VIRGINIA TECH

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Invited Talk

IEEE Smart Cities Week 2022

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Smart Energy Efficiency in Smart Cities

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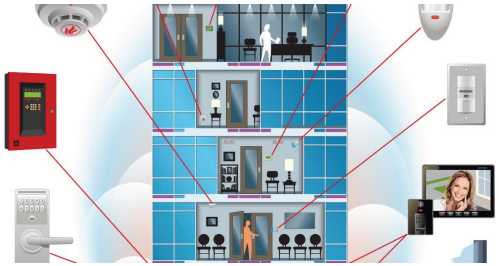
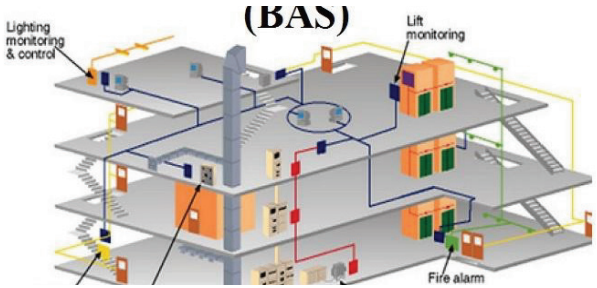
2022 IEEE President-elect



Building Energy Efficiency



- 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 (<500 sq m) or medium-sized (between 500 sq m and 5,000 sq m).
- These buildings typically do not use Building Automation Systems (BAS) to monitor and control their building systems from a central location.
- **Need to** facilitate energy efficiency applications in commercial buildings using a very simple and scalable building automation system (BAS).

An Open Architecture Platform for Building Energy Efficiency

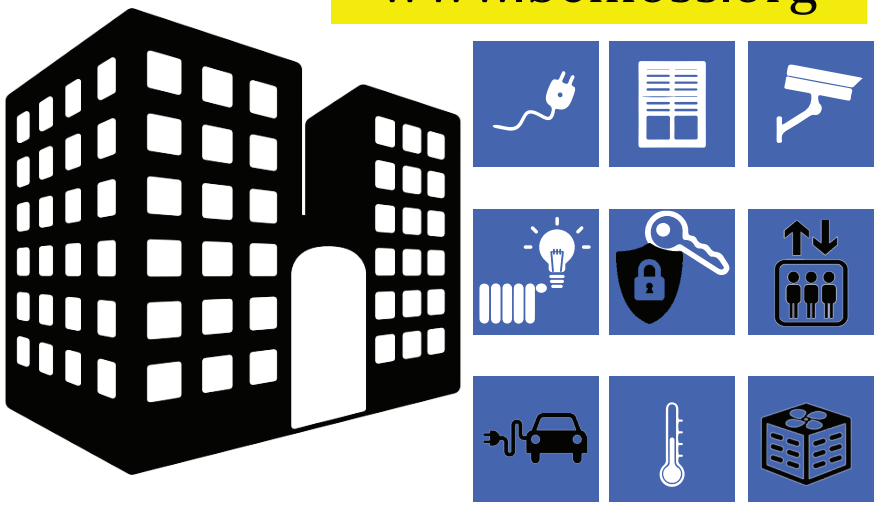
BEMOSS ❯ **It is a Building Energy Management Open Source Software solution** that is engineered to improve sensing and control of all IoT-enabled equipment in commercial buildings

Monitoring & Control ❯ **Three major loads in buildings**

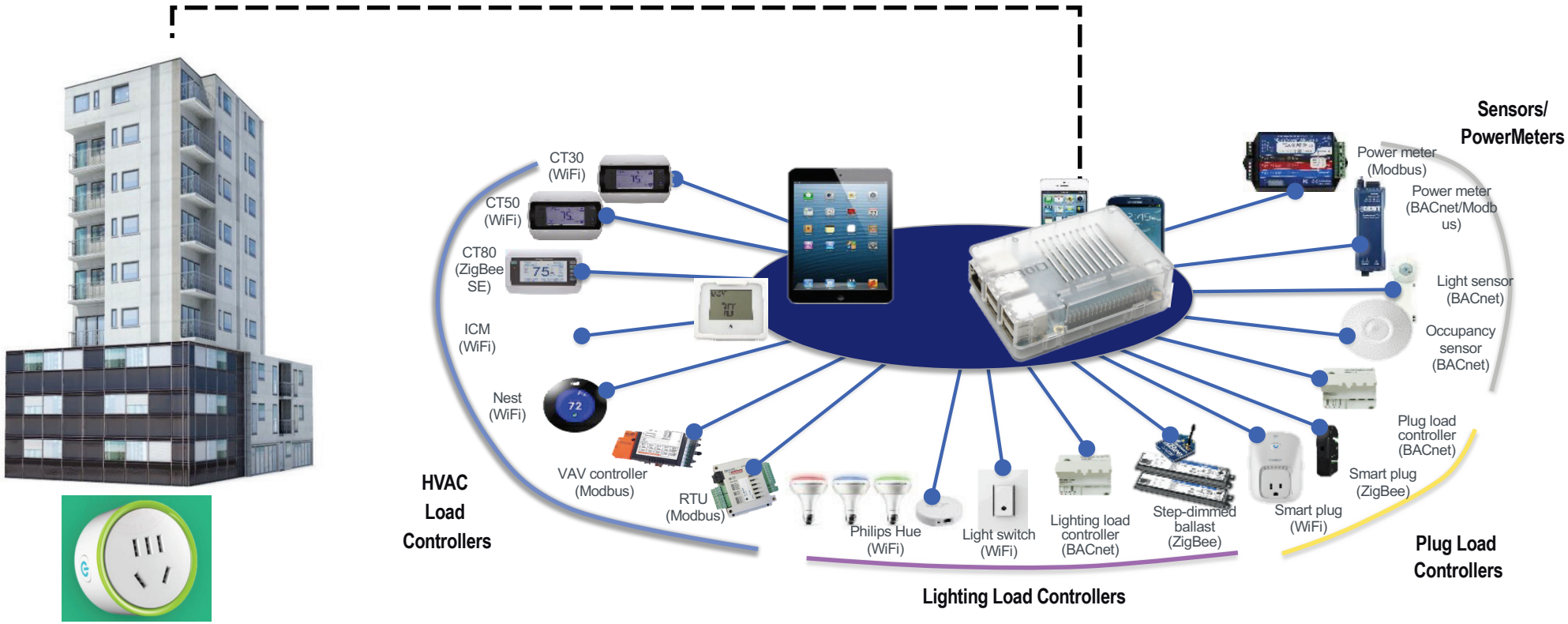
- Heating, Ventilation, AC
- Lighting loads
- Plug loads

Value ❯ Improves energy efficiency and facilitates peak load savings in commercial buildings.

www.bemoss.org



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)

IEEE 802.3

IEEE 802.11 abg WiFi n ac

IEEE 802.15.4

RS-485

IOT

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)

ASHRAE BACnet™

OpenADR

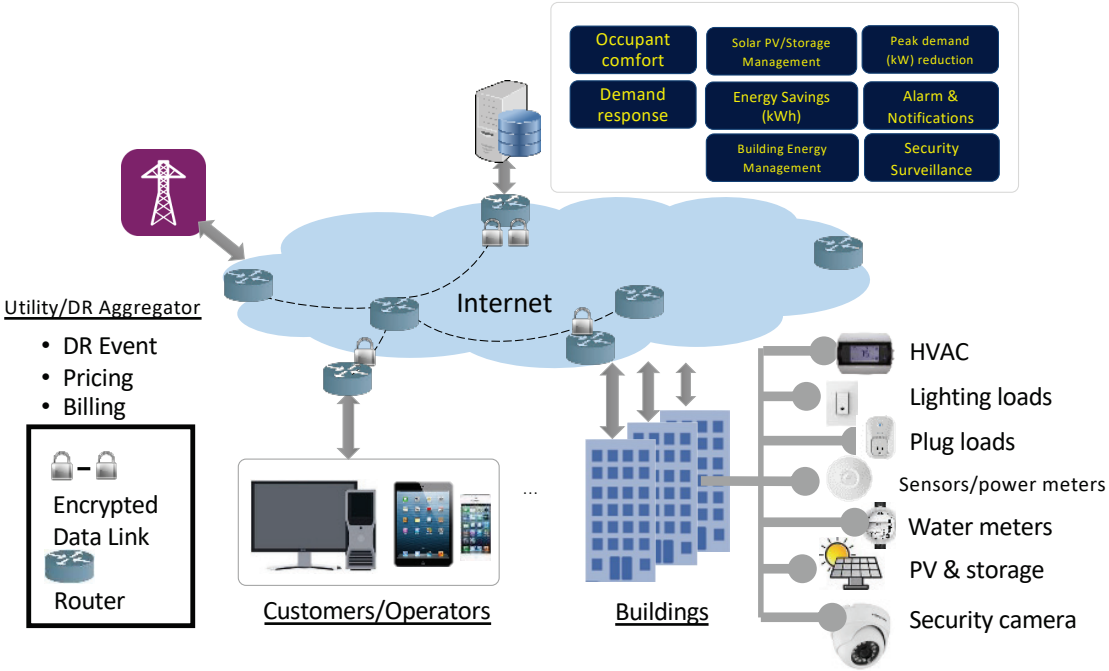
WEB

Modbus

ZigBee®

Smart Energy Profile (SEP)

Campus-wide Application



www.bemconrtrols.com

How to make an old building smart

Customers Controlling Buildings Optimized for Savings

Measured energy savings across deployments

Improved operations and maintenance: Building automation system (BAS) 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 BAS 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).

Building 1 – VT Building in Alexandria, VA

Area: 2,500 sq m
Energy: 14-25 MWh/mo.
Peak load: 61 kW

Alexandria, Virginia, USA

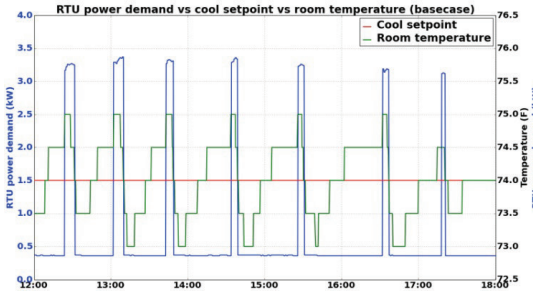
Energy and Peak Savings from HVAC Control

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

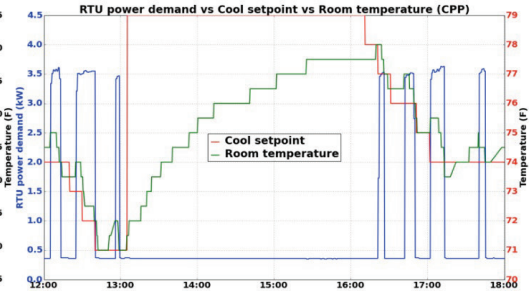
Using BAS, Building Operator saved 27% on HVAC consumption alone




Temperature profile BEFORE BAS Demand Reduction



Temperature profile AFTER BAS Demand Reduction



Summer Months (June-July-August)	
Compressor consumption 2014 (Before BAS)	8,340 kWh
Compressor consumption 2016 (After BAS)	6,071 kWh
Average savings	**26.8% savings**

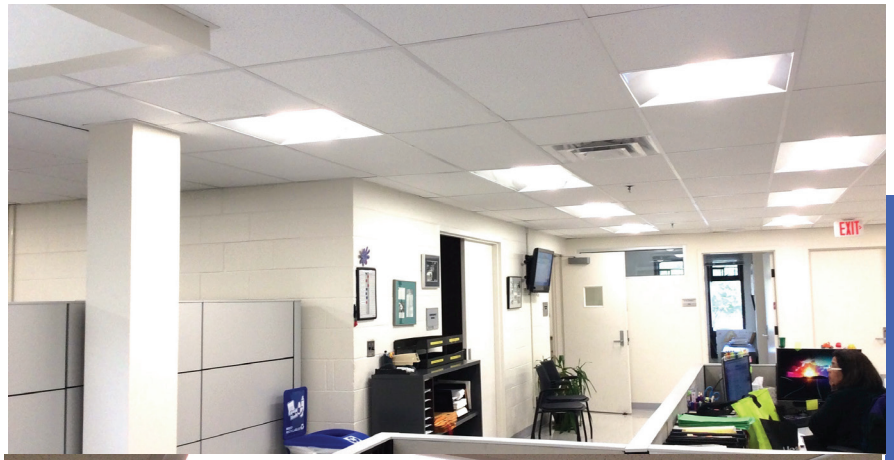
Base case (w/o WiseBldg)

- **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

Energy Savings from Lighting Control



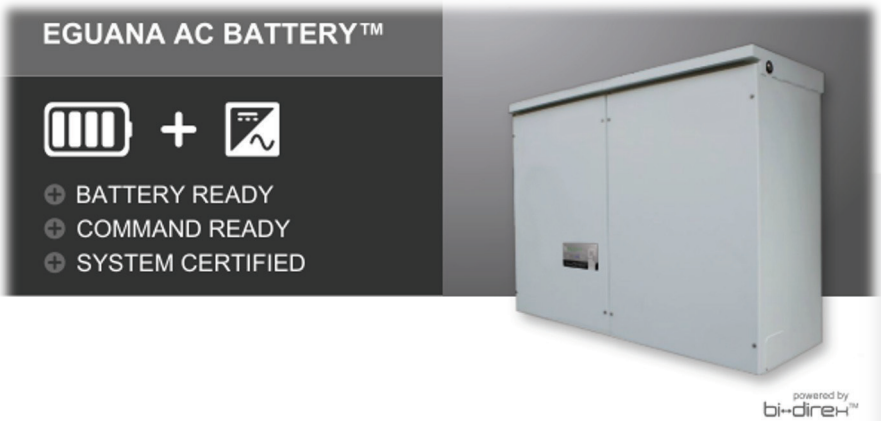
Location: Arlington, VA
Area: 5,000 sq ft
Deployed Devices

- 3 Lighting controllers
- 1 Power meter

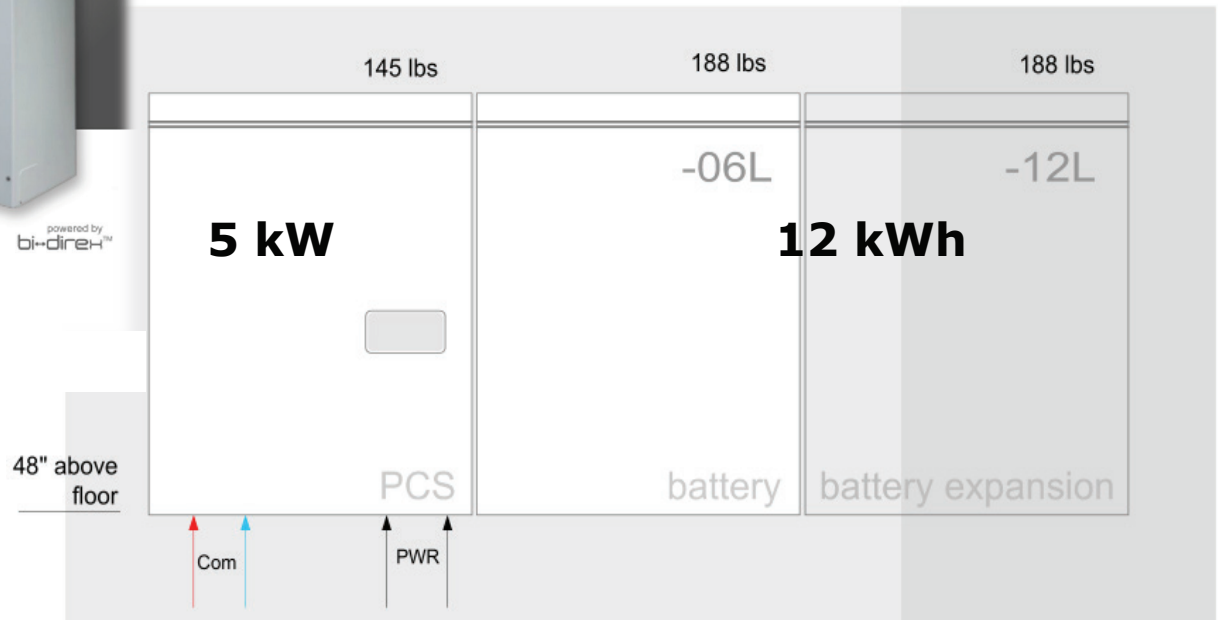
An Average Energy Savings Of 35% Was Achieved Through Dimming Control

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%**

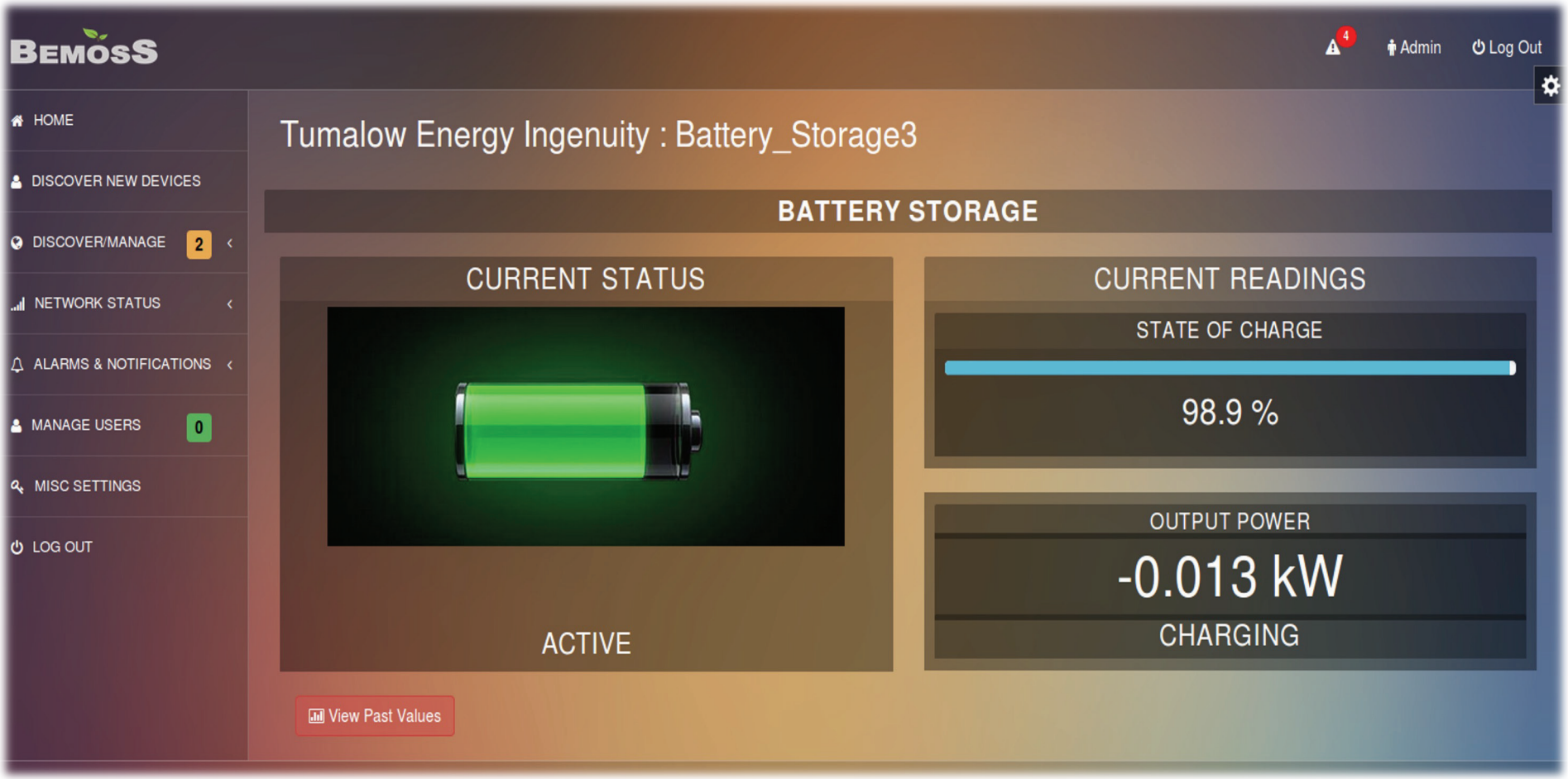
Managing Battery Storage



Battery Cells LG Chem



Battery Storage Monitoring & Control



What is a Smart City

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

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.

https://medium.com/zify/the-importance-of-smart-cities-2a4f7f89a6cd

Internet Of Things

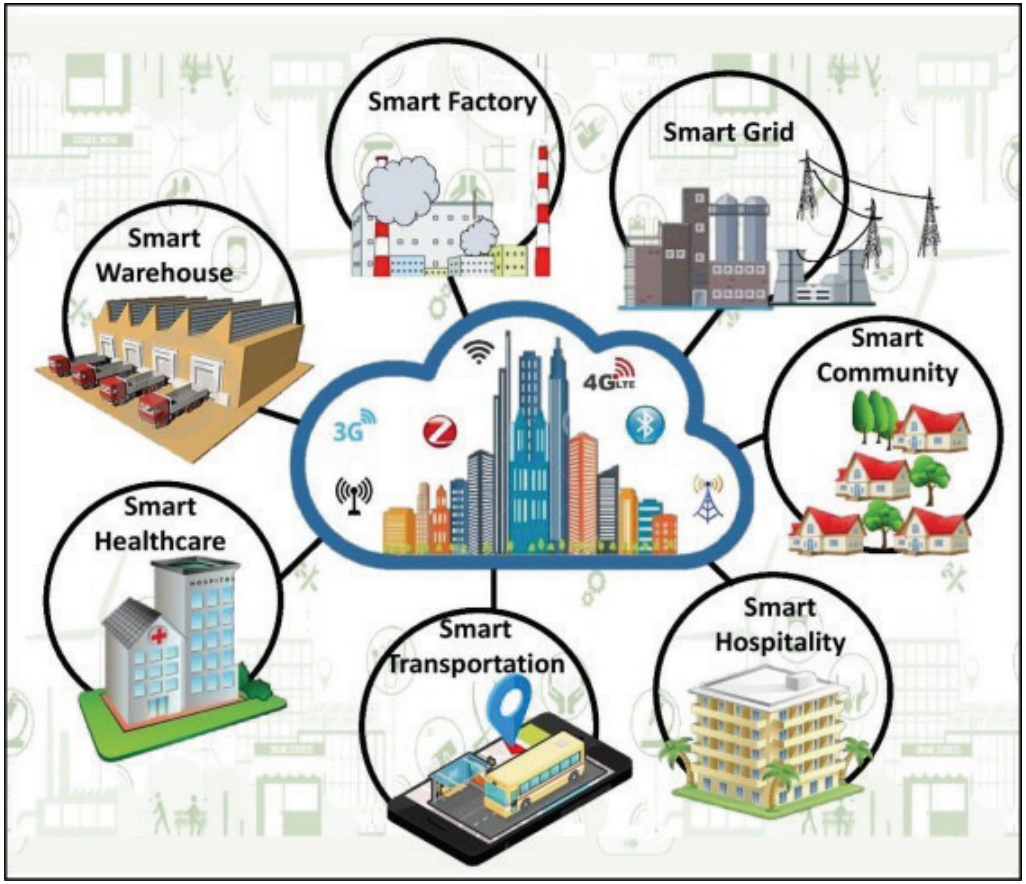
Smart City

A **smart city** is an urban development vision to Integrate Information and Communication technology (ICT) and Internet of Things (IoT) technology in a Secure fashion to manage a city's assets.

To be fully "smart," a city must be "connected."

Building Blocks of a Smart City

Range of Deployments in a Smart City

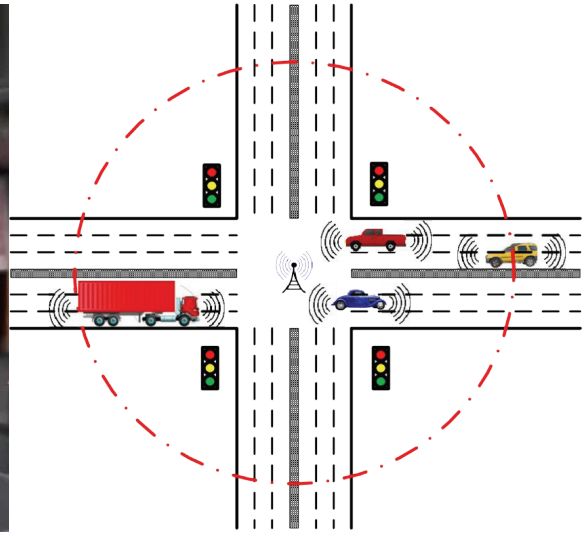


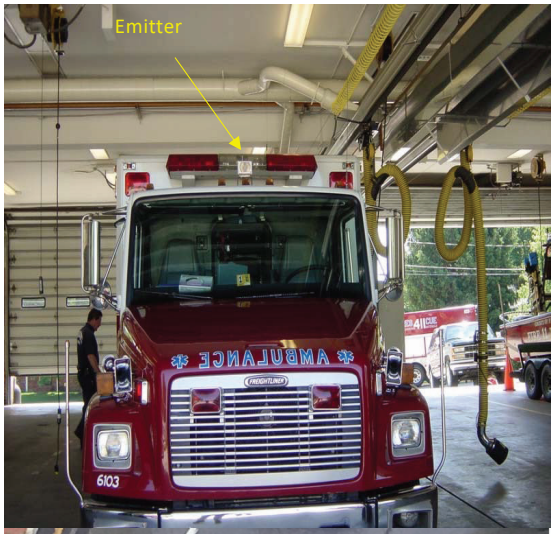
Cities across the world are deploying technology to gather data trying to become cleaner, reduce traffic, and improve urban life. Starting with energy management, to disaster preparedness, to public safety, to parking spot assistance, to paying bills online, to facilitate emergency vehicle movement,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

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





Optical Based Traffic Signal Preemption System For Emergency And Transit Vehicles

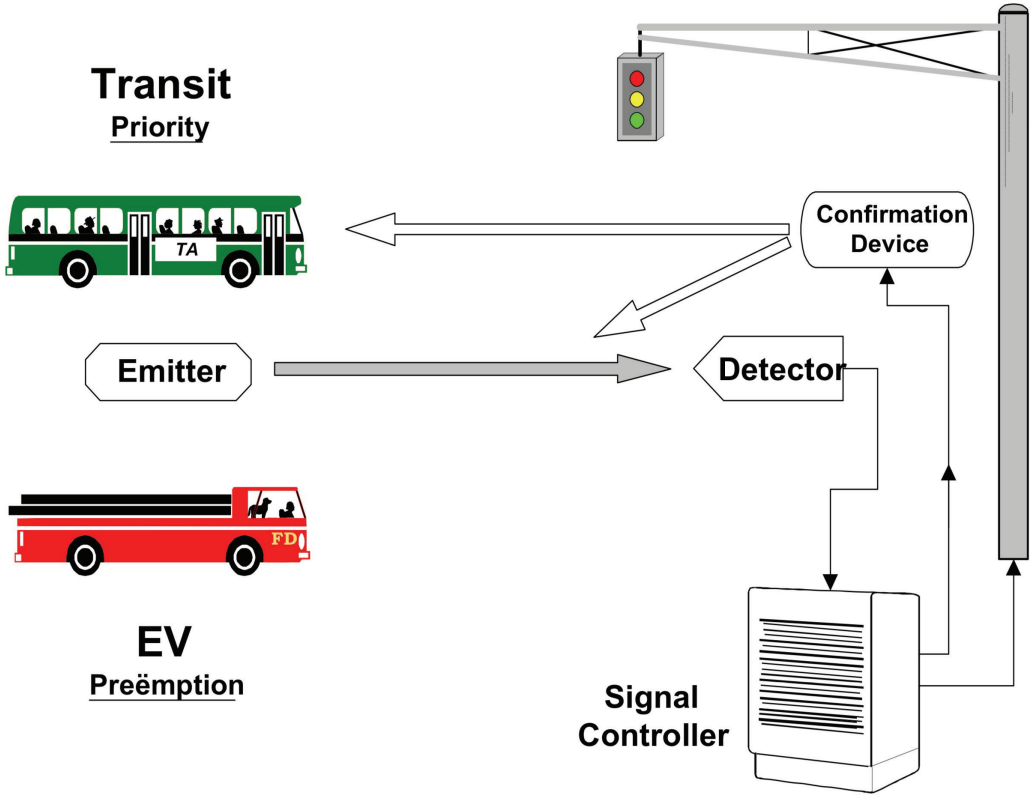
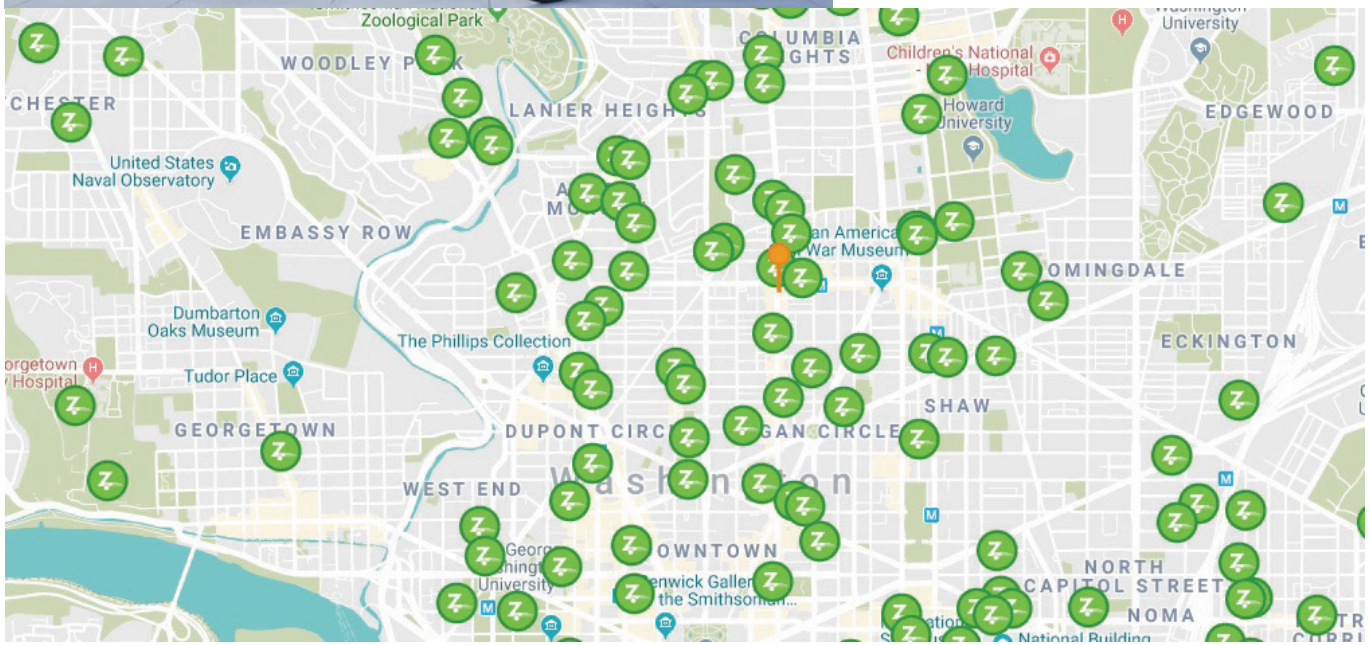


Figure 12 : System Architecture for 3M Opticom Emitter Detection System

https://vtechworks.lib.vt.edu/bitstream/handle/10919/31319/ThesisFinalVersion.pdf?sequence=1


Connected
Transportation

Connected Transportation



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.

Stockholm City Traffic Management

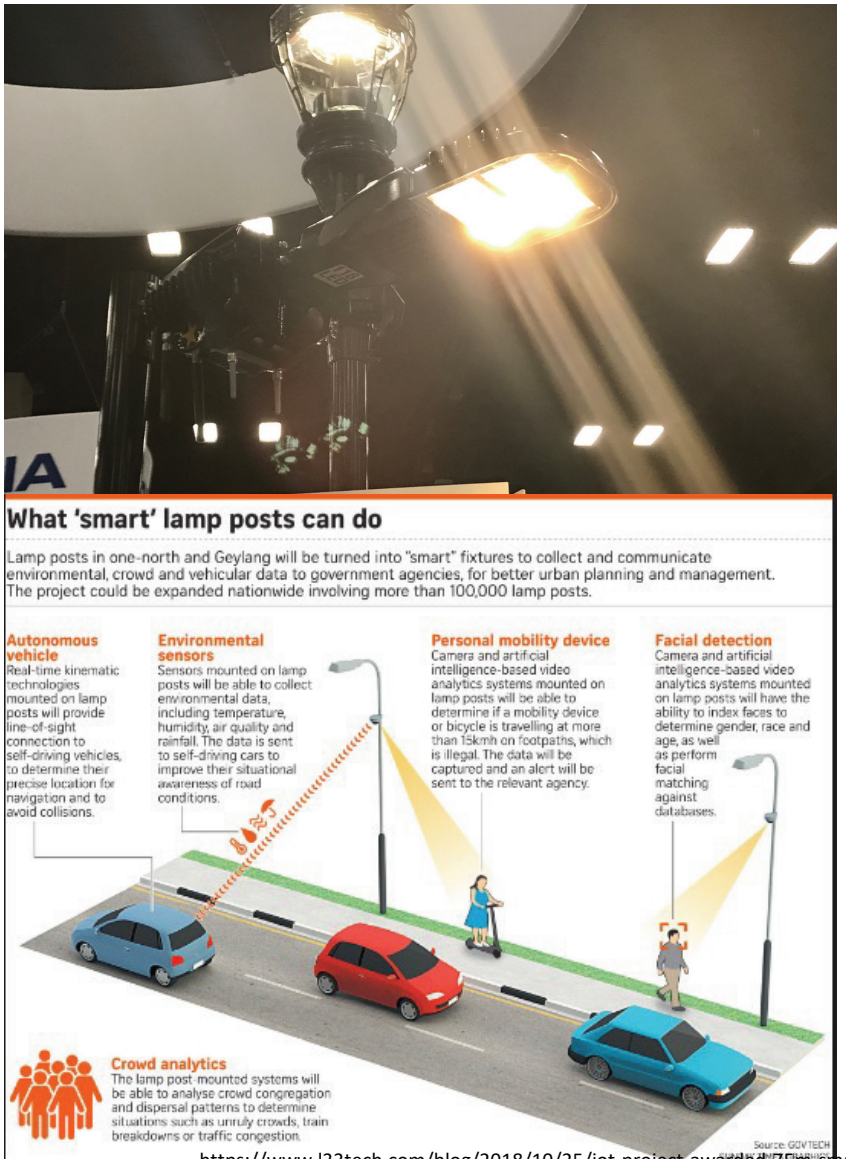
Stockholm

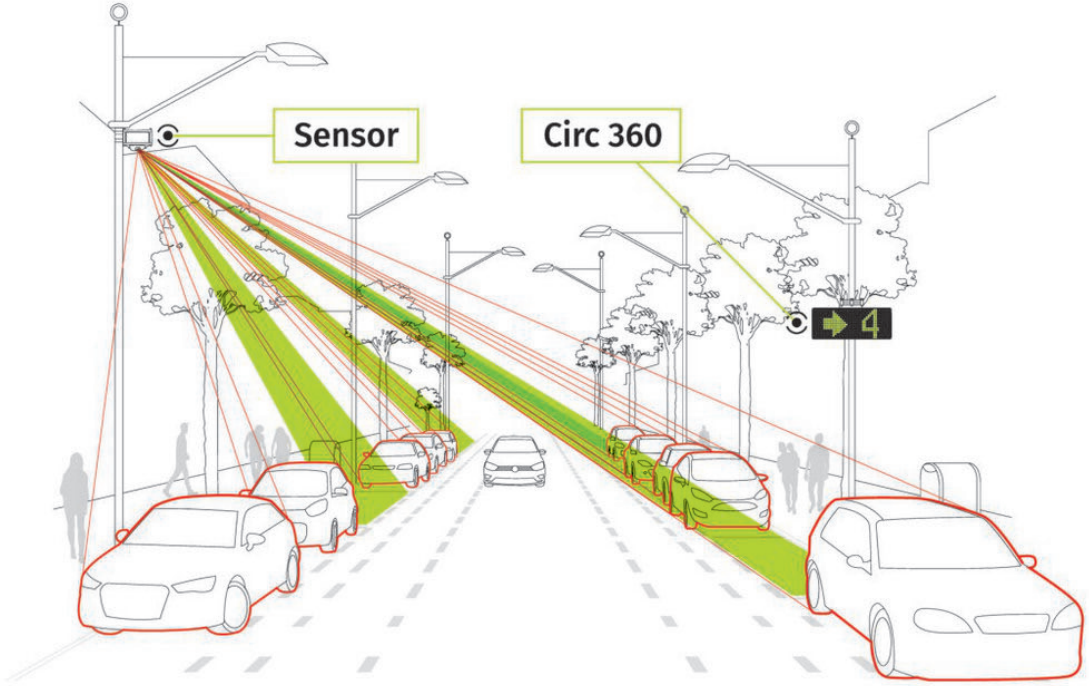
The system allows buses that are more than a minute behind schedule to automatically receive priority at traffic lights

US Deployment:

Smart Lamppost with Camera

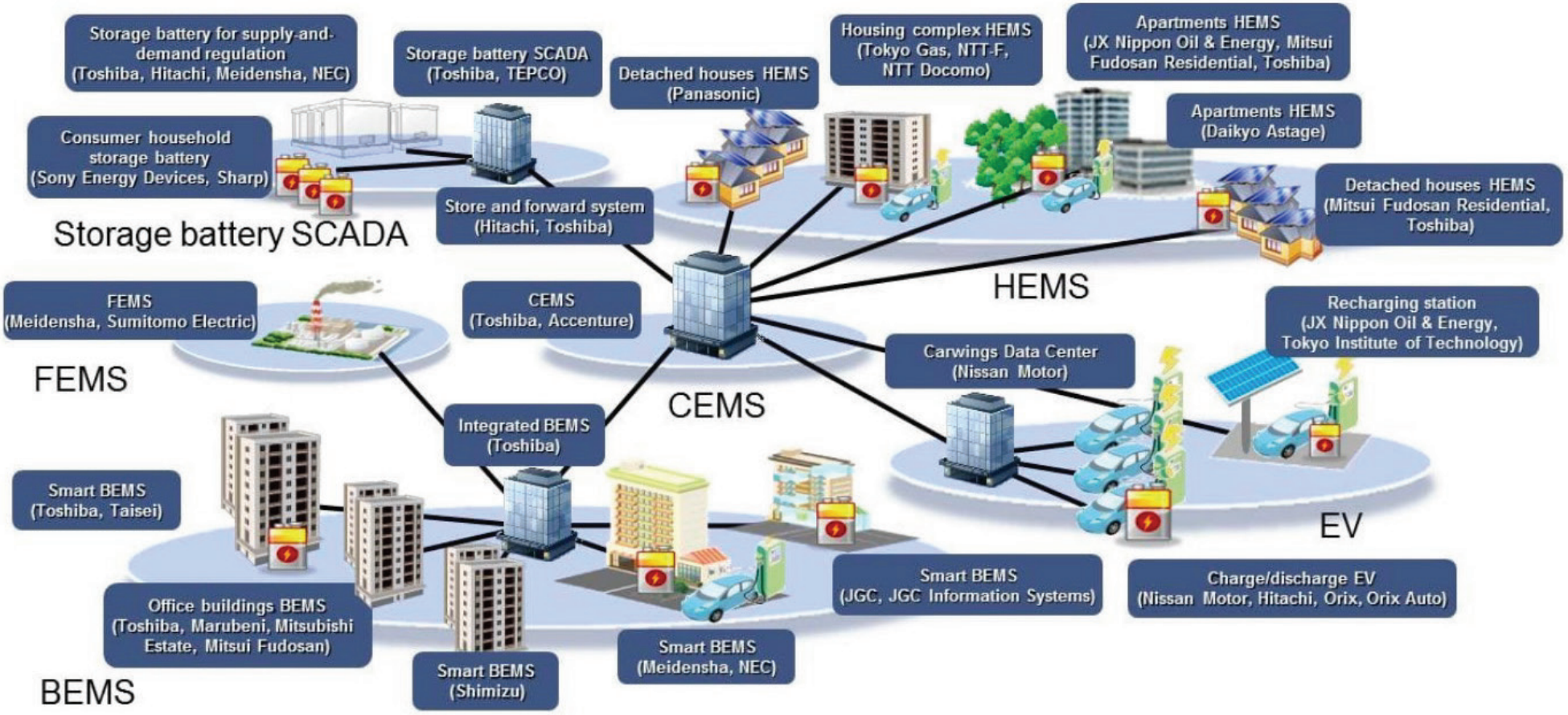
Camera provides surveillance and



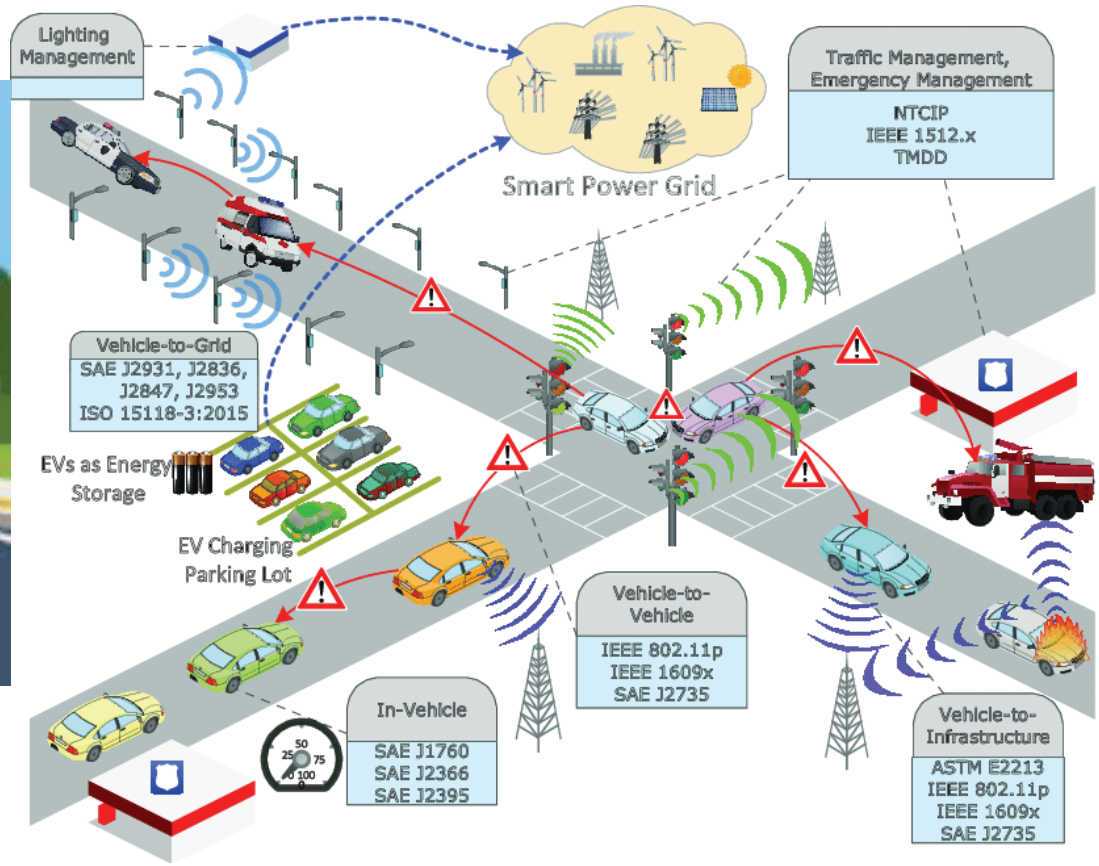


https://www.l33tech.com/blog/2018/10/25/iot-project-awards-in-singapore-smart-lamp-post-sensors-and-cameras-that-collect-a-wide-range-of-data

Yokohama, Japan Smart City Demonstration



Intelligent Transportation System and Smart City are closely coupled



What is Normal

The New Normal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THANK YOU

Smart Energy Efficiency in Smart Cities

Prof. Saifur Rahman (www.srahman.org)

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