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BEM CONTROLS

Role of IoT in Energy Efficiency In a Smart City Connected Community

Invited Talk

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

Beijing Jiao Tong University, China, 23 November 2019

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Virginia Tech Research Center
Arlington, Virginia, USA

PPT slides will be available at

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Role of IoT in Energy Efficiency in a Smart City Connected Community
Global Electric Power Sector: Engaging with Environmental Issues
Role of IoT in Energy Efficiency and Public Safety in a Smart City Connected Community
An Energy Internet Platform for Transactive Energy and Demand Response Applications
Innovations in Power & Energy Society Smart Grid for Integration of Renewables
Saifur Rahman, PhD
Keynote Speech
The Smart City Building Blocks and Their Synergy with Smart Villages
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What is a Smart City

- There is no single consensus definition of a smart city, but there is some agreement that a smart city is one in which information and communication technology (ICT) facilitates improved insight into and control over the various systems that affect the lives of residents.

Picture from: http://politic365.com/2017/09/01/smart-cities-require-smart-planning-policy-to-benefit-communities/

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Building Blocks of a Smart City

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Range of Deployments in Smart Cities

Cities across the world are deploying technology to gather data trying to become cleaner, reduce traffic, and improve urban life. Starting with energy management, to disaster preparedness, to public safety, to parking spot assistance, to paying bills online, to facilitate emergency vehicle movement, and much more.

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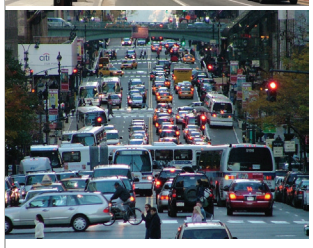
Elements of a Smart City



A neighborhood in a smart city:

- A smart traffic crossing sensitive to traffic volume
- Synchronized traffic lights for smooth flow
- Emergency vehicle priority access

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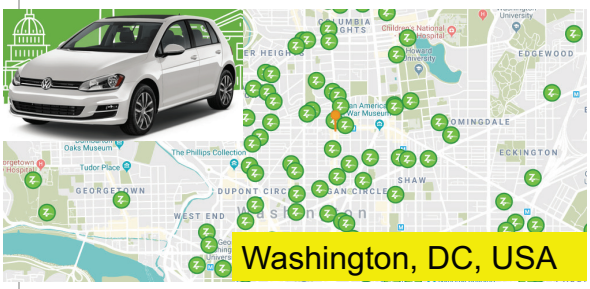
Connected Transportation

- Connected vehicles and travelers will be able to share data with all sorts of equipment, and be able to procure mobility as a service, whenever wherever.



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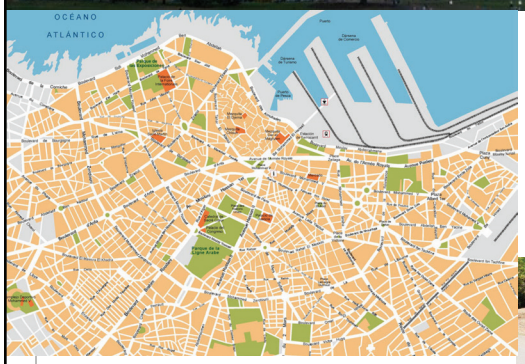

Casablanca, Morocco

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Stockholm City Traffic Management

The system allows buses that are more than a minute behind schedule to automatically receive priority at traffic lights

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Internet of Things (IoT)

IoT-enabled smart buildings offer in-building device mobility, occupant comfort, and indoor activities automation

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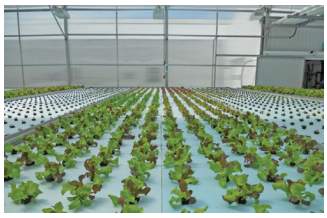
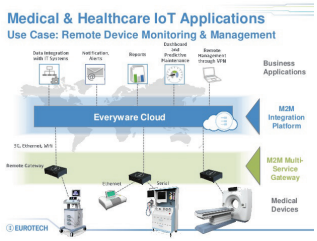
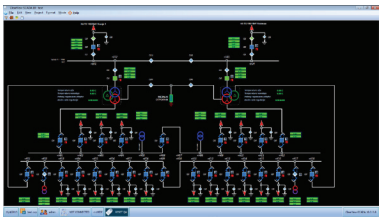
IoT Applications in Healthcare, Agriculture, Transport, Energy







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How do you make a large number of IoT devices work together?

Need a software platform

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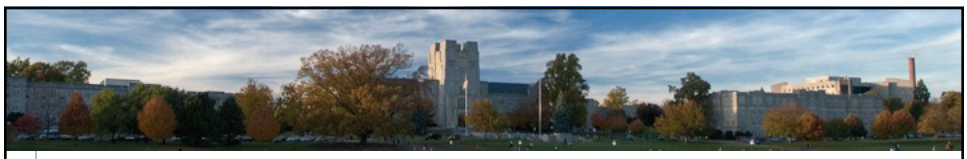

WiseBldg

WiseBldg

An open-architecture software platform that can monitor and control any IoT device with a known API

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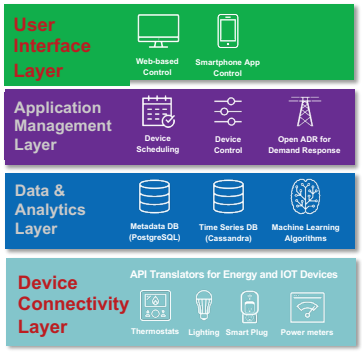
WiseBldg: Building Energy Management Platform

Platform Architecture



Overview

WiseBldg (pronounced "Wise Building") is BEM Controls' powerful, low-cost, open-architecture software platform that can monitor and optimally control major electrical loads (e.g., HVAC, lighting and plug loads), as well as solar PV systems, energy storage units and other IoT sensors in commercial buildings. It is built on the DoE-sponsored BEMOSS platform developed at Virginia Tech.

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WiseBldg: Range of Applications

- **Open, Modular Platform that grows with customer needs**: Start small, add new buildings, open devices at any time
  - *Energy* – HVAC, Lighting, Plug-loads
  - *DERs* – Solar, Battery Storage
  - *Other IOT* – Environmental sensors, Security cameras
- **Easy to operate and maintain:** End-user installs their own *hardware* and controls the system based on insights from WiseBldg and their own daily needs
- **Realtime control:** Take action based on existing situations
- **Analytics**: Smarter and more accurate control informed by load forecasting
- **Future-ready**: AI-driven, blockchain capable

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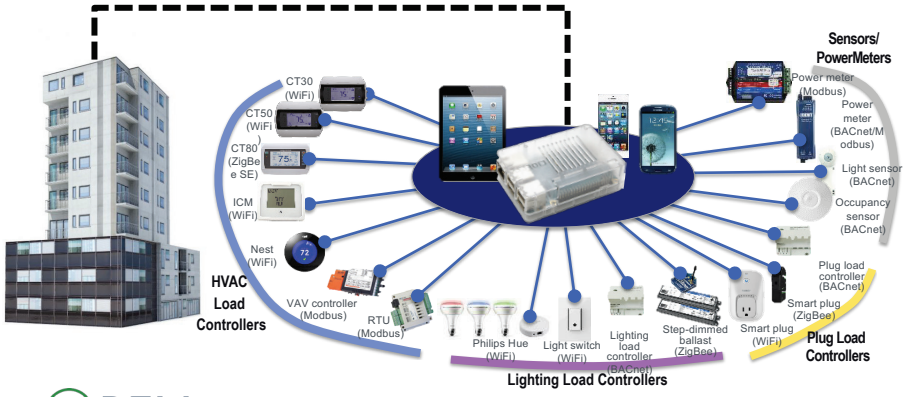
WiseBldg supports multiple IoT devices through industry standard protocols and communications technologies



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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)

IEEE 802.3
IEEE 802.11
WiFi
IEEE 802.15.4
RS-485
BACnet
OpenADR
WEB
Modbus
ZigBee
Smart Energy Profile (SEP)

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Experience from building c ontrols

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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Energy Savings from Sensor Deployment & Control

25,000 sqm building in Alexandria, VA

5 Wireless thermostats

Raising the set point from 6am-6pm demonstrates 10.5% energy savings in HVAC load per degree temperature increase.

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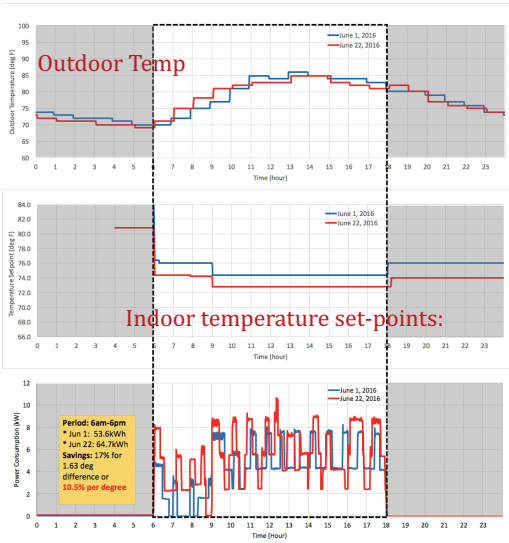

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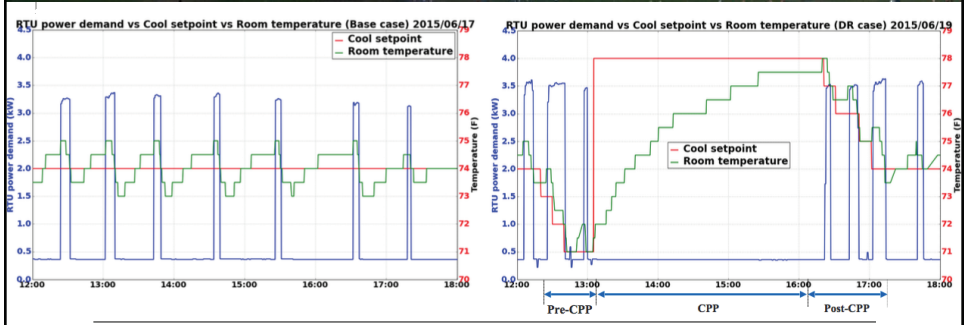
Pre-cooling to cut Peak-time Demand



Parameter	Study Period (12:24-17:14 hrs)		Pre-CPP (12:24 – 13:04 hrs)		CPP (13:04 – 16:04 hrs)		Post-CPP (16:04 – 17:14 hrs)	
	Base case	DR case	Base case	DR case	Basecase	DR case	Basecase	DR case
max(P_{RTU})	**3.37 kW**	**3.63 kW**	3.29 kW	3.56 kW	**3.37 kW**	**0.37 kW**	3.19 kW	3.63 kW
E_{RTU}	**3.51 kWh**	**3.9 kWh**	0.70 kWh	1.18 kWh	**2.16 kWh**	**1.08 kWh**	0.65 kWh	1.64 kWh

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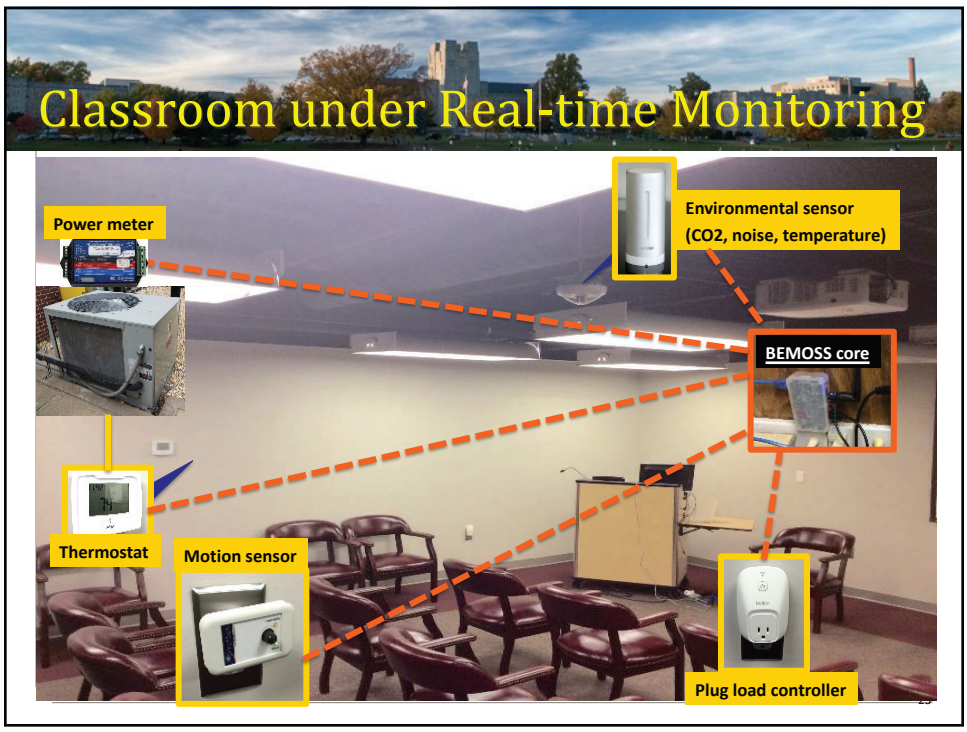
Classroom under Real-time Monitoring
Power meter
Environmental sensor
(CO2, noise, temperature)
BEMOSS core
Thermostat
Motion sensor
Plug load controller

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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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Smart Light Intensity Control

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Energy Savings by Controlling Light Intensity

Based on occupant requirements, light intensity level was reduced during October – December 2016. Results indicate **the average kWh savings of about 34%**.

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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Electricity Savings in Street Lighting
#1
#2
#3
#4
#5
#6
#7
#8
MacArthur Blvd
Clara Barton Pkwy

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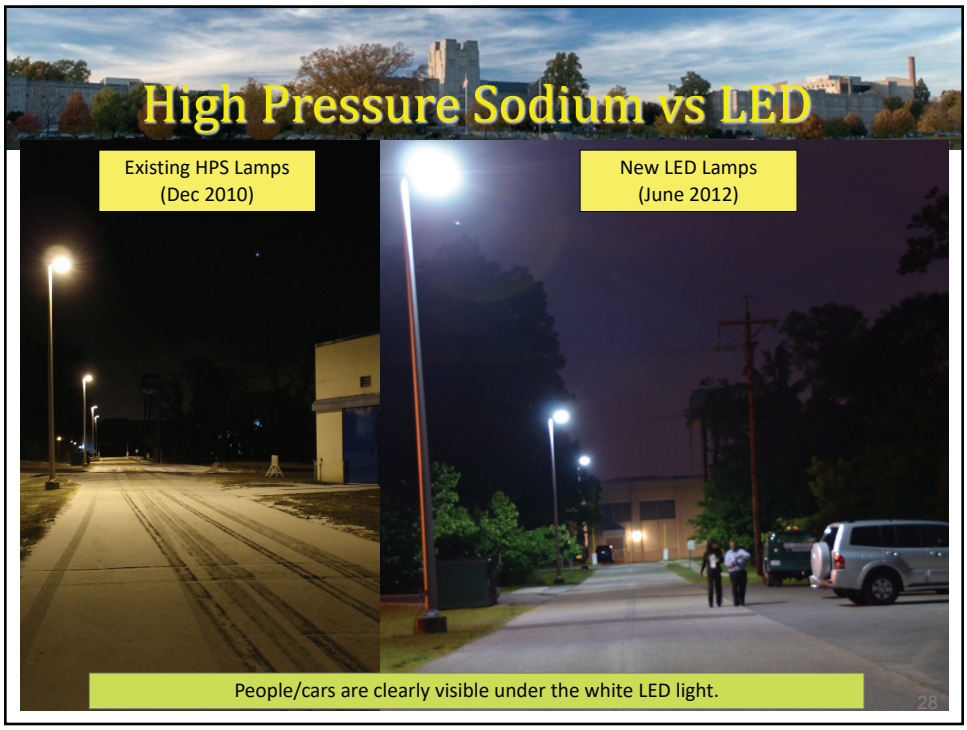
High Pressure Sodium vs LED
Existing HPS Lamps
(Dec 2010)
New LED Lamps
(June 2012)
People/cars are clearly visible under the white LED light.

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ICT-based Lighting Intensity control (80%)

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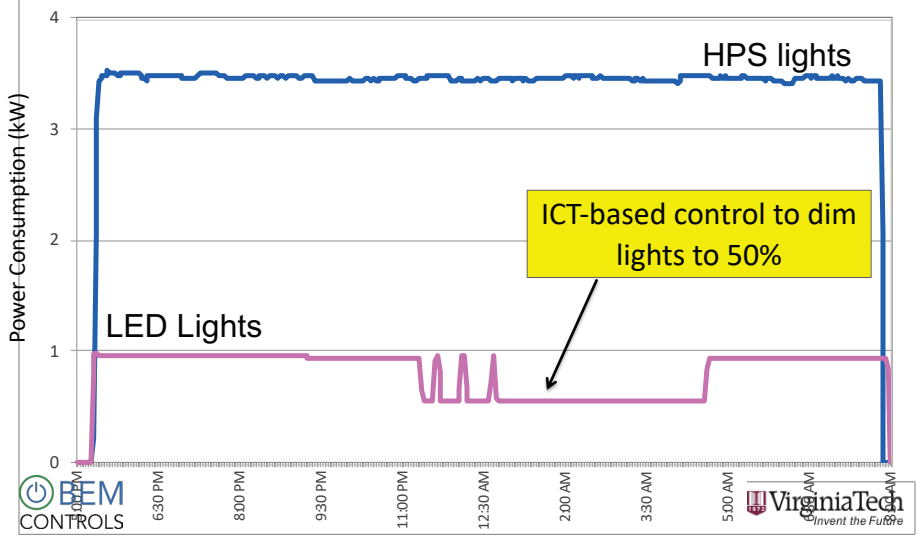
Infrared Sensors Monitor Traffic



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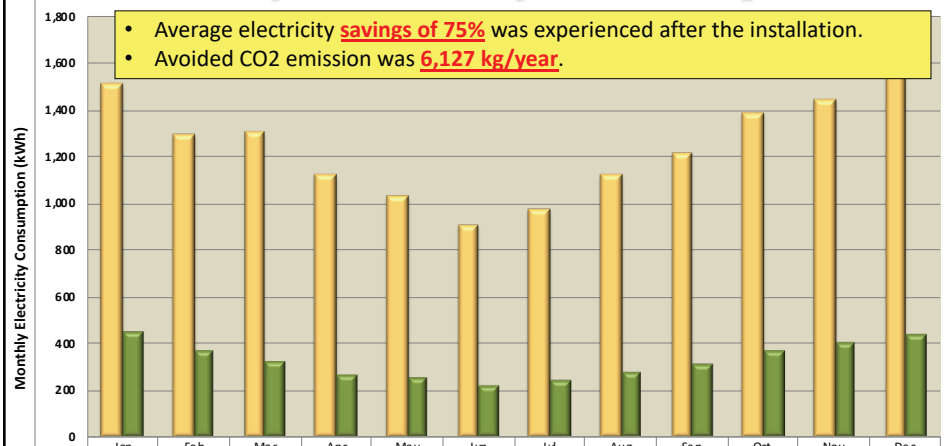
HPS vs LED
Monthly Electricity Consumption

- Average electricity **savings of 75%** was experienced after the installation.
- Avoided CO2 emission was **6,127 kg/year**.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HPS (2011)	1,510	1,289	1,300	1,116	1,027	903	972	1,123	1,210	1,384	1,444	1,552
LED (2012)	444	371	319	264	253	222	240	275	306	364	397	433

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Solar PV System Monitoring and Control

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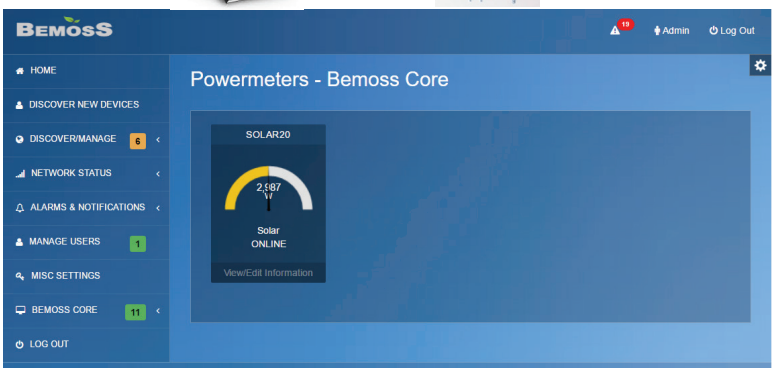
Solar PV and Smart Inverter Integration



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WiseBldg User Interface

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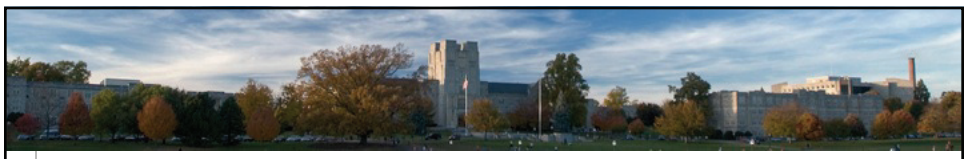
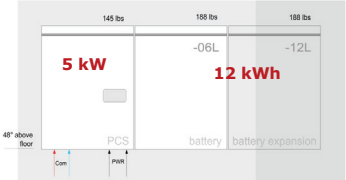


Managing Battery Storage from WiseBldg Platform

Battery Cells

LG Chem



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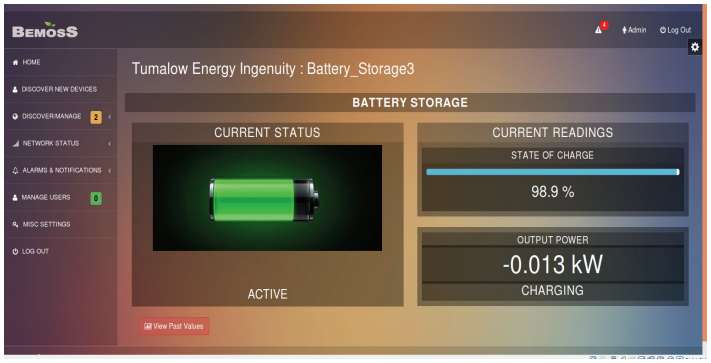
Battery Storage Monitoring & Control



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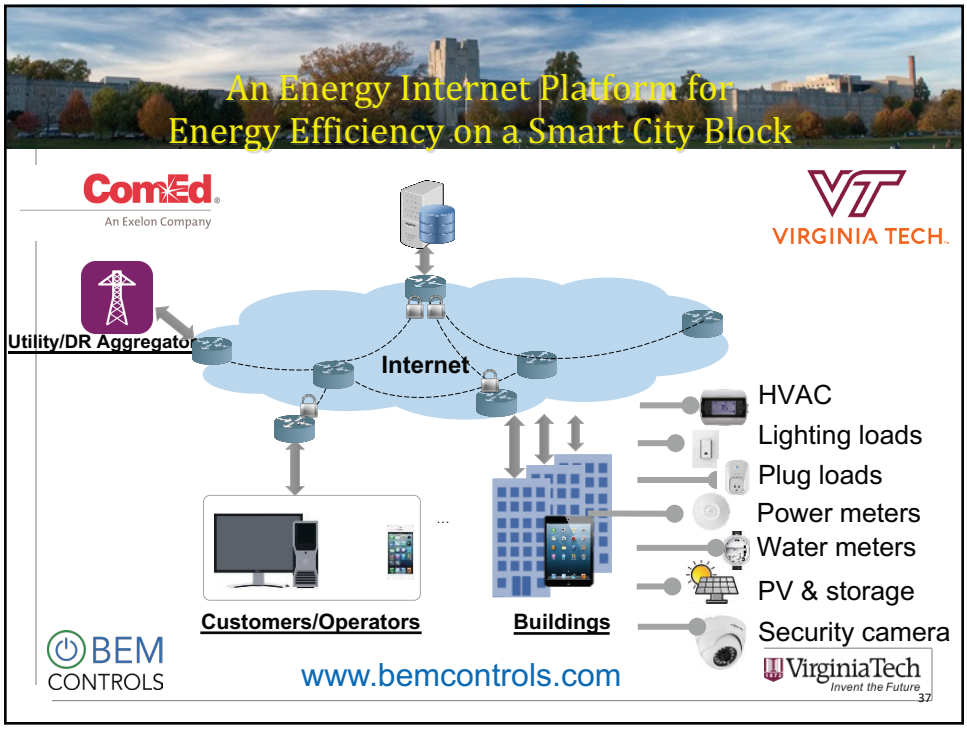
An Energy Internet Platform for
Energy Efficiency on a Smart City Block
ComEd
An Exelon Company
VIRGINIA TECH
Utility/DR Aggregator
Internet
HVAC
Lighting loads
Plug loads
Power meters
Water meters
PV & storage
Security camera
Customers/Operators
Buildings
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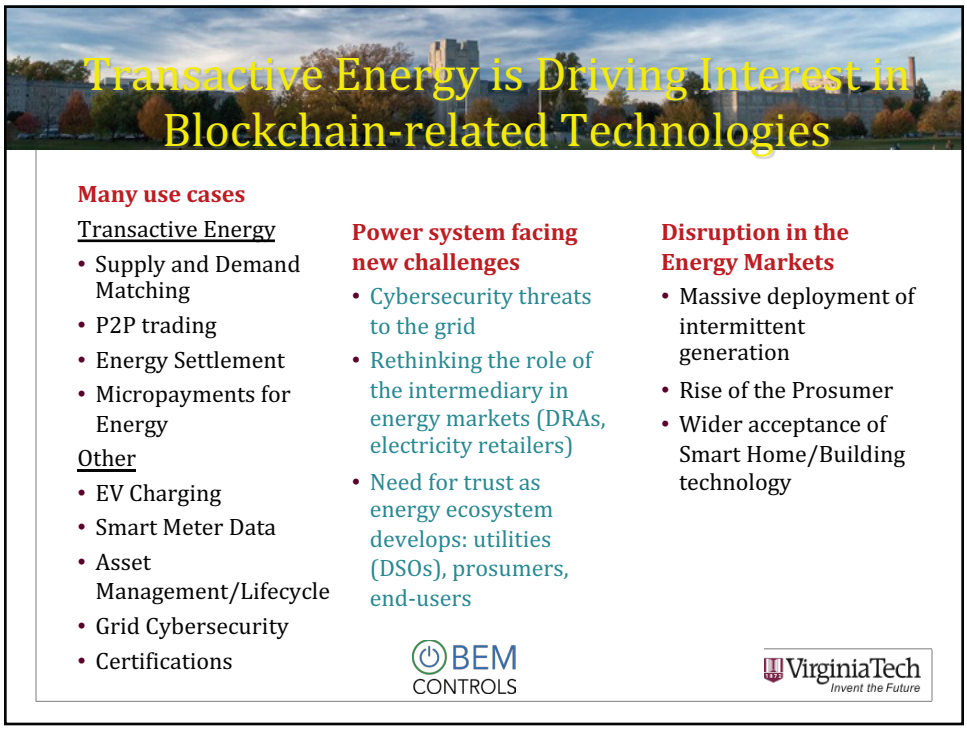
Transactive Energy is Driving Interest in
Blockchain-related Technologies
Many use cases
Transactive Energy
• Supply and Demand Matching
• P2P trading
• Energy Settlement
• Micropayments for Energy
Other
• EV Charging
• Smart Meter Data
• Asset Management/Lifecycle
• Grid Cybersecurity
• Certifications
Power system facing new challenges
• Cybersecurity threats to the grid
• Rethinking the role of the intermediary in energy markets (DRAs, electricity retailers)
• Need for trust as energy ecosystem develops: utilities (DSOs), prosumers, end-users
Disruption in the Energy Markets
• Massive deployment of intermittent generation
• Rise of the Prosumer
• Wider acceptance of Smart Home/Building technology
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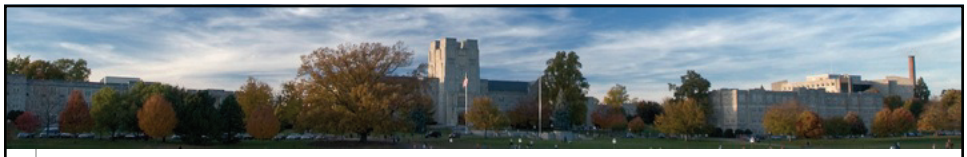
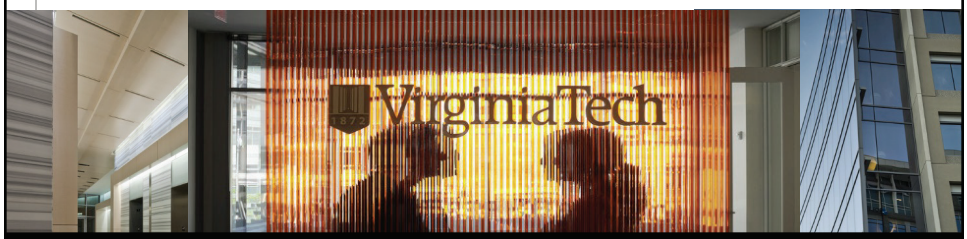


Thank You



Professor Saifur Rahman
Director, Advanced Research Institute
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