Role of the Smart Grid in Facilitating the Integration of Renewables

Invited Speech

IEEE PES No VA/Washington DC Joint-Chapter Webinar
17 September 2020

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ARI

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.

Electric Power Grid

Source: www.sxc.hu

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.

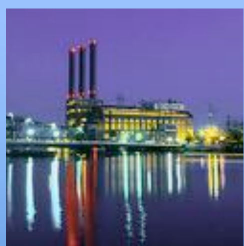
Difference Between a Normal Grid And a Smart Grid

Normal Phone

Smart Phone

Starting and End Points of a Smart Grid

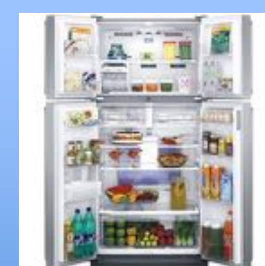
From Generator to Refrigerator


Power Plant

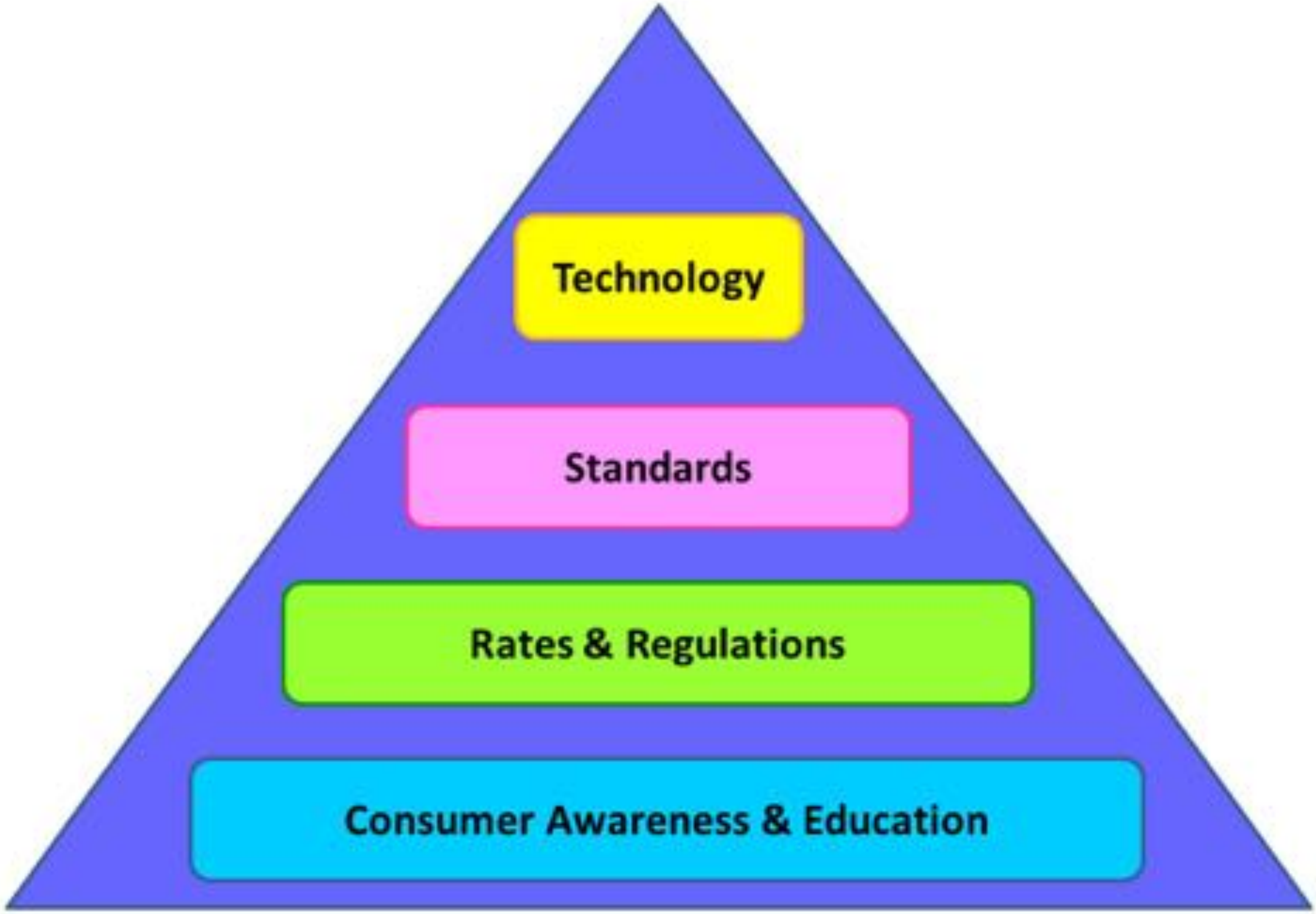

Transmission


Distribution

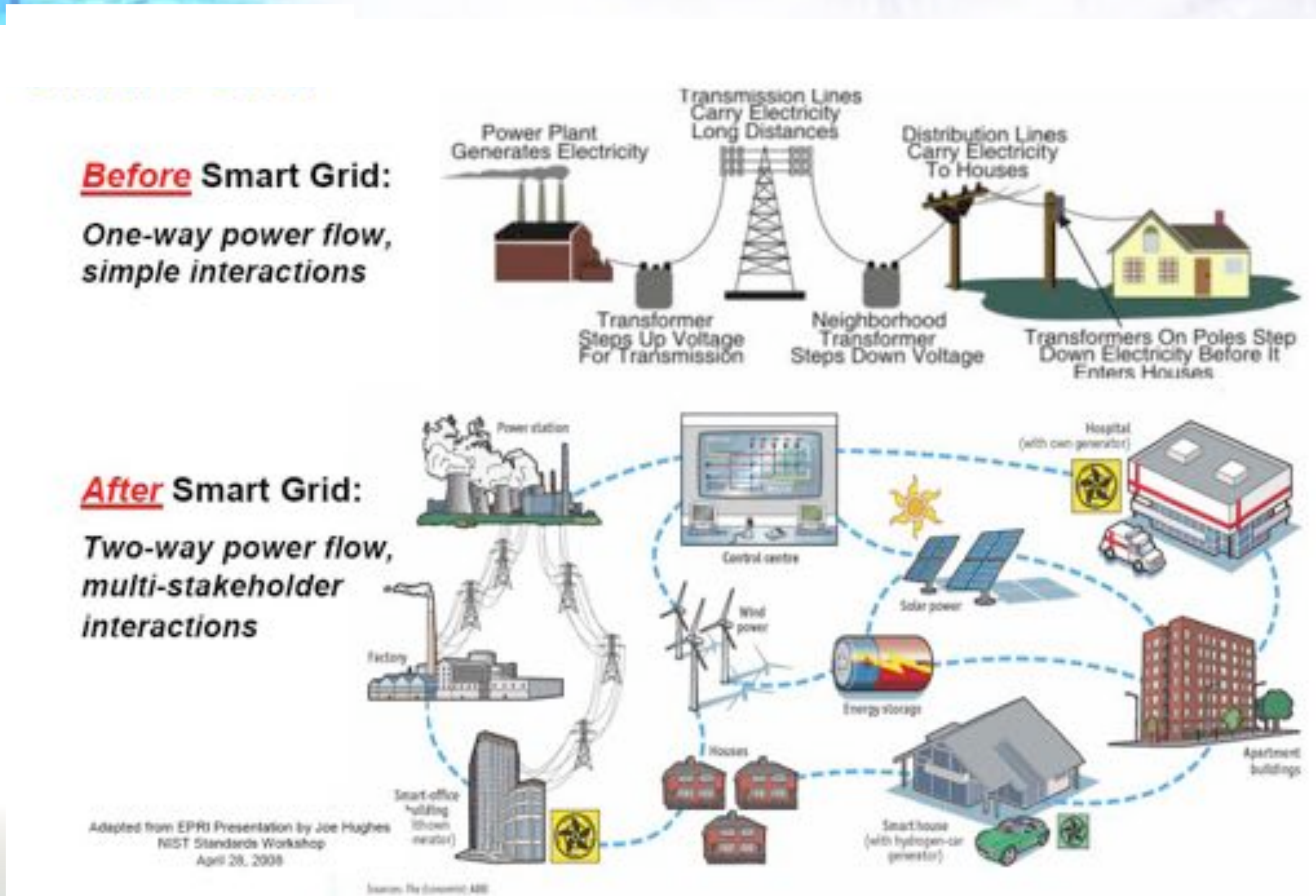

Home
Business


End-use
Appliances

Smart Grid Building Blocks

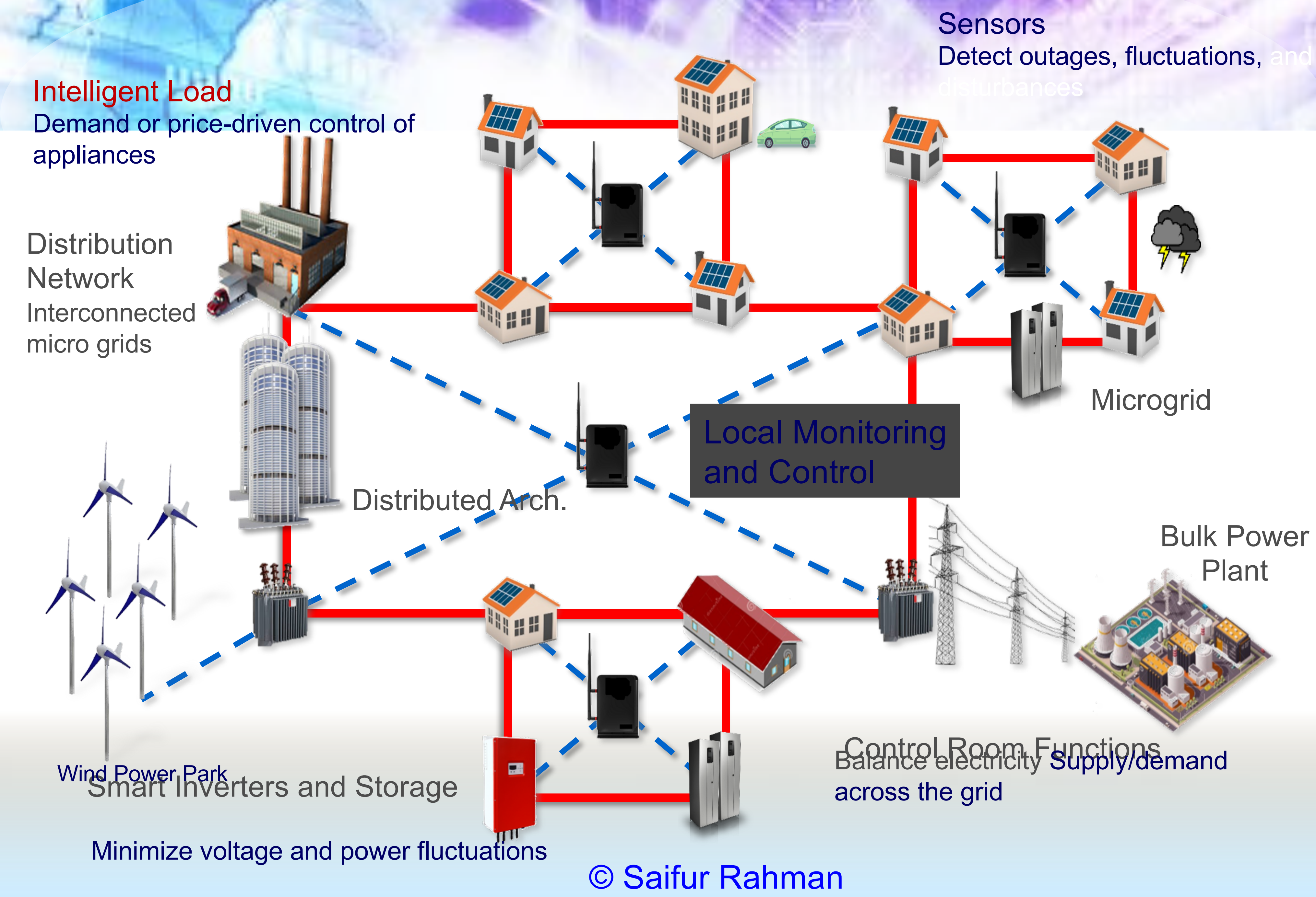


Evolution of the Grid



Source: Altalink, Alberta, Canada

Intelligent Interconnected Microgrids

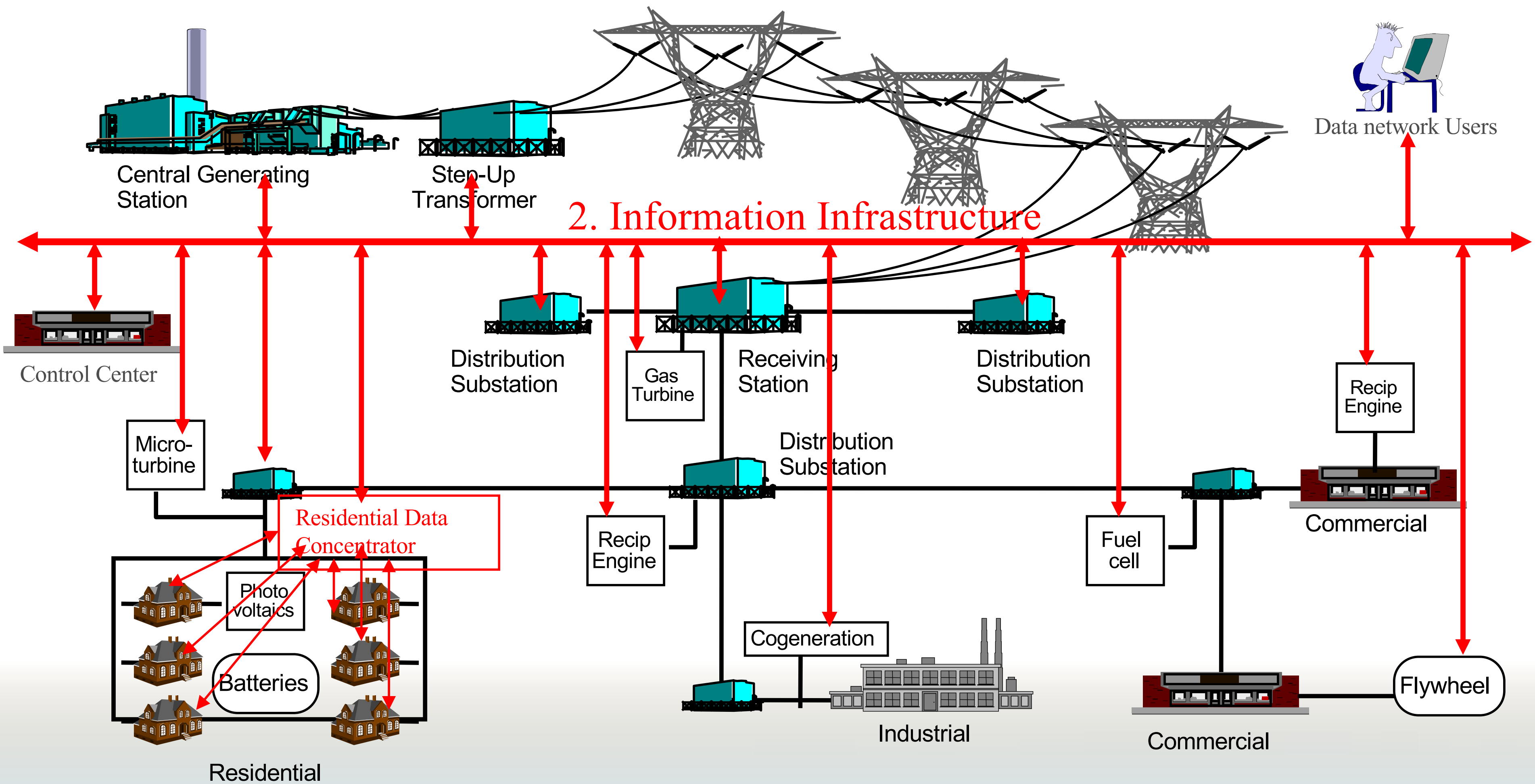


Merging Power Flow with Information Flow:

Integrated Communications

Electric Power & Communication Infrastructures

1.Power Infrastructure



Source: EPRI

Changing Landscape for the Electric Utility

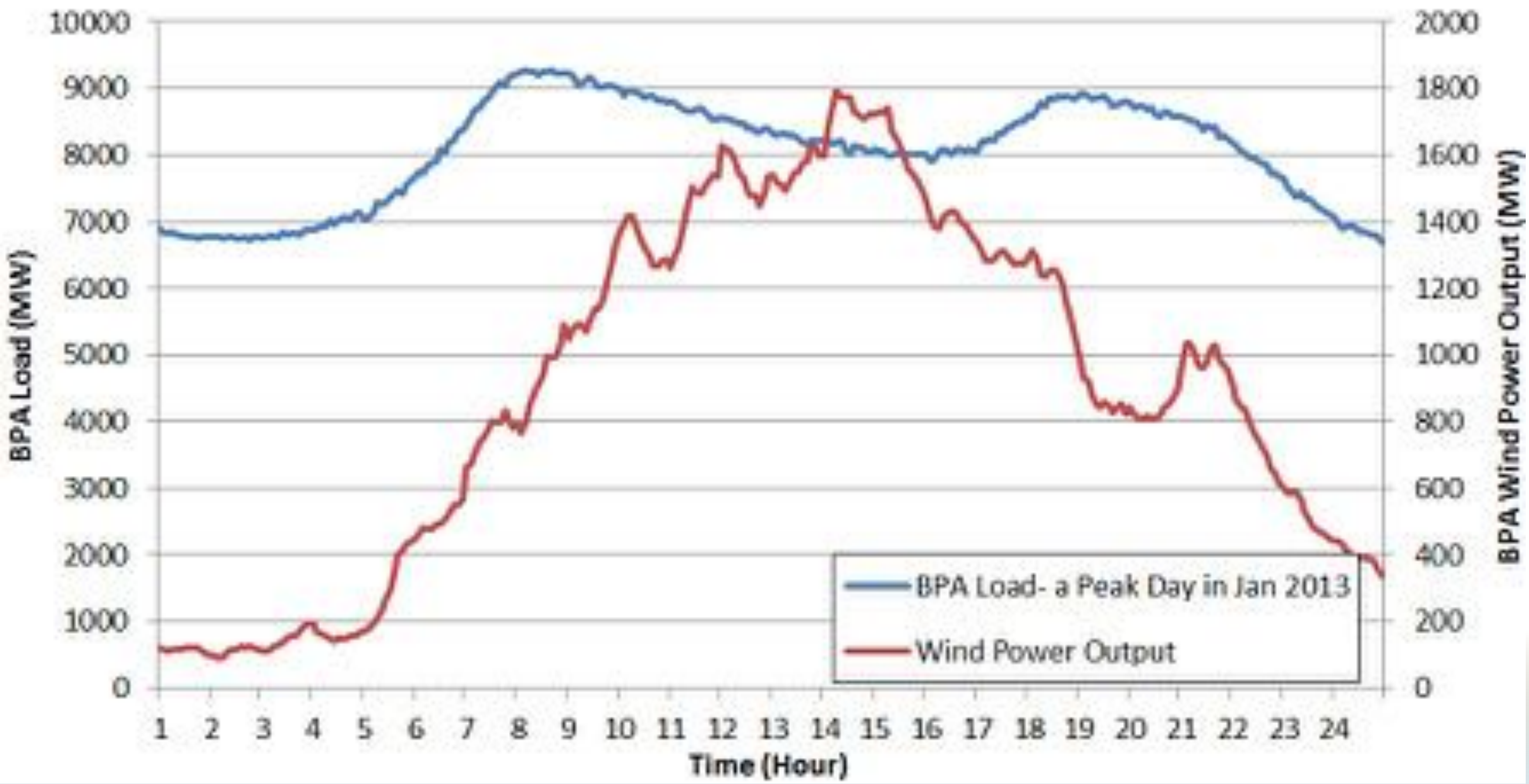
Issues with Distributed Generation

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

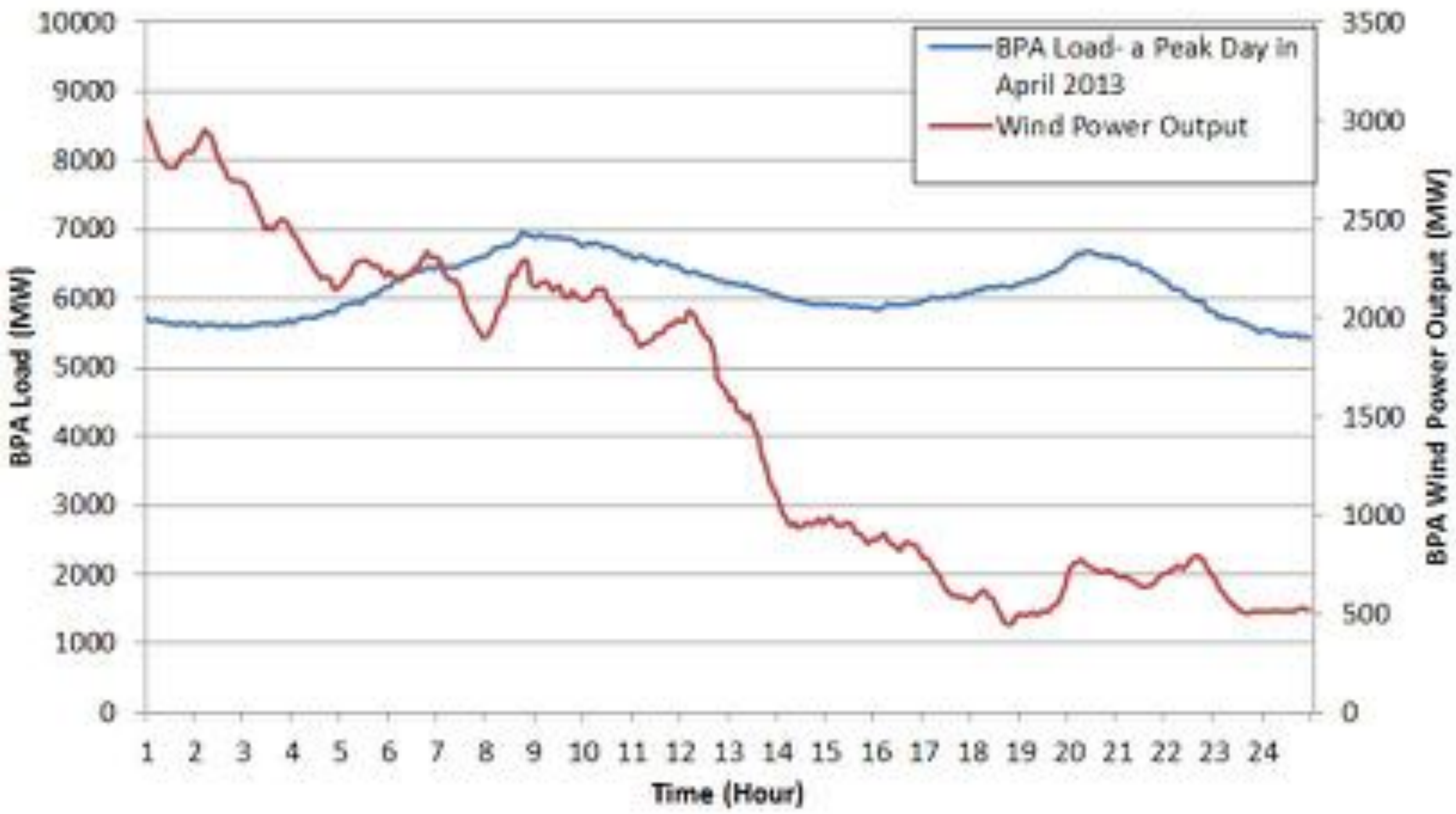
Off-shore Wind turbines, Blyth, U.K.

Wind Energy

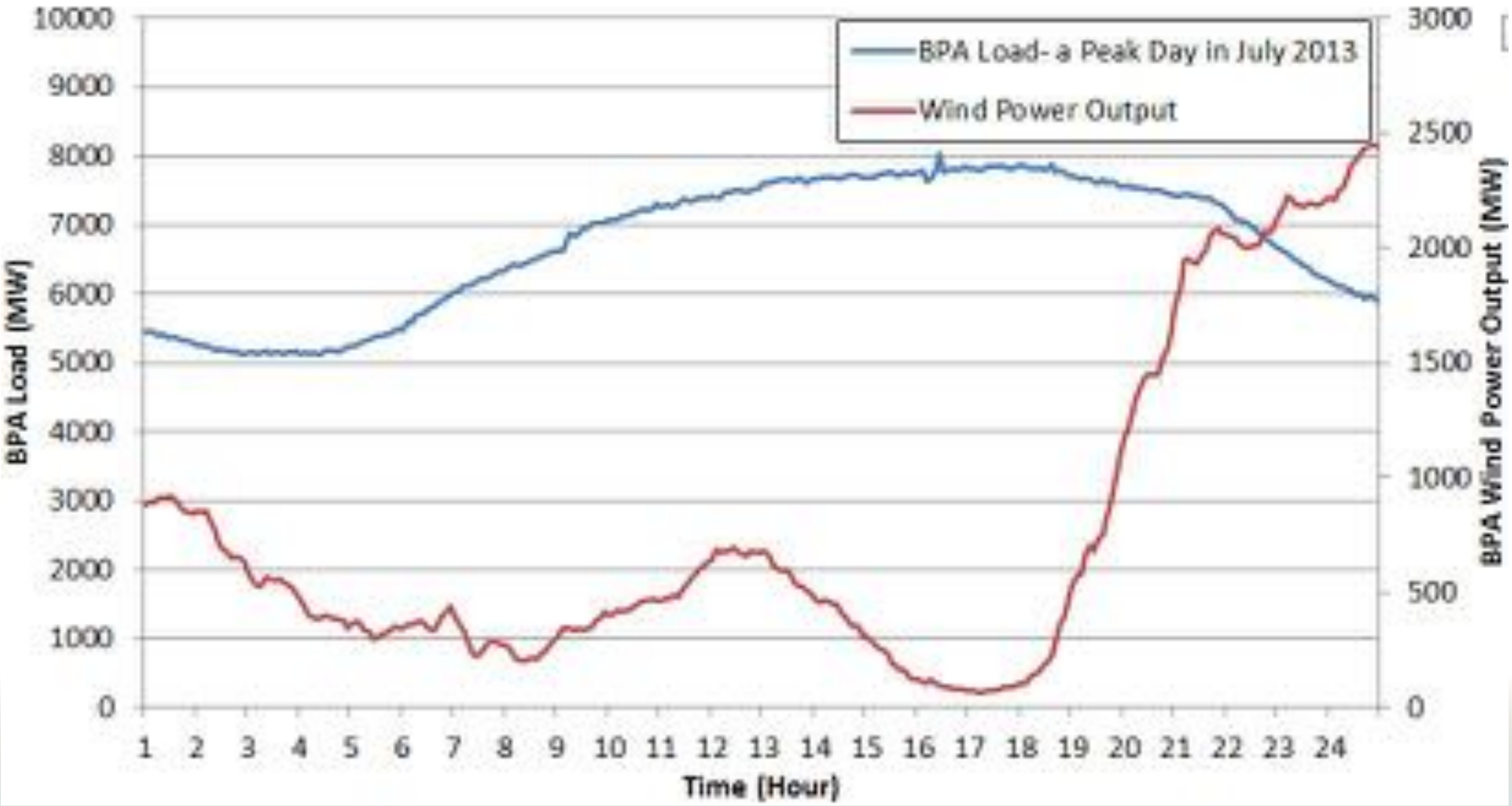
BPA Wind Output and Load Mismatch (January 2013)



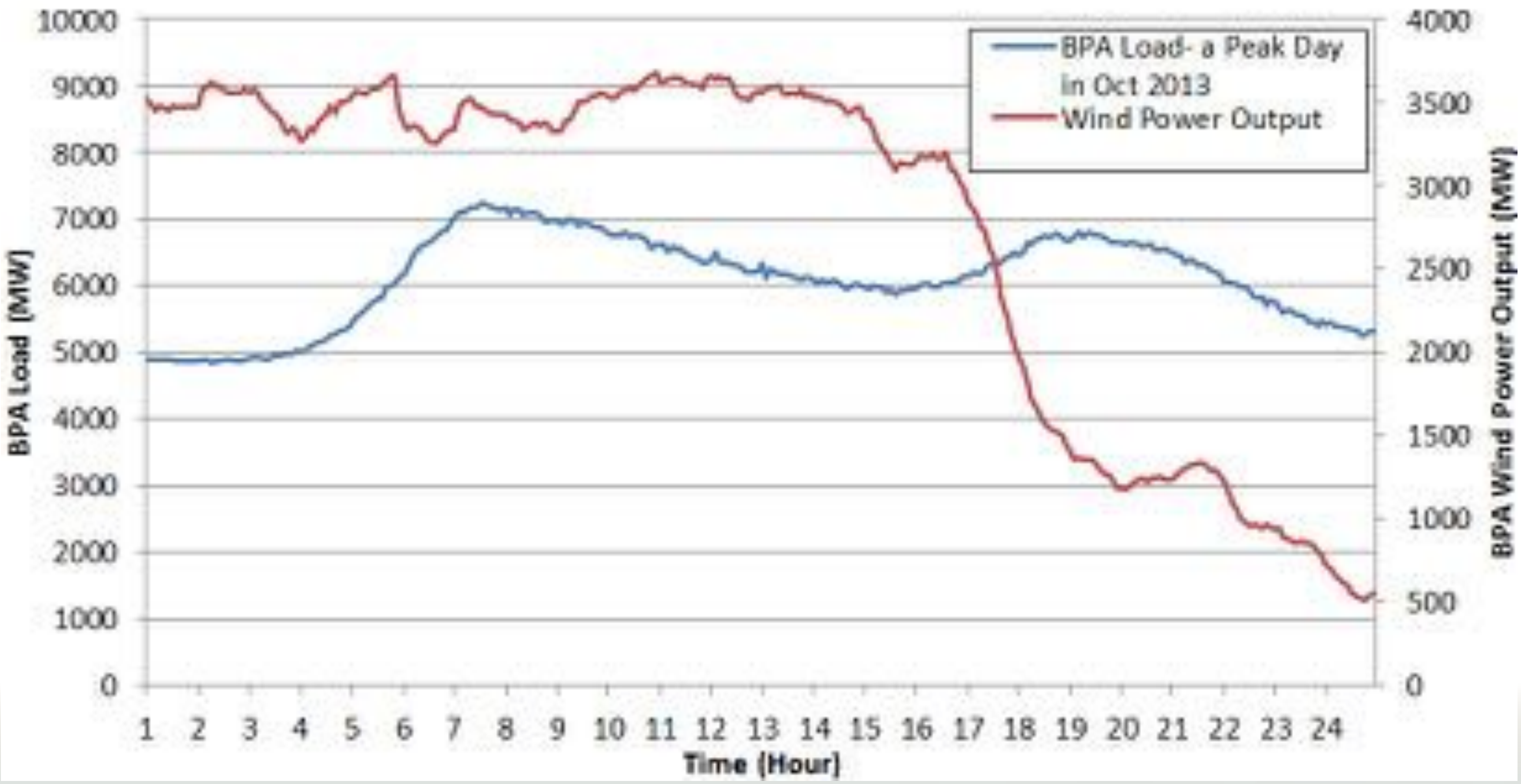
BPA Wind Output and Load Mismatch (April 2013)



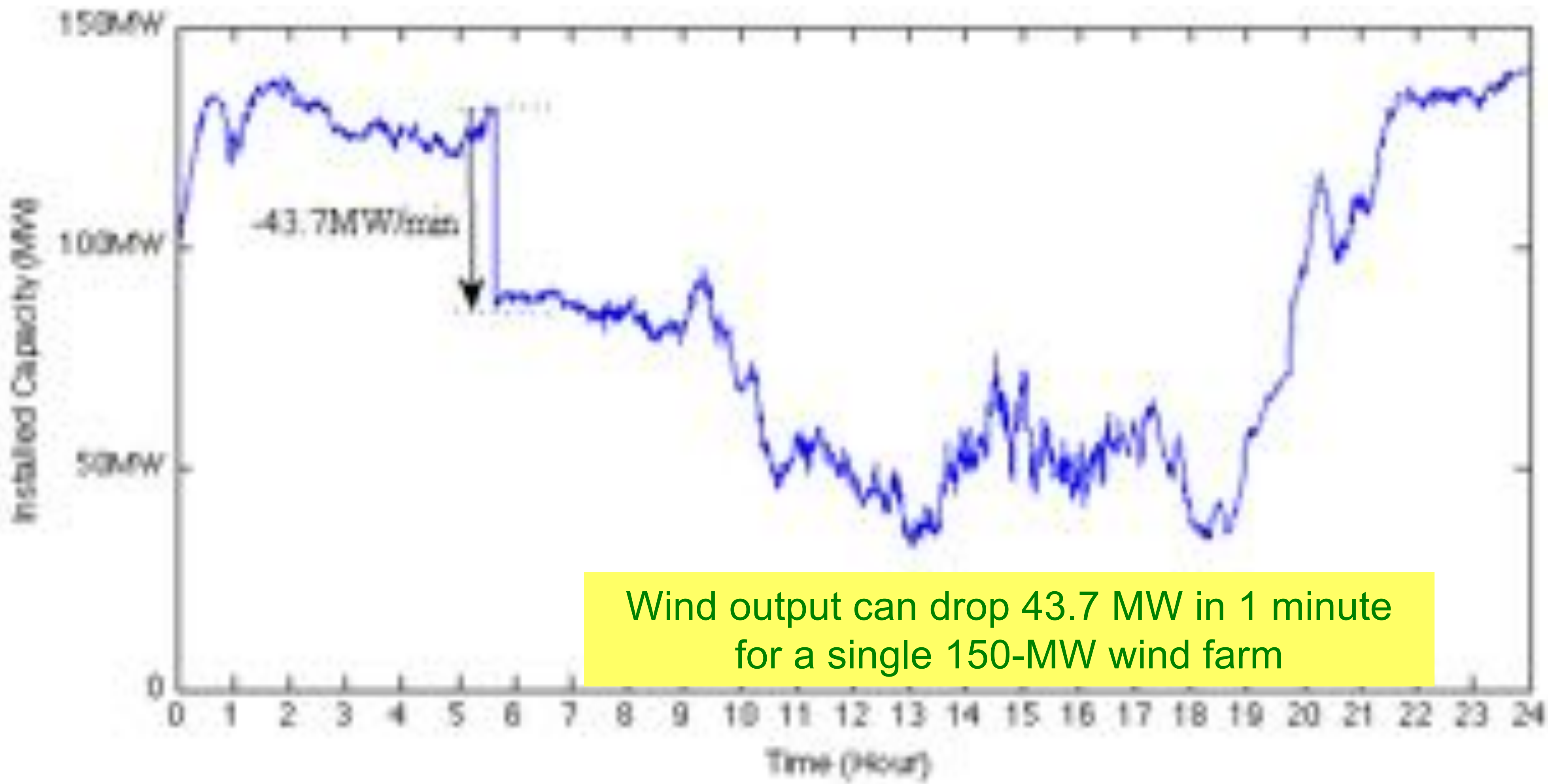
BPA Wind Output and Load Mismatch (July 2013)



BPA Wind Output and Load Mismatch (Oct 2013)



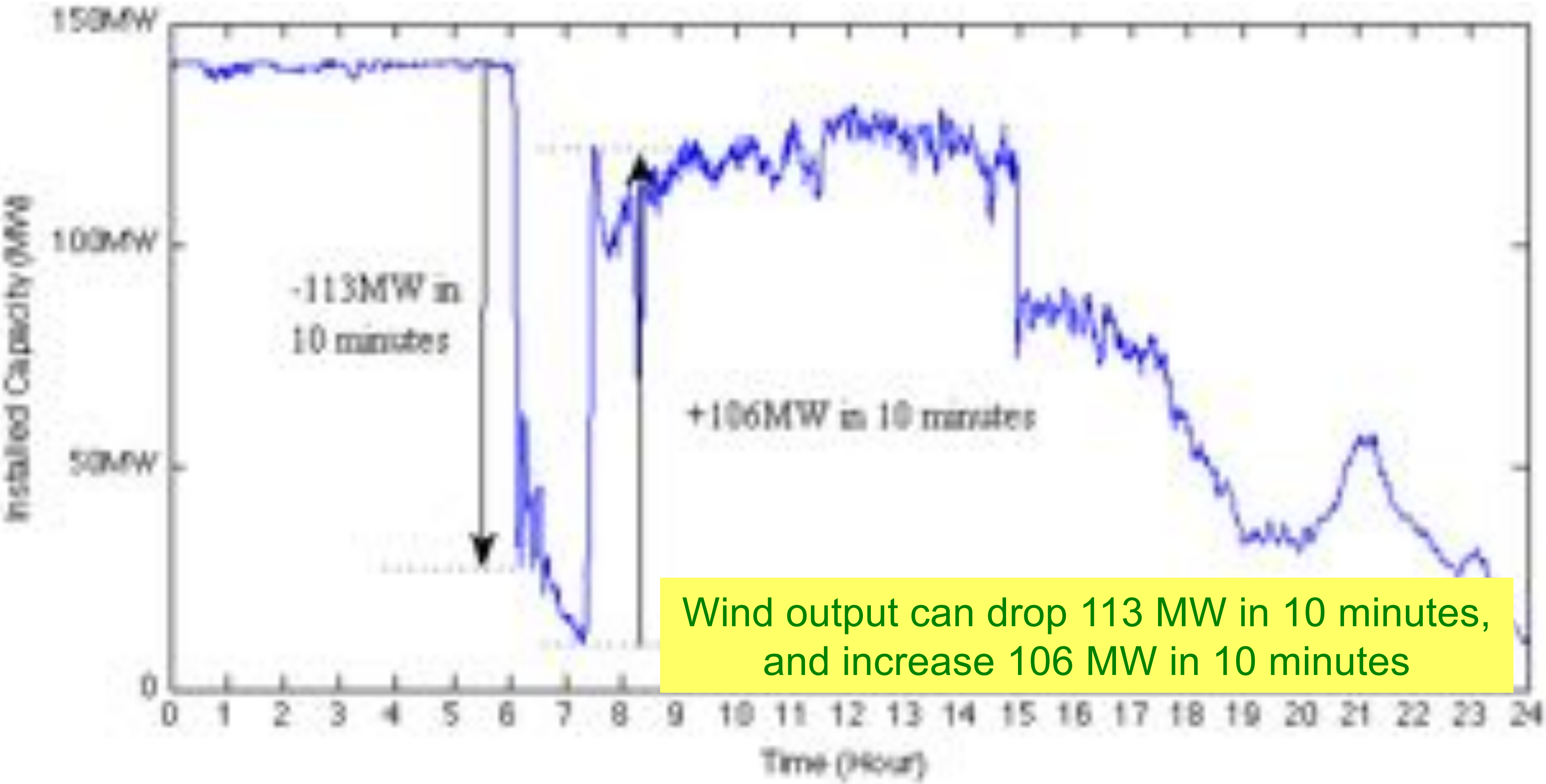
1-minute Variation of a 150MW Wind Farm Output in Texas, 2008



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

Source: NREL

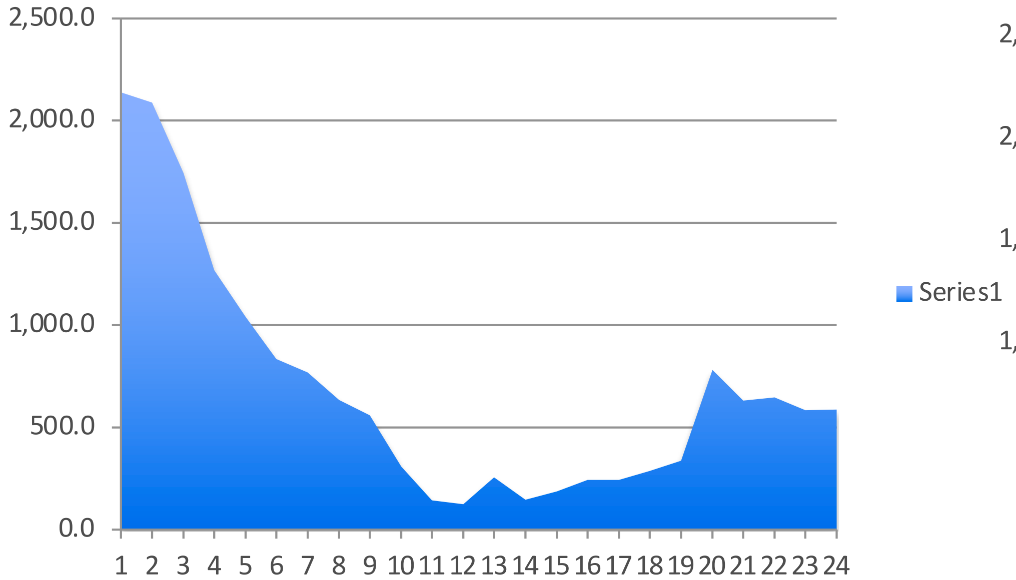
10-min Variation of a 150MW Wind Farm Output in Texas, 2008



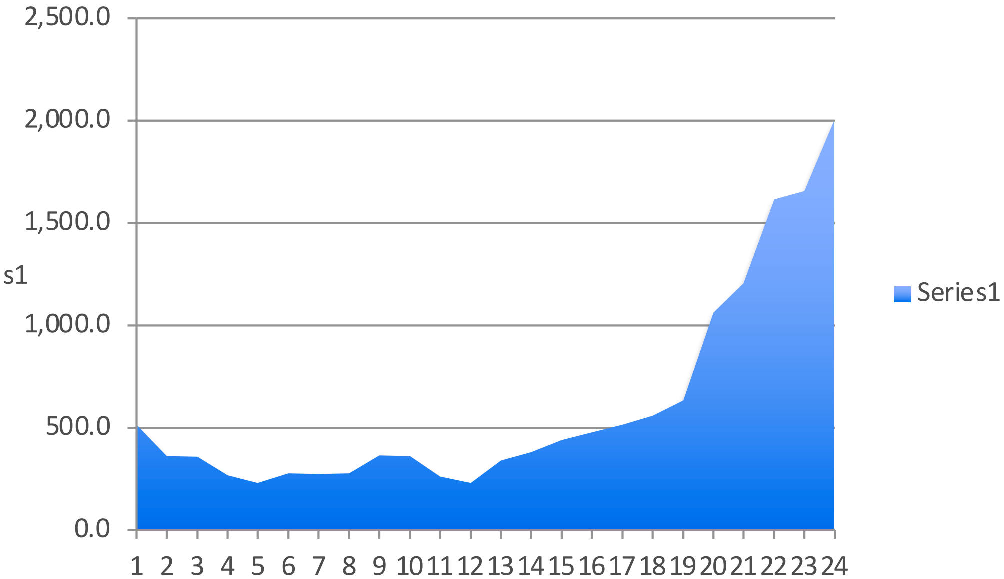
Wind output can drop 113 MW in 10 minutes, and increase 106 MW in 10 minutes

Source: NREL

Hourly wind power variation (MW) in Texas, USA (01 and 02 Jan 2008)



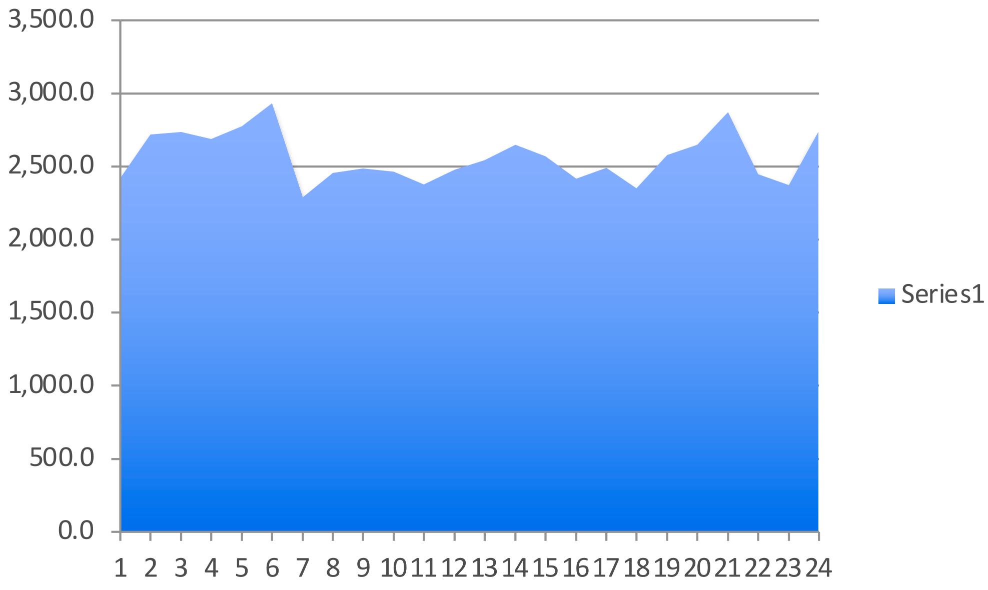
01 Jan 2008



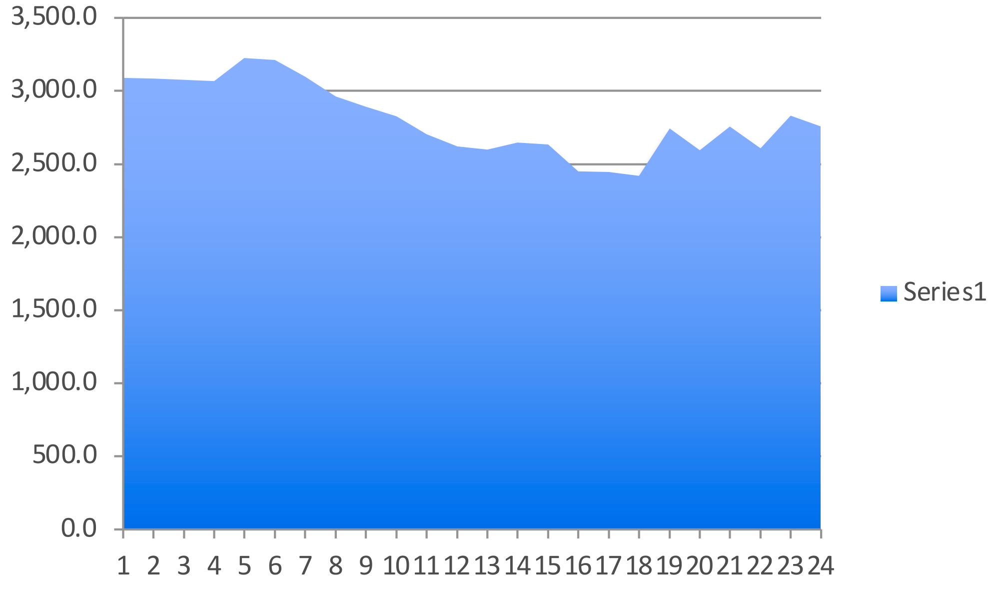
02 Jan 2008

Installed Capacity 4,541 MW

Hourly wind power variation (MW) in Texas, USA (03 and 04 Jan 2008)



03 Jan 2008



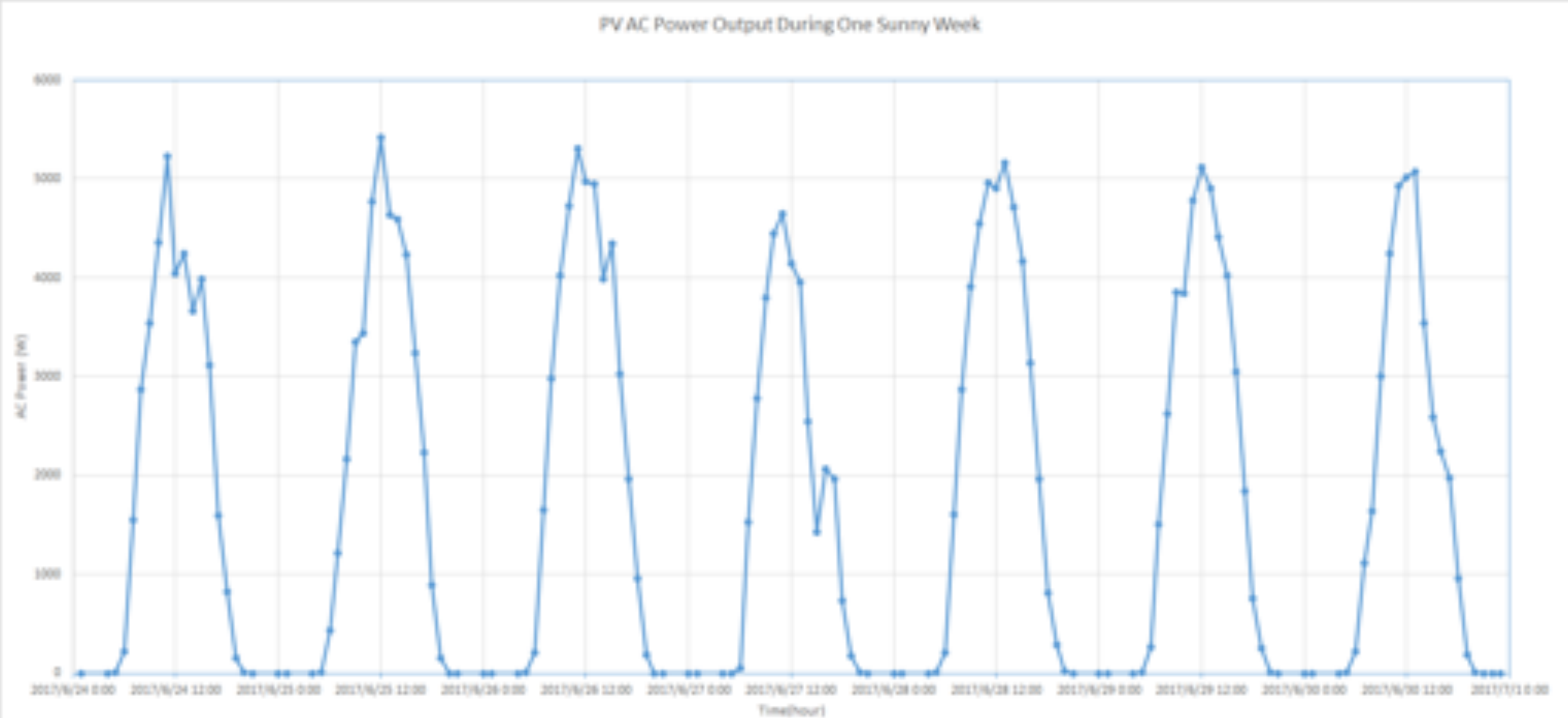
04 Jan 2008

Installed Capacity 4,541 MW

Roof-top Solar Photovoltaics in Virginia

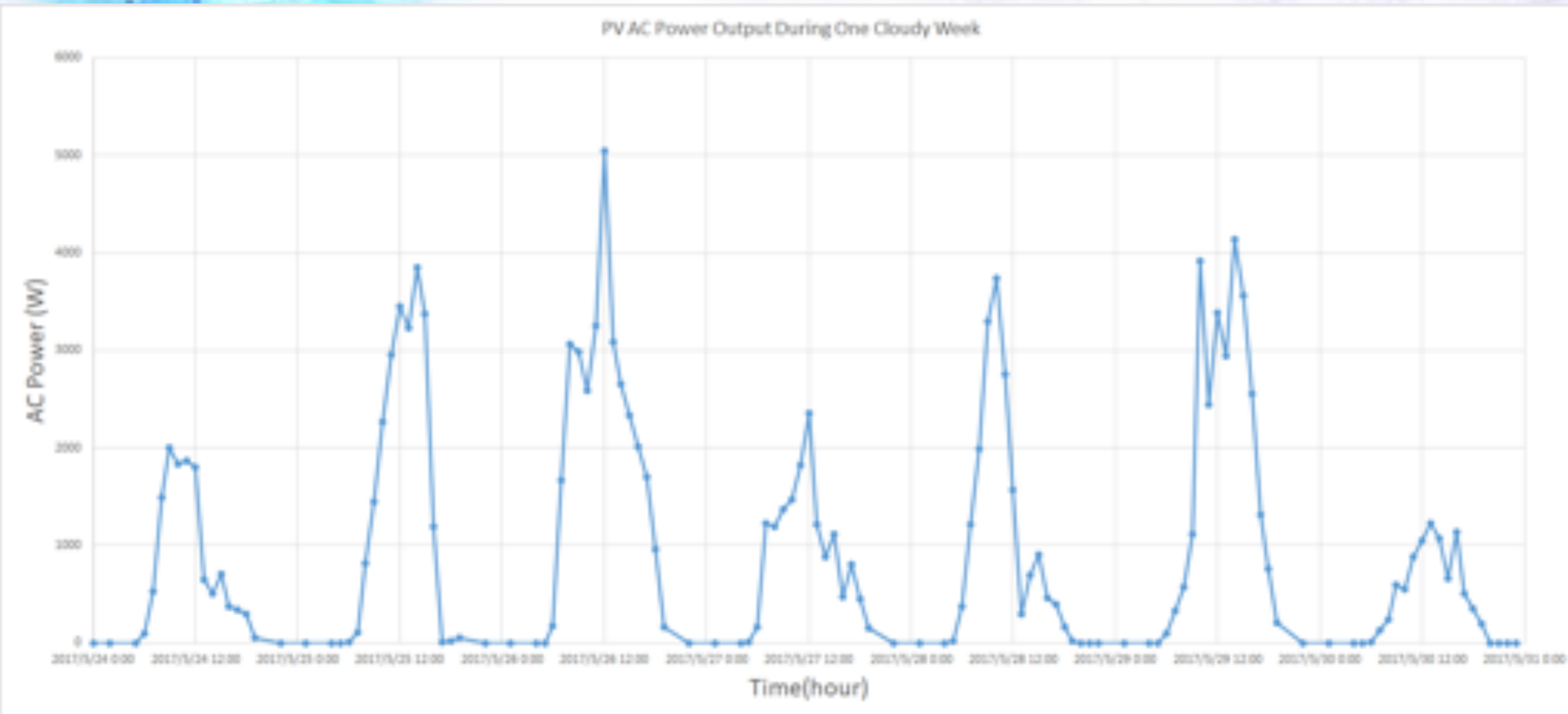
Solar Panels in Winter

7-Day Solar PV Output



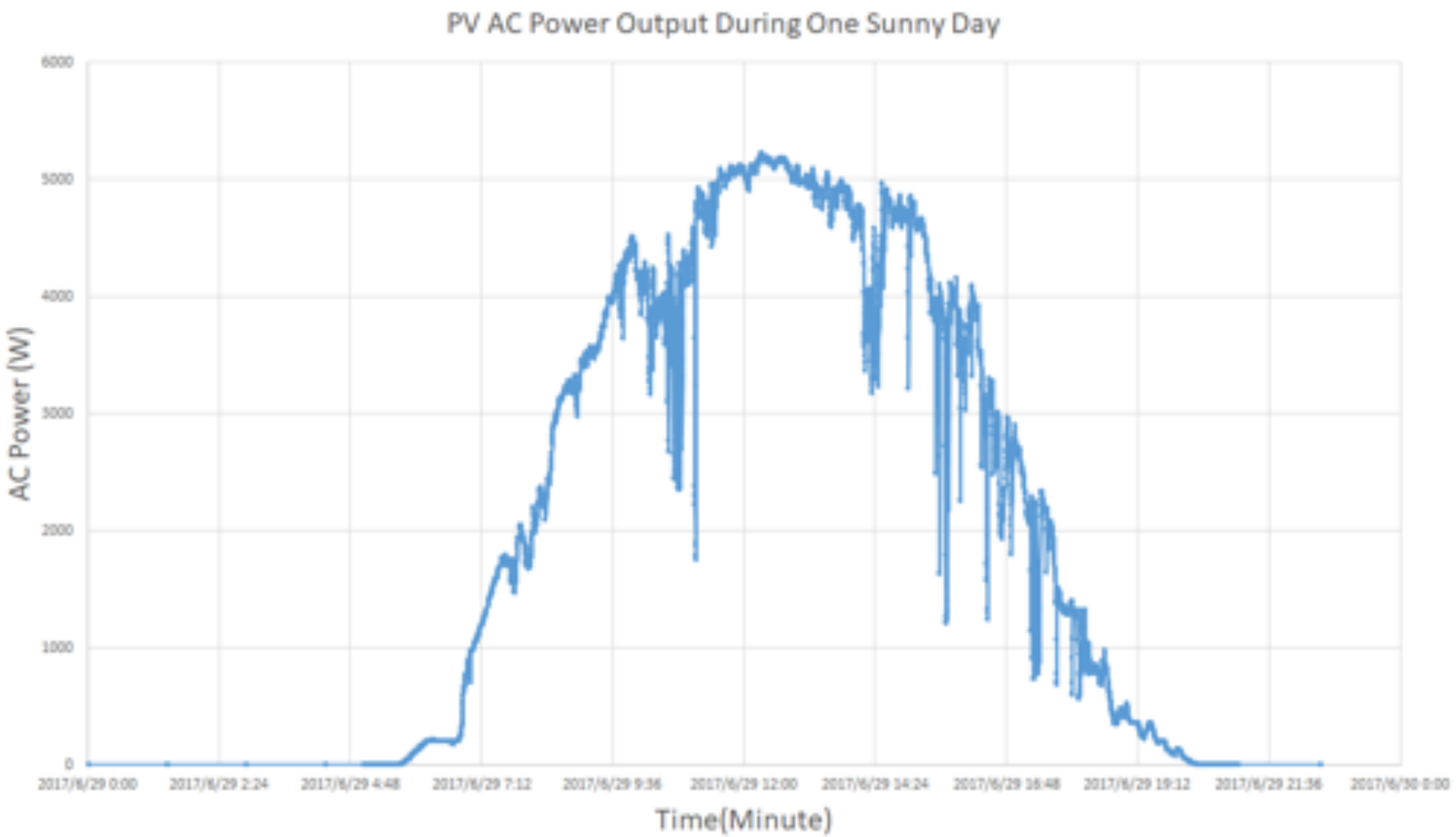
Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7

7-Day Solar PV Output (intermittent)

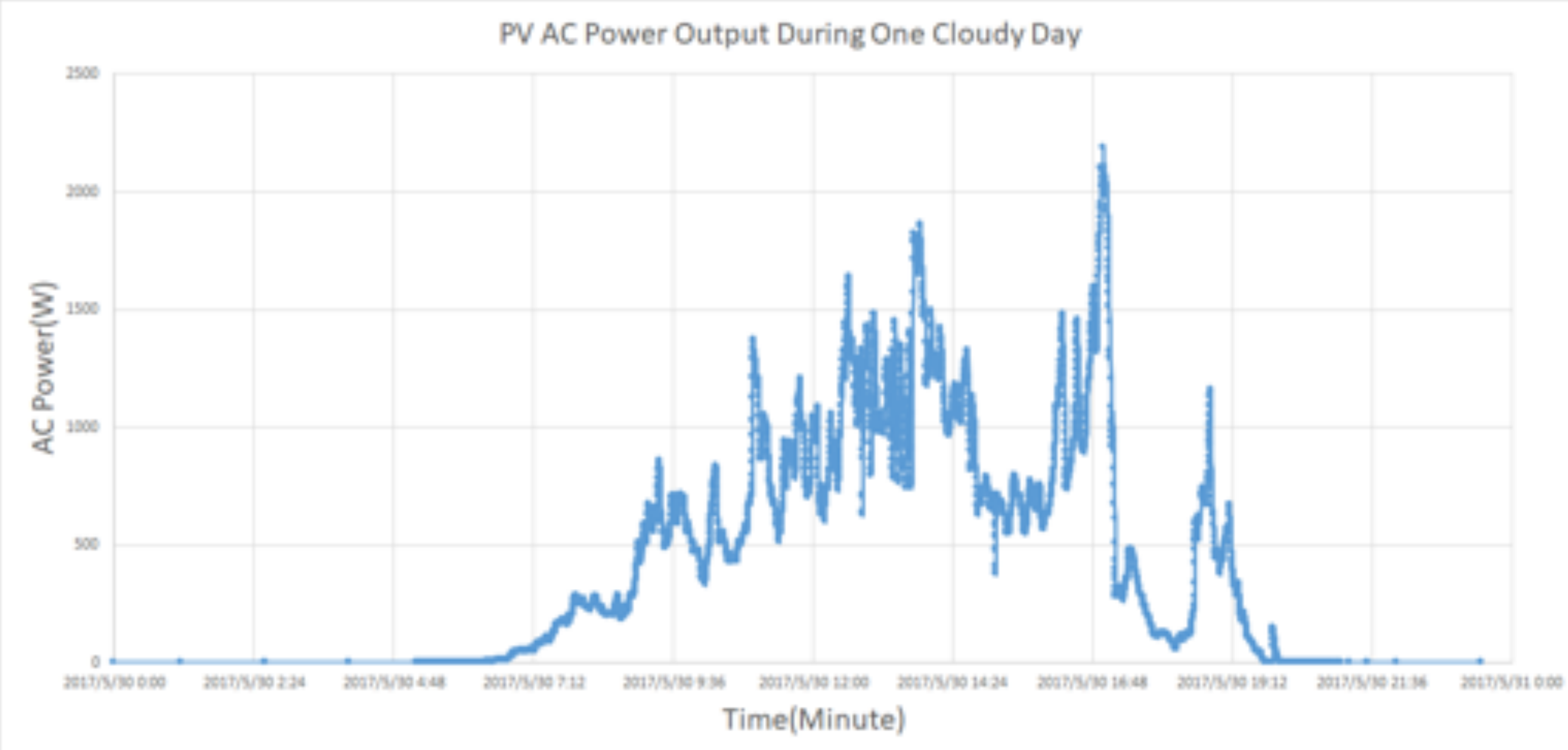


Day 1 **Day 2** **Day 3** **Day 4** **Day 5** **Day 6** **Day 7**

Daily PV Output



Daily PV Output (intermittent)



Can the Intermittency be Absorbed by the Network?

Battery storage

Pumped Storage

Compressed Air Storage

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".

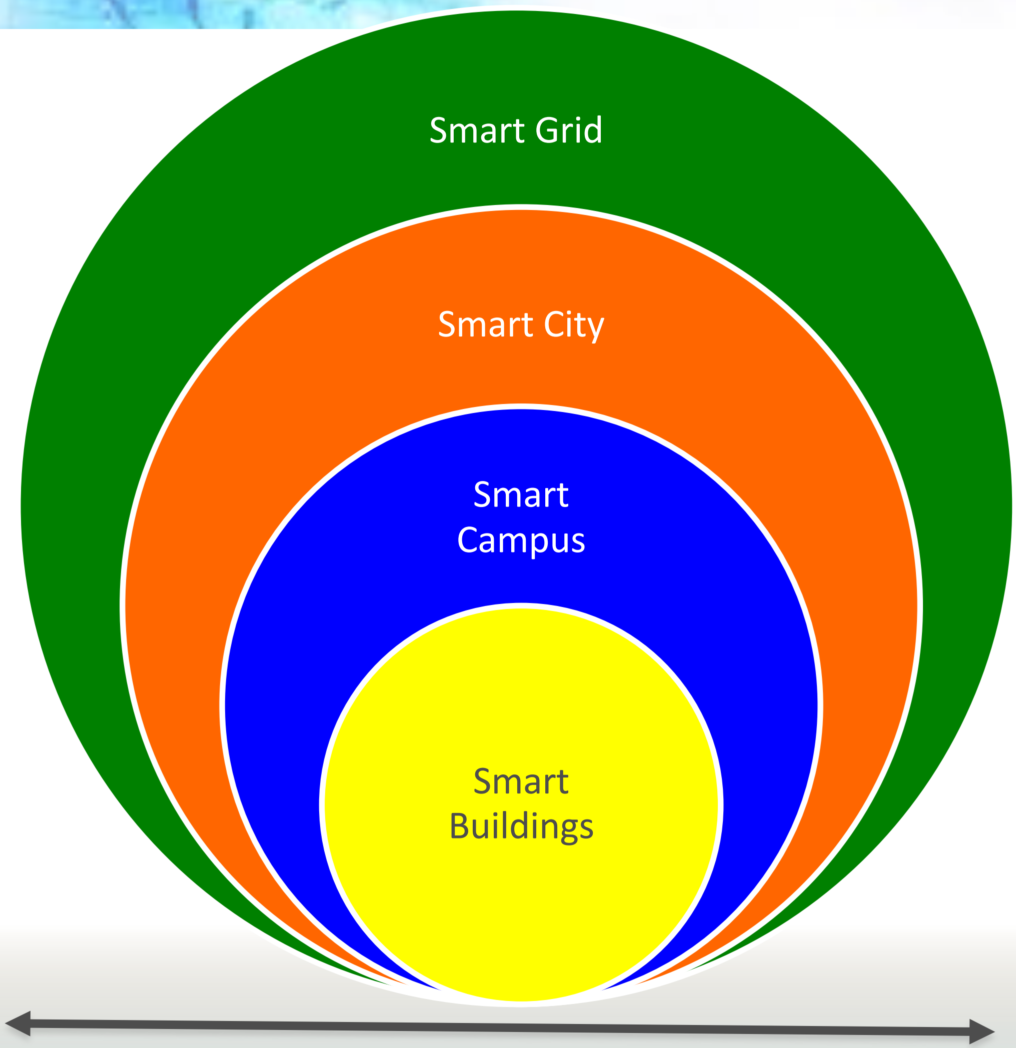
This is different from Demand Side Management (DSM) where the load is controlled by the electric utility and the customer has no control beyond the initial consent.

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 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…

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.

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

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)

I would like to see a broader IEEE

We need to ensure that we are "READY FOR RECOVERY", when we get back to the "NEW NORMAL" after COVID-19. Let us enhance cooperation, collaboration and community spirit.

For this we need to make IEEE broader so that IEEE is more relevant to the work our members do regardless where they work.

We need more participation from volunteers globally in IEEE governance. A broader based IEEE will make the Institute more relevant to technologists and academics from all parts of the world.

I would like to see more IEEE Senior Members and IEEE Fellows from Regions 8, 9 & 10

IEEE President-elect Candidate 2020

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PES accomplishments:

- PES University
- PES Corporate Engagement Program
- PES Chapters' Councils in China, India, Africa and Latin America

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