Integrating Solar/Wind Generation into the Electric Power Grid: Benefits & Challenges

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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

Wind Energy

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

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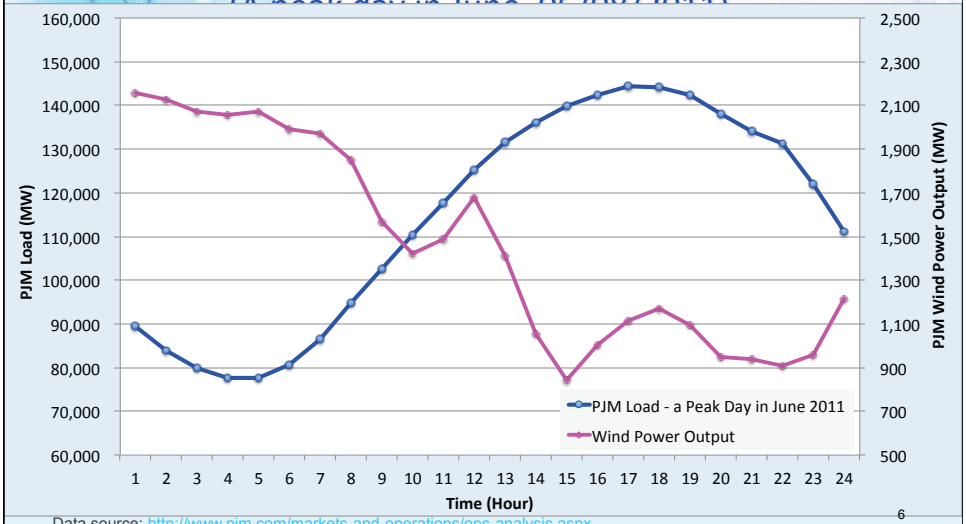
Wind Output & Load Mismatch (PJM)



Data source: http://www.pjm.com/markets-and-operations/ops-analysis.aspx

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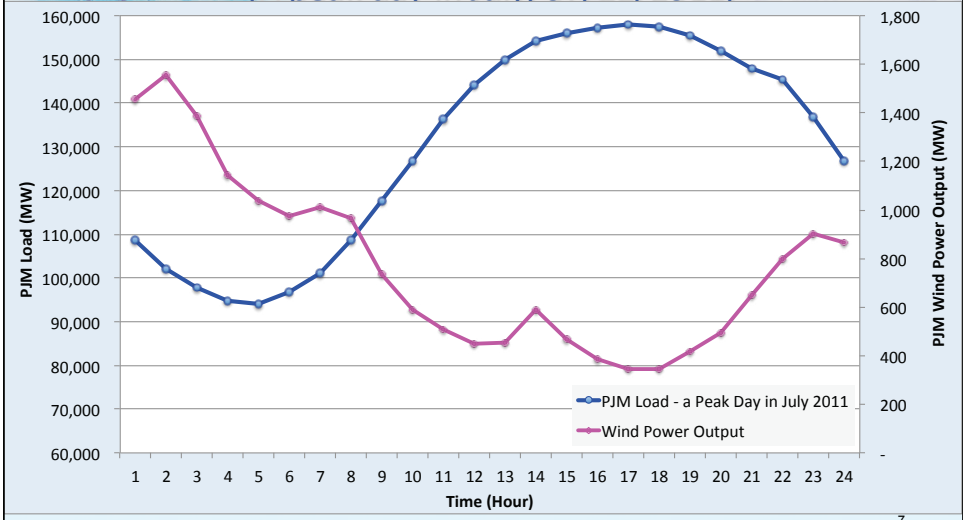
Wind Output & Load Mismatch (PJM)

(A peak day in July, 07/22/2011)



Data source: http://www.pjm.com/markets-and-operations/ops-analysis.aspx

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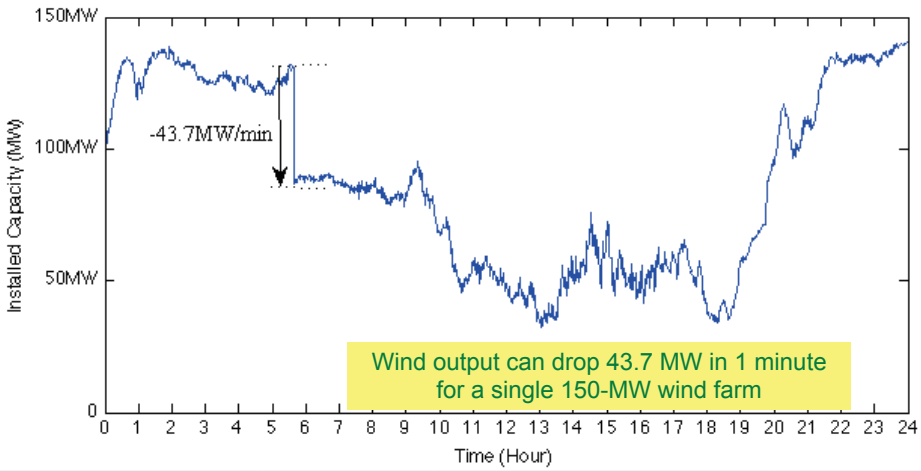
1-minute Variation of a 150MW Wind Farm Output in Texas, 2008



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

Source: NREL

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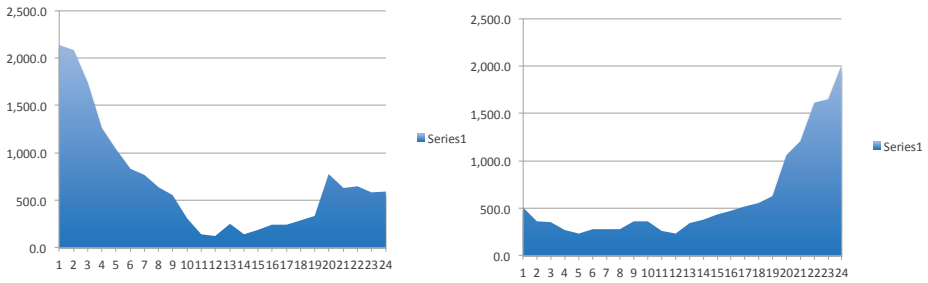
Hourly wind power variation (MW) in Texas, USA (01 and 02 Jan 2008)



01 Jan 2008 02 Jan 2008

Installed Capacity 4,541 MW

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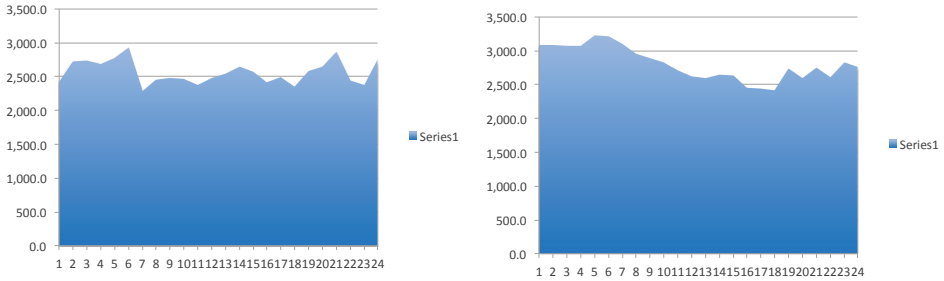
Hourly wind power variation (MW) in Texas, USA (03 and 04 Jan 2008)



03 Jan 2008 04 Jan 2008

Installed Capacity 4,541 MW

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Roof-top Solar Photovoltaics in Virginia

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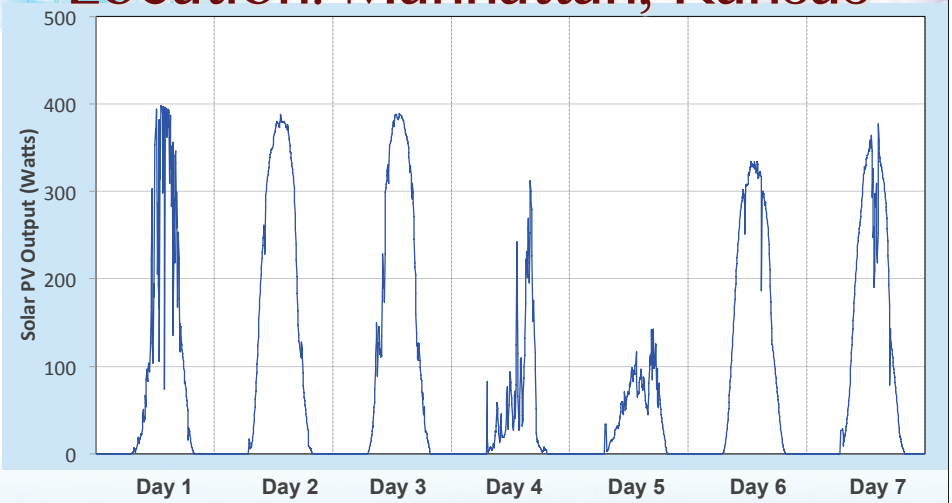
7-Day Solar PV Output Location: Manhattan, Kansas



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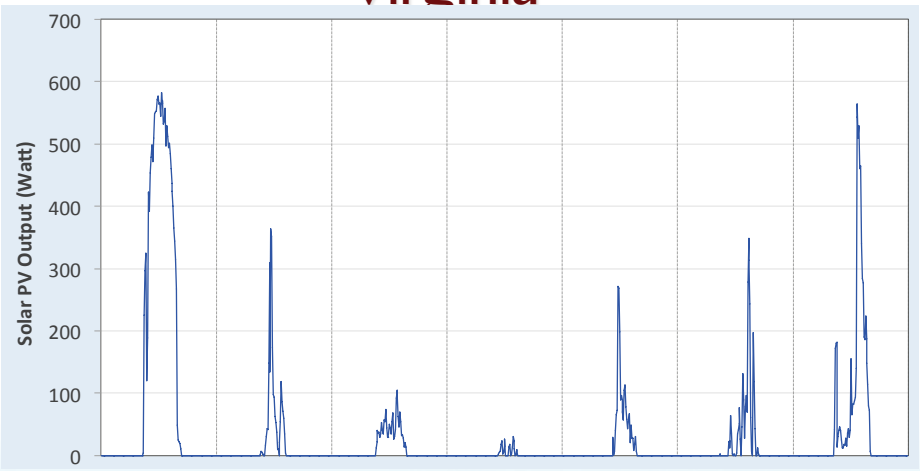
7-Day Solar PV Output Location: Blacksburg, Virginia



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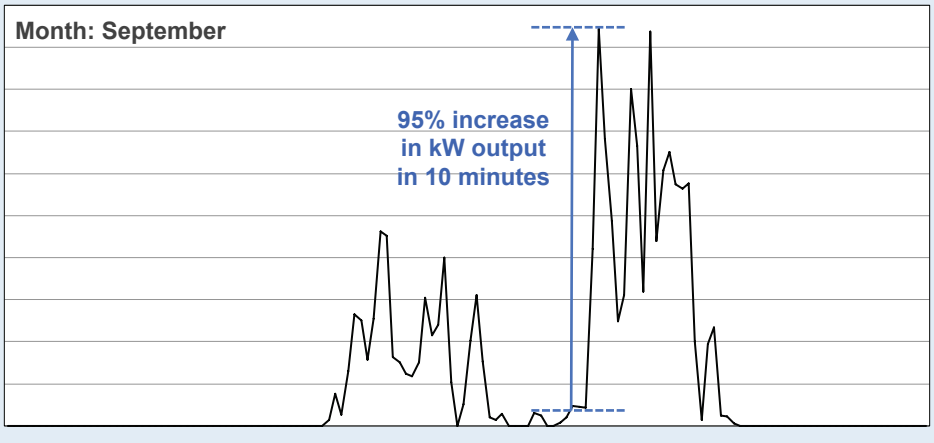
A 24-hour Solar PV Output (kW) Location: Blacksburg, Virginia



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Is there a better way to give credit to renewables?

- Can the short term intermittency be absorbed by the the network?
- Storage?
  - Batteries
  - Pumped storage hydro
  - Compressed air energy storage (CAES)
- Any other options?

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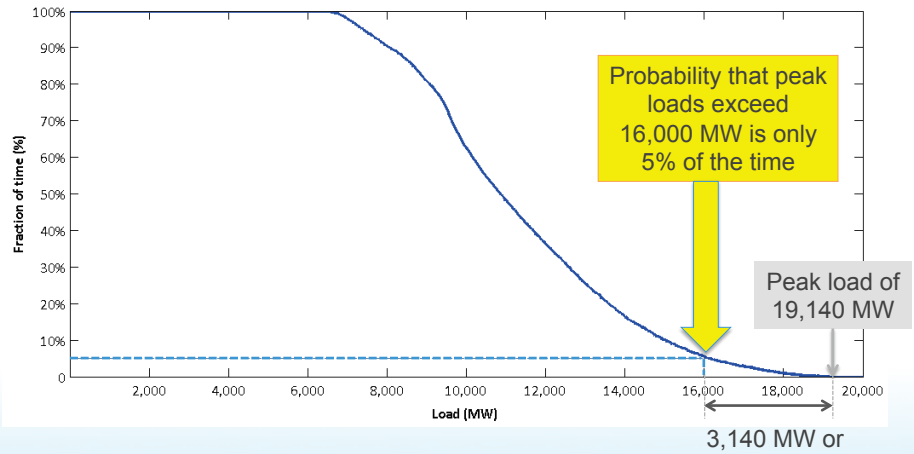
Peak Load Issue

Peak Load Reduction Dominion Virginia Power (2010)

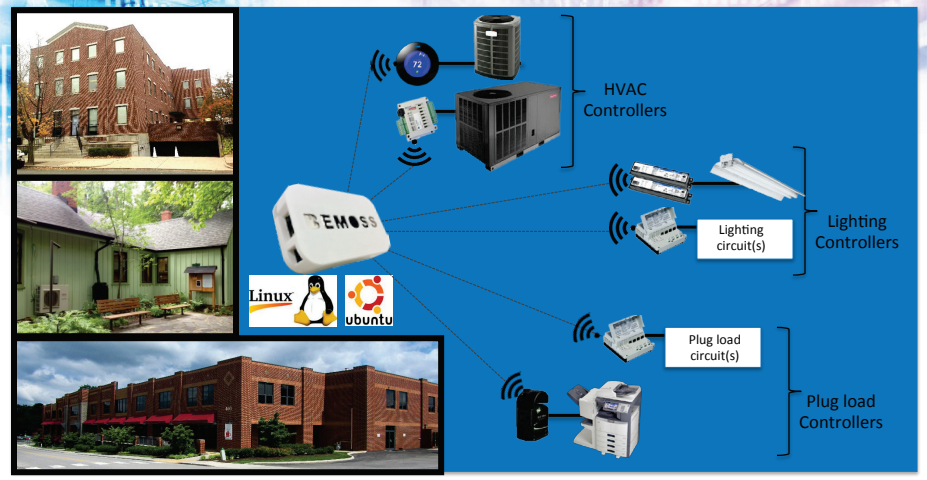


Demand Response

"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.

Building Energy Management Open Source Software (BEMOSS)



October 30, 2014

Turnkey FOA Design Review
DOE BTO Office
Washington, D.C.

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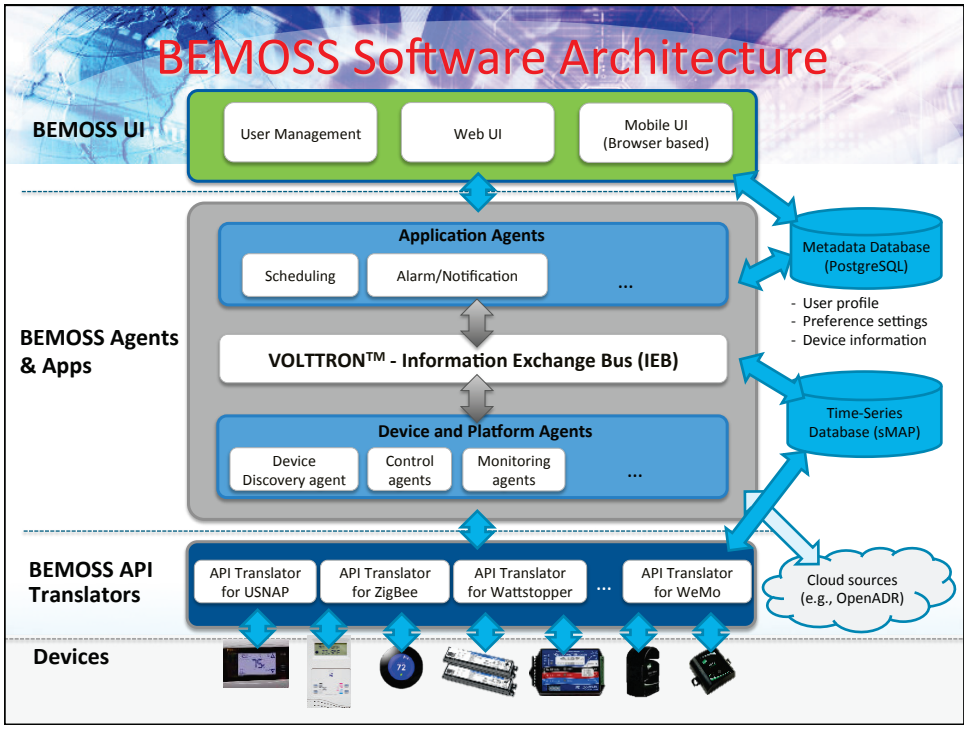
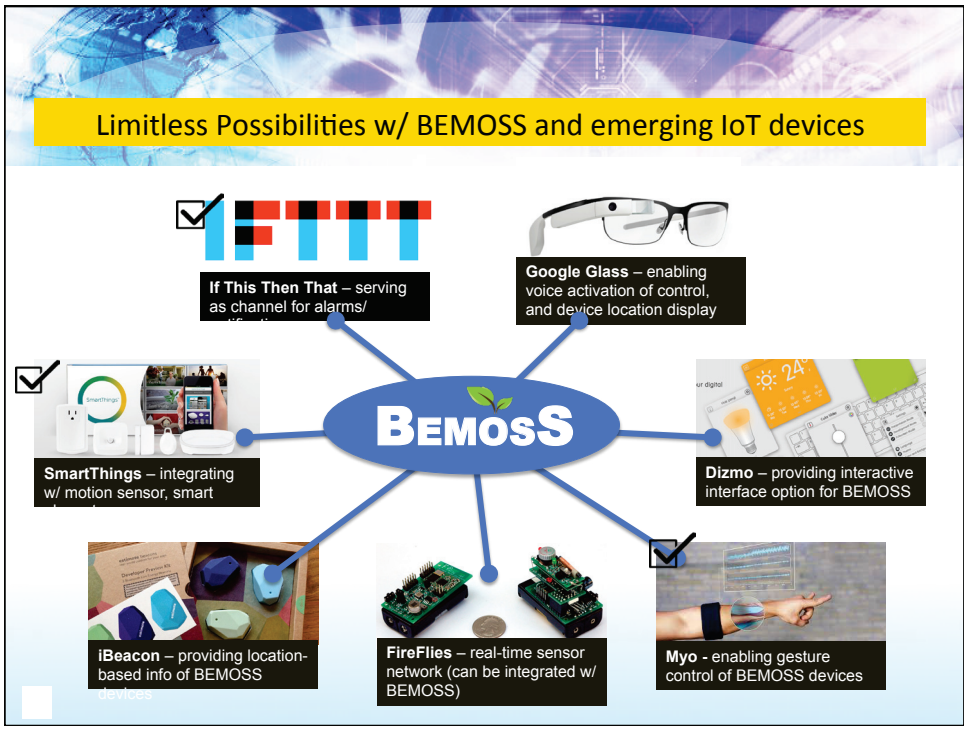
Virginia Tech

As of Oct 2014, BEMOSS can automatically discover and control:


BEMOSS: Solutions for Small Buildings
BEMOSS
beagleboard
HVAC Controllers
WiFi
WiFi
ZigBee
WiFi
WiFi
ZigBee
Plug Load Controllers
ZigBee mesh
ZigBee mesh
Lighting Load Controllers


Solutions for Larger Buildings
Every floor has this set up
Plug Load Controllers
HVAC Controllers
BEMOSS Zone 1
beagleboard
Modbus TCP
WiFi
WiFi
ZigBee
Floor 1
Power Meters
Modbus TCP
WiFi
ZigBee
WiFi
WiFi
WiFi
ZigBee mesh
BACnet IP
BACnet MS/TP
ZigBee mesh
Lighting Load Controllers


BEMOSS Software Architecture
BEMOSS UI
User Management
Web UI
Mobile UI (Browser based)
BEMOSS Agents & Apps
Application Agents
Scheduling
Alarm/Notification
...
VOLTTRON™ - Information Exchange Bus (IEB)
Device and Platform Agents
Device Discovery agent
Control agents
Monitoring agents
...
Metadata Database (PostgreSQL)
- User profile
- Preference settings
- Device information
Time-Series Database (sMAP)
BEMOSS API Translators
API Translator for USNAP
API Translator for ZigBee
API Translator for Wattstopper
...
API Translator for WeMo
Cloud sources (e.g., OpenADR)
Devices


Limitless Possibilities w/ BEMOSS and emerging IoT devices
If This Then That – serving as channel for alarms/
Google Glass – enabling voice activation of control, and device location display
BEMOSS
SmartThings – integrating w/ motion sensor, smart
Dizmo – providing interactive interface option for BEMOSS
iBeacon – providing location-based info of BEMOSS
FireFlies – real-time sensor network (can be integrated w/ BEMOSS)
Myo - enabling gesture control of BEMOSS devices

What Role Can the Smart Grid Play?

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 our electricity delivery and use more efficient.

FierceSmartGrid: *There are many definitions of "smart grid" -- how do you define it?*

Saifur Rahman: "Smart grid" is a concept with many elements -- it's not a physical thing. I like to say that a smart grid starts at the generator and ends at the refrigerator.

http://www.fiercesmartgrid.com/story/smart-grid-starting-generator-ending-refrigerator/2013-02-19?utm_medium=nl&utm_source=internal

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This is the Electric Power Grid

Source: www.sxc.hu

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Difference Between a Normal Grid And a Smart Grid

Normal Phone

Smart Phone

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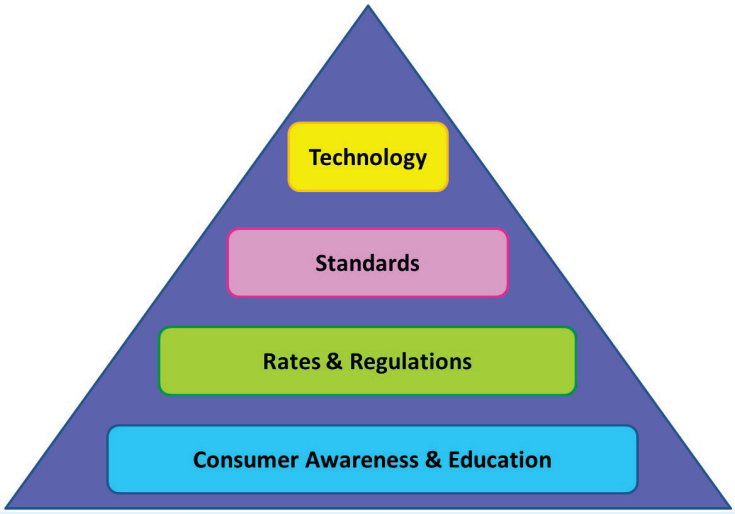
What is the Motivation for a Smart Grid

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

Starting and End Points of a Smart Grid

From Generator to Refrigerator

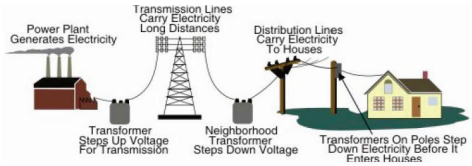
Building Blocks of the Smart Grid



Evolution of the Grid

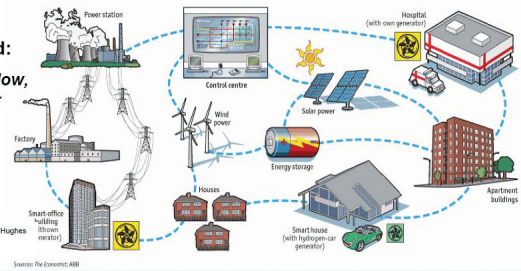
Before **Smart Grid:**

One-way power flow, simple interactions



After **Smart Grid:**

Two-way power flow, multi-stakeholder interactions



Source: Altalink, Alberta, Canada

Merging Power Flow with Information Flow:

Integrated Communications

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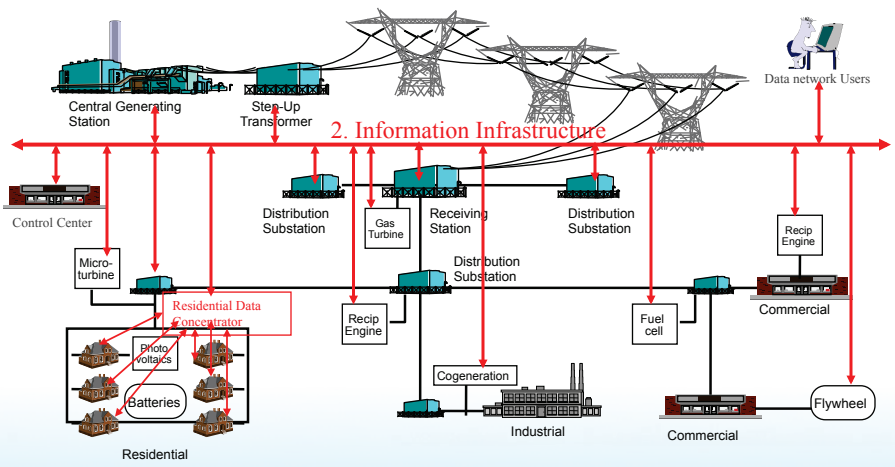
Electric Power & Communication Infrastructures

1.Power Infrastructure



Source: EPRI

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Technical Issues

- Renewables integration
- Demand response application
- Peak load reduction
- Remote meter reading & billing
- Transformer/Switchgear loading
- Service monitoring and recovery

Technical Benefits

- Conservation Voltage Reduction
- Peak Load Reduction
- Faster Outage Recovery
- Renewables Integration

Faster Recovery from Outages

- Smart meters allow automated outage information notification
- Distribution automation and advanced switching capability allow sectionalizing and faster distribution circuit reconfiguration to restore healthy sections to service

Benefits of the smart grid

Peak load reduction, generator efficiency improvements and distributed generation integration are major benefits of the smart grid

Demand response can provide significant peak load reductions

A smooth load shape allows better asset utilization

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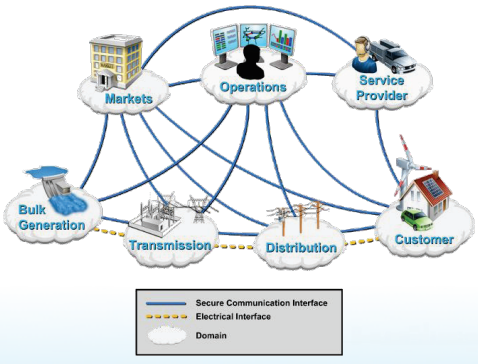
Smart Grid Information Clearinghouse

www.sgiclearinghouse.org

Thank you

Prof. Saifur Rahman
www.saifurrahman.org



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