Connectivity in the Smart Grid for the Integration of Renewables in Saudi Arabia

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"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.

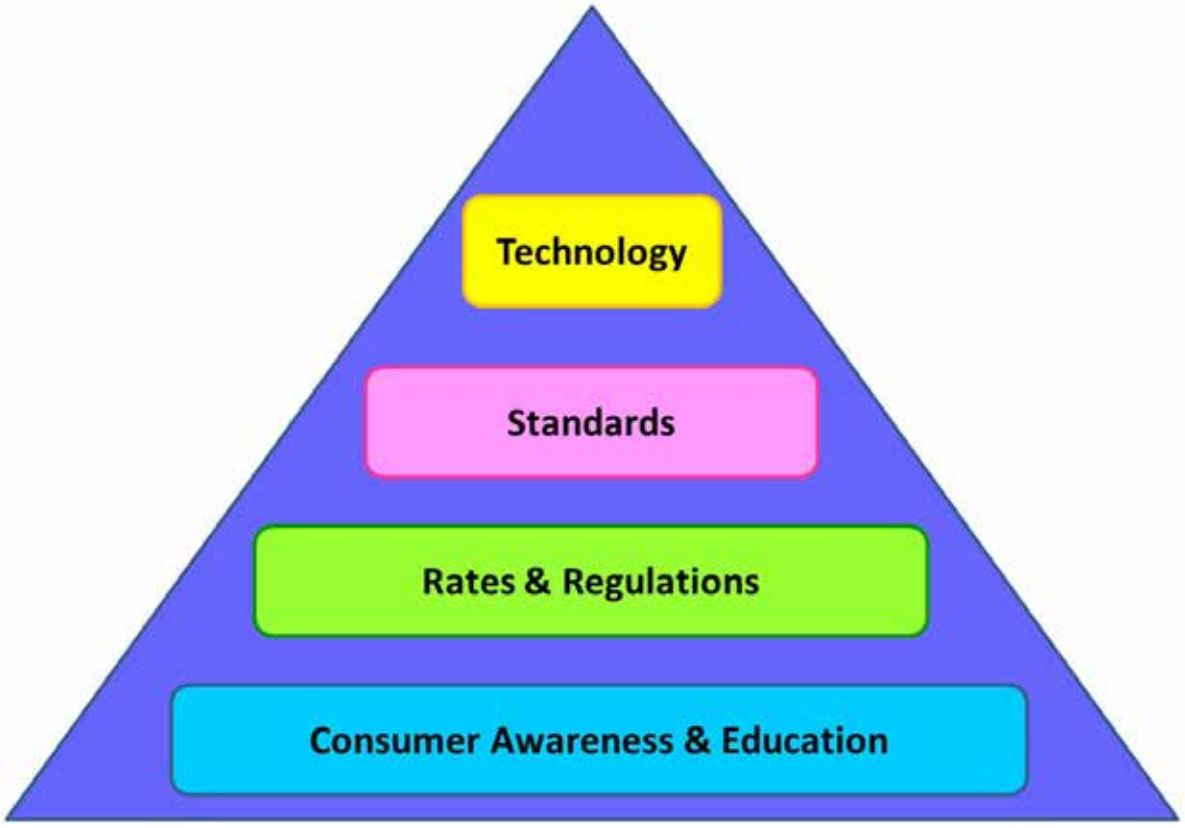
Motivations for a Smart Grid

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

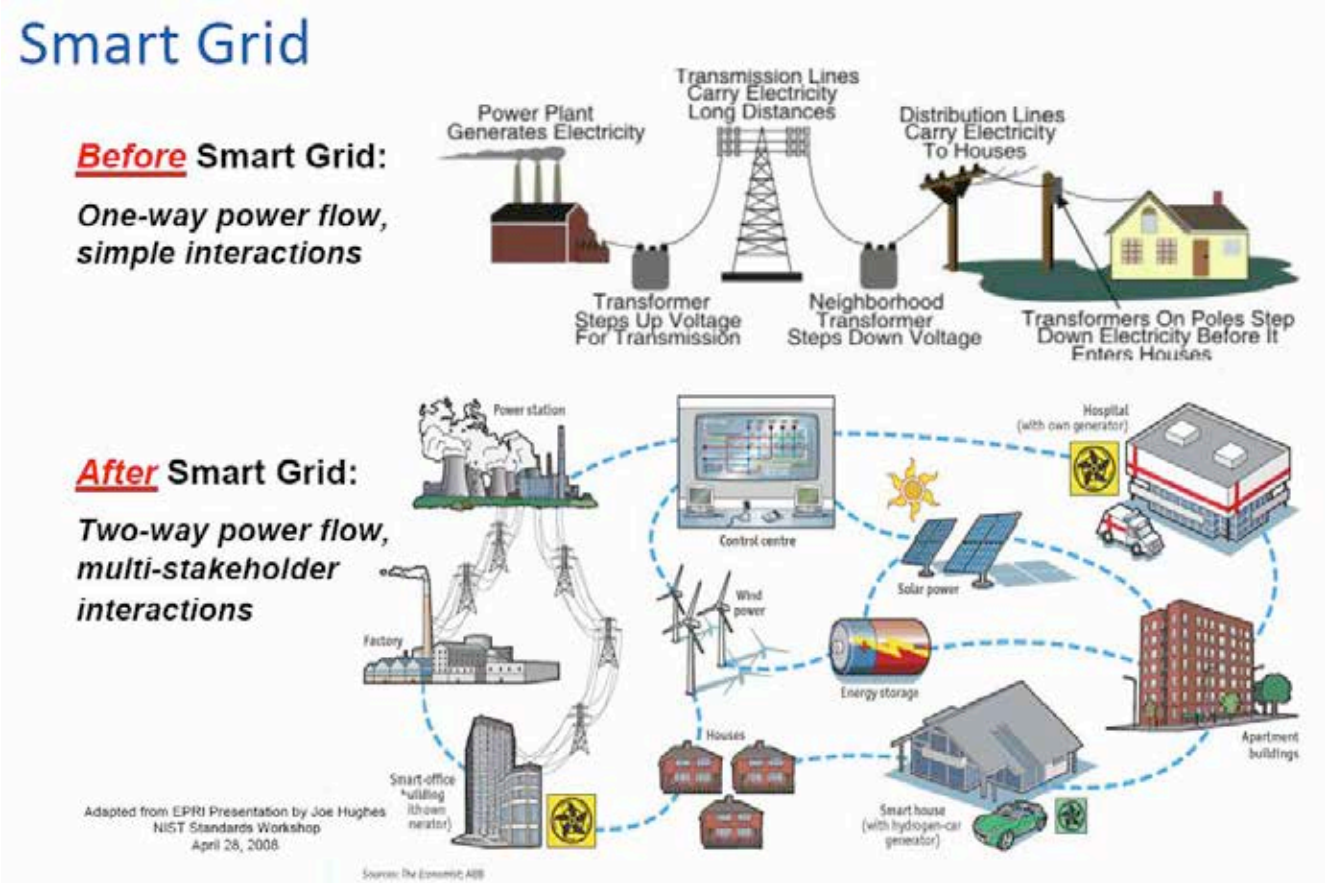
Starting and Ending Points of a Smart Grid

From Generator to Refrigerator



Smart Grid Building Blocks

Evolution of the GRID



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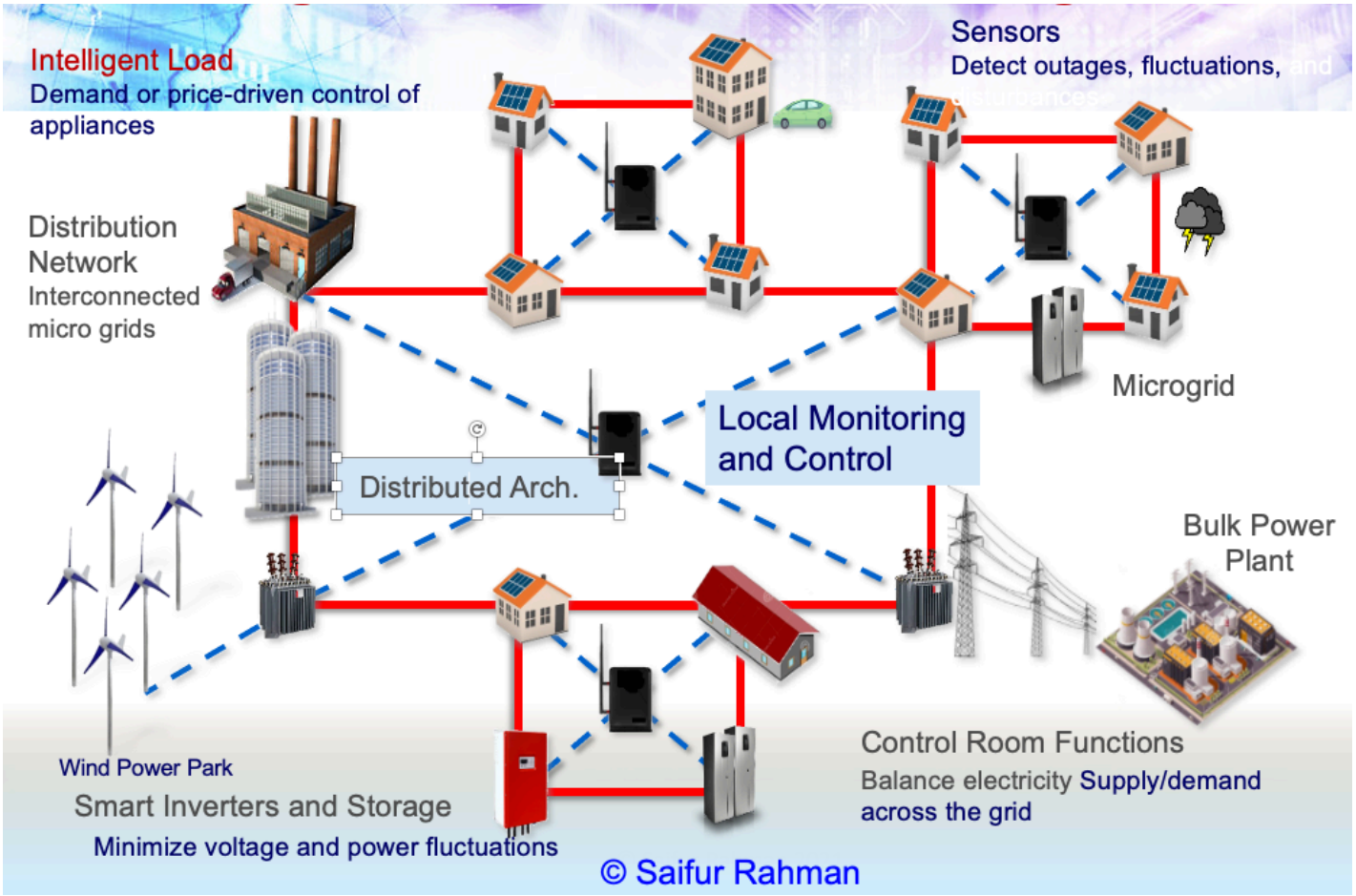
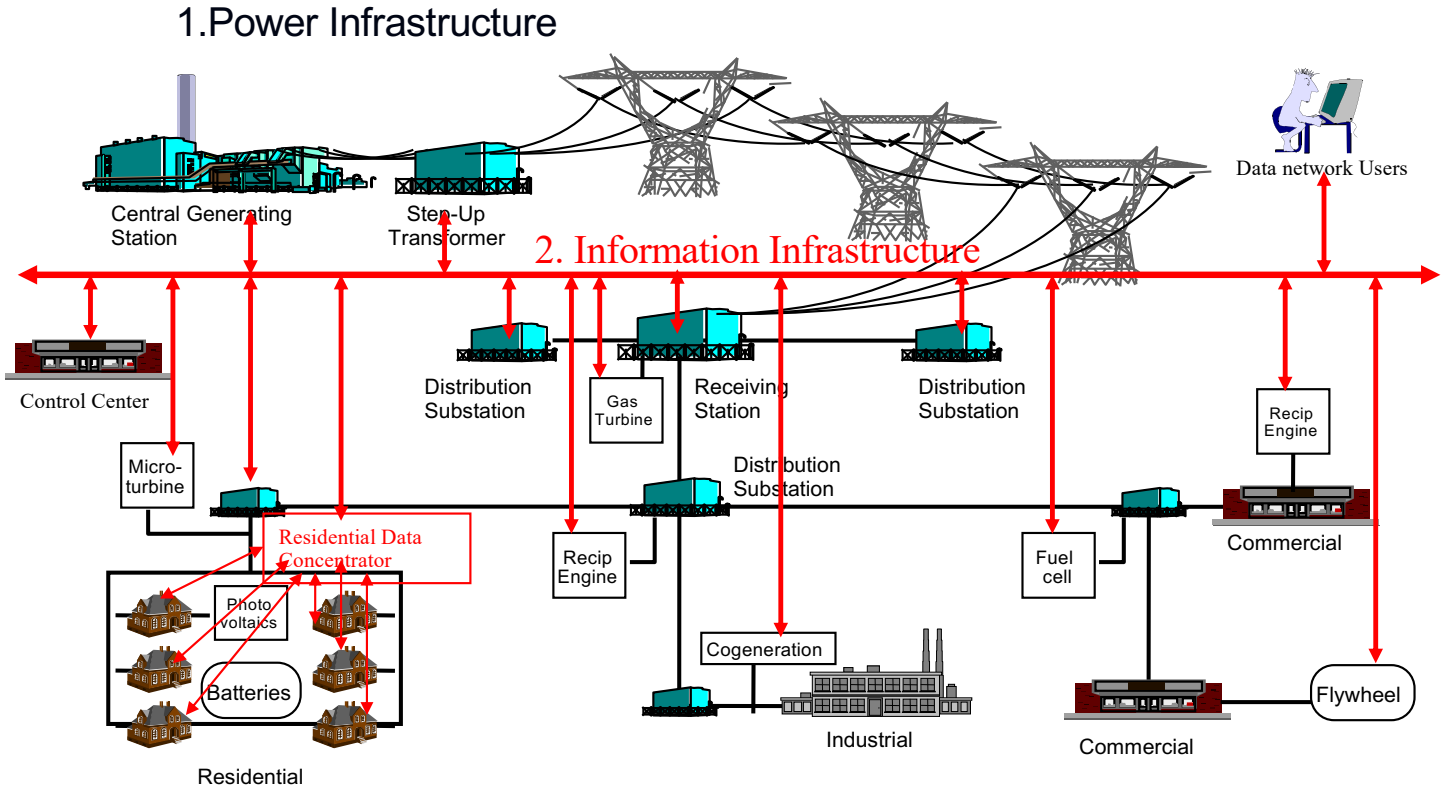
Intelligent Interconnected Microgrids



Merging Power Flow with Information Flow

Integrated Communications

Electric Power & Communication Infrastructures



Source: EPRI

Issues in Smart Grid Deployment

- Regulatory
- Business
- Technical
- Security and Privacy

Regulatory Issues

- Time varying rates
- Who pays the upfront costs
- Who owns the data

Business Issues

- Return on investment
- Customer acceptance
- Trained manpower

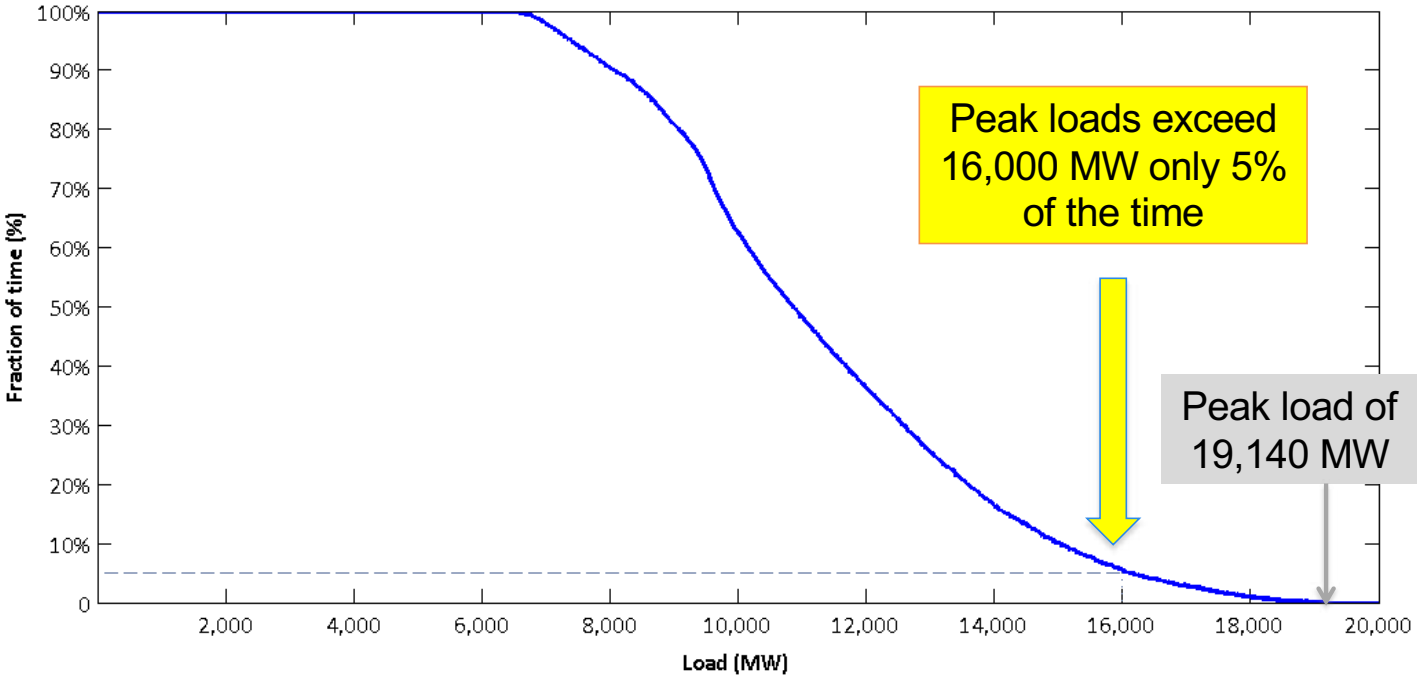
Security and Privacy Issues

- Data transmission over the public internet
- Data sharing by multiple parties
- Ownership of the data

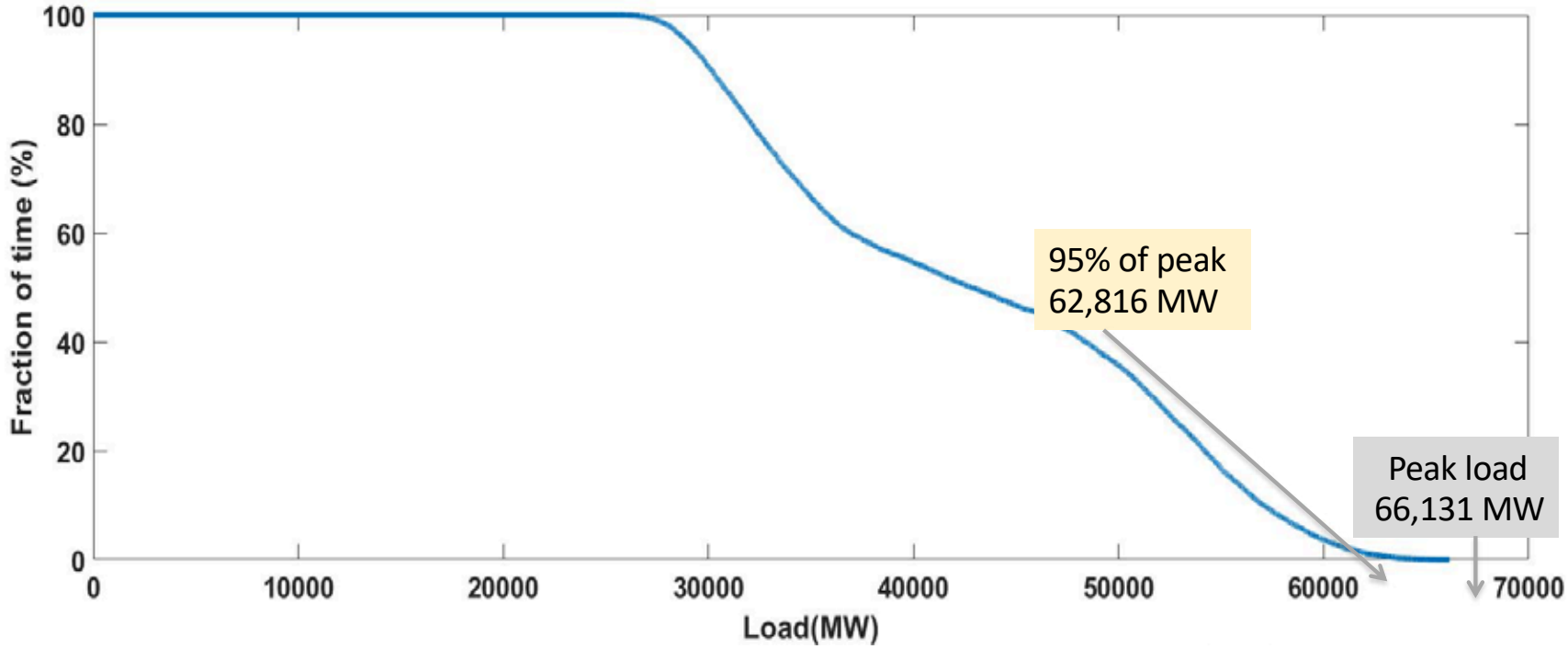
Technical Issues

- Service monitoring and recovery
- Remote meter reading & billing
- Transformer/Switchgear loading
- Peak load reduction
- Renewables integration
- Demand response application

Electrical Load Profile in Virginia, USA



Electrical Load Profile in KSA in 2016



Peak Load and its Duration

- In the US highest 20% of the load happens 5% of the time
- In Australia highest 15% of the load happens 1% of the time
- In Egypt highest 15% of the load happens 1% of the time
- In Saudi Arabia highest 5% of the load happens 0.75% of the time

Changing Landscape for the Electric Utility

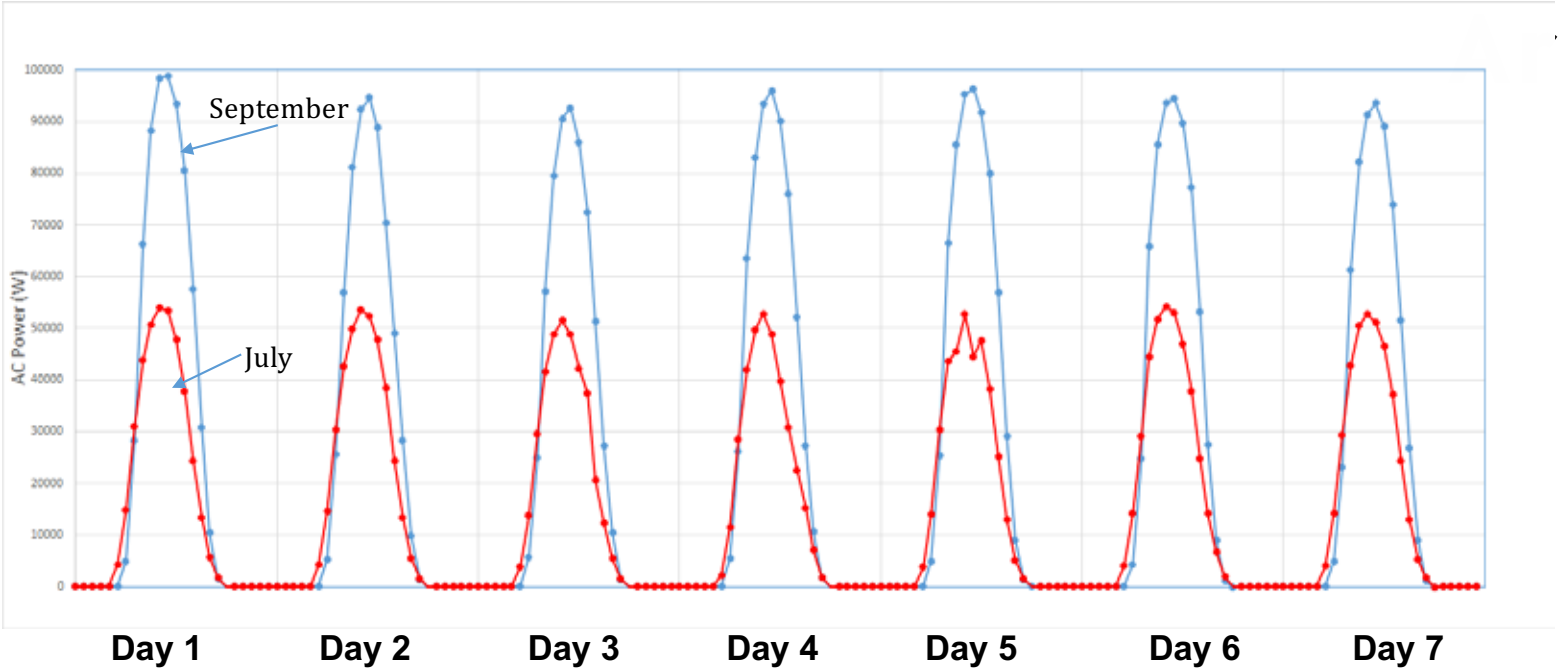
In-depth Look at Solar PV in KSA

2-MW Roof-top Solar PV plant at KAUST

Solar PV Panels in Saudi Arabia

Reality Check

Solar PV Array (100kWp) in Riyadh



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Solar PV Panel Cleaning Cost and Frequency

How Can the Smart Grid Help

It helps to integrate intermittent sources of generation into the electric power grid.

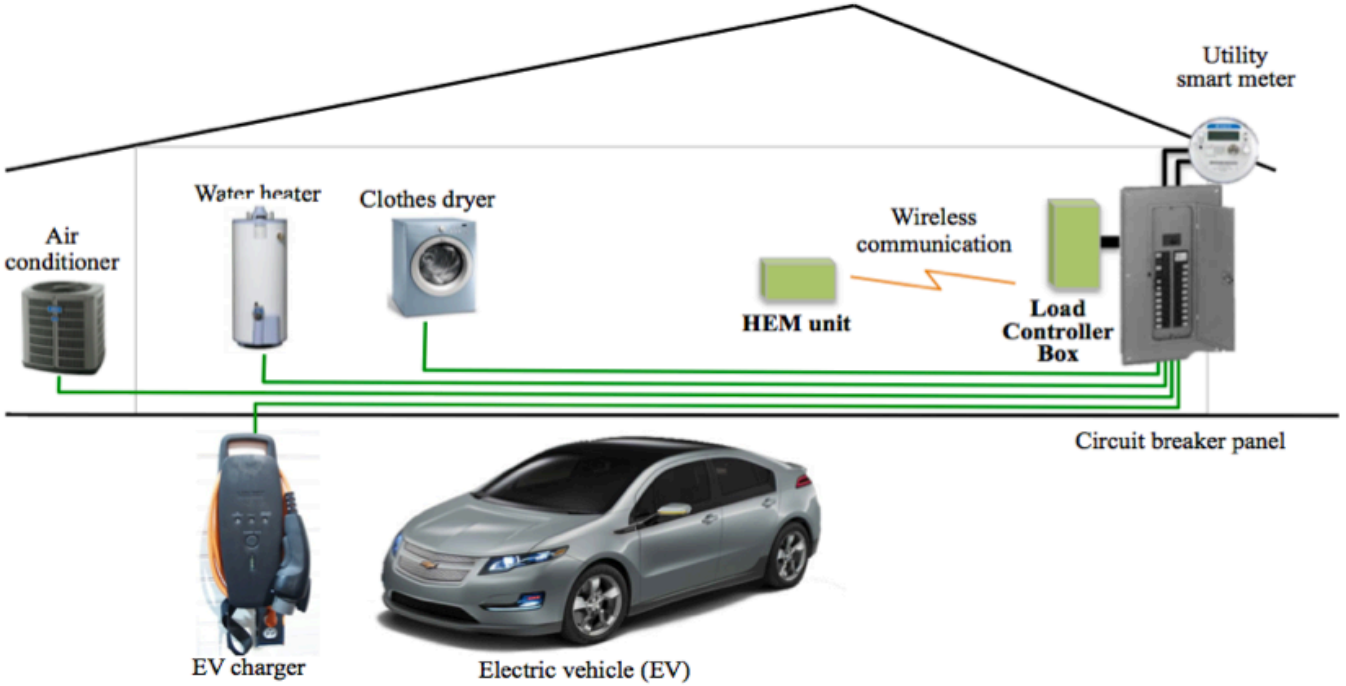
Short term load control for a large number of end-use devices through demand response makes it possible to get quick load relief to match fluctuations in generation.

Demand Response

Demand Response is a customer action to control load to meet a certain target. Here the customer chooses what load to control and for how long.

Selective Control of Appliances

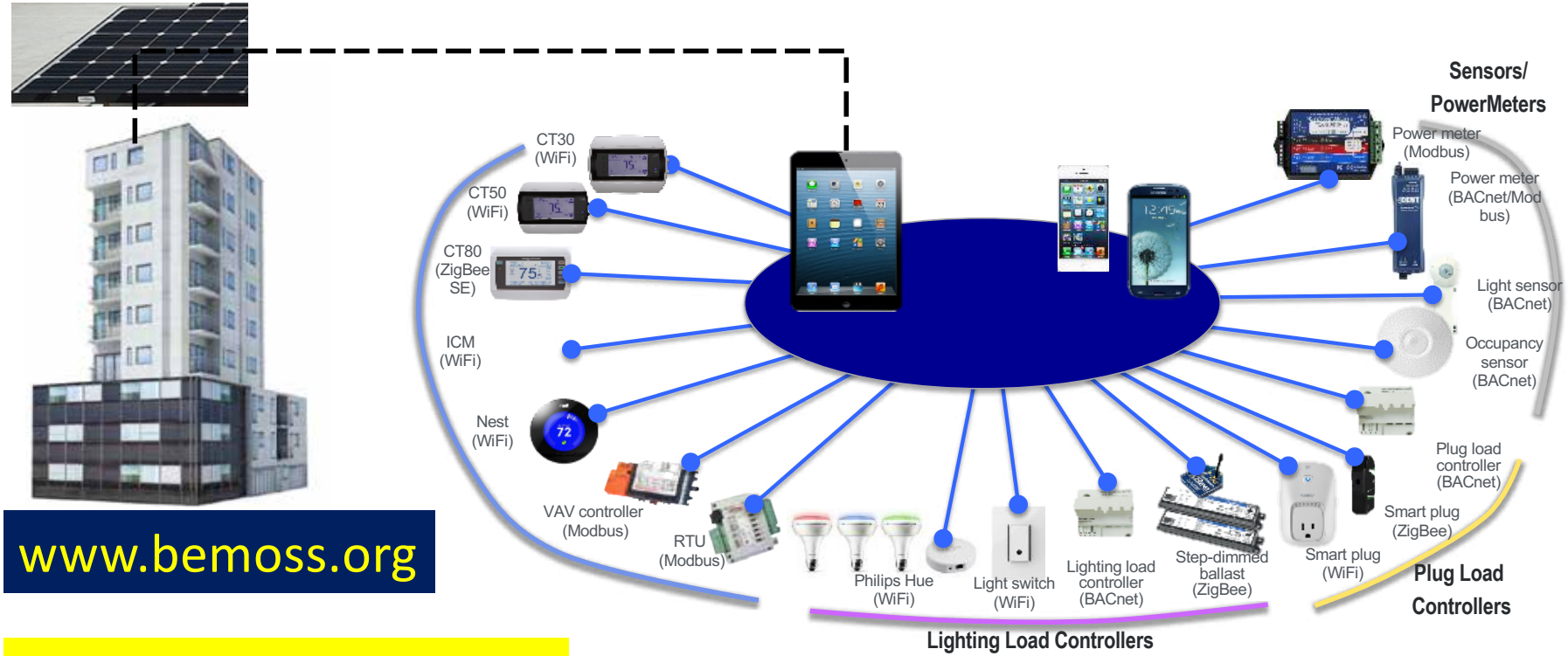
Two components: 1) HEM unit and 2) load controller box



IoT-based Building Automation Systems

- In KSA the roof-top solar is gaining popularity
- Roof-top solar helps with mitigating peak loads
- Building Automation Systems (BAS) help to maintain comfortable/healthy indoor environment
- Low-cost customizable BAS systems is needed

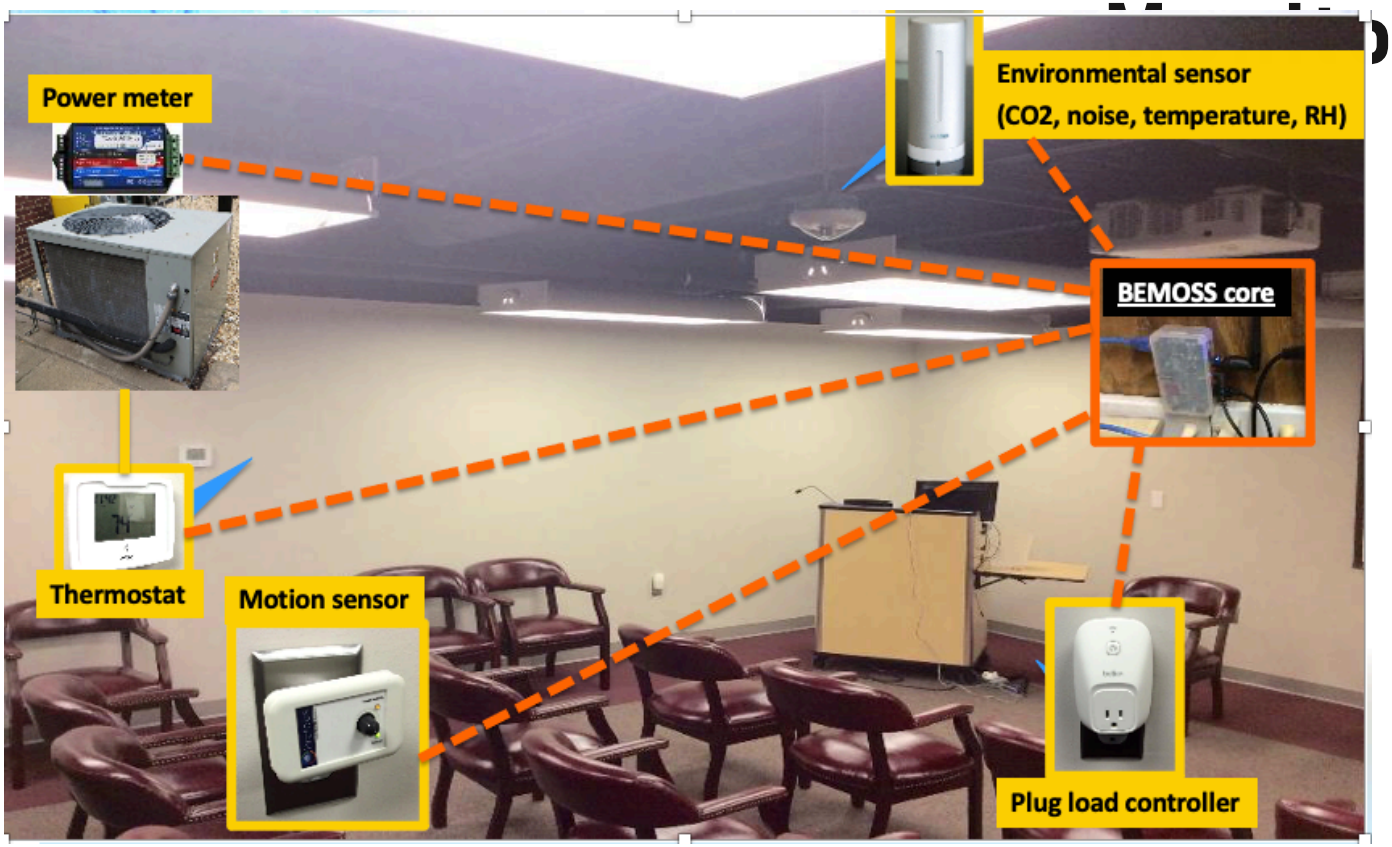
IoT Device Integration for Building Automation System (BAS)



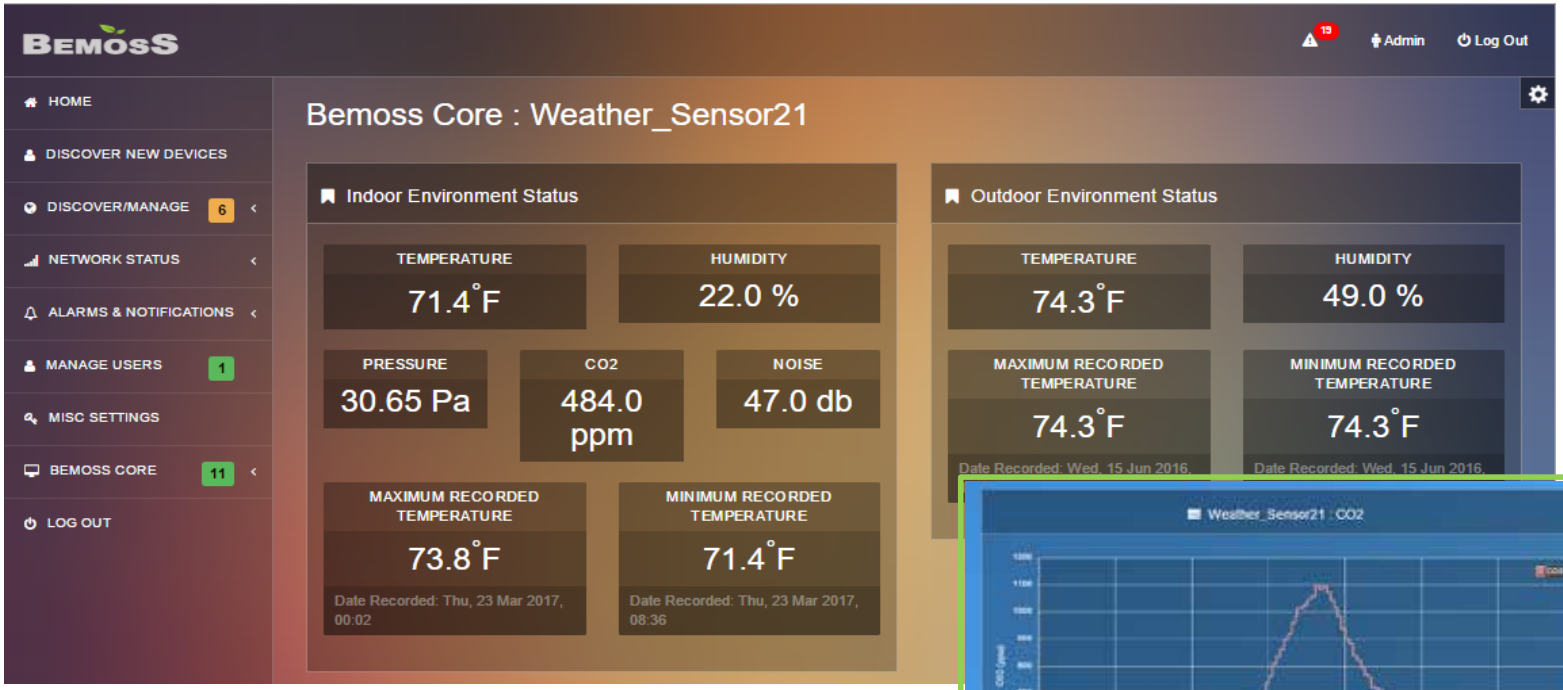
www.bemoss.org

www.bemcontrols.com

VT Classroom under Real-time Monitoring



Indoor Envrionmental Monitoring



Energy Savings from Lighting Control

Location: Arlington, Virginia

Area: 5,000 sq ft

Deployed Devices

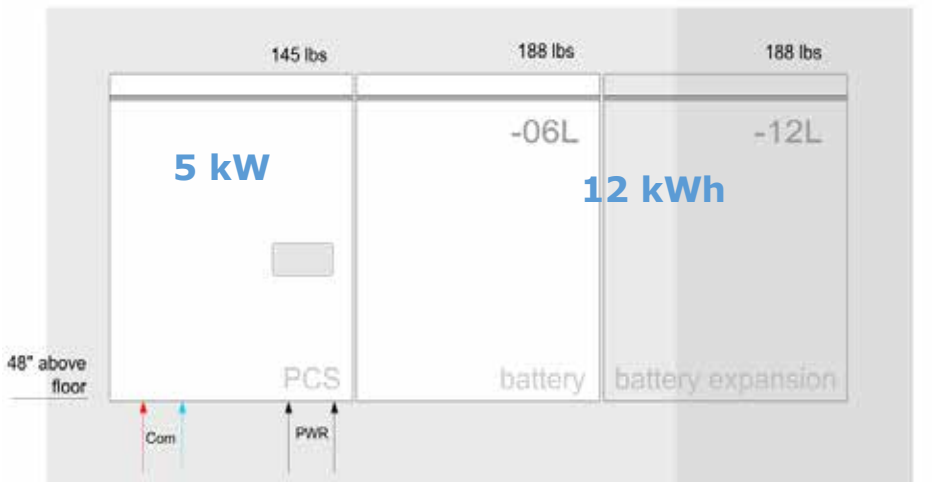
- 3 Lighting controllers
- 1 Power meter

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%**

Managing Battery Storage from a BAS Platform

Battery Cells LG Chem



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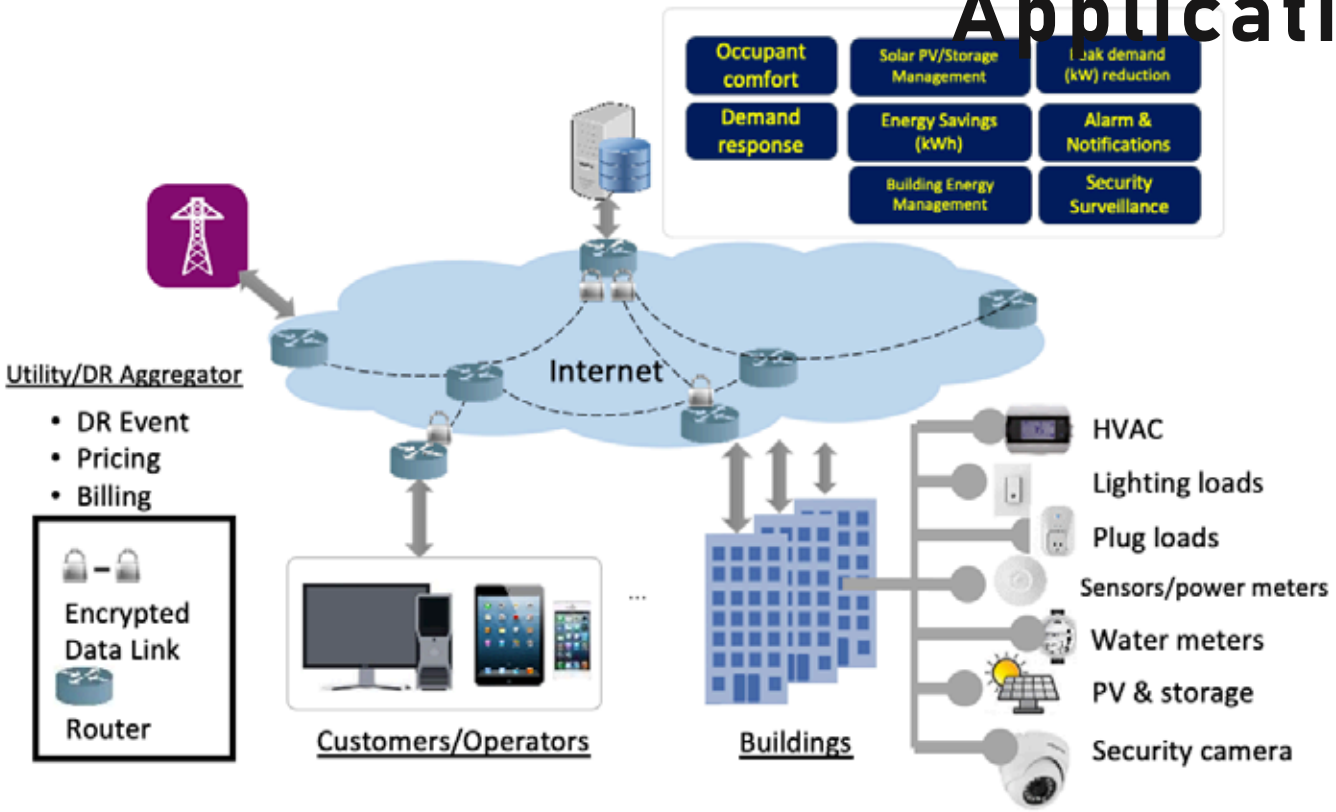
Battery Storage Data Access from a BAS Network

Roof-top Solar Photovoltaics at Virginia Tech

BAS for a Campus-wide Application



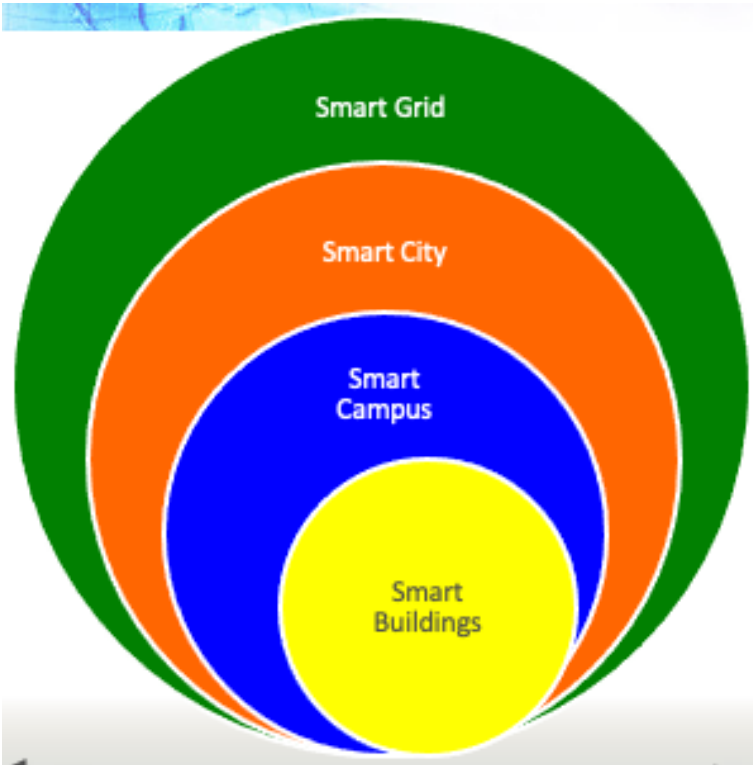
New Paradigm for the Power System

- Historically: Demand driven supply (supply responds to demand)
- New Reality: Supply driven demand

(demand needs to adjust to meet fluctuating supply with help from storage)

THE SMART GRID ECOSYSTEM

The Smart Grid



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…


ENRICHMENT
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