Role of the Smart Grid in Facilitating the Integration of Renewables into the Power Grid

Keynote Speech

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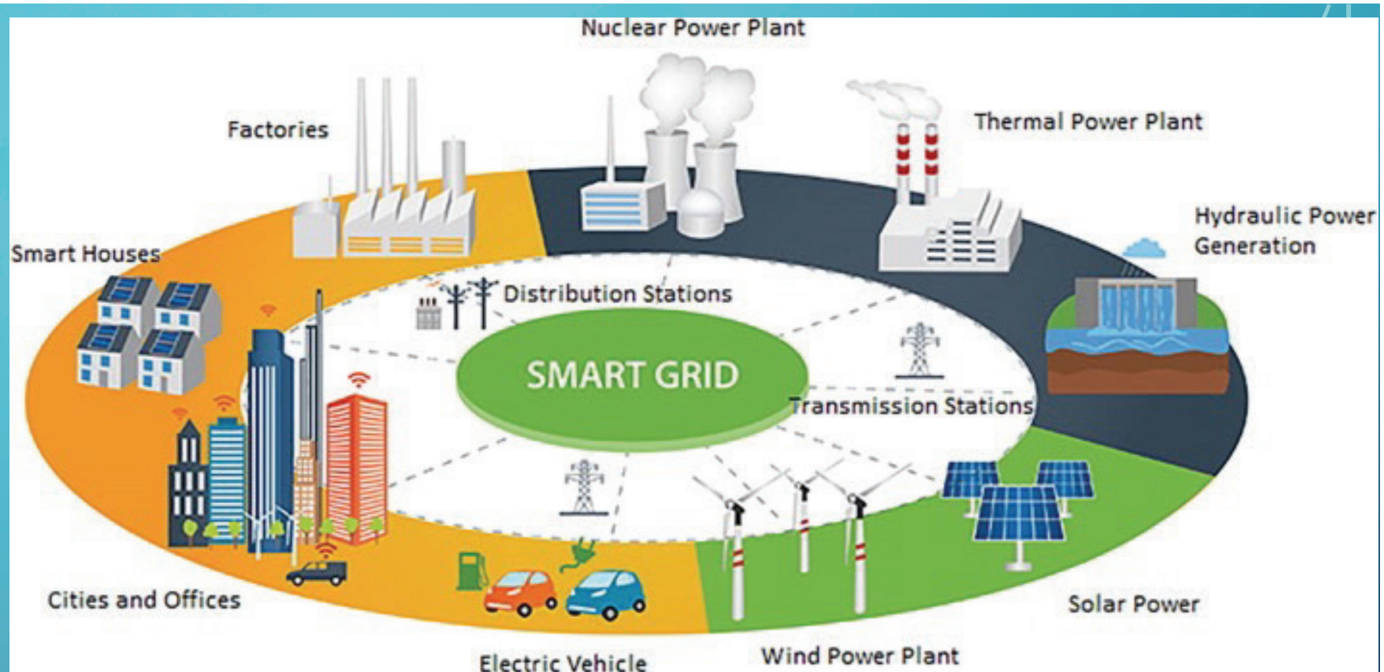
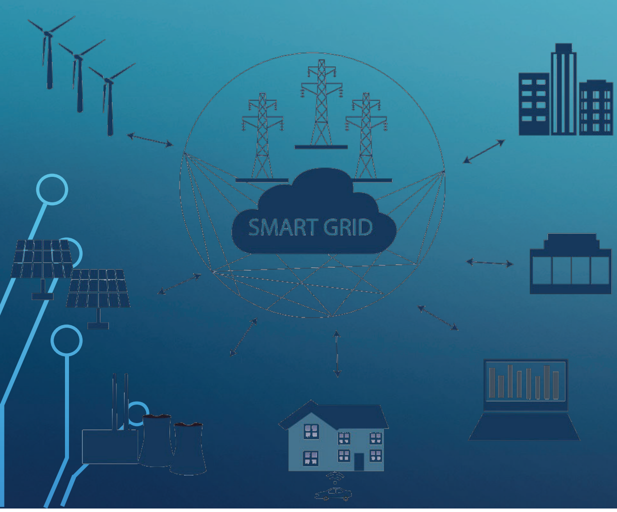
What is a Smart Grid

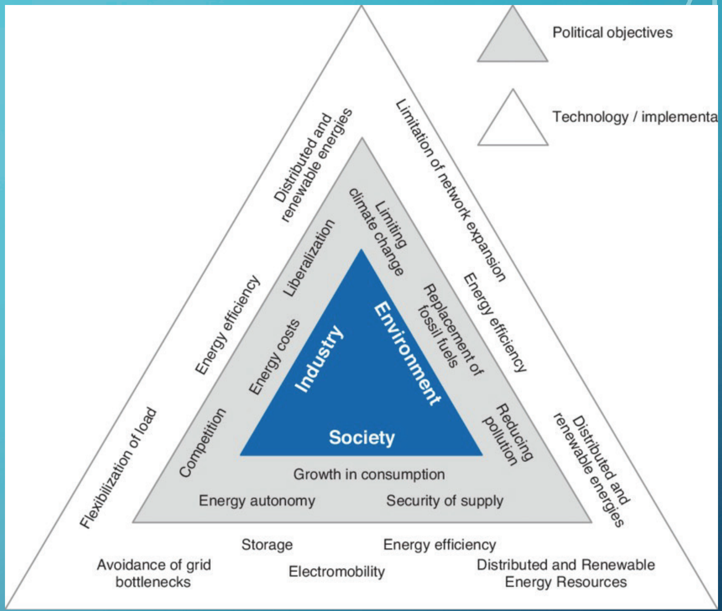




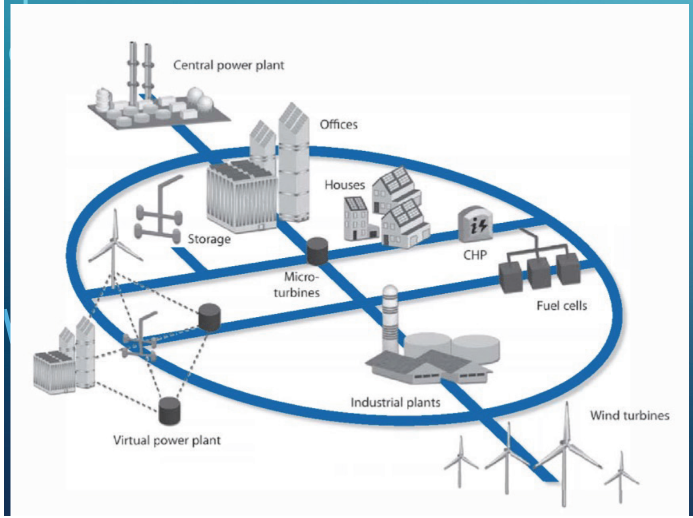
"Smart grid" is a concept with many elements where monitoring and control of each element in the chain of generation, transmission, distribution and end-use allow the electricity delivery and use to be more efficient.

Motivation for a Smart Grid

Motivation for a Smart Grid on the basis of the energy management triangle - political objectives and technical implementation.



https://www.researchgate.net/figure/Motivation-for-a-Smart-Grid-on-the-basis-of-the-energy-management-triangle-political_fig1_263264024

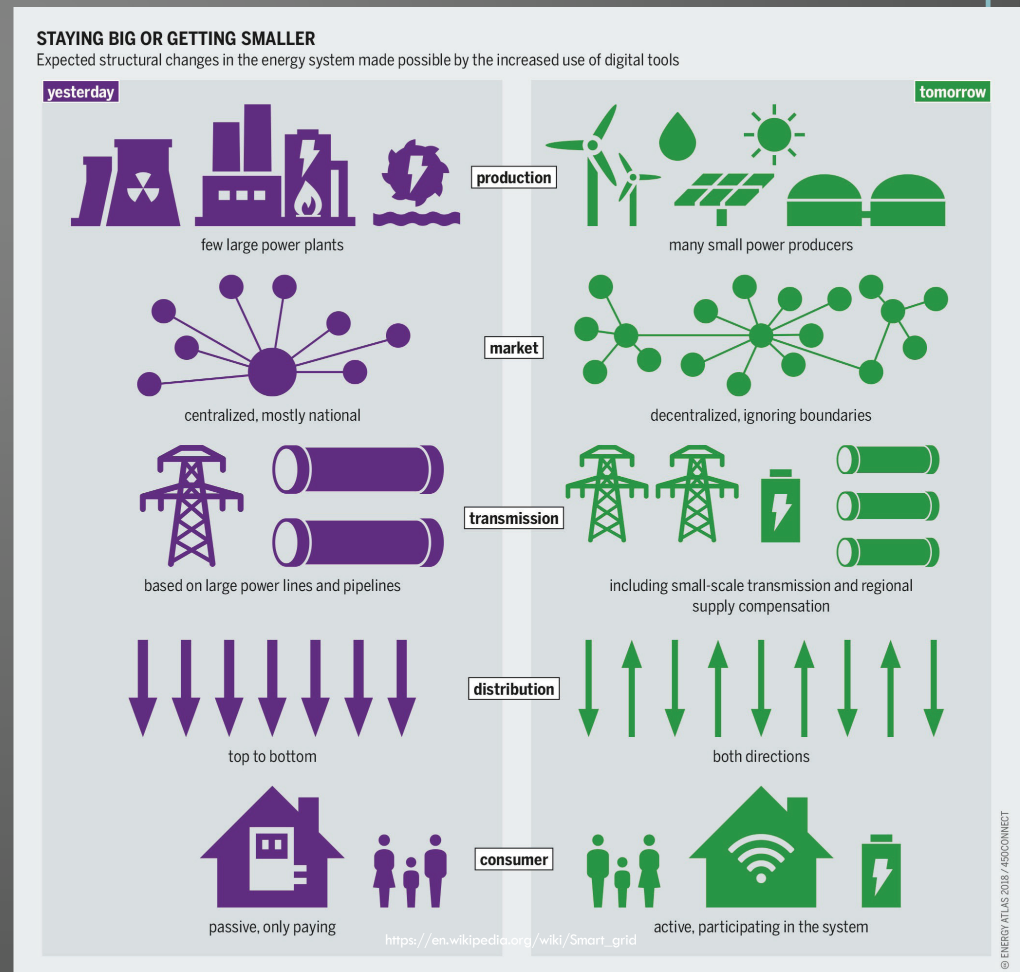


Desire to make the grid smarter, safer, reliable and more cost-effective using advanced sensors, communication technologies and distributed computing.

Difference Between a Normal Grid and a Smart Grid

Normal Phone

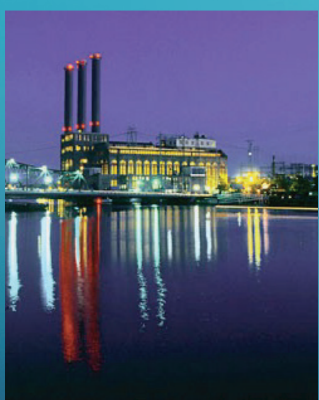
Smart Phone



https://en.wikipedia.org/wiki/Smart_grid

Starting and End Points of a Smart Grid

It starts at the Generator and ends at the Refrigerator



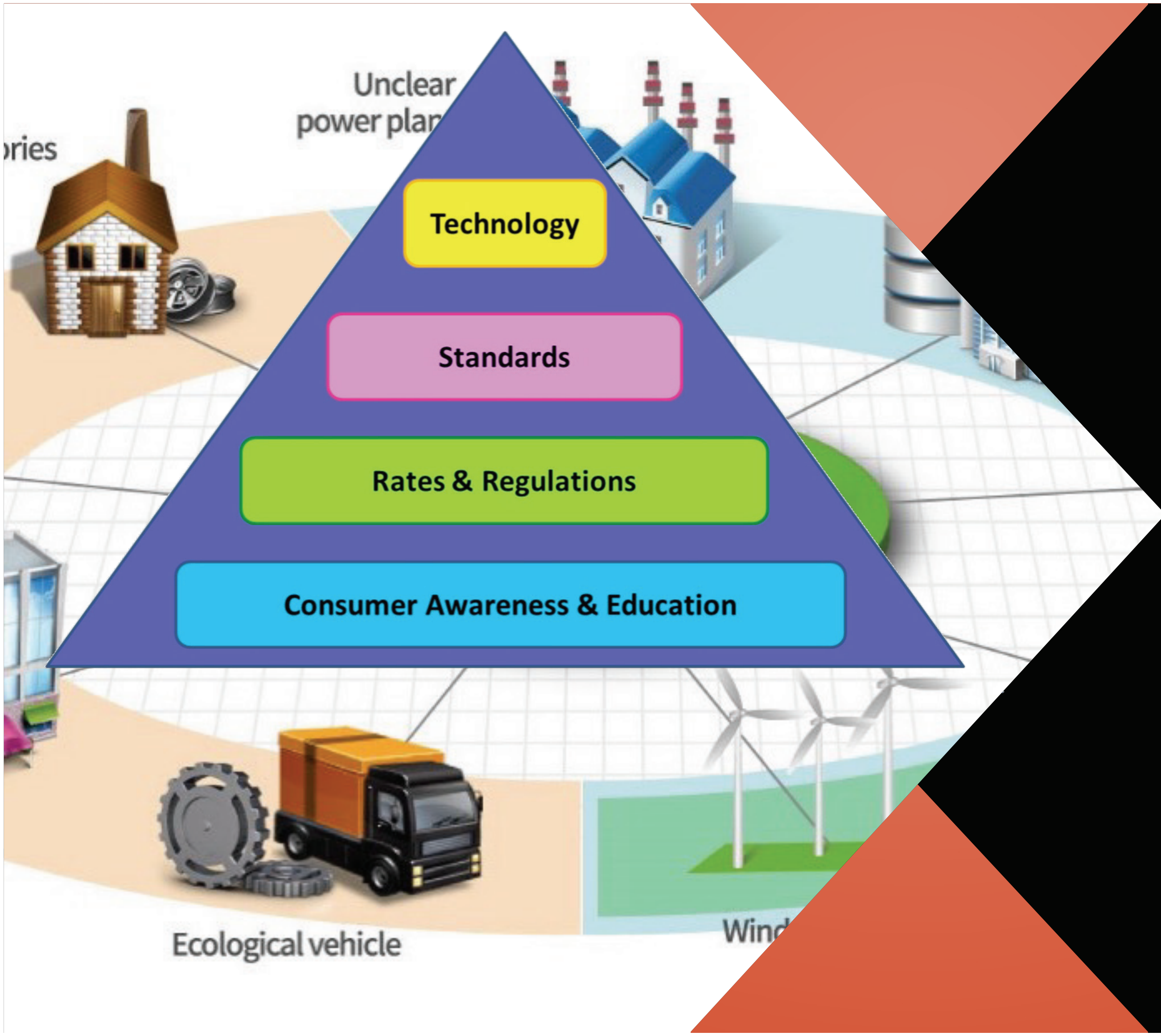
Power Plant

Transmission

Distribution

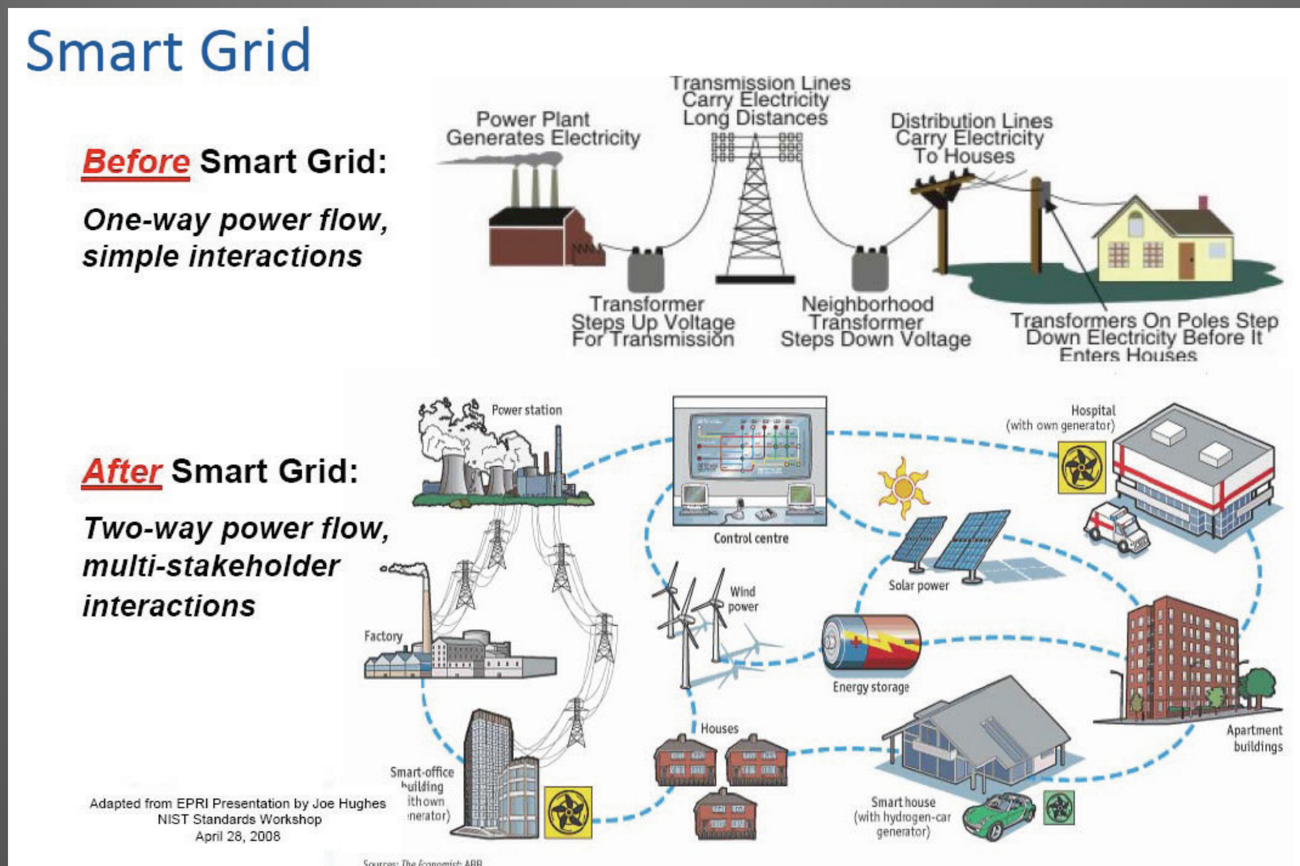
Home Business

End-use Appliances



Smart Grid Building Blocks

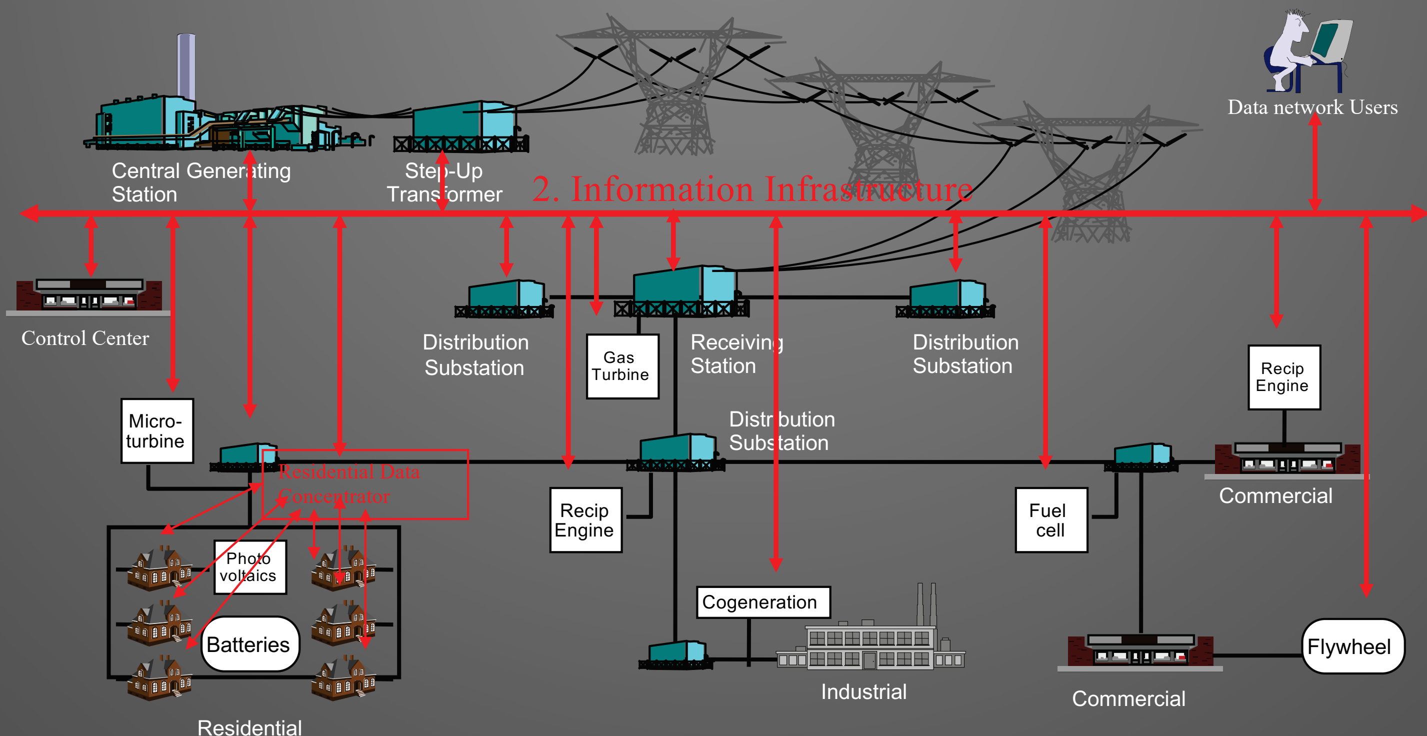
Evolution of the Grid



Source: Altalink, Alberta, Canada

Electric Power and Communication Infrastructures

1.Power Infrastructure



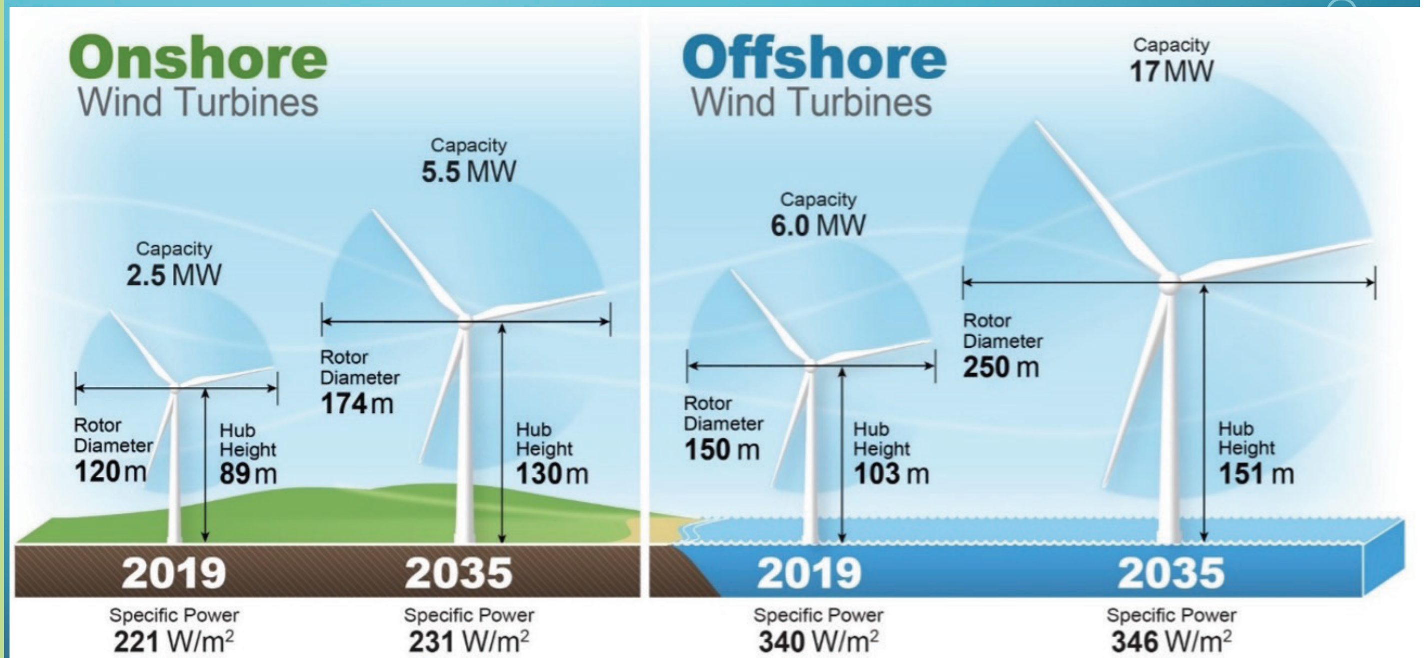
Source: EPRI

Changing Landscape for the Electric Utility

Issues with Distributed Generation

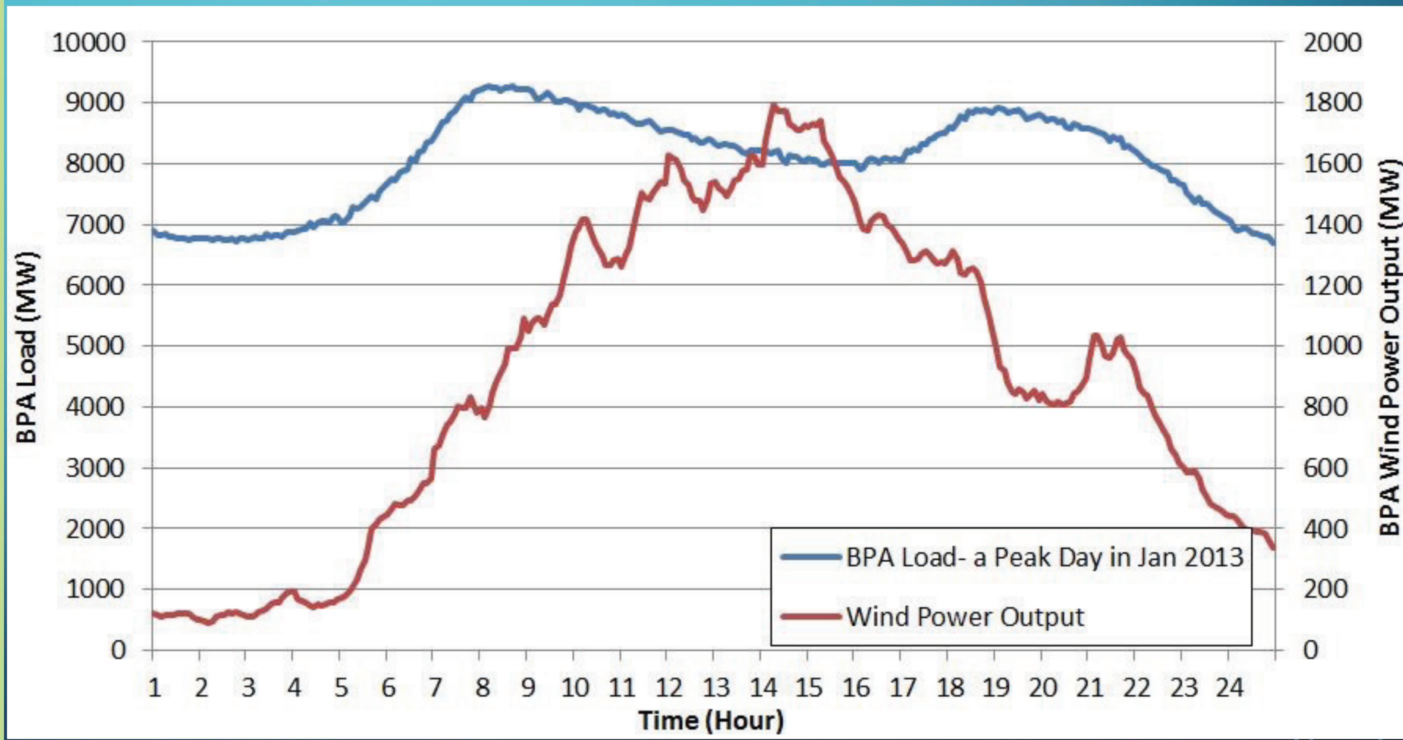
- Wind and solar are intermittent
- Hydro is space limited
- Resource is free but not always usable

Wind Energy

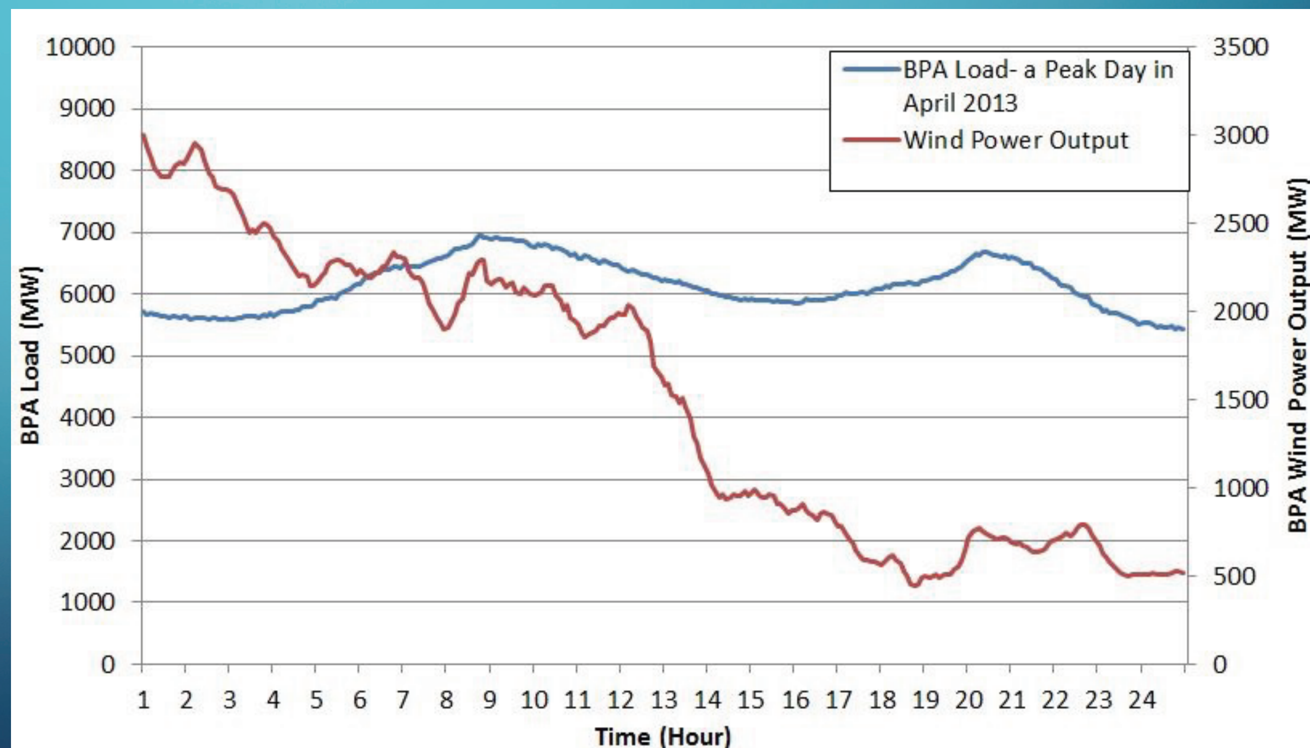


https://www.renewableenergyworld.com/wind-power/wind-power-experts-expect-wind-energy-costs-to-decline-up-to-35-by-2035/#gref

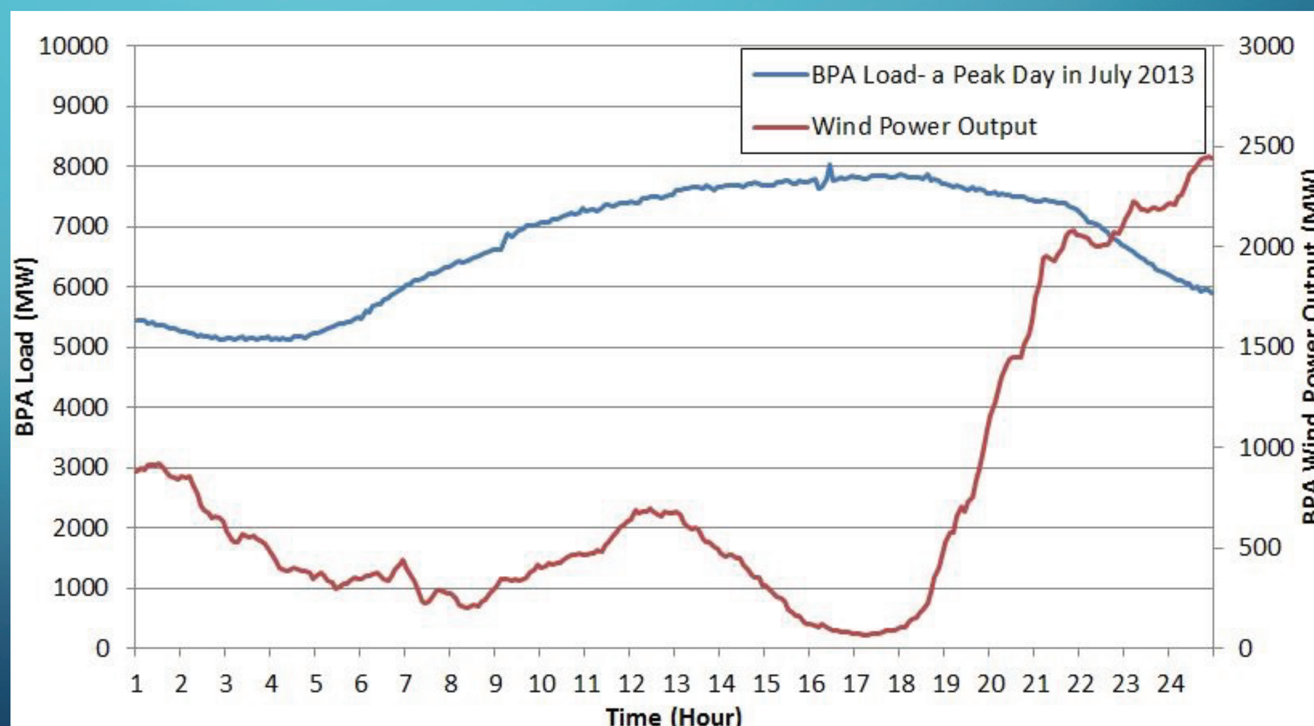
BPA Wind Output and Load Mismatch (A typical day in January)



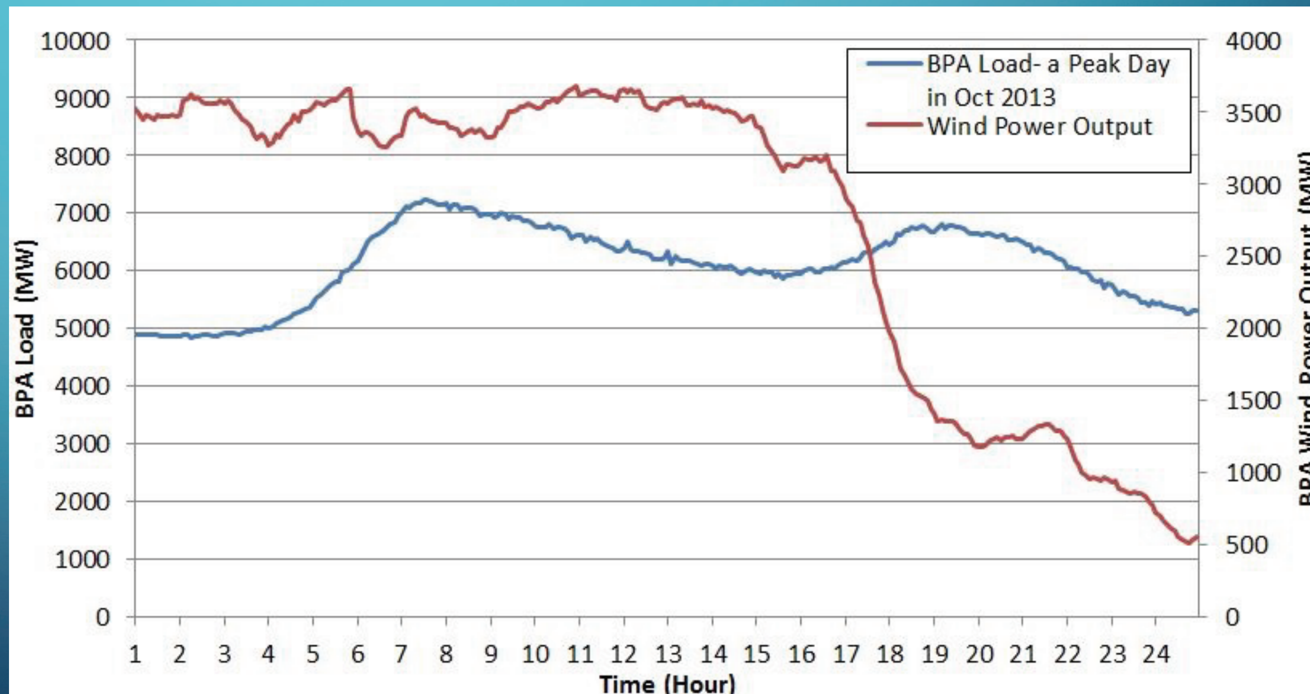
BPA Wind Output and Load Mismatch (A typical day in April)



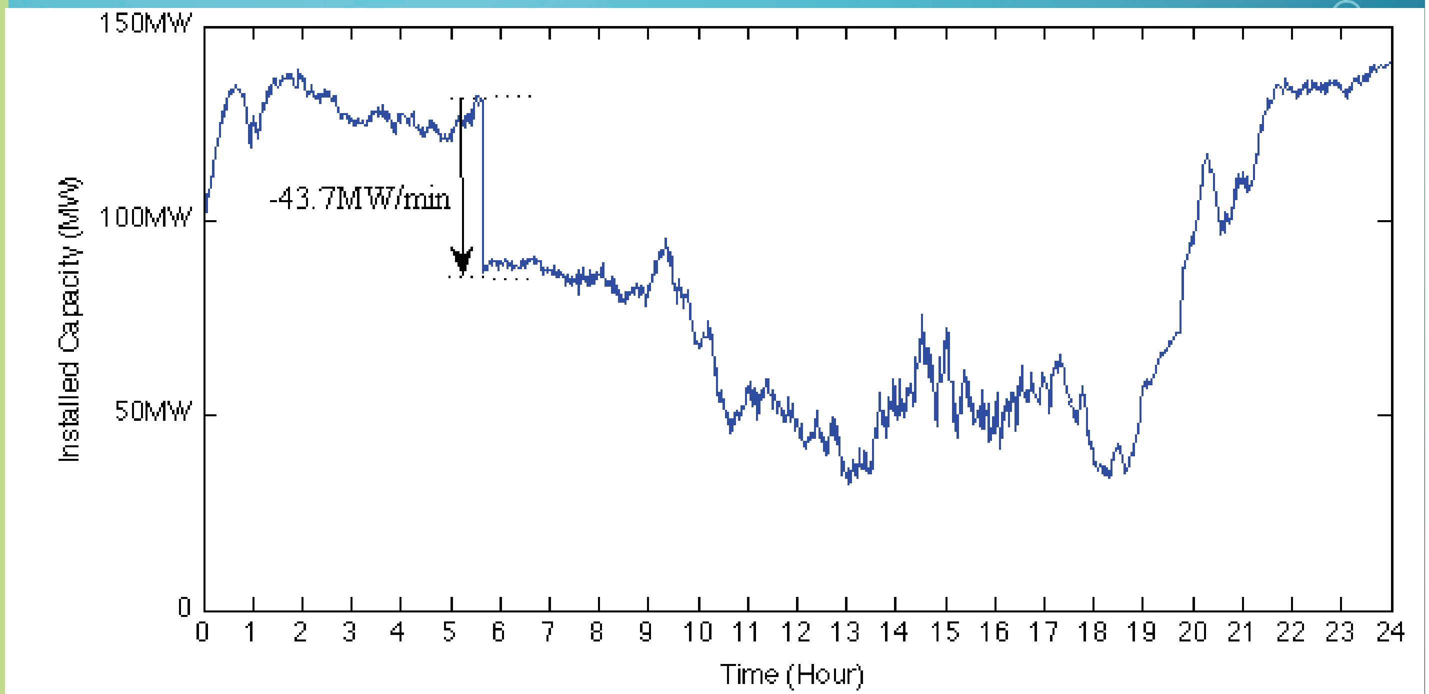
BPA Wind Output and Load Mismatch (A typical day in July)



BPA Wind Output and Load Mismatch (A typical day in October)



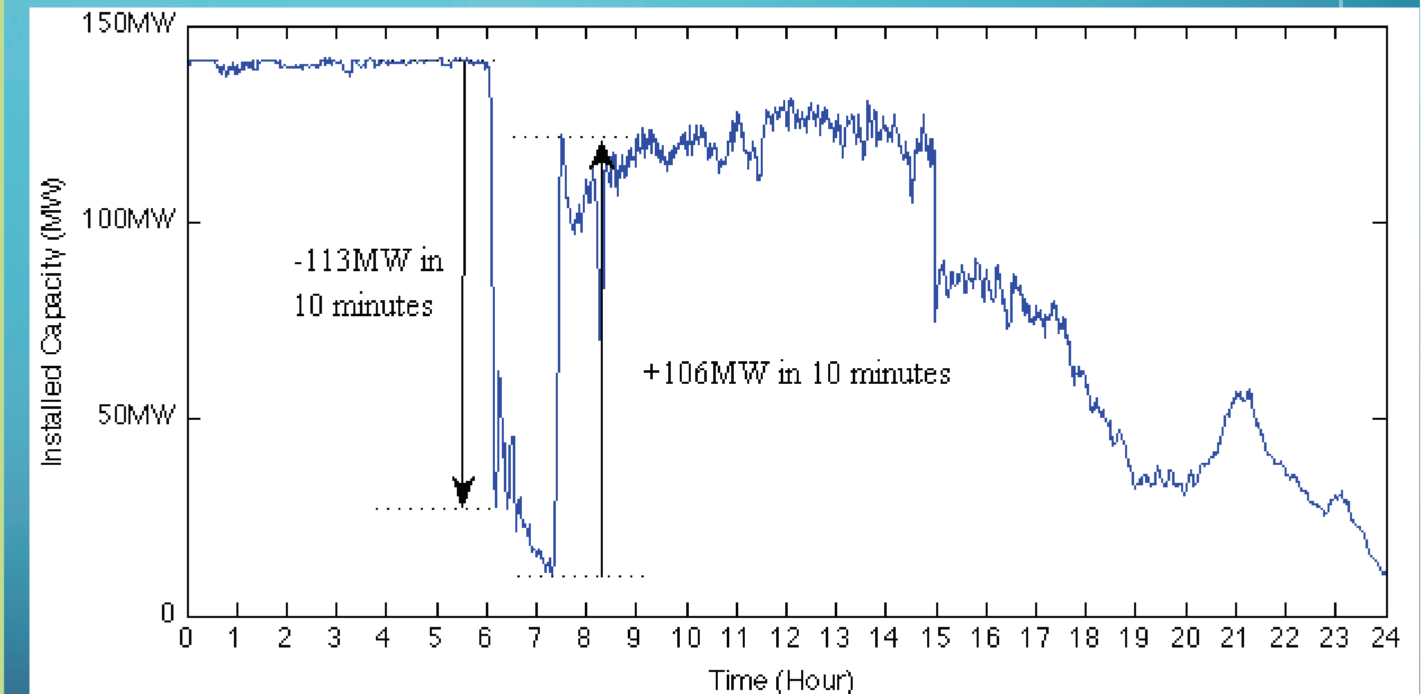
1-minute Variation of a 150MW Wind Farm Output in Texas



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

Source: NREL

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

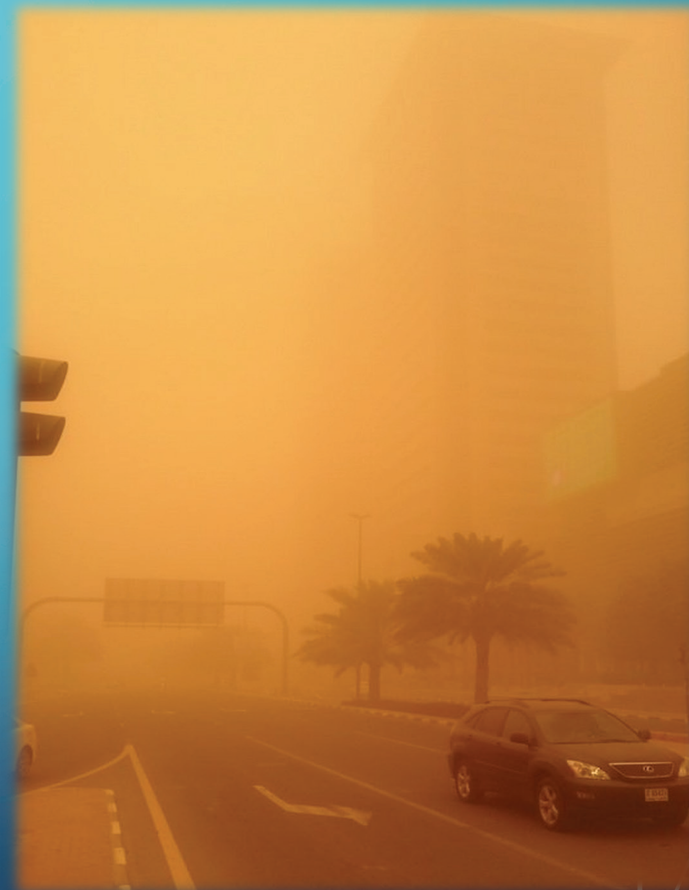

Solar
Energy

Roof-top Solar Photovoltaics in Virginia


Solar Panels in Winter
SOLERS

Intermittency Caused by Weather Events

Solar PV Project in UAE



Sand Storm in Abu Dhabi

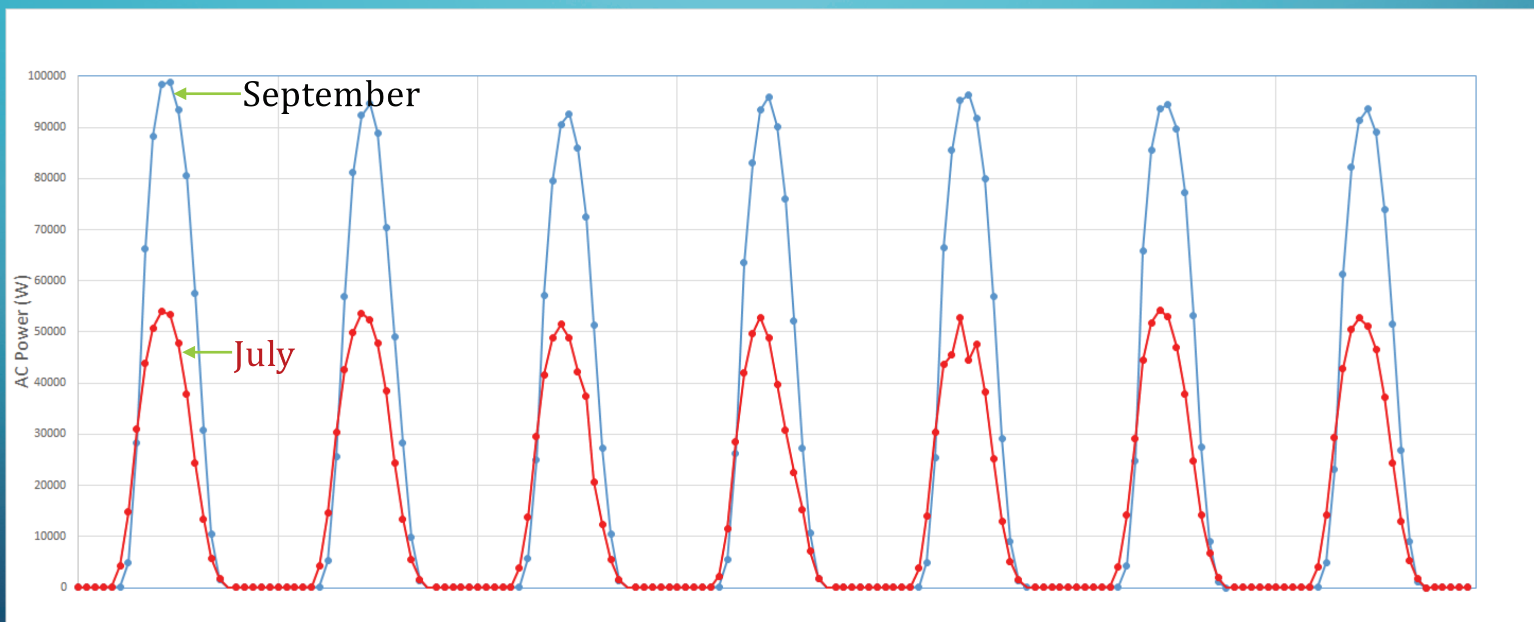
In-depth look at Solar PV in Saudi Arabia

2-MW Roof-top Solar PV plant at KAUST

Solar PV Panels in Saudi Arabia

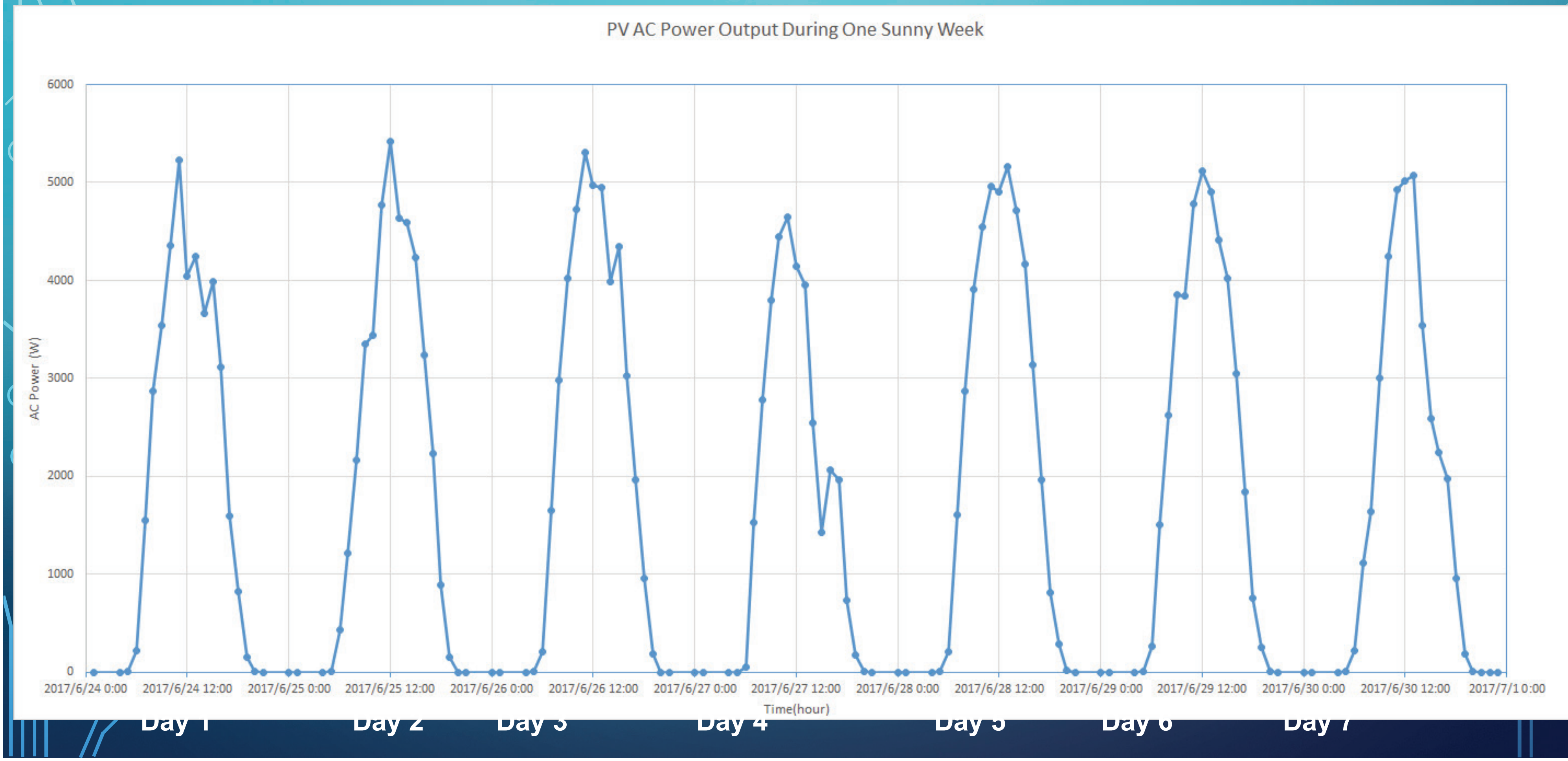
Reality Check

Solar PV Array (100kWp) Riyadh Area

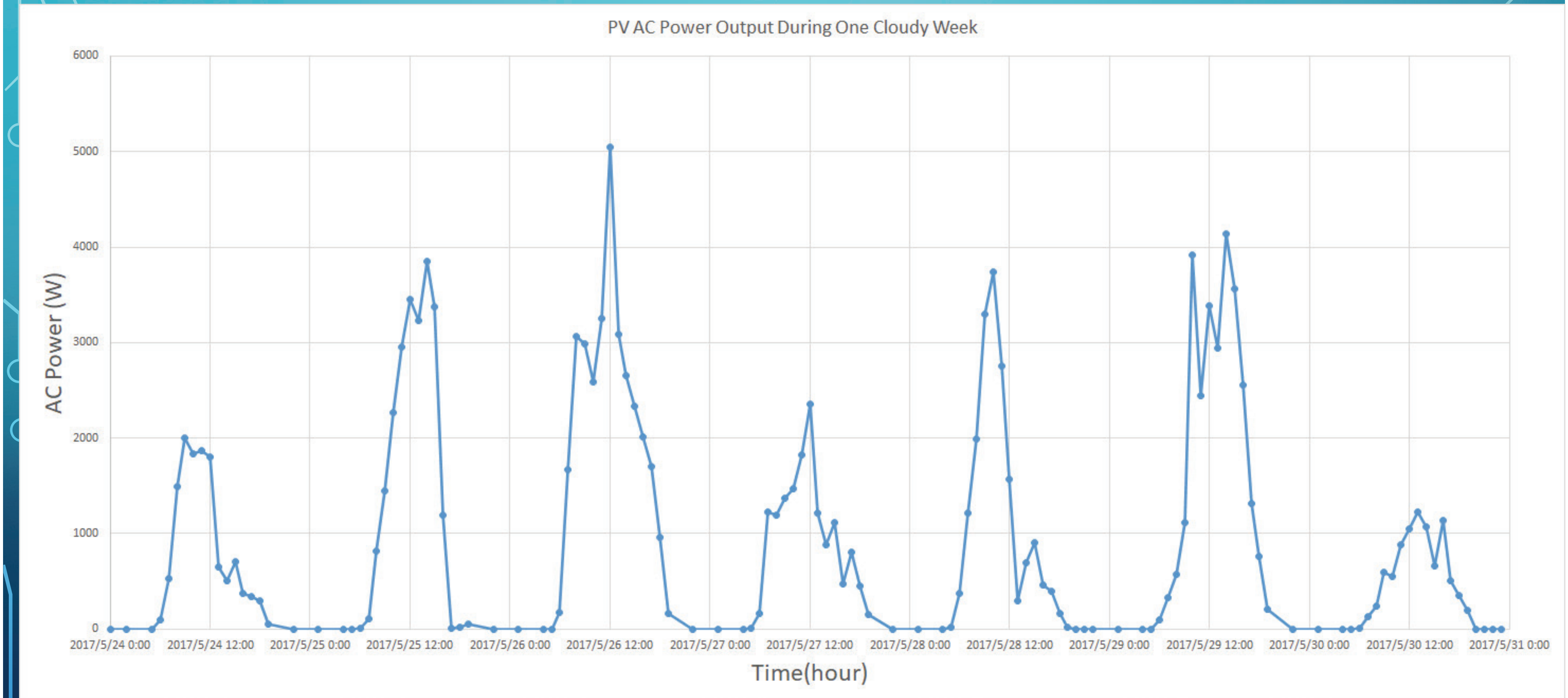


Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7

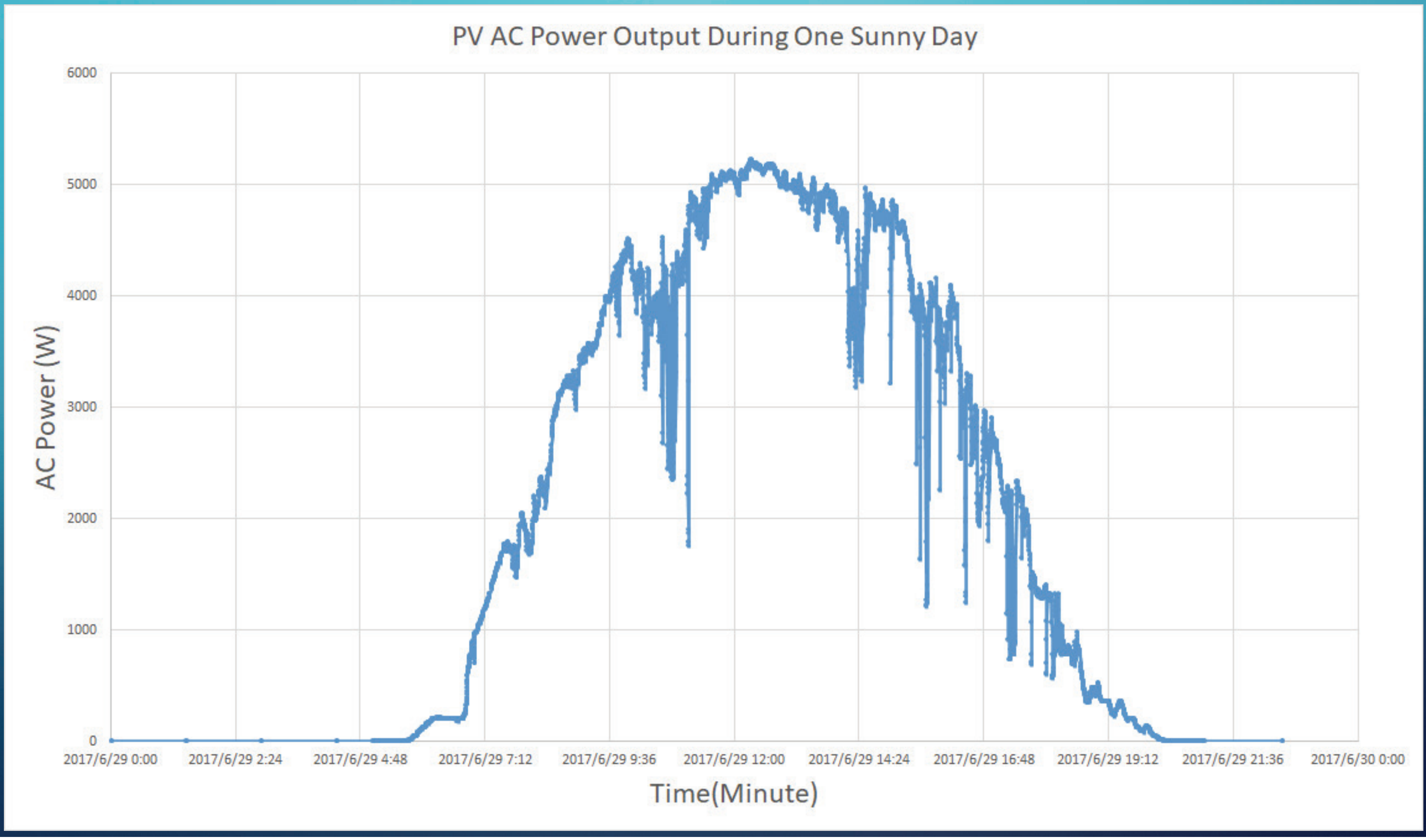
7-Day Solar PV Output (Virginia)



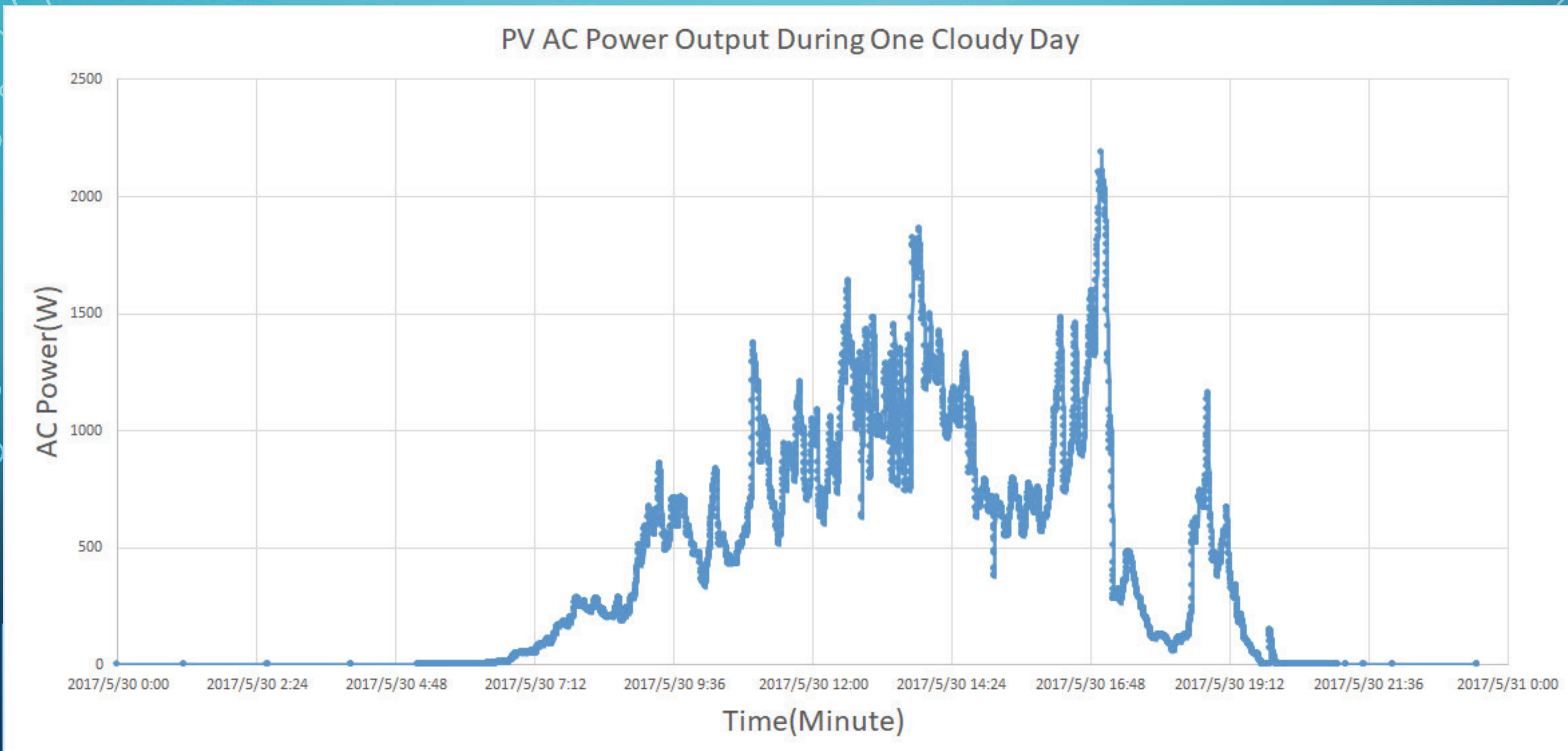
7-Day Solar PV Output (Virginia, cloudy)



Daily PV Output (Virginia)



Daily PV Output (Virginia, intermittent)



Some Intermittency can be Absorbed by the Network with no or Little Storage

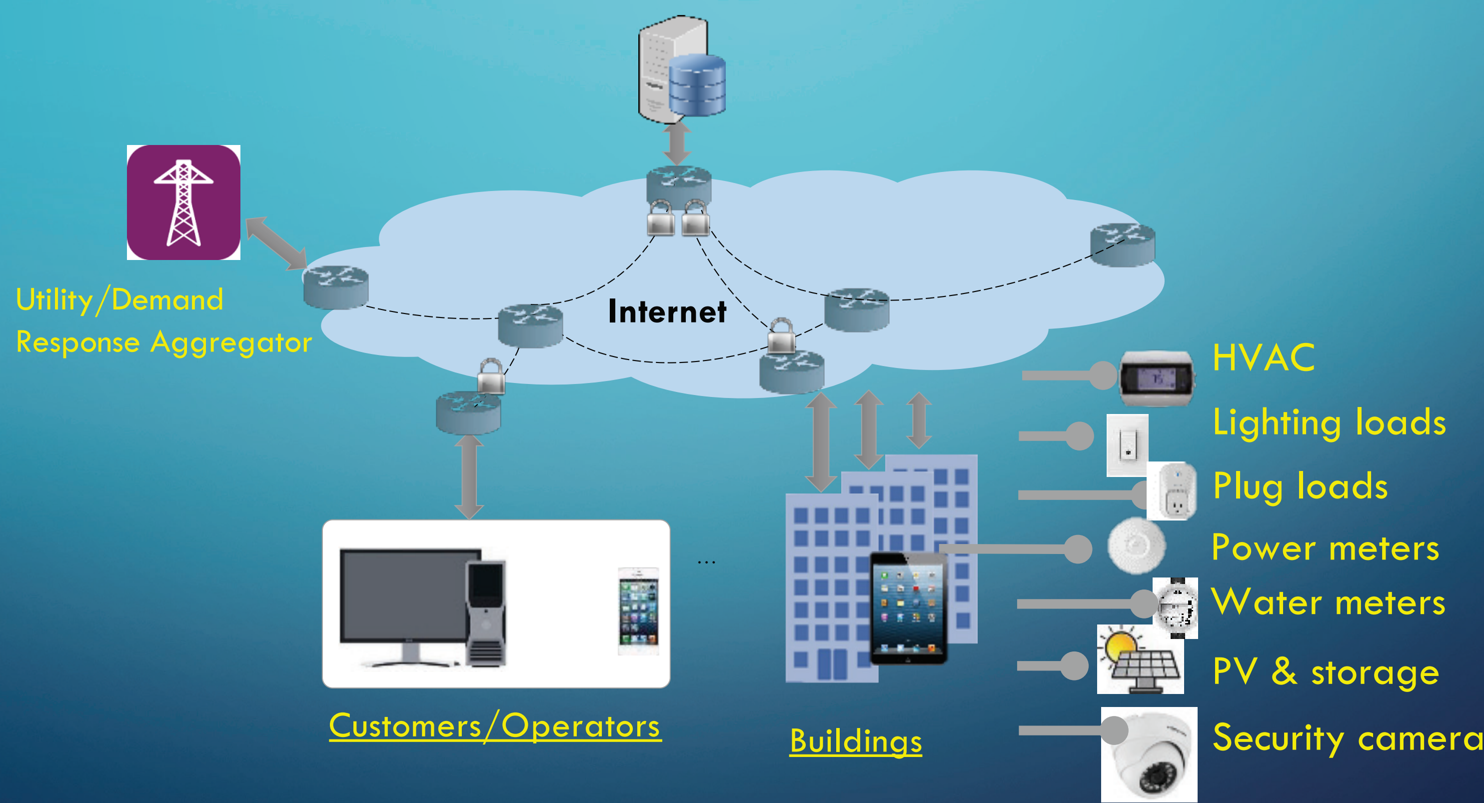
Demand Response can Provide Significant Support to Manage Intermittency

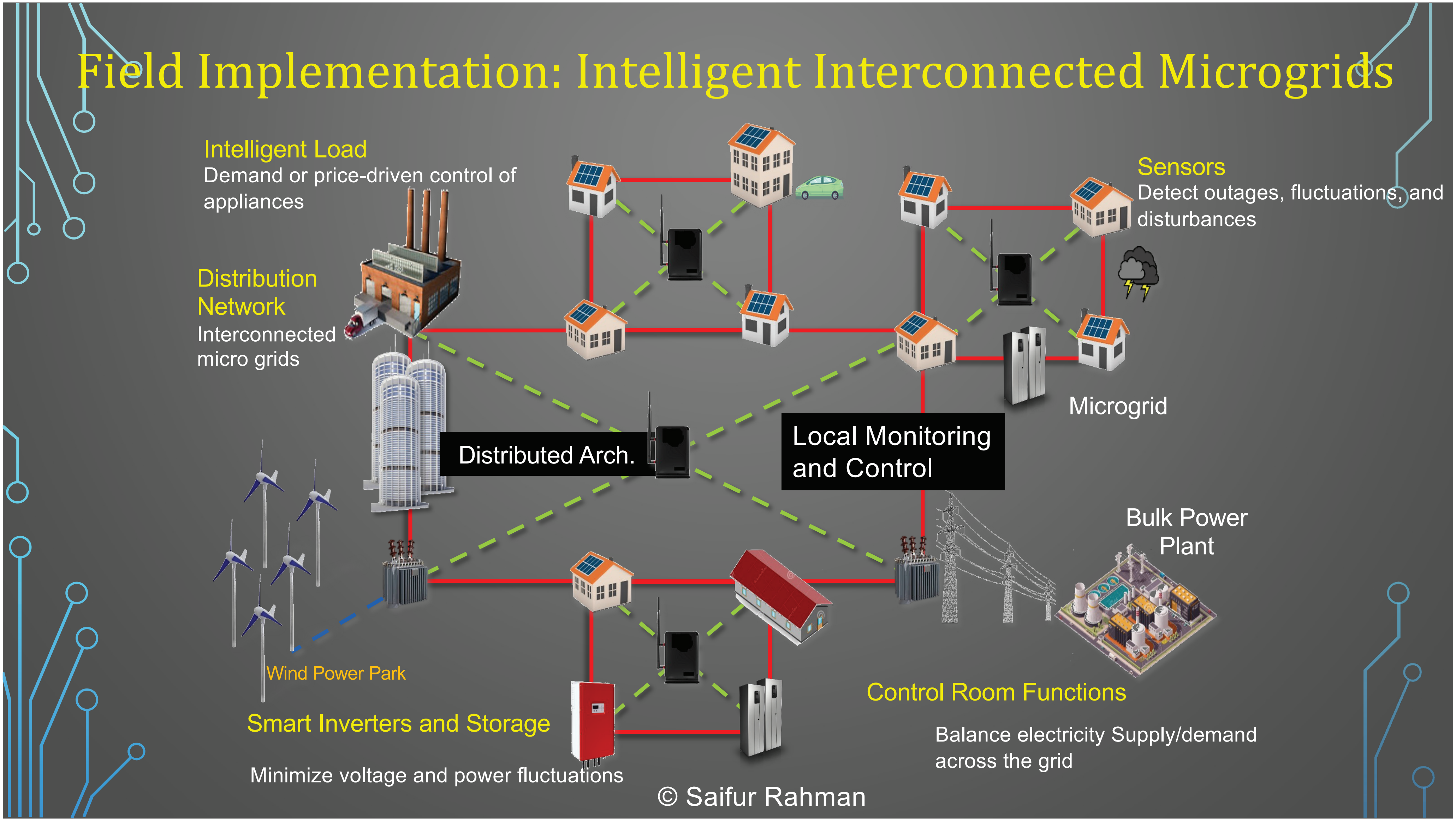
Demand Response Requires Sensor/Controller Connectivity

ICT can Provide the Platform for this Connectivity

An Open-Architecture Platform for IoT Device Integration in a Building

Smart Campus




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

Historically: Demand driven supply (supply responds to demand)

New Reality: Supply driven demand (demand needs to adjust to meet fluctuating supply with storage)

The Smart Grid Ecosystem

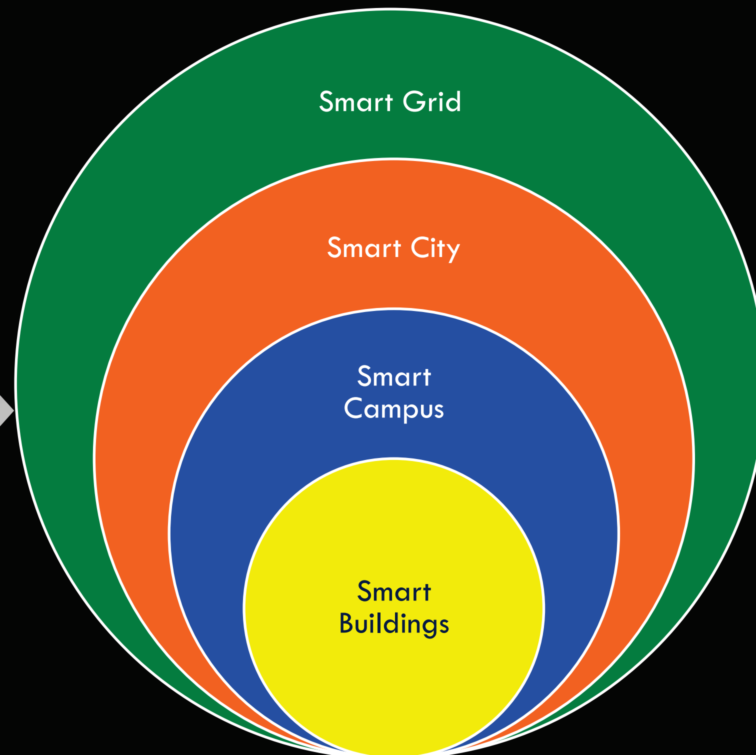
Smart grid: Bi-directional flows of energy, remote control/automation of power, integrated distributed energy…

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…

Ecosystem



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

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