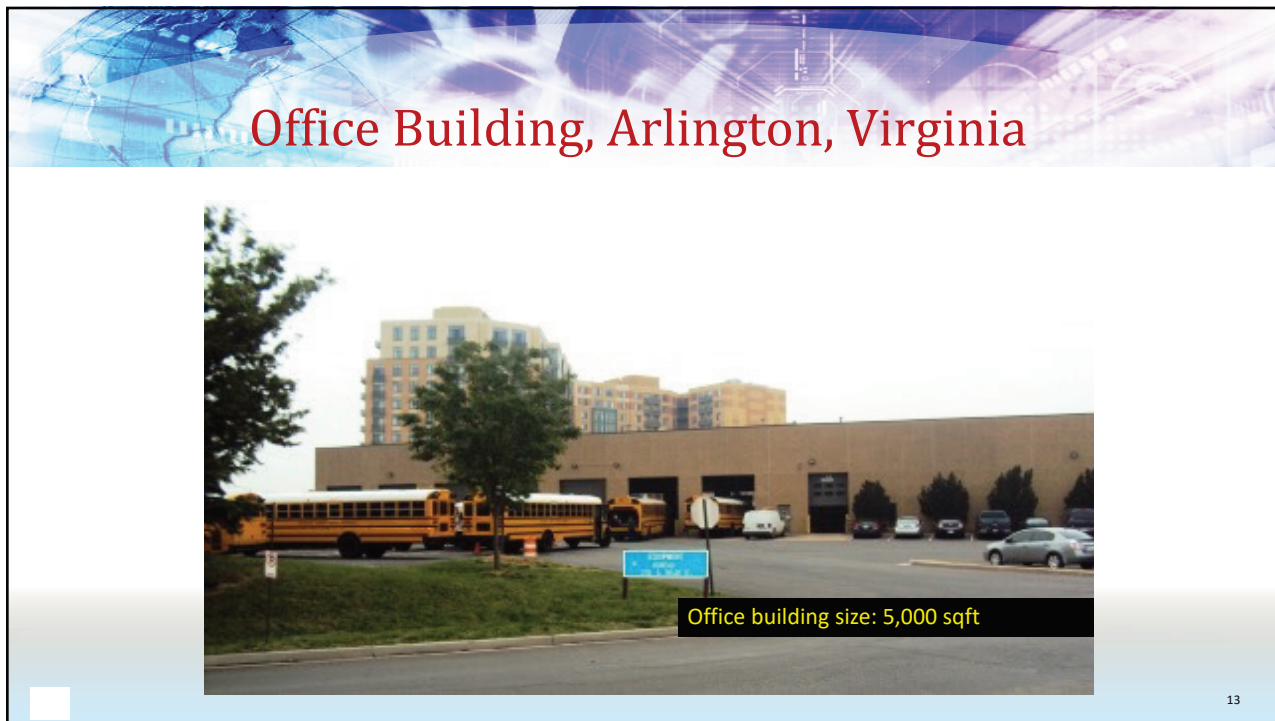


Outdoor Air Intake

IoT sensors Indoor Air Supply Lines



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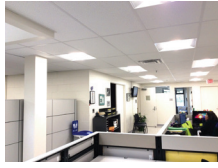

Energy Savings from Lighting Control

Location: Arlington, Virginia

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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Solar PV System Monitoring and Control



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IoT Platform User Interface



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Managing Battery Storage from IoT Platform



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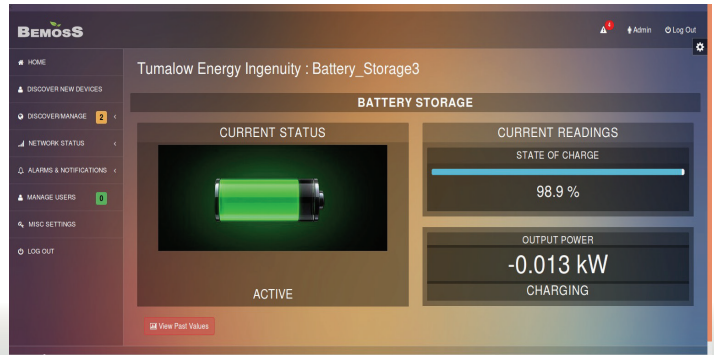
Battery Storage Data Access from IoT Platform



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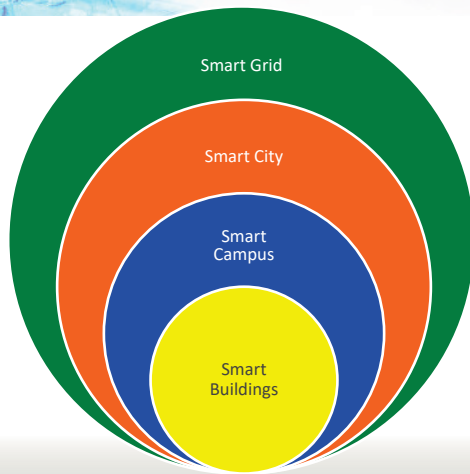
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Battery Storage Monitoring & Control



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The Smart Grid Ecosystem



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.

Supported by ICT and distributed networks of intelligent sensors, data centers/clouds

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Thank You



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IEEE President Election
www.ieee.org/elections

