Role of the Smart Grid in Facilitating the Integration of Renewables

Keynote Speech

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1

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.

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2

Electric Power Grid

Source: www.sxc.hu

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Motivation for a Smart Grid

Desire to make the grid smarter, safer, reliable and more cost-effective using advanced sensors, communication technologies and distributed computing.

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Difference Between a Normal Grid And a Smart Grid

Normal Phone

Smart Phone

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Starting and End Points of a Smart Grid

From Generator to Refrigerator

Power Plant

Transmission

Distribution

Home Business

End-use Appliances

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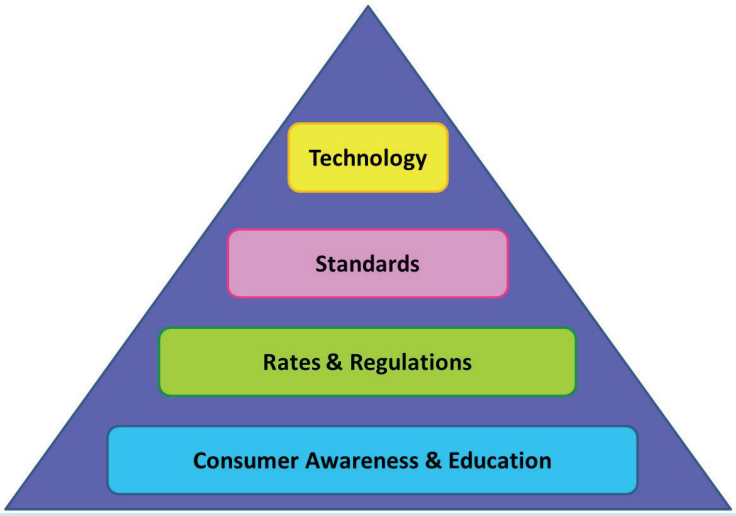
Smart Grid Building Blocks



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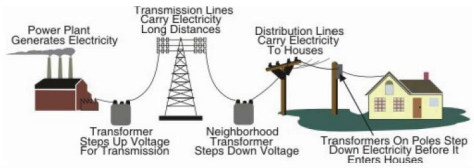
Evolution of the Grid

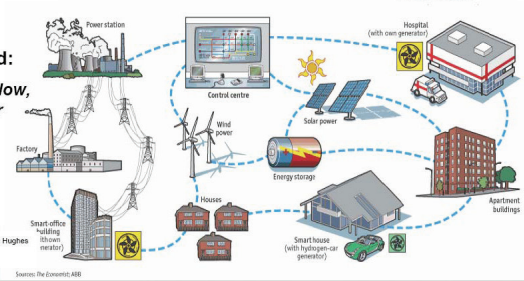
Before **Smart Grid:**

One-way power flow, simple interactions



After **Smart Grid:**

Two-way power flow, multi-stakeholder interactions



Adapted from EPRI Presentation by Joe Hughes NIST Standards Workshop April 28, 2008

Sources: The Economist; ABB

Source: Altalink, Alberta, Canada

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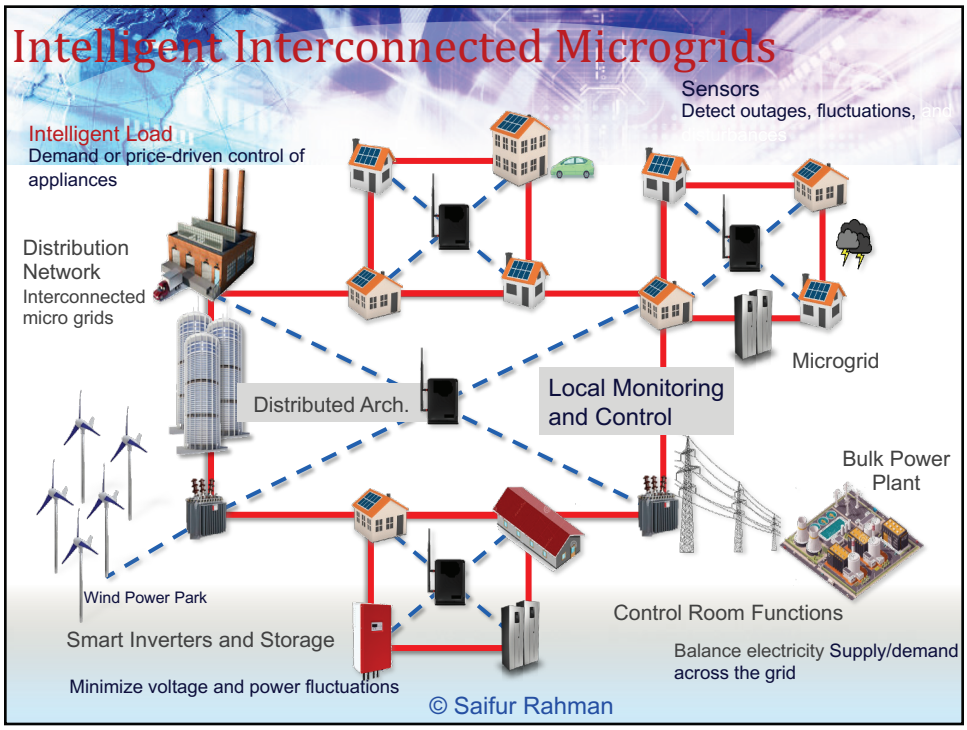
Intelligent Interconnected Microgrids
Sensors
Detect outages, fluctuations,
Intelligent Load
Demand or price-driven control of appliances
Distribution Network
Interconnected micro grids
Microgrid
Distributed Arch.
Local Monitoring and Control
Bulk Power Plant
Wind Power Park
Control Room Functions
Smart Inverters and Storage
Balance electricity Supply/demand across the grid
Minimize voltage and power fluctuations
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9


Merging Power Flow with Information Flow:
Integrated Communications
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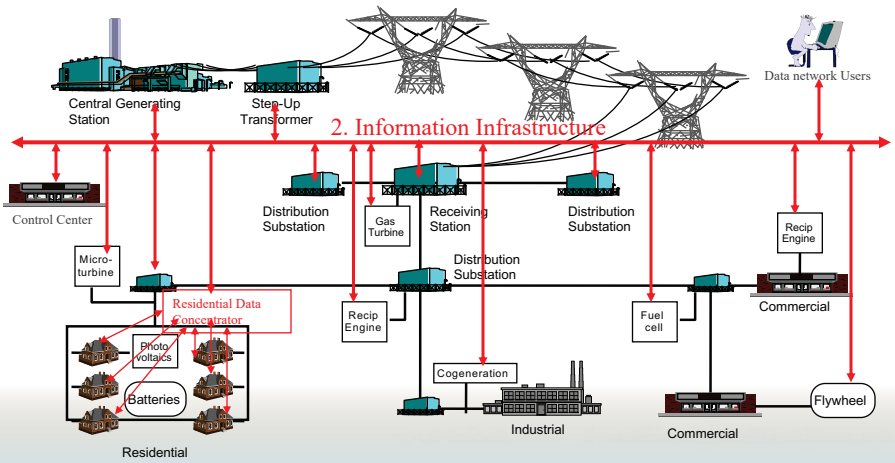
10

Electric Power & Communication Infrastructures

1.Power Infrastructure



Source: EPRI

11

11

Changing Landscape for the Electric Utility

12

12

Issues with Distributed Generation

- Wind and solar are intermittent
- Hydro is space limited
- Resource is free but not always usable

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Off-shore Wind turbines, Blyth, U.K.

Wind Energy

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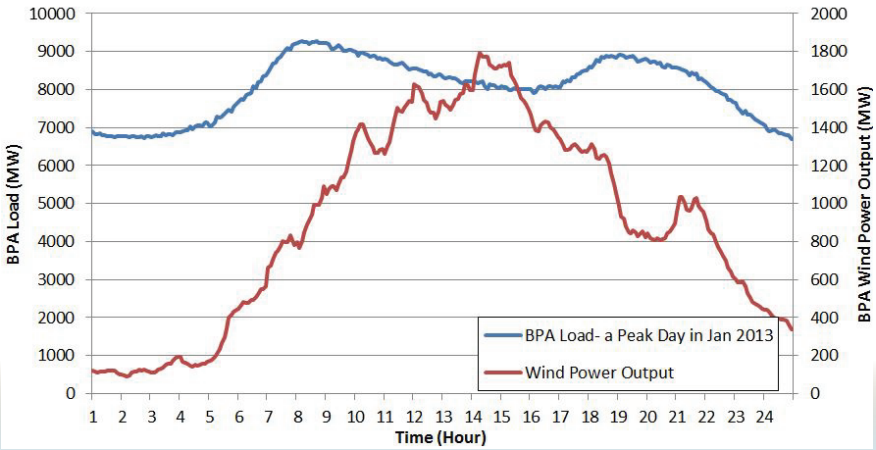
14

BPA Wind Output and Load Mismatch (January)



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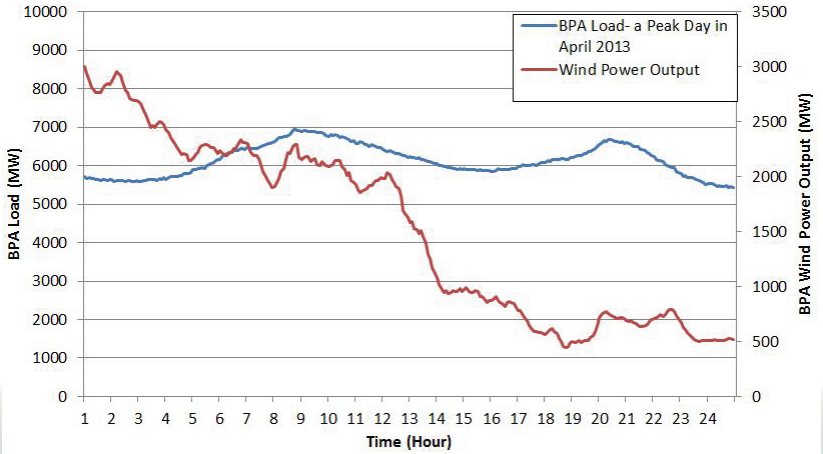
BPA Wind Output and Load Mismatch (April)



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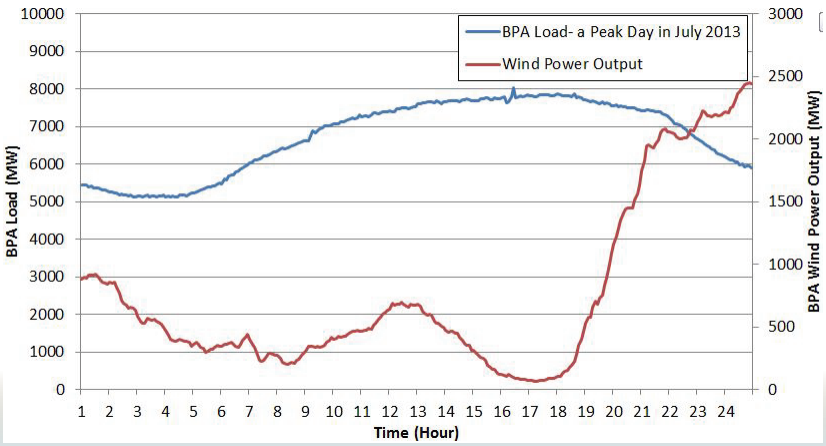
16

BPA Wind Output and Load Mismatch (July)



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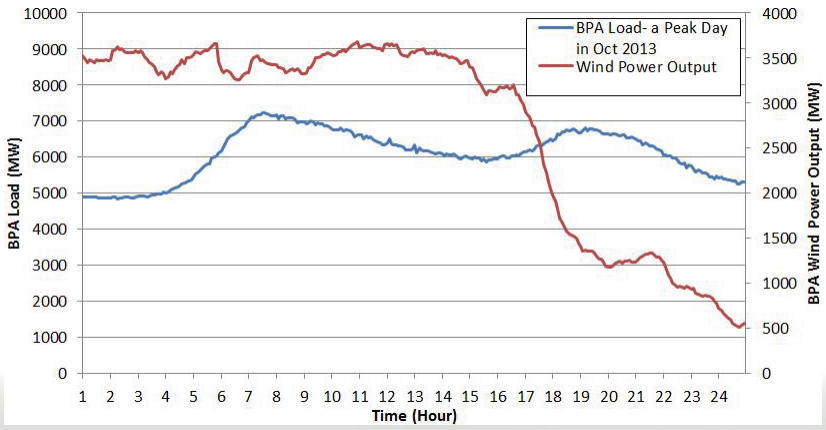
17

BPA Wind Output and Load Mismatch (Oct)



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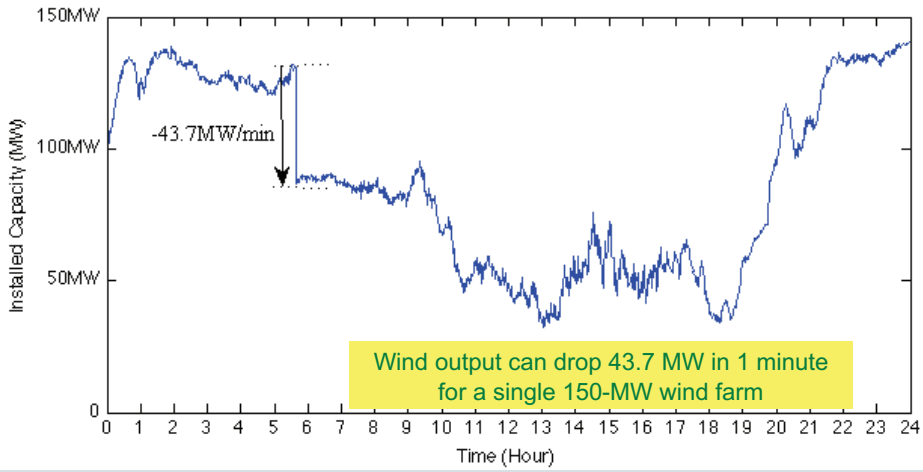
18

1-minute Variation of a 150MW Wind Farm Output in Texas



Wind output can drop 43.7 MW in 1 minute for a single 150-MW wind farm

Source: NREL

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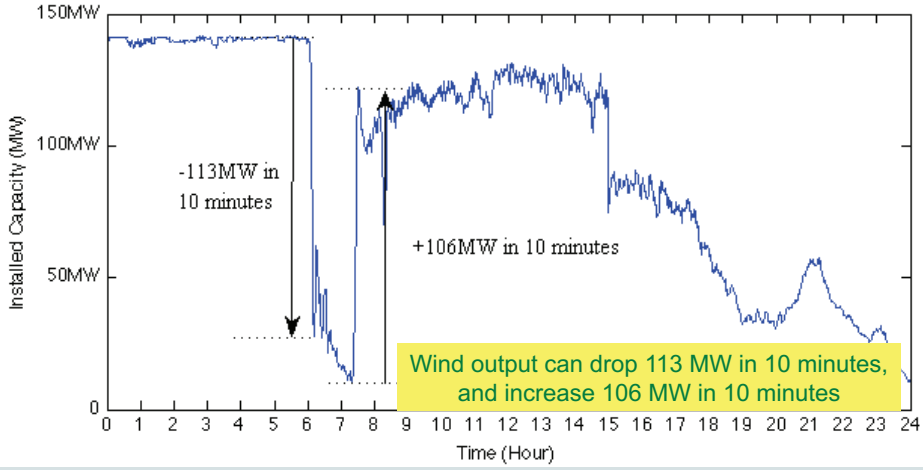
10-min Variation of a 150MW Wind Farm Output in Texas



Wind output can drop 113 MW in 10 minutes, and increase 106 MW in 10 minutes

Source: NREL

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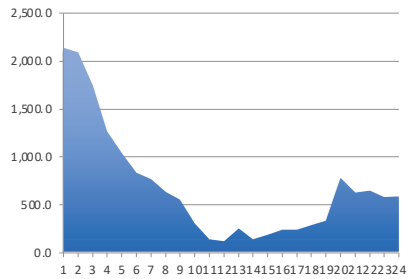
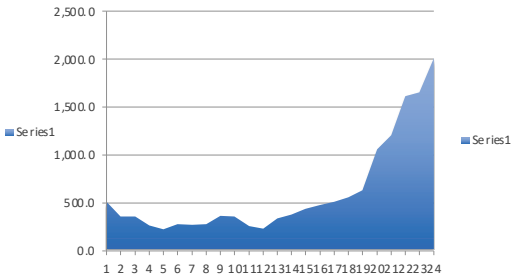
Hourly wind power variation (MW) in Texas, USA (01 and 02 Jan)



01 Jan 2008



02 Jan 2008

Installed Capacity 4,541 MW

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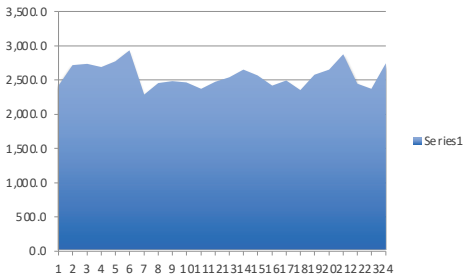
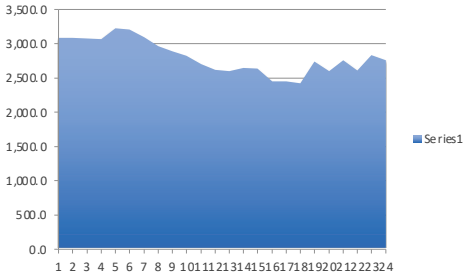
21

Hourly wind power variation (MW) in Texas, USA (03 and 04 Jan)



03 Jan 2008



04 Jan 2008

Installed Capacity 4,541 MW

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22

Intermittency Caused by Weather Events

Sand Storm in Abu Dhabi

Solar PV Project in UAE

23

23

In-depth look at Solar PV in KSA

2-MW Roof-top Solar PV plant at KAUST

24

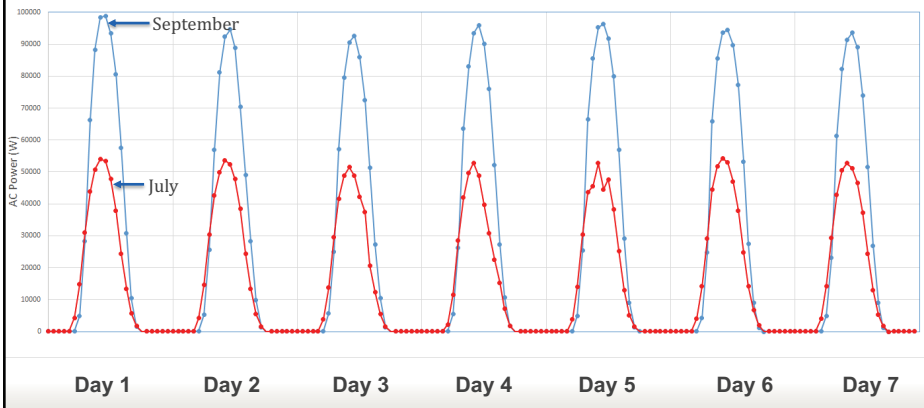
Solar PV Panels in Saudi Arabia

Reality Check

25

25

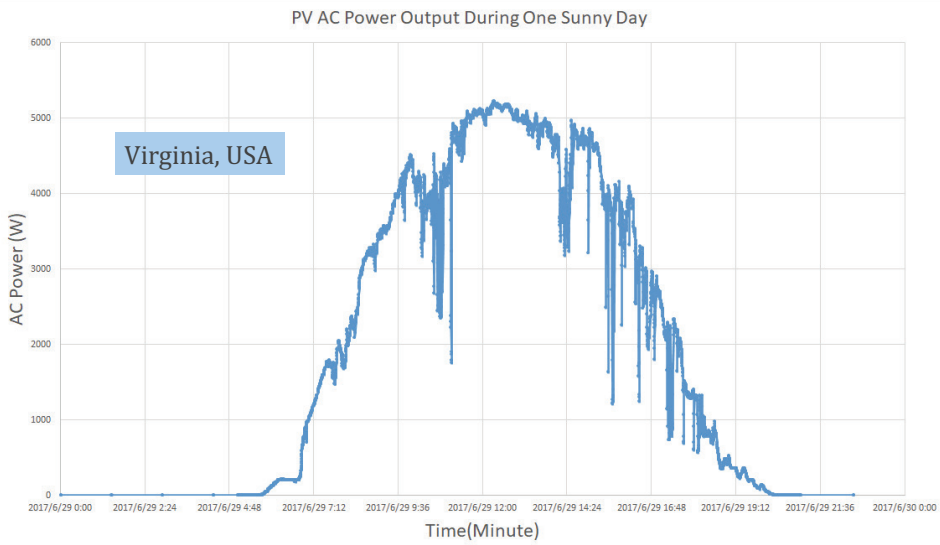
Solar PV Array (100kWp) Riyadh Area



26

26

Daily PV Output



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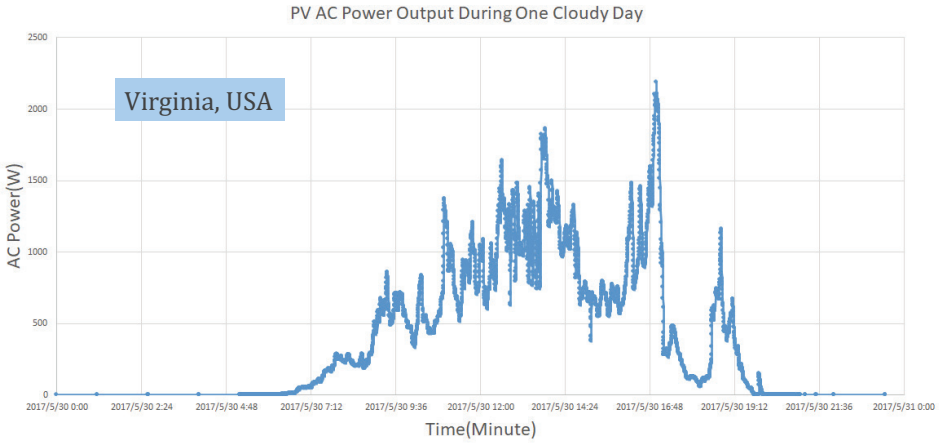
Daily PV Output (intermittent)



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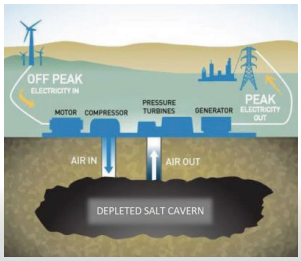
28

Can the Intermittency be Absorbed by the Network?

Battery storage

Pumped Storage

Compressed Air Storage



29

29

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.

30

30

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.

31

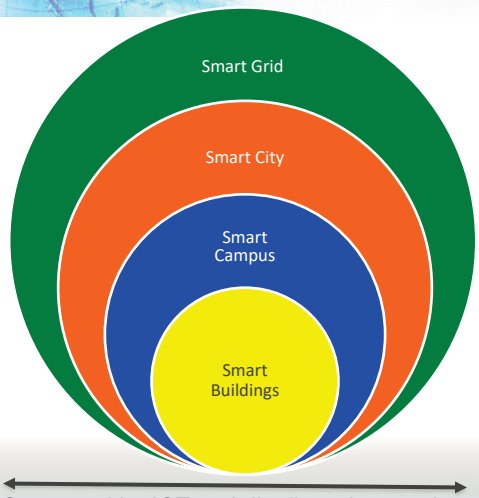
New Paradigm for the Power System

- 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

32

THE SMART GRID ECOSYSTEM



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

33

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…

33

What makes a Building Smart

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

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.

34

Cumulative Benefits of Building Load Control

- A large number of buildings can be controlled to absorb large fluctuations of supply in the short term
- Minimal storage is required
- Investment is for monitoring and control

35

Thank You

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36