

Role of the Smart Grid in Facilitating the Integration of Renewables

Keynote Speech

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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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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

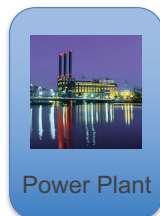
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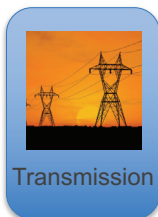
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Starting and End Points of a Smart Grid

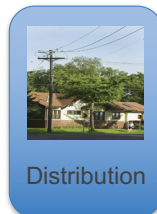
From Generator to Refrigerator



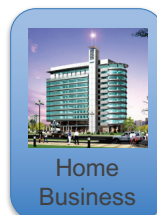
Power Plant



Transmission



Distribution



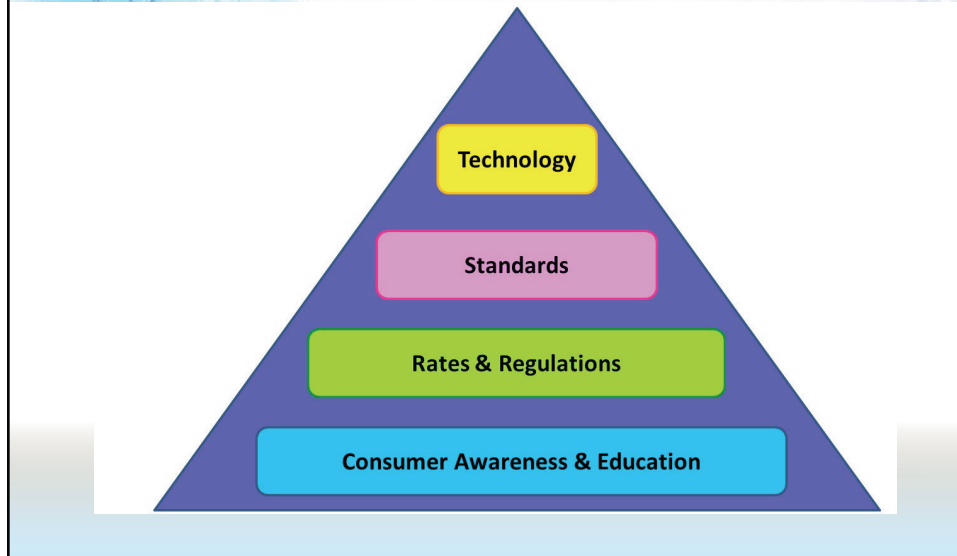
Home
Business



End-use
Appliances

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Smart Grid Building Blocks

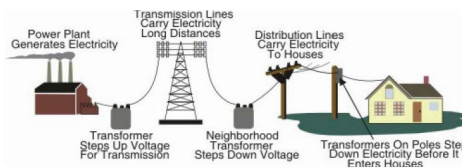


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Evolution of the Grid

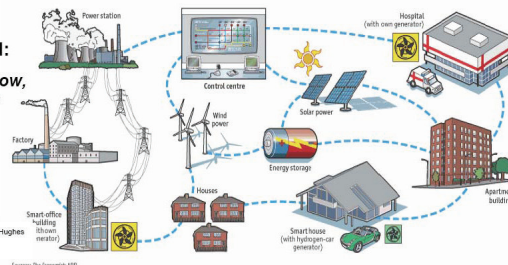
Before Smart Grid:

*One-way power flow,
simple interactions*



After Smart Grid:

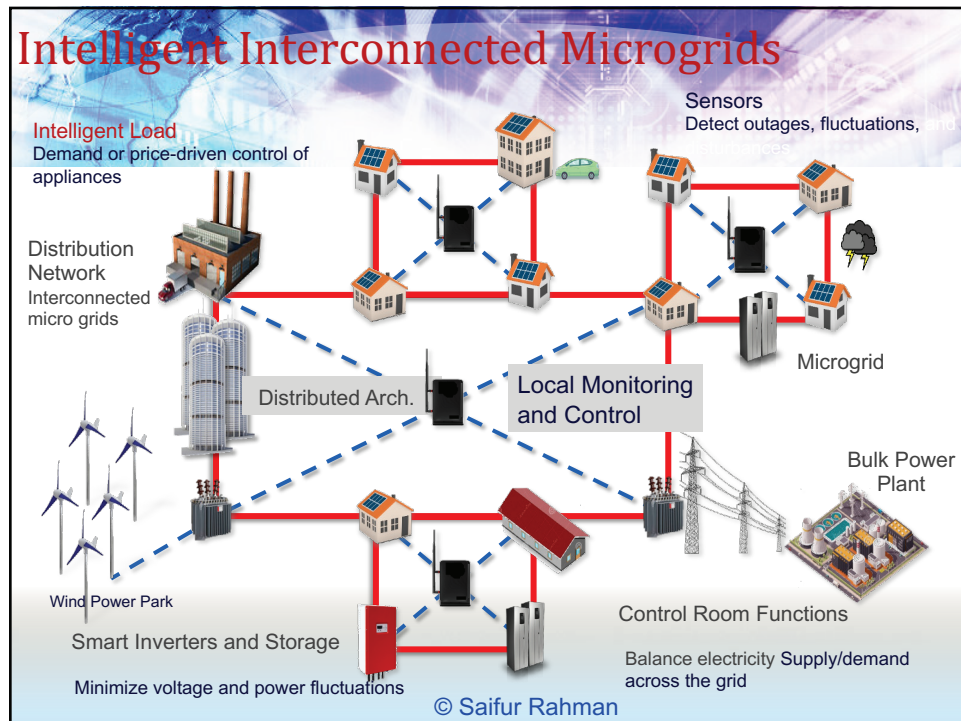
*Two-way power flow,
multi-stakeholder
interactions*



Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 26, 2008
Source: The Economist, 488

Source: Altalink, Alberta, Canada

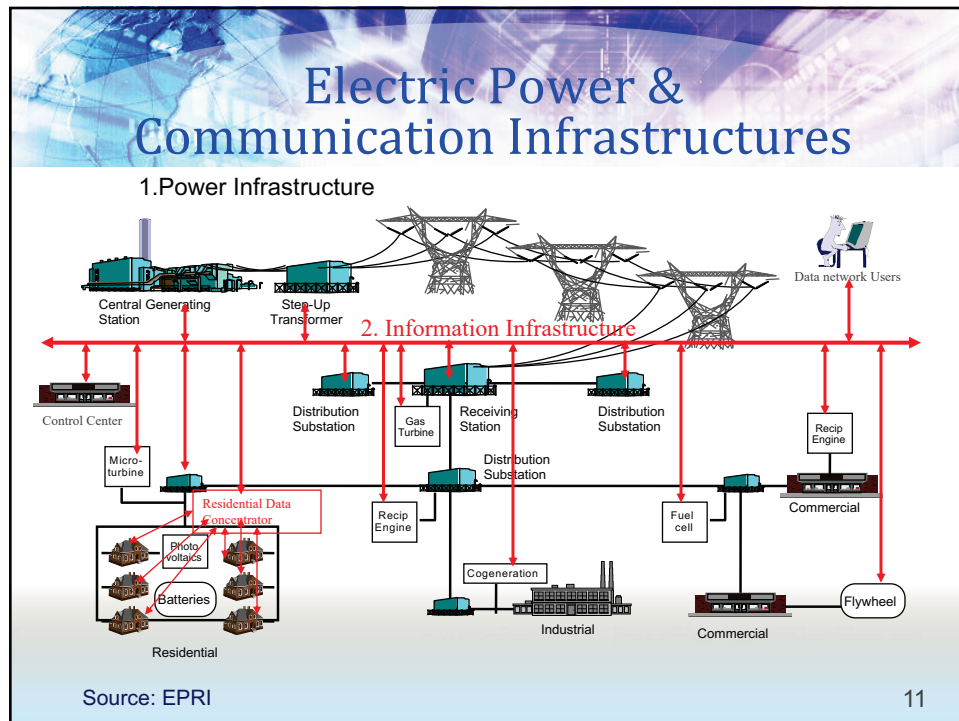
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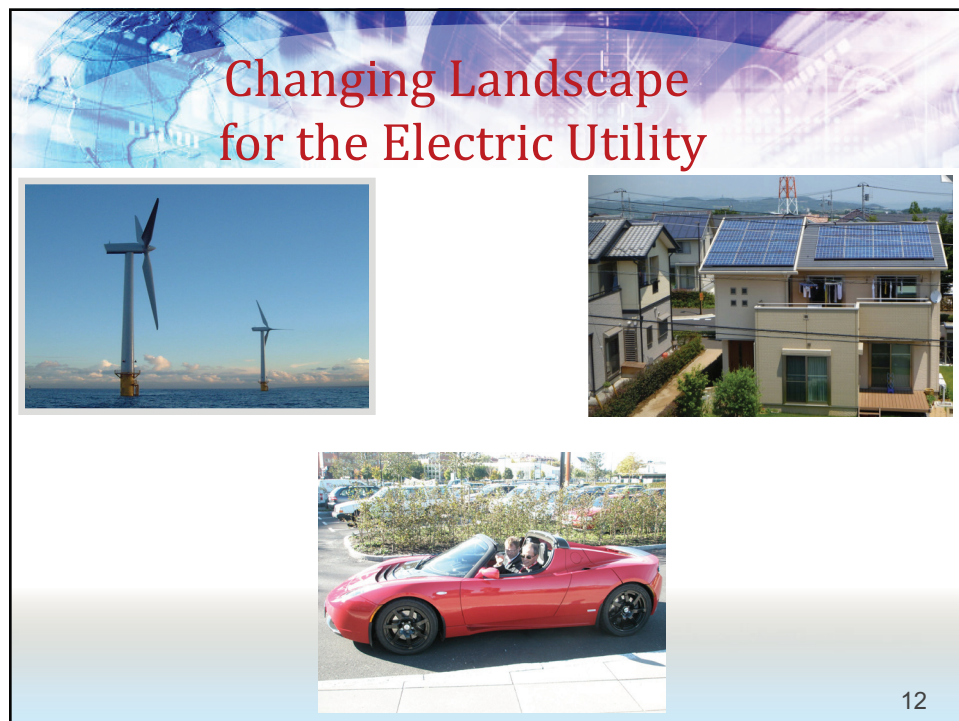
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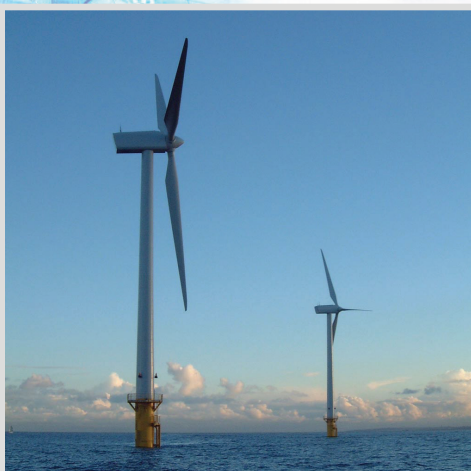
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Issues with Distributed Generation

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

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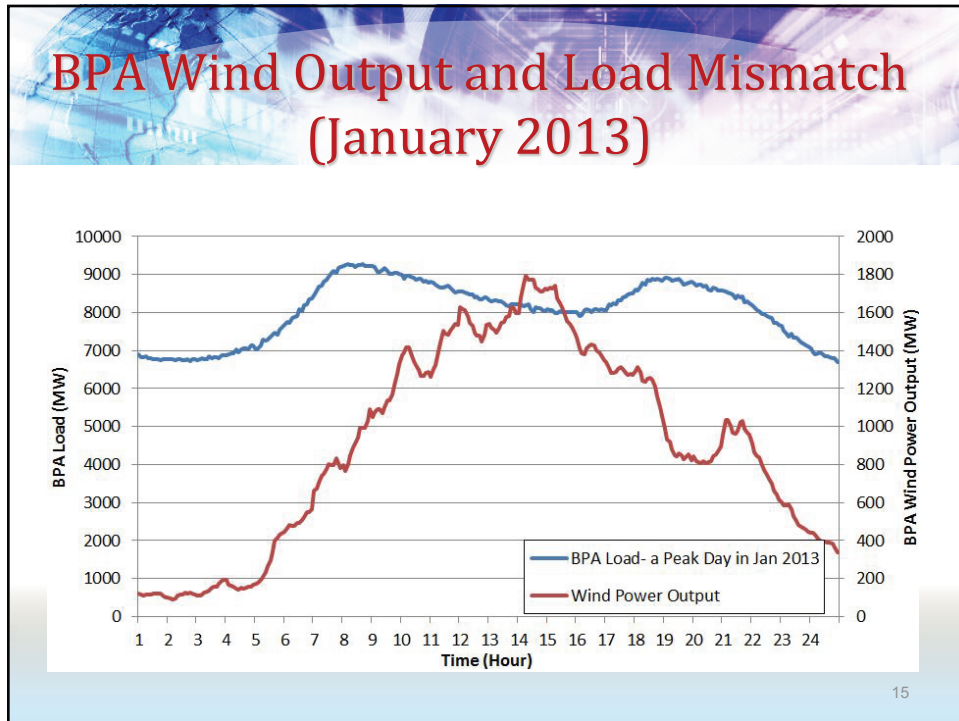
Wind Energy



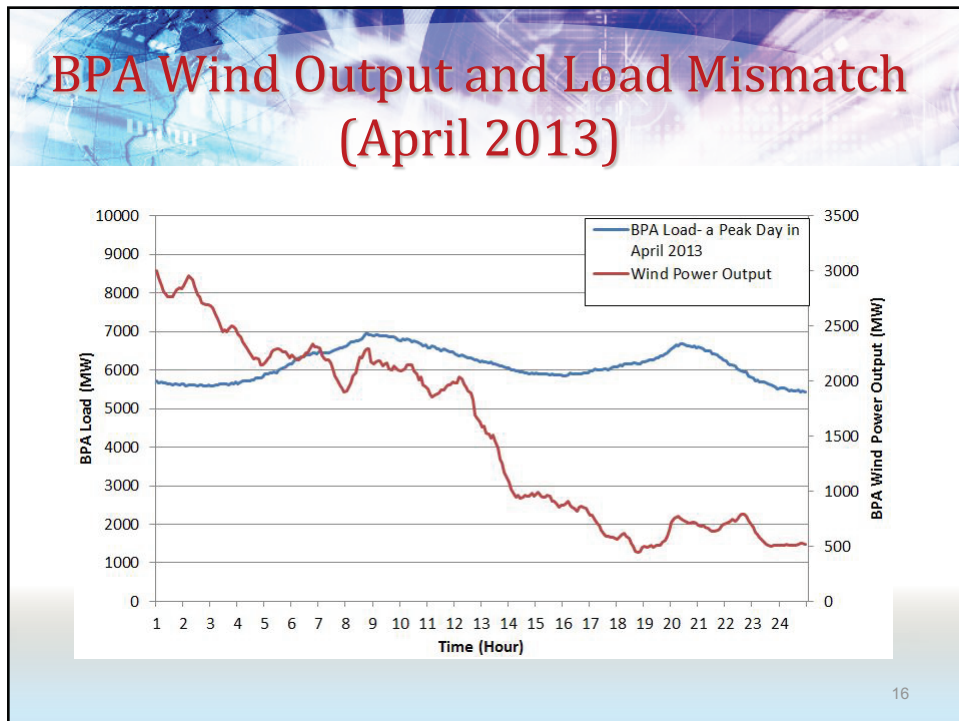
Off-shore Wind turbines, Blyth, U.K.

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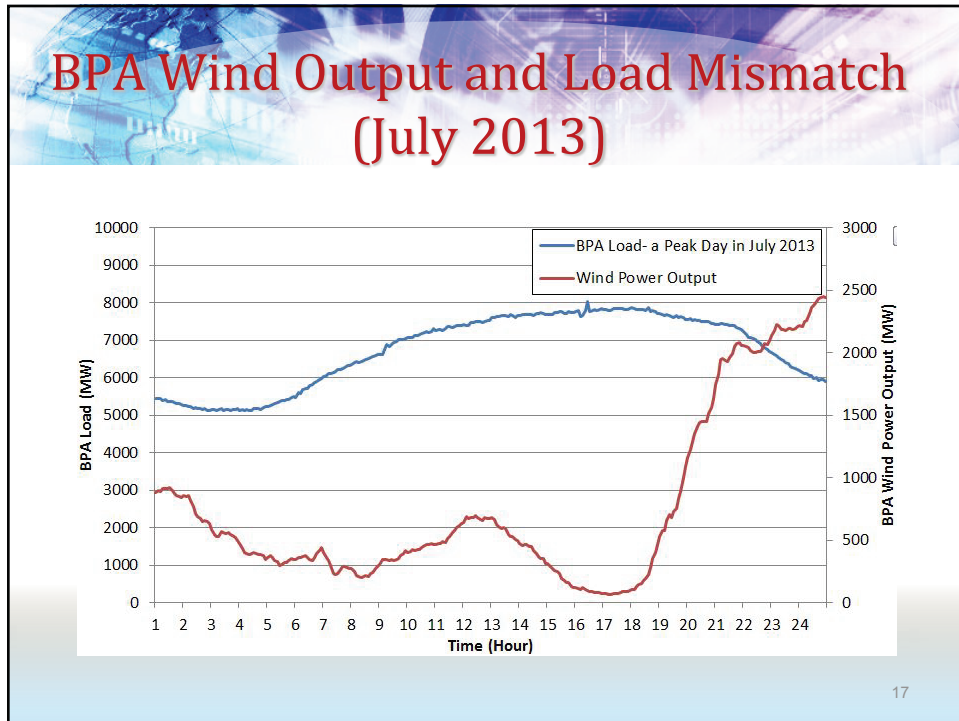
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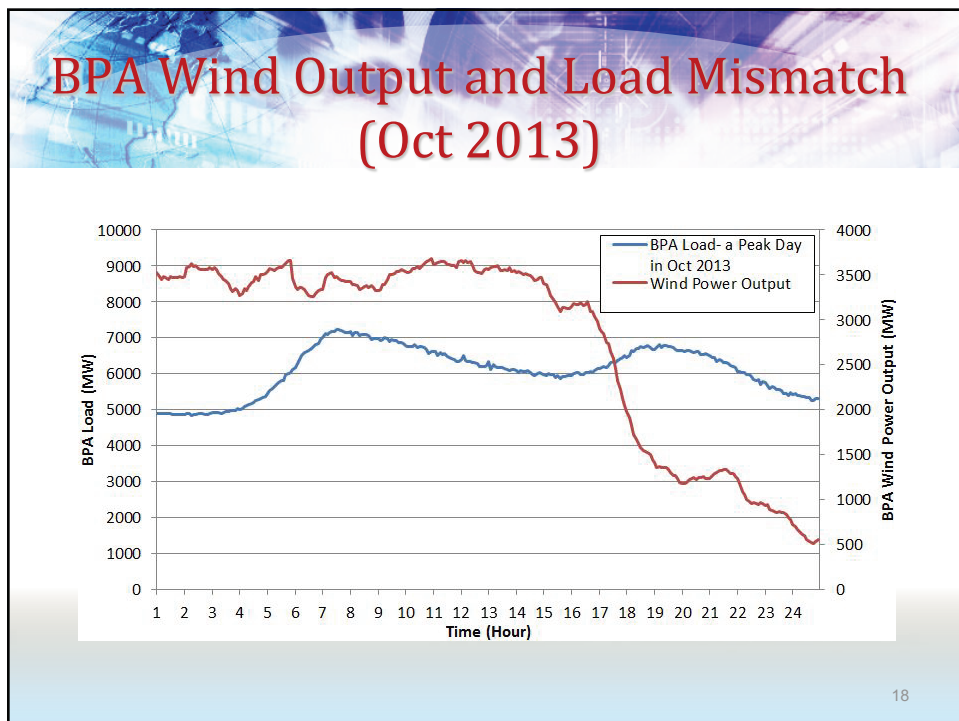
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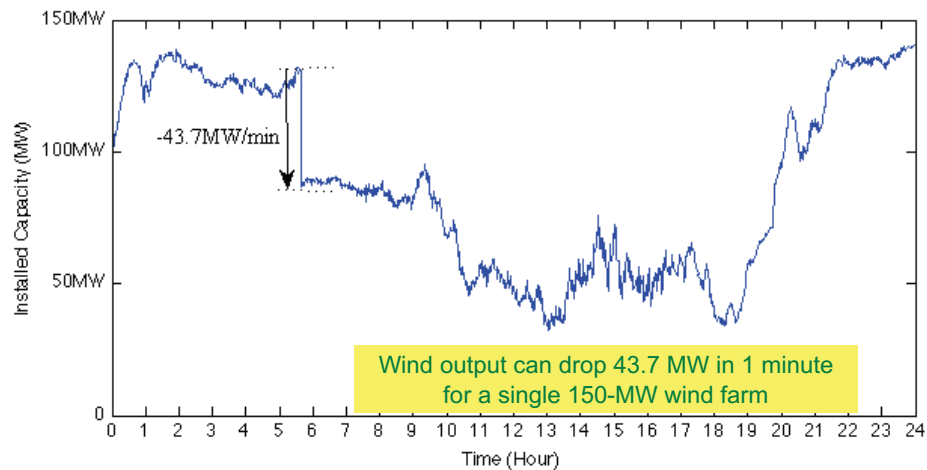


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1-minute Variation of a 150MW Wind Farm Output in Texas

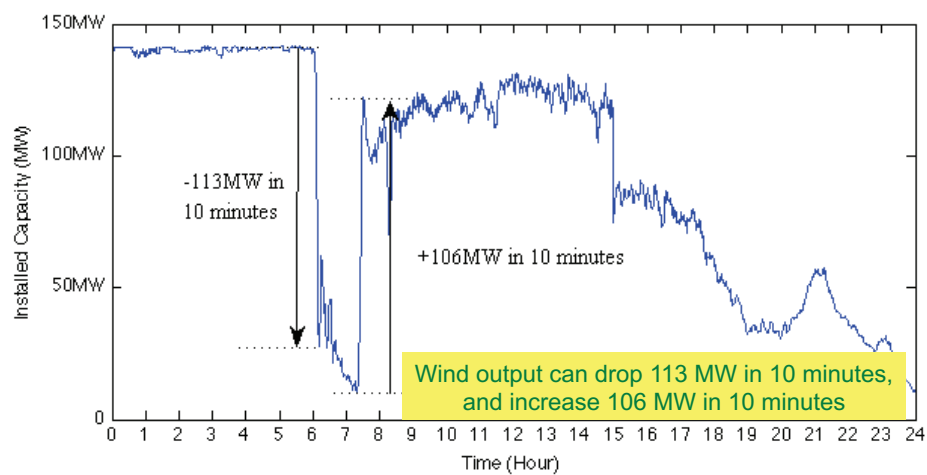


Source: NREL

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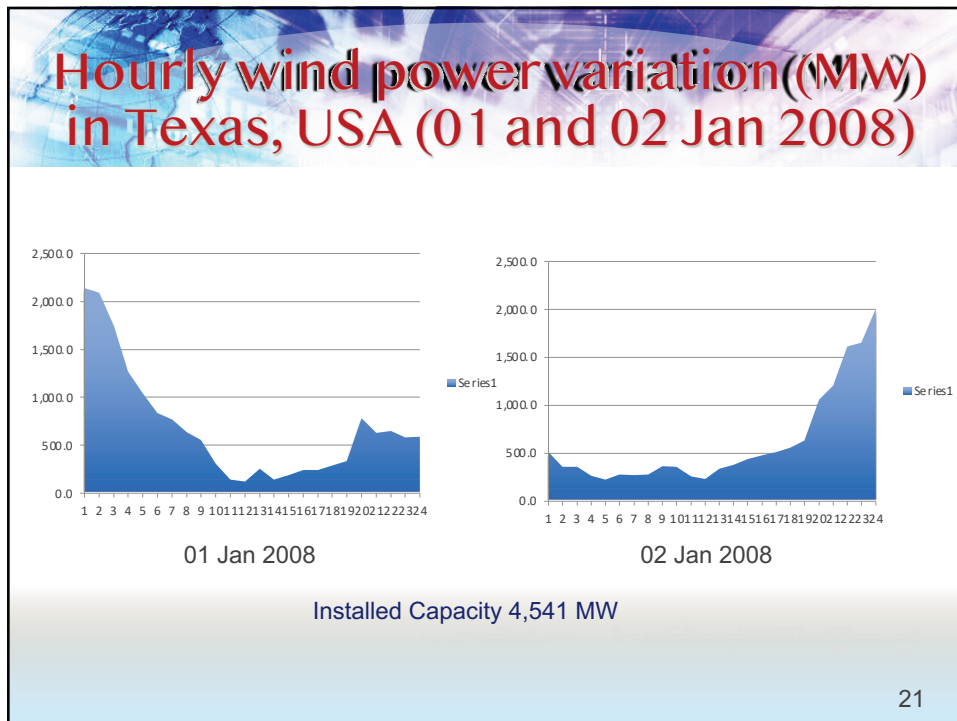
10-min Variation of a 150MW Wind Farm Output in Texas



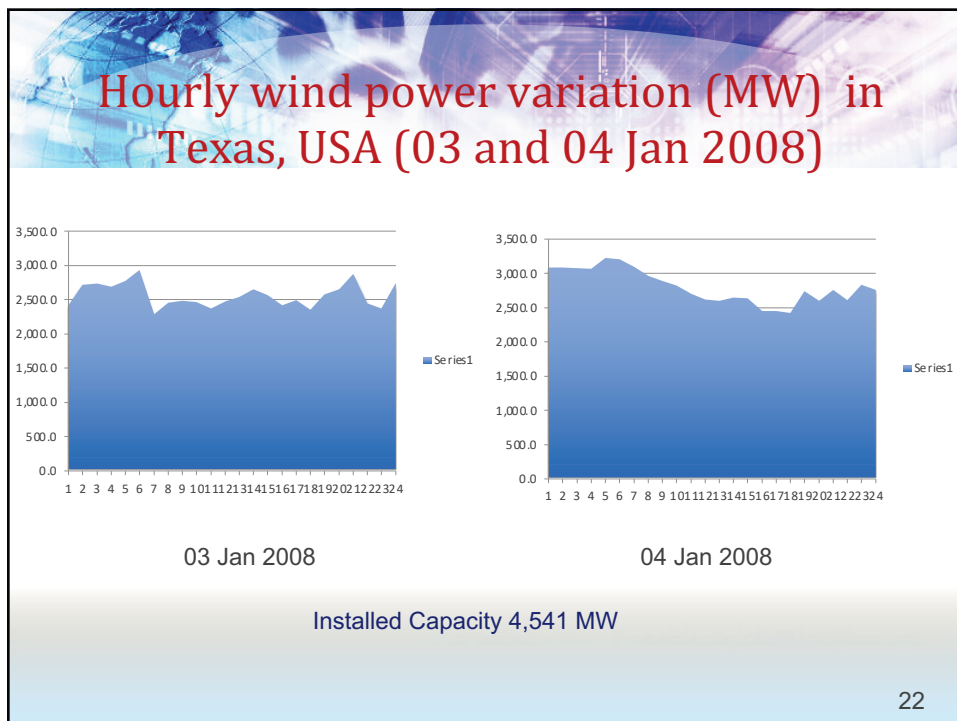
Source: NREL

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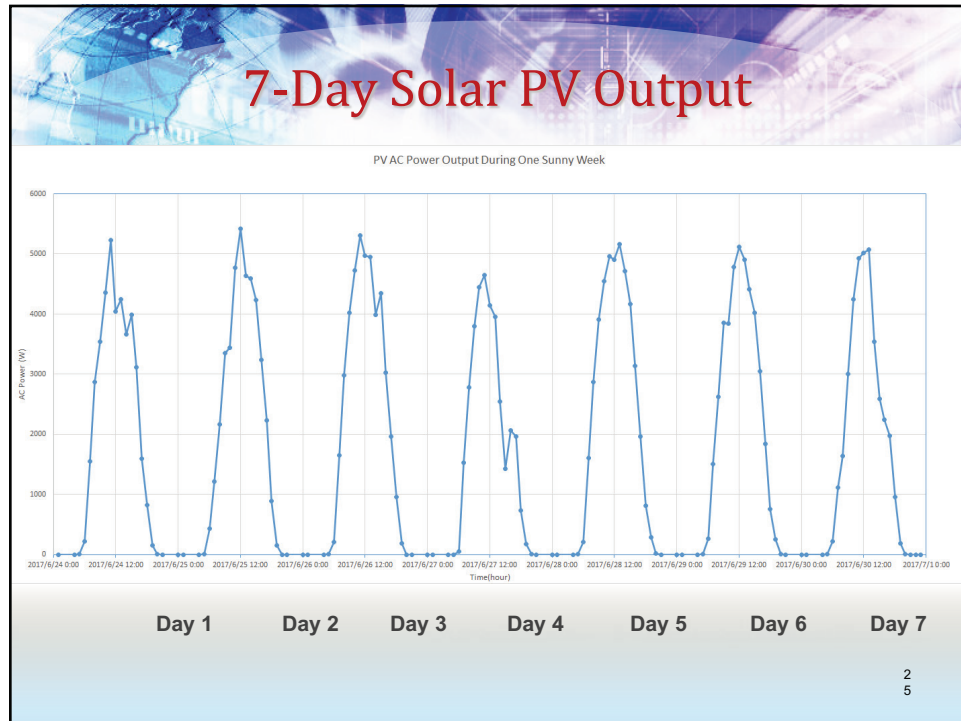
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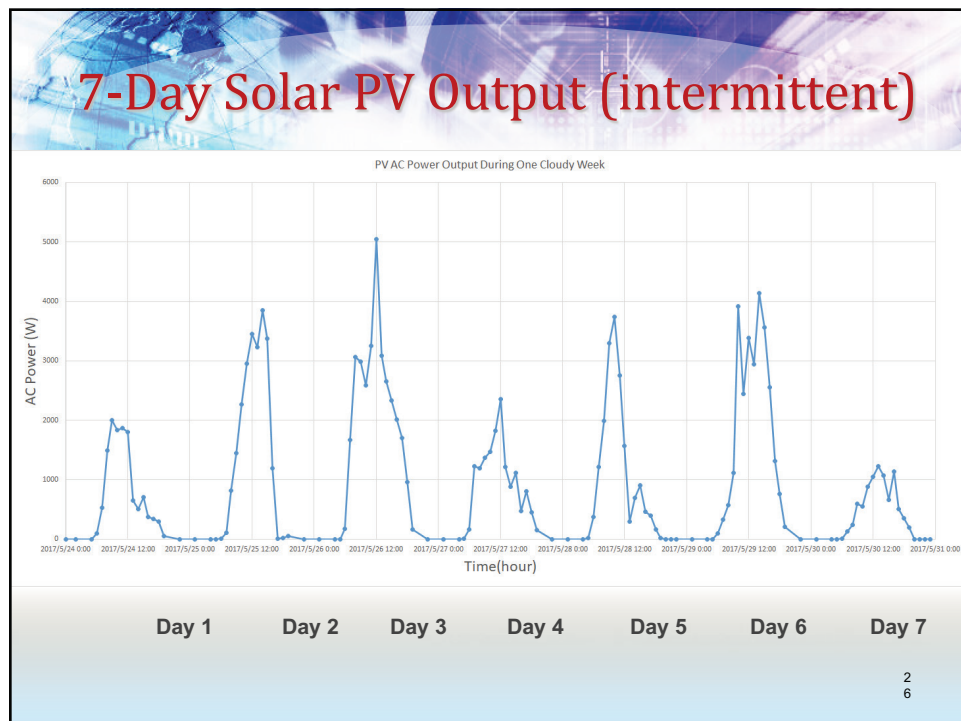
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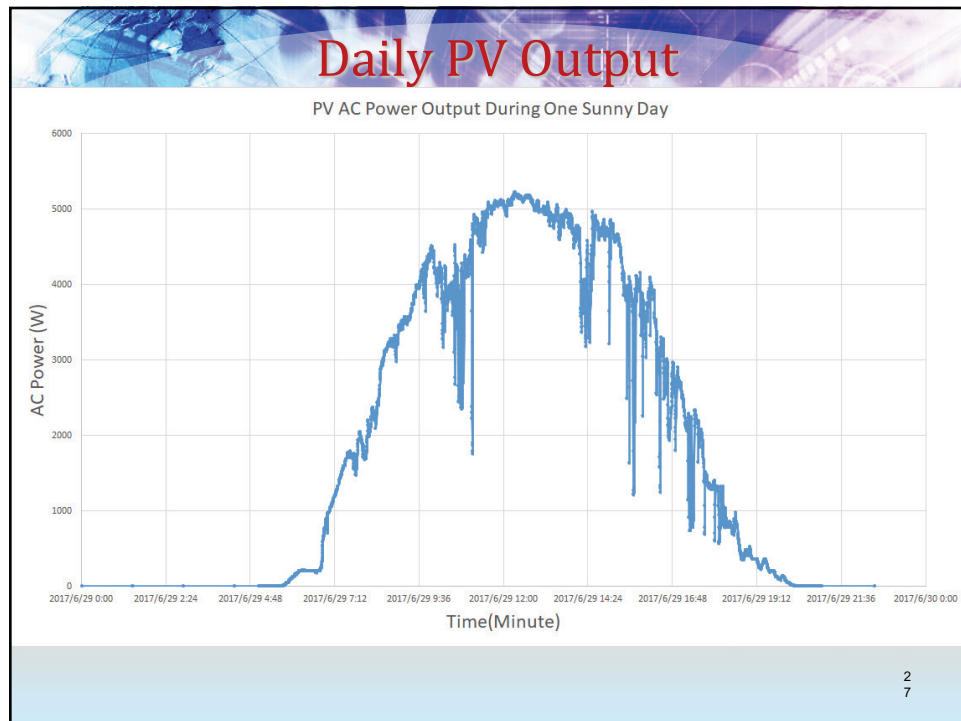
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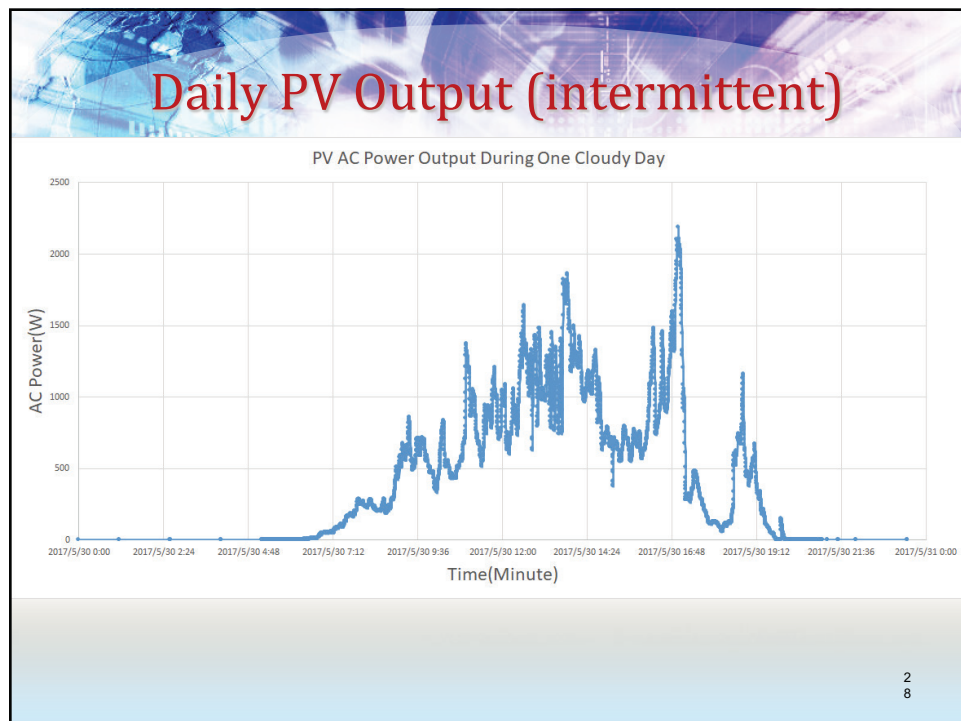
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Can the Intermittency be Absorbed by the Network?

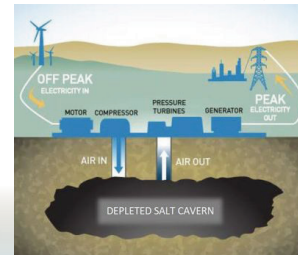


Battery storage



Pumped Storage

Compressed Air Storage



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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.

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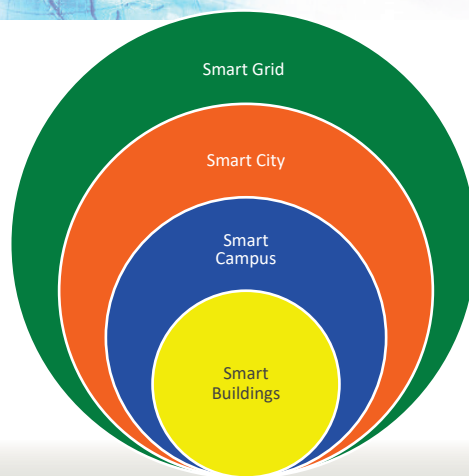
New Paradigm for the Power System

- 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

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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

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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.

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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

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Addressing the Intermittency in Renewable Generation

- Smart vs. not-so-smart load control
(adjust temperature set points in an air conditioner or water heater vs. turning the unit off)
- Size the storage to take advantage of demand dynamics
- Control the renewable generation to avoid instability (output control from PV inverters)

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Thank you
Prof. Saifur Rahman

www.saifurrahman.org

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