Role of ICT in Optimal Management of Smart Buildings, Smart Cities & Smart Grids

Keynote Speech

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PPT slides are available at
www.srahman.org
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Keynote Speech, 6th IEEE International Conference on EE and ICT MIST, Dhaka, Bangladesh

Advanced information and communication technology (ICT) applications in commercial buildings, schools, libraries, shopping centers, etc. offer low-cost but highly effective monitoring and control opportunities. Sensors deployed in key locations in buildings can monitor the building environment in real-time, collect information for intelligent decision making, and facilitate various services. Such large-scale deployment of sensors and controllers makes the building energy efficient.
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, productive users, grid integration…

Supported by ICT and distributed networks of intelligent sensors, data centers/clouds.
What makes a Building Smart

A single platform for monitoring and control of HVAC, lighting, water supply, sensor networks, security camera & fire emergency.


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An Open-Architecture Platform for IoT Device Integration in a Smart Building
Smart Campus Management using the Cloud

Utility/Demand Response Aggregator

Customers/Operators

Buildings

Internet

HVAC
Lighting loads
Plug loads
Power meters
Water meters
PV & storage
Security camera
Building Blocks of 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
Stockholm City Traffic Management

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 locates empty parking spaces
Regular trash cans need to be emptied 1–3 times per day. Smart ones only need to be emptied four times a week.
Smart City Demonstration
Yokohama, Japan
Field Implementation Examples
Academic Building in Alexandria, Virginia

Area: 2500 Sq Metre  
Energy: 14-25 MWh/mo.  
Peak load: 61 kW
Classroom under Real-time Monitoring and Control

- BEMOSS core
- Plug load controller
- Environmental sensor (CO2, noise, temperature)
- Motion sensor
- Thermostat
- Power meter
- Plug load controller
Indoor Environmental Monitoring

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

Date Recorded: Thu, 23 Mar 2017, 09:32
Date Recorded: Thu, 23 Mar 2017, 09:32

Weather_Sensor21: CO2

Graph showing CO2 levels over time.
## Energy Savings from Air Conditioning Control

### Summer Months (June-July-August)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor consumption 2014 (Before Control)</td>
<td>8,340 kWh</td>
</tr>
<tr>
<td>Compressor consumption 2016 (After Control)</td>
<td>6,071 kWh</td>
</tr>
<tr>
<td>Average savings</td>
<td>26.8% savings</td>
</tr>
</tbody>
</table>
Office Building, Arlington, Virginia

Office building size: 500 sqm

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Lighting Intensity Control
Energy Savings by Controlling Lighting Intensity

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

<table>
<thead>
<tr>
<th>Month</th>
<th>Total Measured Energy Consumption (kWh)</th>
<th>Total Calculated Energy Consumption without Dimming (kWh)</th>
<th>Energy Savings by Dimming (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2016</td>
<td>264.37</td>
<td>399.90</td>
<td>33.89%</td>
</tr>
<tr>
<td>November 2016</td>
<td>278.13</td>
<td>423.78</td>
<td>34.37%</td>
</tr>
<tr>
<td>December 2016</td>
<td>280.76</td>
<td>426.40</td>
<td>34.16%</td>
</tr>
<tr>
<td>Total (October-December)</td>
<td>823.26</td>
<td>1250.08</td>
<td>34.14%</td>
</tr>
</tbody>
</table>

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.
Electricity Savings in Street Lighting
People/cars are clearly visible under the white LED light.

Existing HPS Lamps (Dec 2010)

New LED Lamps (June 2012)
ICT-based Lighting Intensity control
Infrared Sensors to Monitor Traffic

Power Consumption (kW)

HPS lights

ICT-based control to dim lights to 50%

LED Lights
HPS vs LED
Monthly Electricity Consumption

- Average electricity savings of 75% was experienced after the installation.
- Avoided CO2 emission was 6,127 kg/year.
Changing Landscape for the Electric Utility
How Can the Smart Grid Help?
What is a Smart Grid

"Smart grid" is a concept with many elements where monitoring and control of each element in the chain of generation, transmission, distribution and end-use allow the electricity delivery and use to be more efficient.
Motivation for a Smart Grid on the basis of the energy management triangle - political objectives and technical implementation.

Desire to make the grid smarter, safer, reliable and more cost-effective using advanced sensors, communication technologies and distributed computing.
Difference Between a Normal Grid and a Smart Grid

Normal Phone

Smart Phone

Normal Phone

Smart Phone
Starting and End Points of a Smart Grid

It starts at the Generator and ends at the Refrigerator
Smart Grid Building Blocks

- Technology
- Standards
- Rates & Regulations
- Consumer Awareness & Education
Evolution of the Grid

**Smart Grid**

**Before** Smart Grid:
One-way power flow, simple interactions

**After** Smart Grid:
Two-way power flow, multi-stakeholder interactions

Source: Altalink, Alberta, Canada
Electric Power and Communication Infrastructures

1. Power Infrastructure

- Central Generating Station
- Step-Up Transformer
- Distribution Substation
- Receiving Station
- Distribution Substation
- Residential Data Concentrator
- Micro-turbine
- Gas Turbine
- Recip Engine
- Flywheel

2. Information Infrastructure

- Control Center
- Data network Users
- Commercial
- Industrial
- Fuel cell
- Commercial
- Cogeneration
- Recip Engine

Source: EPRI
Intelligent Load
Demand or price-driven control of appliances

Sensors
Detect outages, fluctuations, and disturbances

Local Monitoring and Control
Balance electricity Supply/demand across the grid

Distributed Network
Interconnected micro grids

Smart Inverters and Storage
Minimize voltage and power fluctuations

Bulk Power Plant

Wind Power Park

Distributed Arch.
New Paradigm for the Electric Power System

Historically: Demand driven supply (supply responds to demand)

New Reality: Supply driven demand (demand needs to adjust to meet fluctuating supply with storage)