ISGT Singapore 23 May 2018

SMART BUILDINGS & A SMART CITY
CONNECTED COMMUNITY

Keynote Speech
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President-elect, IEEE Power & Energy Society

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Arlington, Virginia, USA

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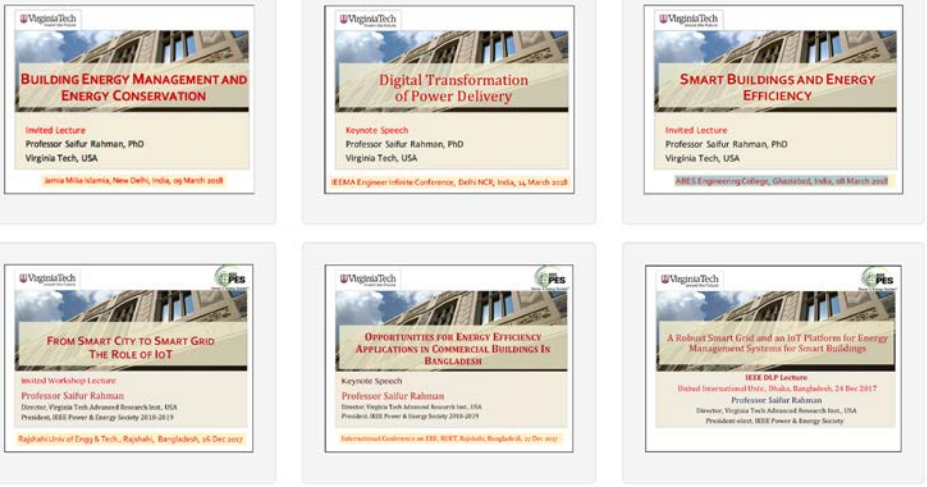
A Sample List of Presentations



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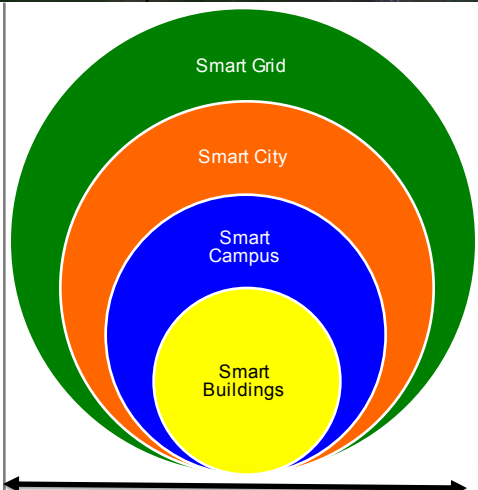
From Smart Buildings to Smart Grid



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

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, productive users, grid integration…

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The fact of buildings

- Use 40% of total energy
  - Residential and Commercial consumes 60% of it
- Use 25% of water
- Emmitt 30% of GHG (Green House Gas)
  - Mainly from the consumption of fossil fuel
  - Some of them are from the construction
- Worth 10% of global GDP
- People spend 80% to 90% of their time in buildings

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Current Building Operation

- High Energy Consumption
- High consumption of water
- Unhealthy/uncomfortable environment
- Waste from construction and demolition

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What is a Smart Building

Smart buildings use information technology during operation to connect a variety of sub-systems, which typically operate independently, so that these systems can share information to optimize total building performance. Smart buildings look beyond the building equipment within their four walls. They are connected and responsive to the smart power grid, and they interact with building operators and occupants to empower them with new levels of visibility and actionable information.

Source: Institute of Building Energy Efficiency 2011

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Why Smart Buildings

- Increasingly stringent regulations
- Use energy more efficiently
- Reduce CO_2 footprint

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Smart Buildings

A smart building connects the building automation system with building operations, such as HVAC, lighting, water supply, sensor network and fire emergency.

Implementing smart building solutions can provide:

- up to 30% savings of water usage
- up to 40% savings of energy usage
- reduce building maintenance costs by 10-30 percent

Source: Smart Building Market To Grow 30% by 2020, http://www.iotsolutionprovider.com/smart-building/smart-building-market-to-grow-30-by-2020, December 2015.

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Smart buildings do not have to be new buildings

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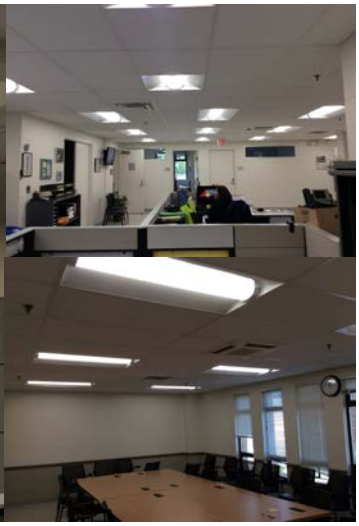
Office Building, Arlington, Virginia

Smart Light Intensity Control



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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Temperature Control in a Commercial Office Building

Retailed building: ~50,000 sqft
Peak demand: ~160kW
Electricity consumption: 46-65MWh/month

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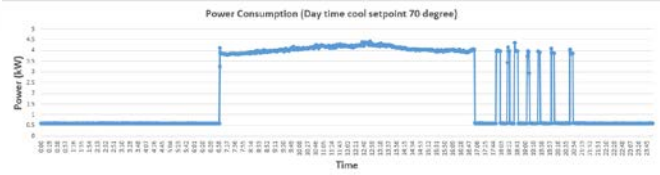
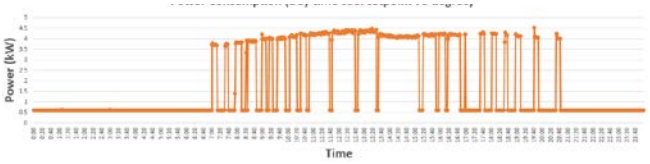
Electricity Savings

June 6, 2016:
day-time cool set point 21 deg C.



May 27, 2016:
day-time cool set point 24 deg C.



	Day-time cool set point	Total daily energy usage	Electricity Savings
June 6, 2016	21 deg C	52.1 kWh	7.4 kWh (14.2%)
May 27, 2016	24 deg C	44.7 kWh	

Solar PV System Integrated into Building Energy Management System

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Monitoring & Control of Renewables

Smart inverter control

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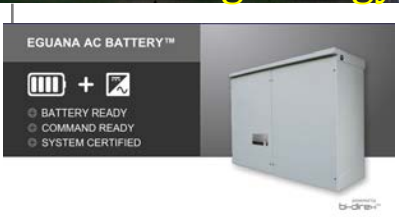
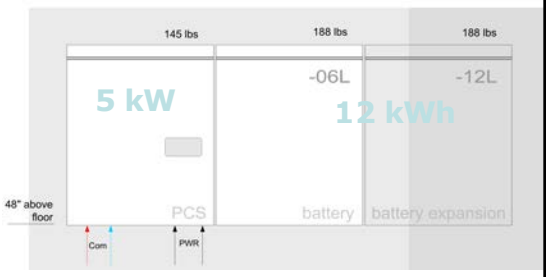
Battery Storage Integrated into Building Energy Management System



Battery Cells LG Chem



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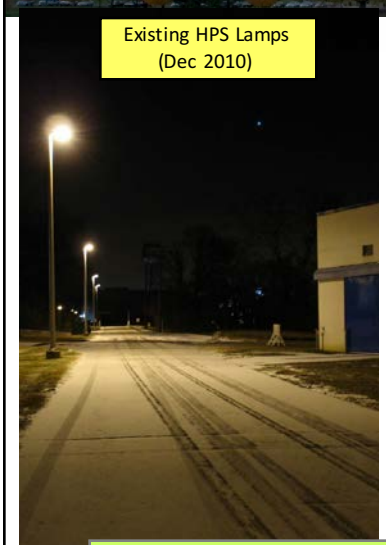
Battery Storage Monitoring & Control

Demand-sensitive LED Lighting Project

HPS vs LED



People/cars are clearly visible under the white LED light.

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Light Intensity = 80%

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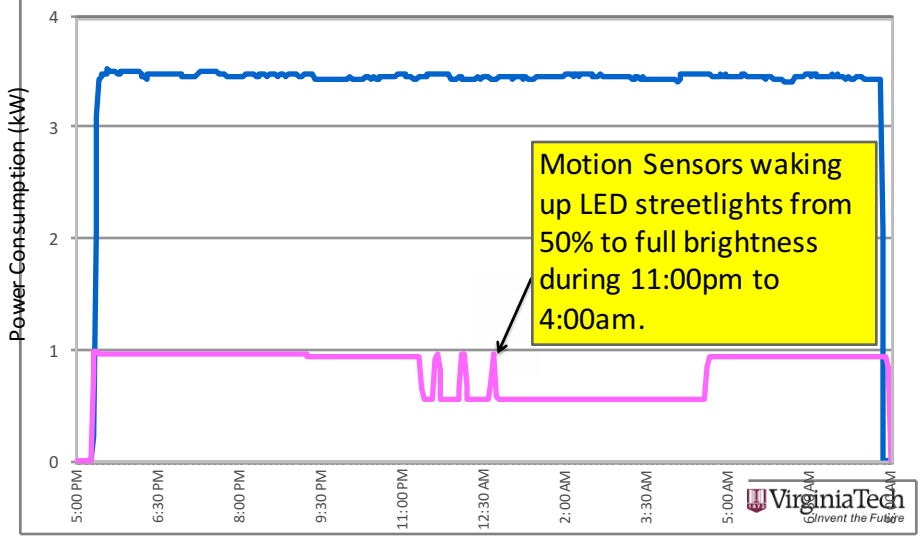
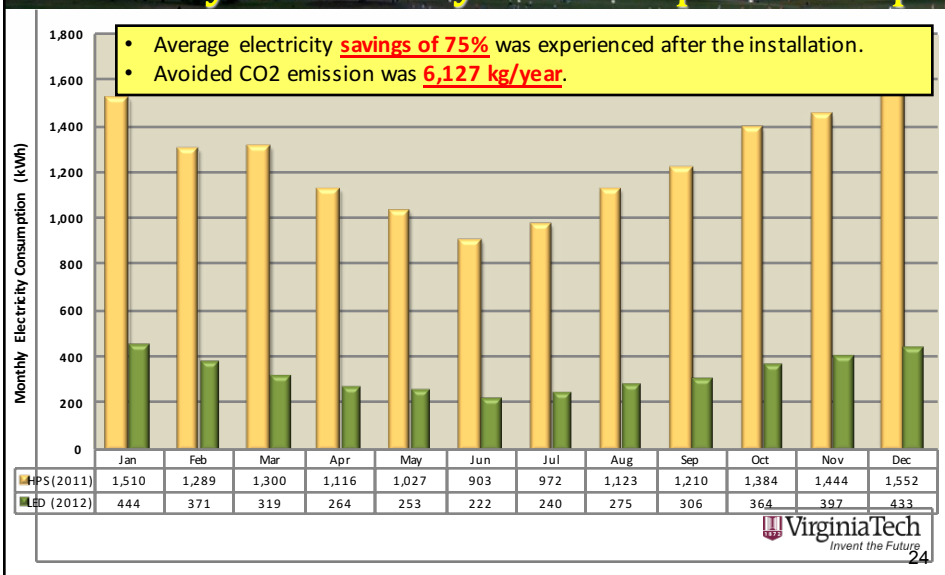
Comparison of kW Consumptions



Monthly Electricity Consumption Drop



	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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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.

Source: Wikipedia

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Smart Cities

Smart cities address urban challenges such as pollution, energy efficiency, security, parking, traffic, transportation, and others by utilizing advanced technologies in data gathering and communications interconnectivity.

Source: http://www.iotphils.com/solutions/smart-cities/#prettyPhoto, December 2015.

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A Connected City

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

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Smart/Connected City

- A smart/connected city is a system of interconnected systems including:
  - Employment
  - Health care
  - Retail/entertainment
  - Public services
  - Residences
  - Energy distribution
  - Transportation
- The system of systems is tied together by information and communications technologies (ICT) that transmit and process data about all sorts of activities within the city.

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Smart/Connected City, contd.

- Smart/connected cities contain and use "intelligent infrastructure"
  - Devices and equipment that can sense the environment and/or their own status, send data, and often, receive commands.
- Smart/connected cities use new analytical processes that have been facilitated by ICT advances
  - Big data analysis
  - Crowdsourcing to gather data and solve problems
  - Gamification to incentivize behaviors
  - Engage the connected citizen

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Connected Transportation

- Connected vehicles and travelers will be able to share data with all sorts of equipment, not only transportation-related devices and infrastructure, as they become integrated into the Internet of Things
- Travelers will increasingly be able to procure mobility as a service, rather than purchase vehicles or make other long-term commitments to particular modes of travel (eg, self-driven cars)

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How to Provide for EV Charging Without Impacting the Peak Load

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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

Smart City Platform for City Info and Services

Source: Howard Bandler, IEEE Electrification, March 2016

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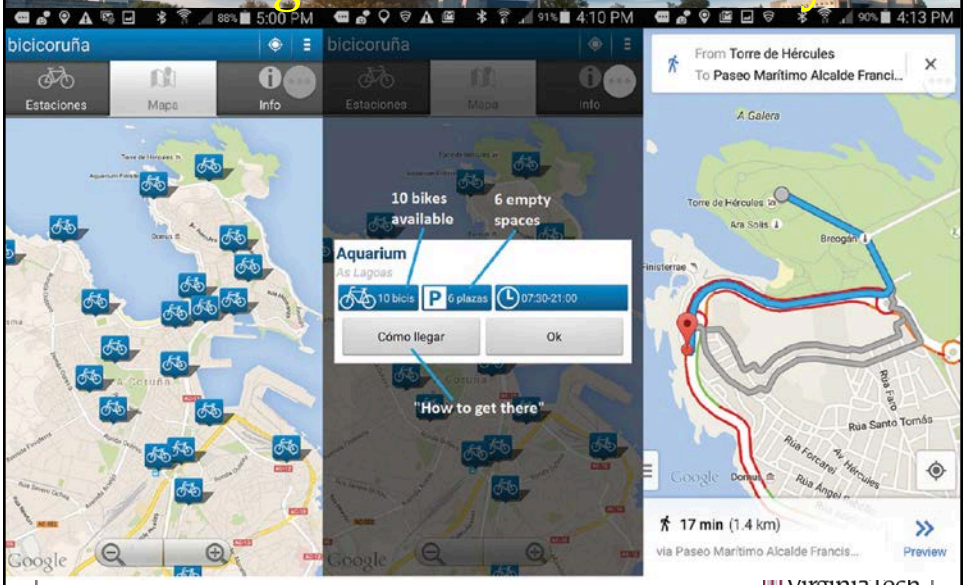
Finding Bikes in a Smart City



Source: Howard Bandler, IEEE Electrification, March 2016

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Santander, Spain

- Living experimental laboratory smart city
- 10,000 sensors located around downtown
  - Attached to street lamps, poles, building walls, beneath the asphalt of parking lots.
- Sensors data collection from:
  - Traffic, environment, weather, and people.
- Smart phone applications makes the data available to citizens
  - Real-time transit information, culture event schedules, tourist sightseeing information, and retail offers.

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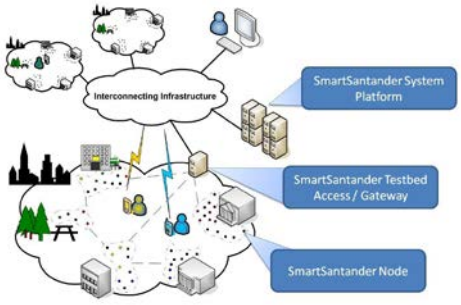
Santander, Spain



Pictures from:
http://www.smartsantander.eu/
https://www.bloomberg.com/news/articles/2013-05-16/spains-santander-the-city-that-runs-on-sensors

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Singapore

- Sensors, cameras, and global positioning system (GPS) devices provide information on traffic, even predicting future congestion and recommending alternate routes.
- 95% of residents and businesses have access to a super-fast, next generation broadband connection

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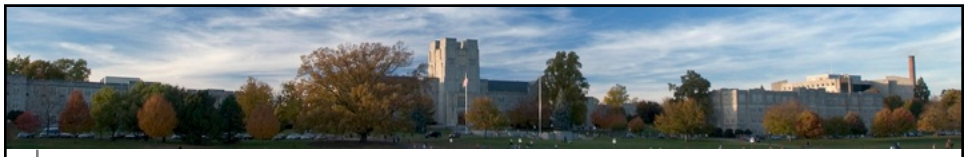

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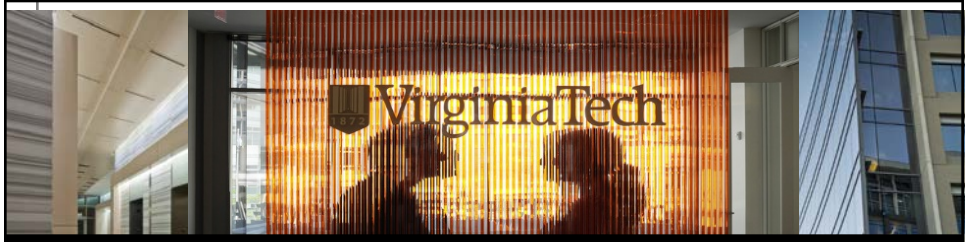

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