Role of the Smart Grid in Facilitating the Integration of Renewables

Invited Talk

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ARI

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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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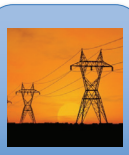
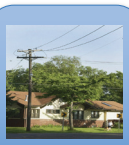
Starting and End Points of a Smart Grid

From Generator to Refrigerator

Power Plant



Transmission



Distribution

Home Business

End-use Appliances

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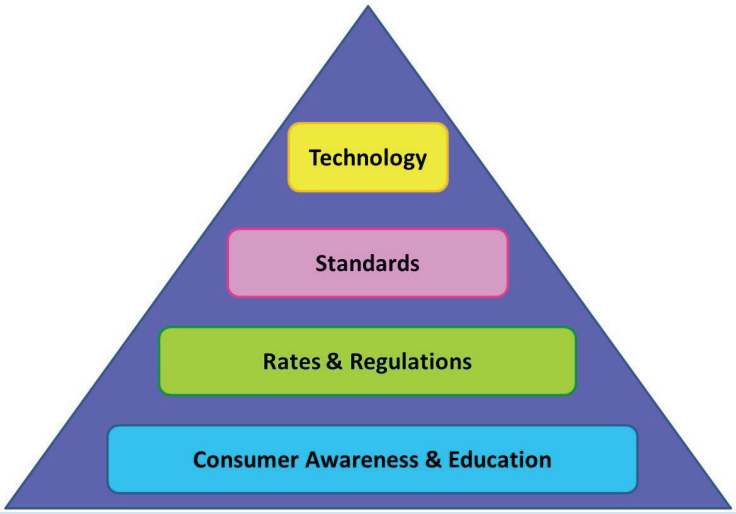
Smart Grid Building Blocks



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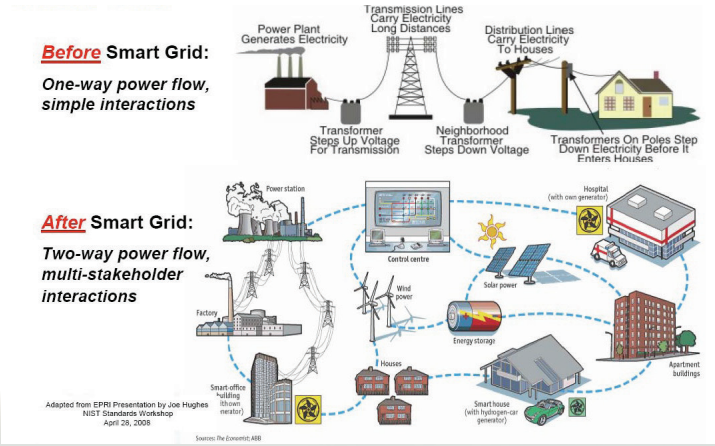
Evolution of the Grid



Source: Altalink, Alberta, Canada

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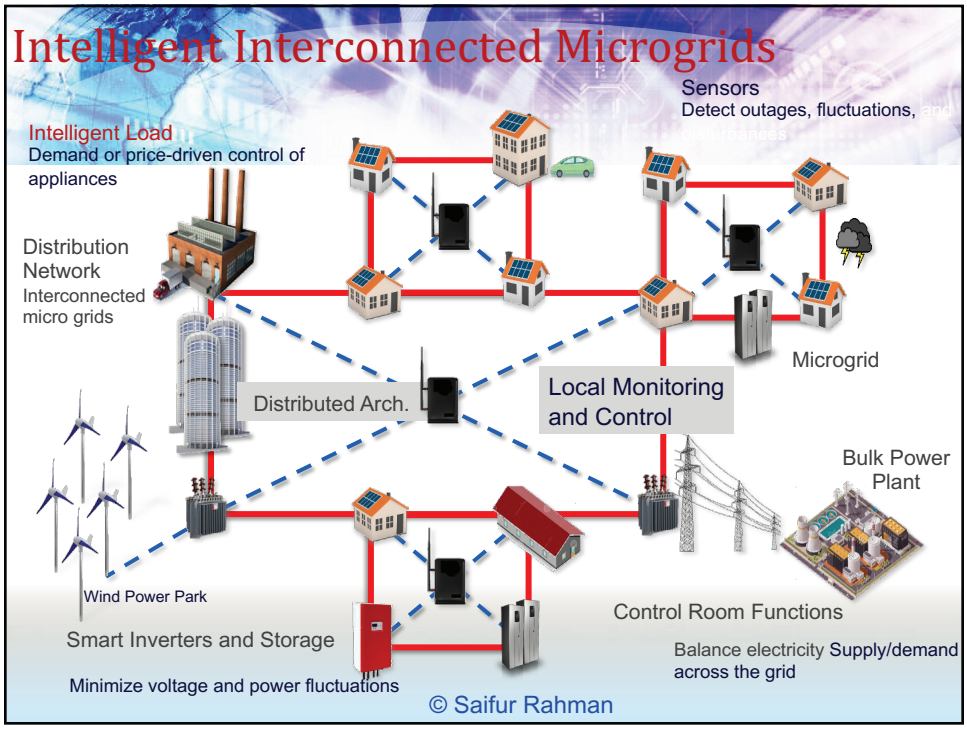

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Merging Power Flow with Information Flow:

Integrated Communications

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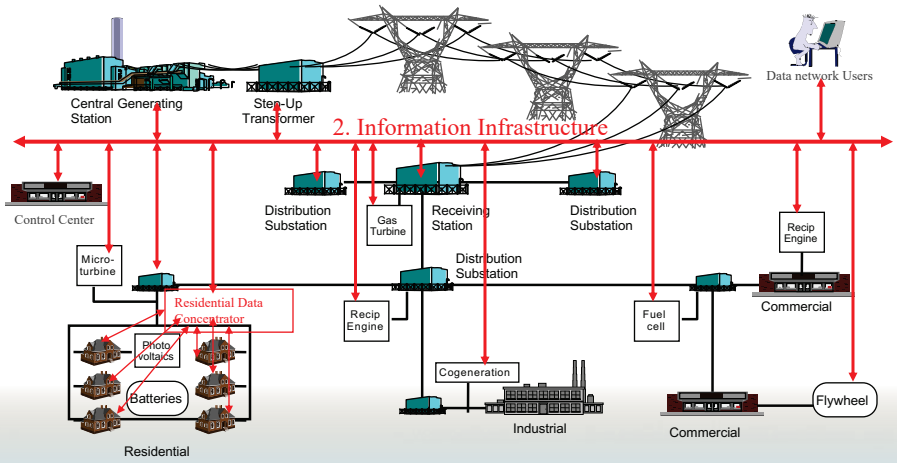
Electric Power & Communication Infrastructures

1.Power Infrastructure



Source: EPRI

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Changing Landscape for the Electric Utility

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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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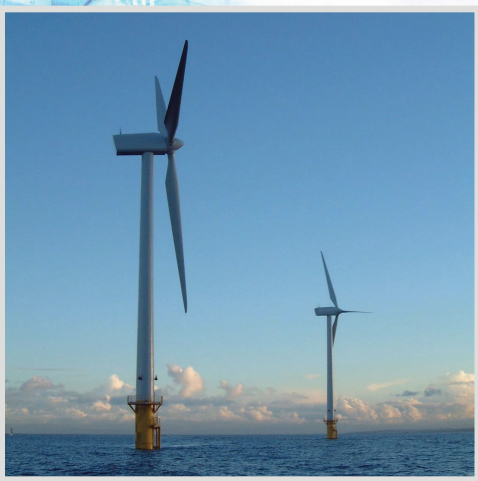

Off-shore Wind turbines, Blyth, U.K.

Wind Energy

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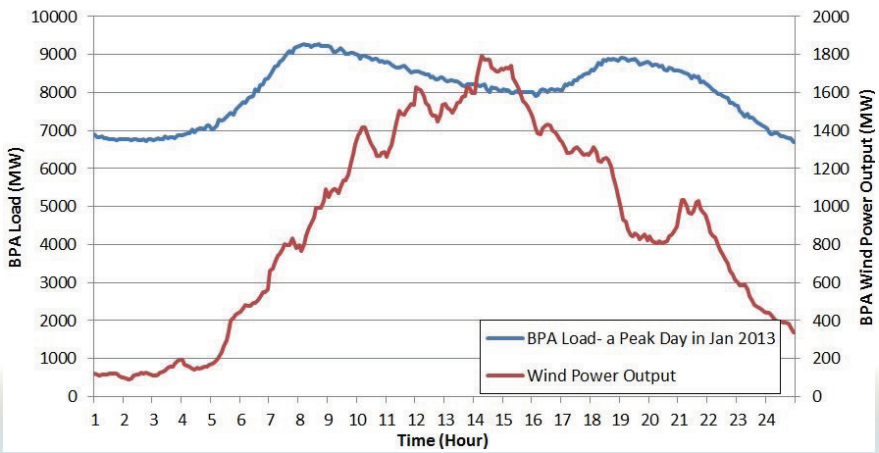
BPA Wind Output and Load Mismatch (January 2013)



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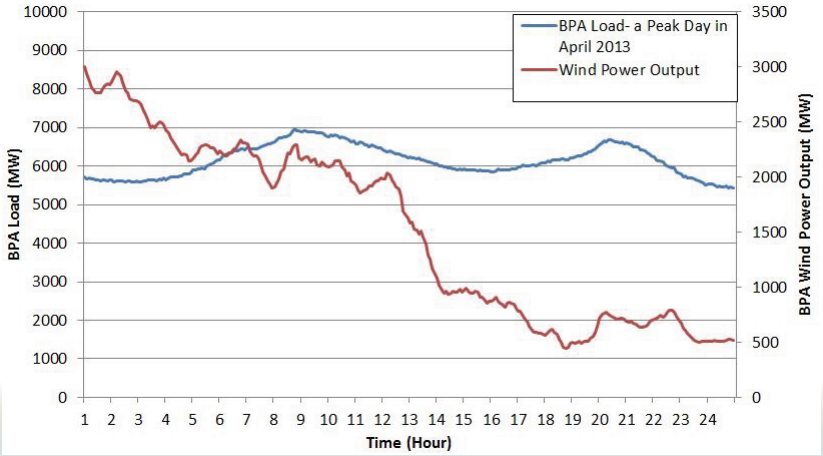
BPA Wind Output and Load Mismatch (April 2013)



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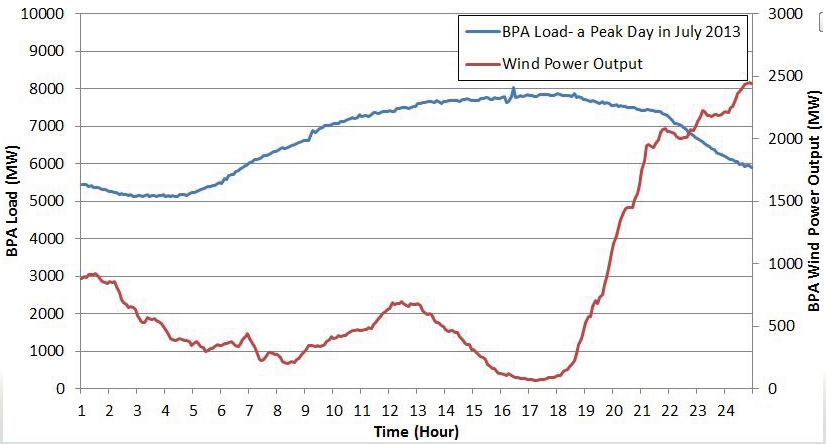
BPA Wind Output and Load Mismatch (July 2013)



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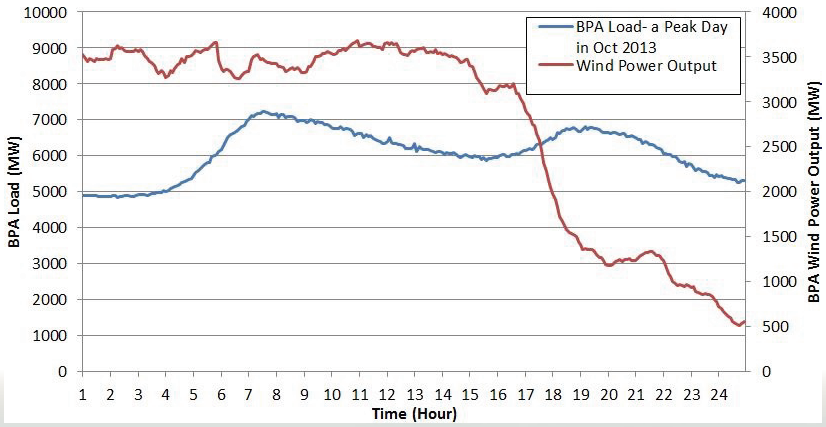
BPA Wind Output and Load Mismatch (Oct 2013)



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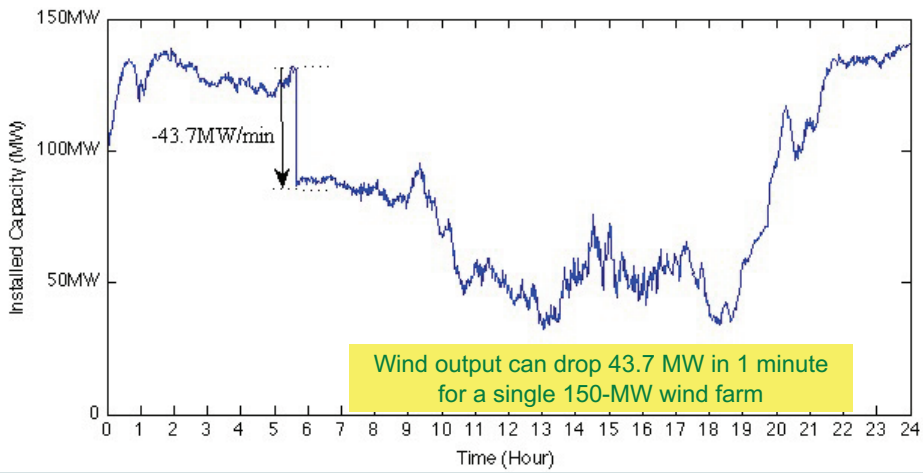
1-minute Variation of a 150MW Wind Farm Output in Texas



Source: NREL

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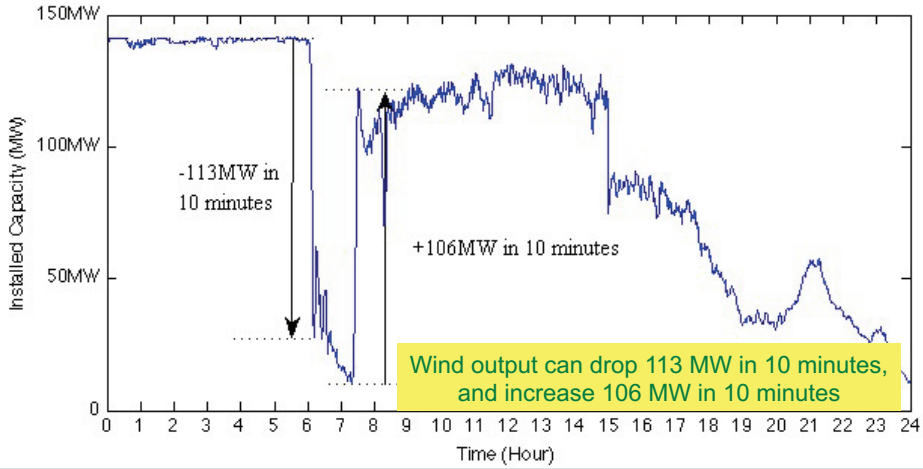
10-min Variation of a 150MW Wind Farm Output in Texas



Source: NREL

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Roof-top Solar Photovoltaics in Virginia

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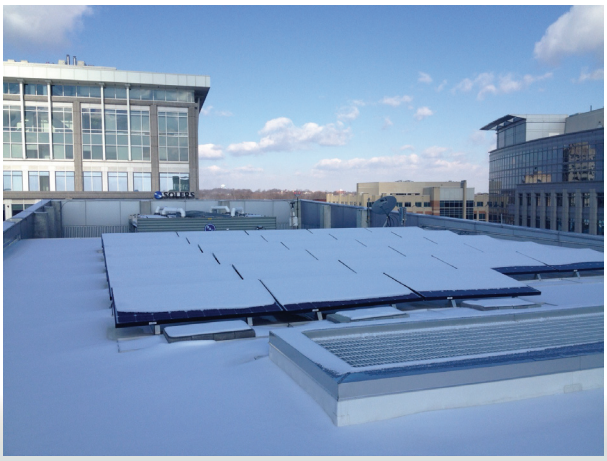
Solar Panels in Winter



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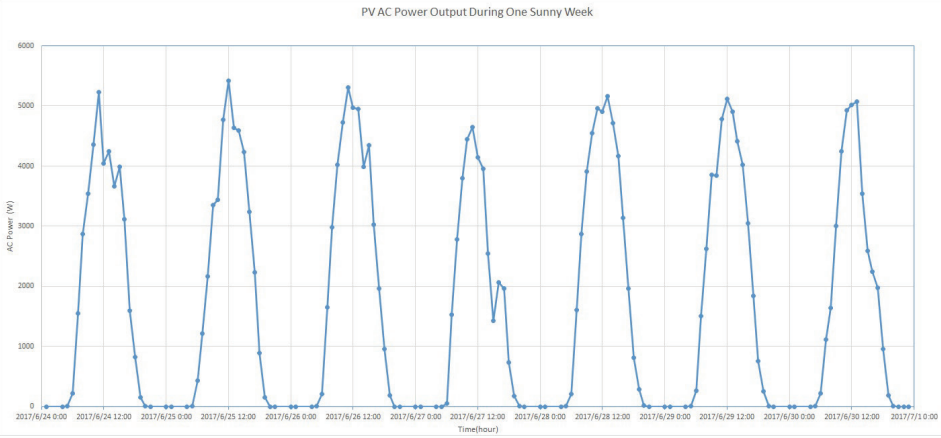
7-Day Solar PV Output



Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7

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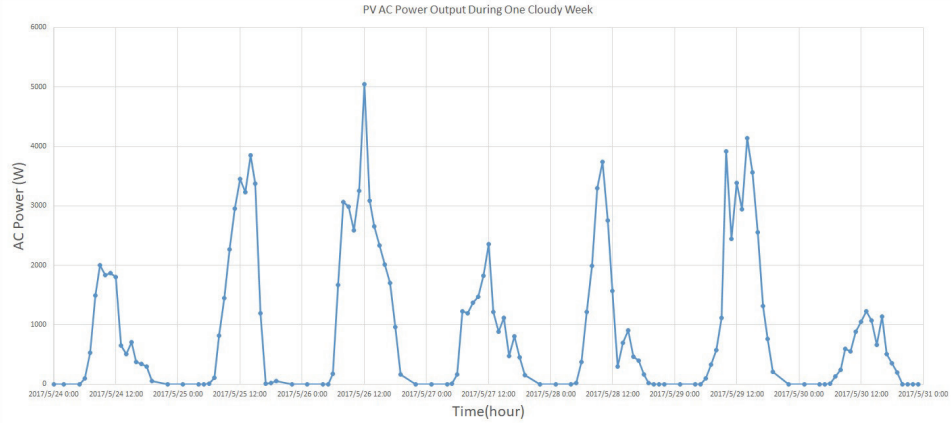
7-Day Solar PV Output (intermittent)



Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7

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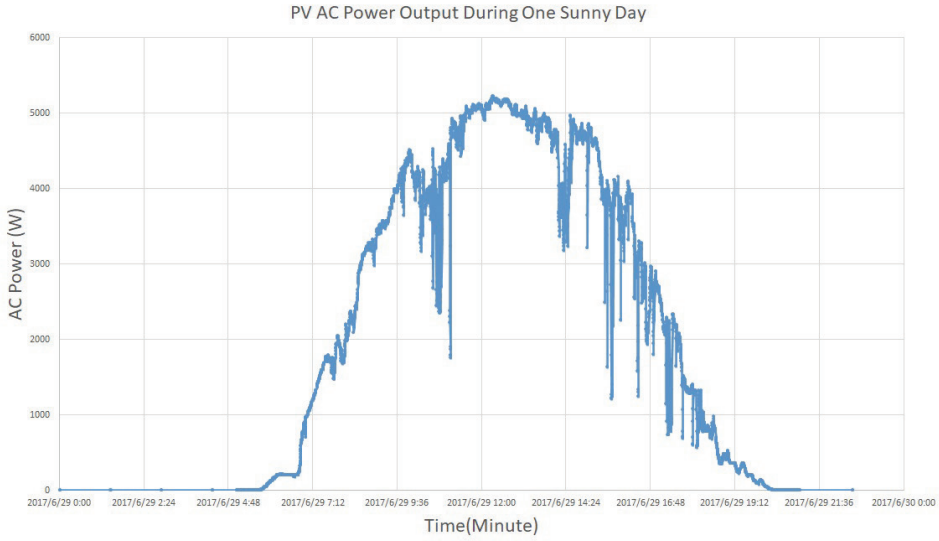
Daily PV Output



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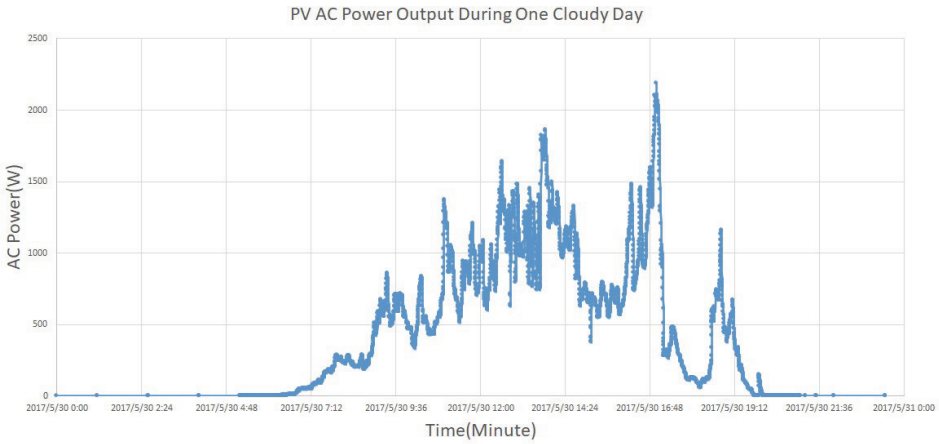
Daily PV Output (intermittent)



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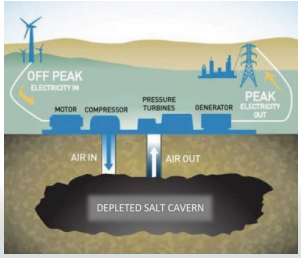
Can the Intermittency be Absorbed by the Network?

Battery storage

Pumped Storage

Compressed Air Storage



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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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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.

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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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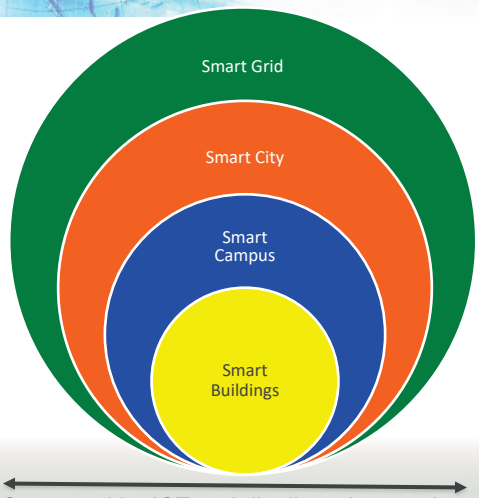
THE SMART GRID ECOSYSTEM



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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IEEE President-elect candidate

Thank You

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