

# The State of the Art in Smart Grids

Invited Talk at EMI, Rabat, Morocco

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PPT slides will be available at

[www.saifurrahman.org](http://www.saifurrahman.org)



# What is the Smart Grid ?

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## This is the Electric Power Grid



Source: [www.sxc.hu](http://www.sxc.hu)

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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.

## Smart Grid Definition

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



## Difference Between a Normal Grid And a Smart Grid



**Normal Phone**



**Smart Phone**

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## Beginning and End of Smart Grid

**From Generator to Refrigerator**



**Power Plant**



**Transmission**



**Distribution**

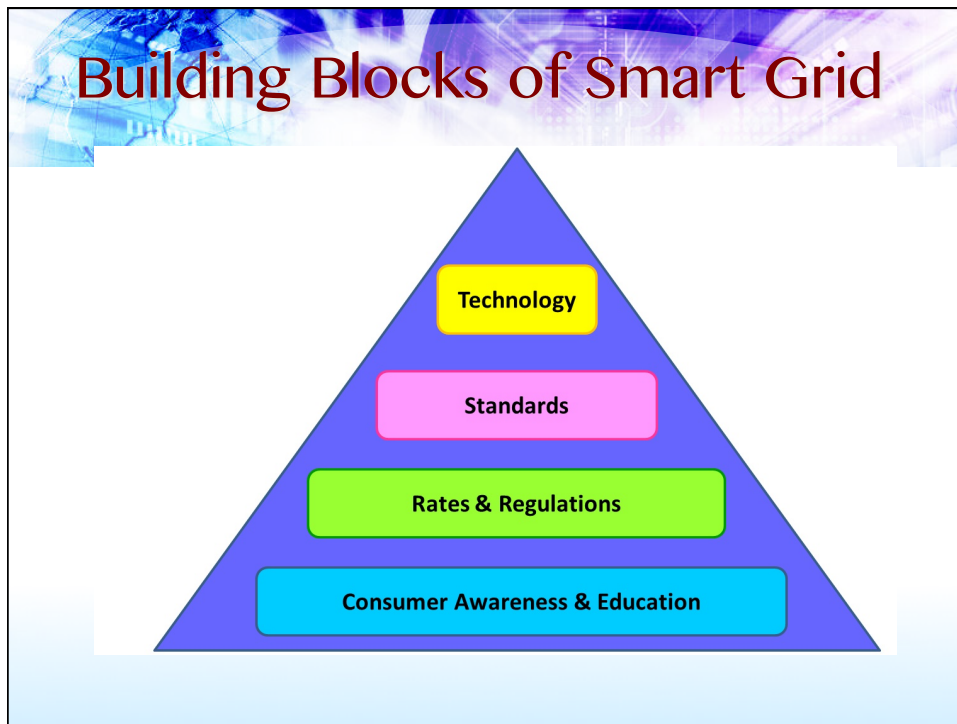


**Home  
Business**



**End-use  
Appliances**





## What Makes it Smart?

Intelligence  
Two-way communication  
Real-time monitoring & control

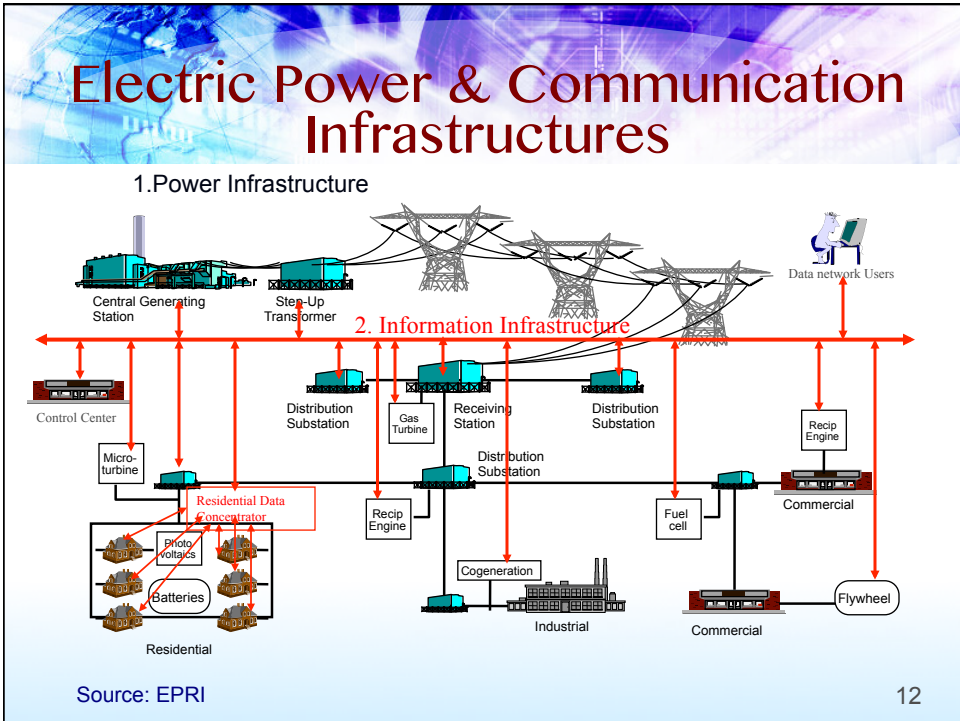
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# Merging Power Flow with Information Flow

## Integrated Communications

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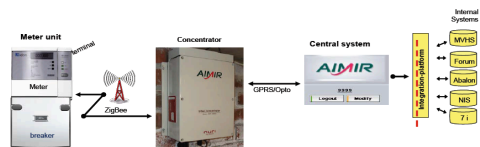
## Beginning of the Smart Grid

- Smart meter is just the beginning of a smart grid



The Flow of Metering Data

- Two-way communication allows customer participation



Göteborg Energi

## Smart Meters in Gothenburg, Sweden

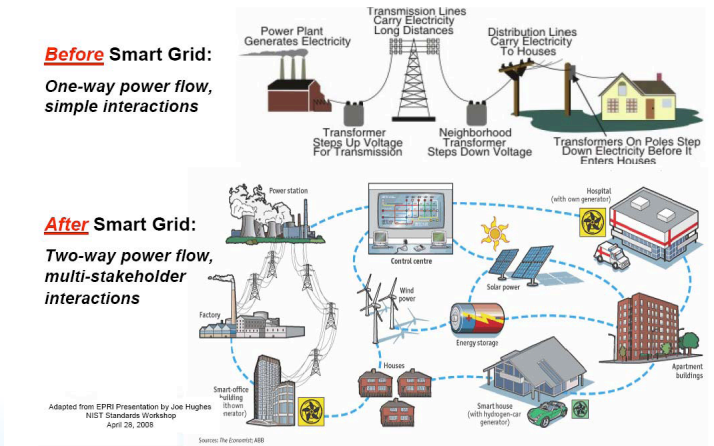




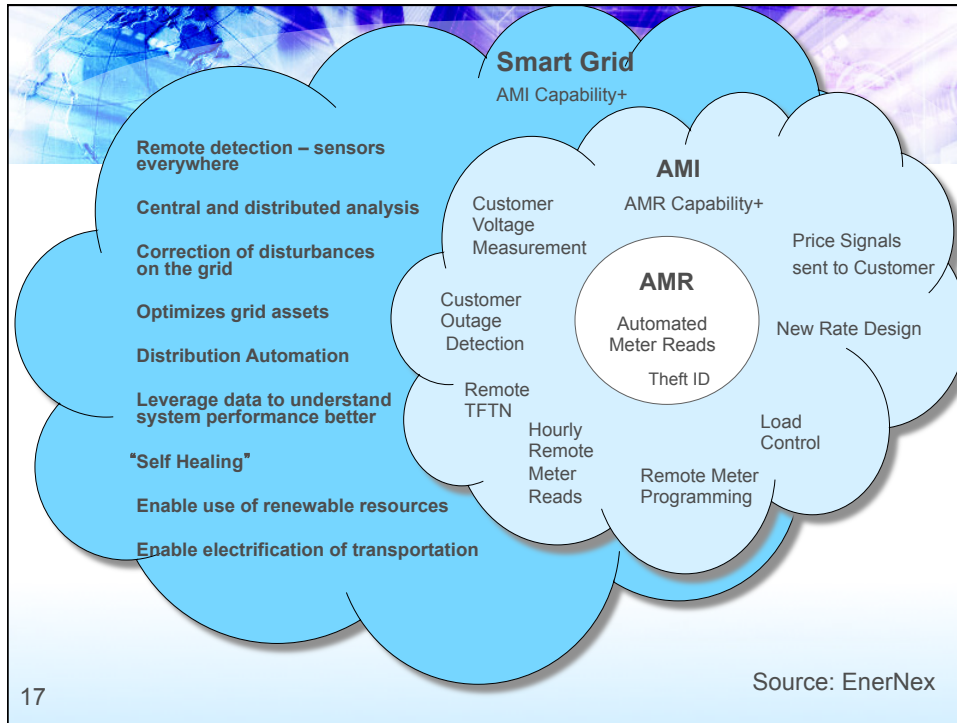
# Data Hub for Meter Data Collection and Transmission



# Evolution of the Grid

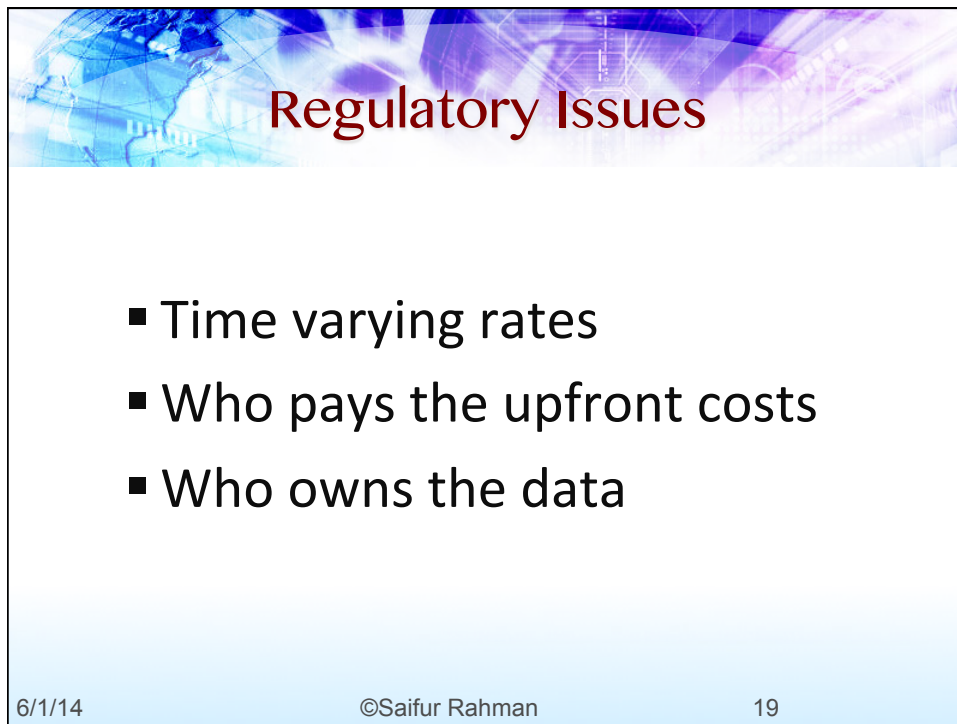


Source: Altalink, Alberta, Canada



## Issues in Smart Grid Deployment

- Regulatory
- Business
- Technical
- Security and Privacy

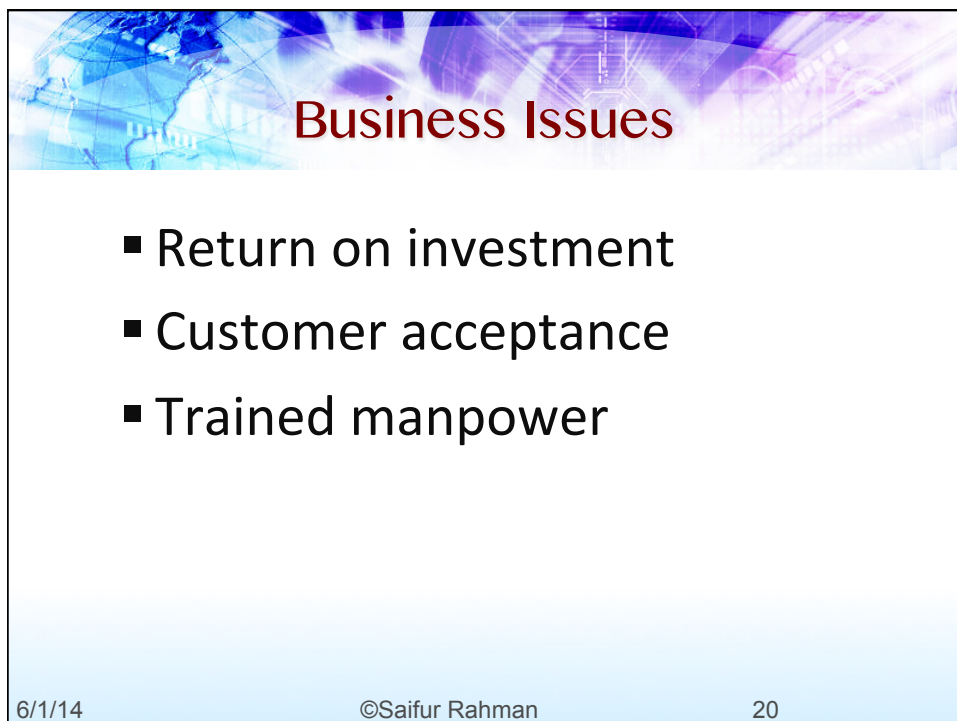


The slide features a header with a blue and purple abstract background containing a globe and data lines. The title "Regulatory Issues" is centered in a red serif font. Below the title is a white area with a light blue gradient at the bottom, containing a bulleted list of three items. At the bottom of the slide, there is a footer with the date "6/1/14", the copyright notice "©Saifur Rahman", and the page number "19".

## Regulatory Issues

- Time varying rates
- Who pays the upfront costs
- Who owns the data

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The slide features a header with a blue and purple abstract background containing a globe and data lines. The title "Business Issues" is centered in a red serif font. Below the title is a white area with a light blue gradient at the bottom, containing a bulleted list of three items. At the bottom of the slide, there is a footer with the date "6/1/14", the copyright notice "©Saifur Rahman", and the page number "20".

## Business Issues

- Return on investment
- Customer acceptance
- Trained manpower

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The header of the slide features a blue and purple abstract background with a globe and circuit-like patterns. The title "Technical Issues" is centered in a dark red font.

## Technical Issues

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

6/1/14

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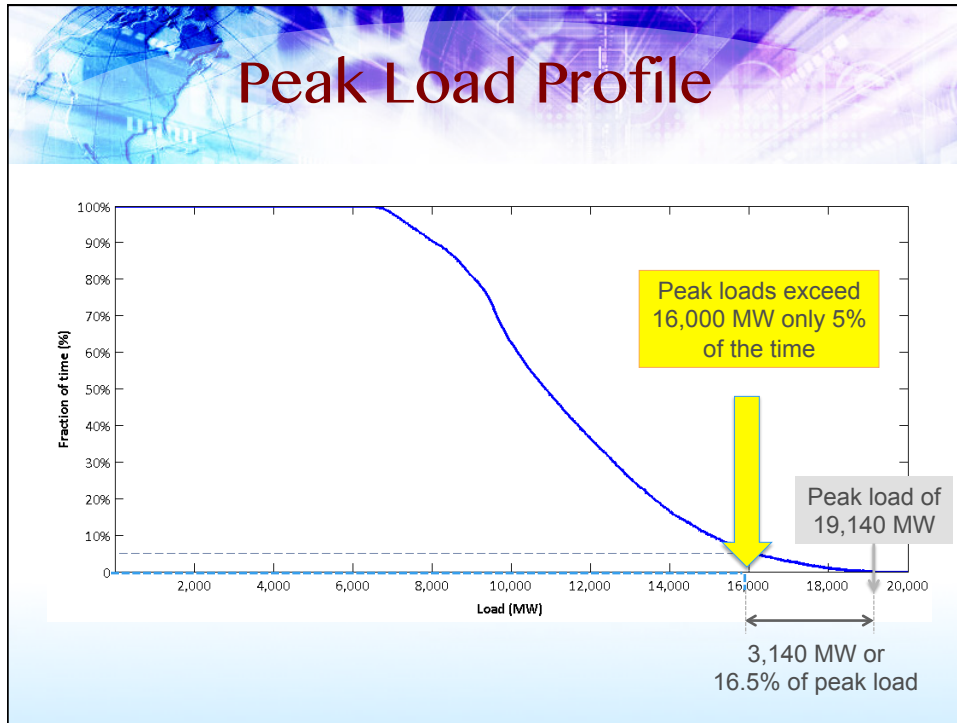
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The header of the slide features a blue and purple abstract background with a globe and circuit-like patterns. The title "Faster Recovery from Outages" is centered in a dark red font.

## 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



## Peak Load and its Duration

- In the **US** 20% of the load happens 5% of the time
- In **Australia** 15% of the load happens less than 1% of the time
- In **Egypt** 15% of the load happens 1% of the time
- In **Saudi Arabia** 5% of the load happens 0.5% of the time

## Smart Grid and Peak Load Reduction

Two-way information flow allows  
selective load monitoring and control

Smart grid can selectively address  
particular appliance types

Duration of appliance operation can be  
monitored and controlled

## Changing Landscape of the Electric Utility



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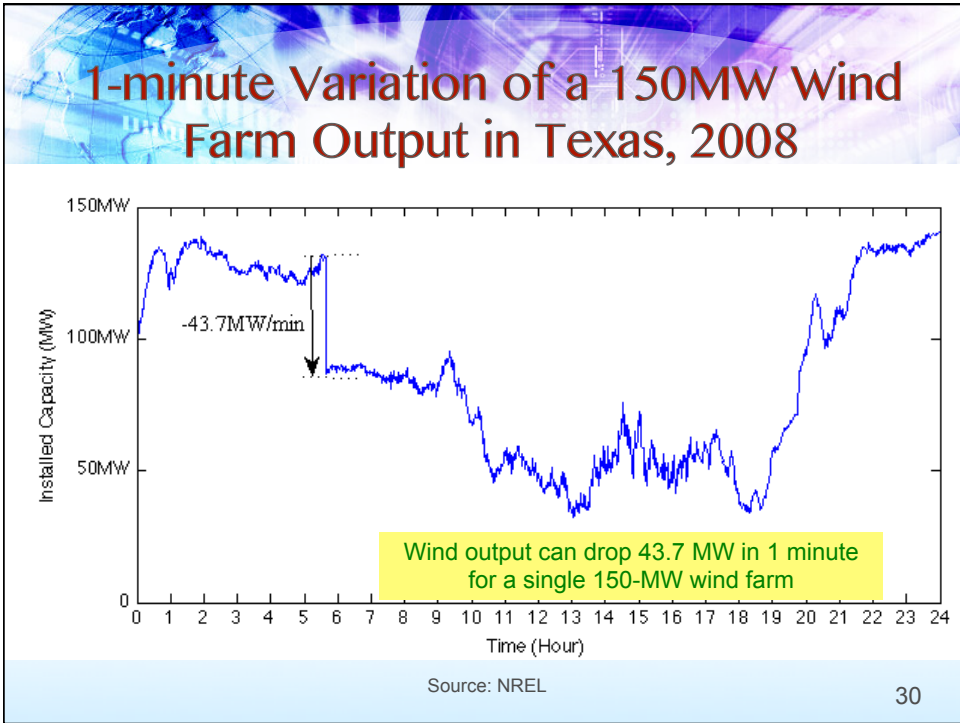
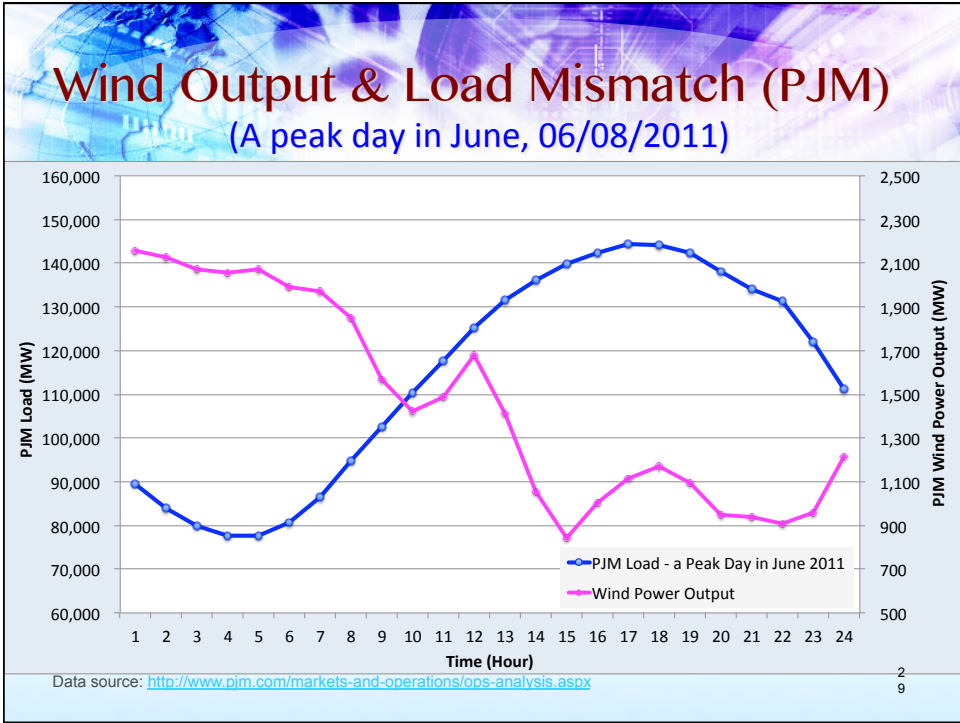
## Issues with Distributed Generation

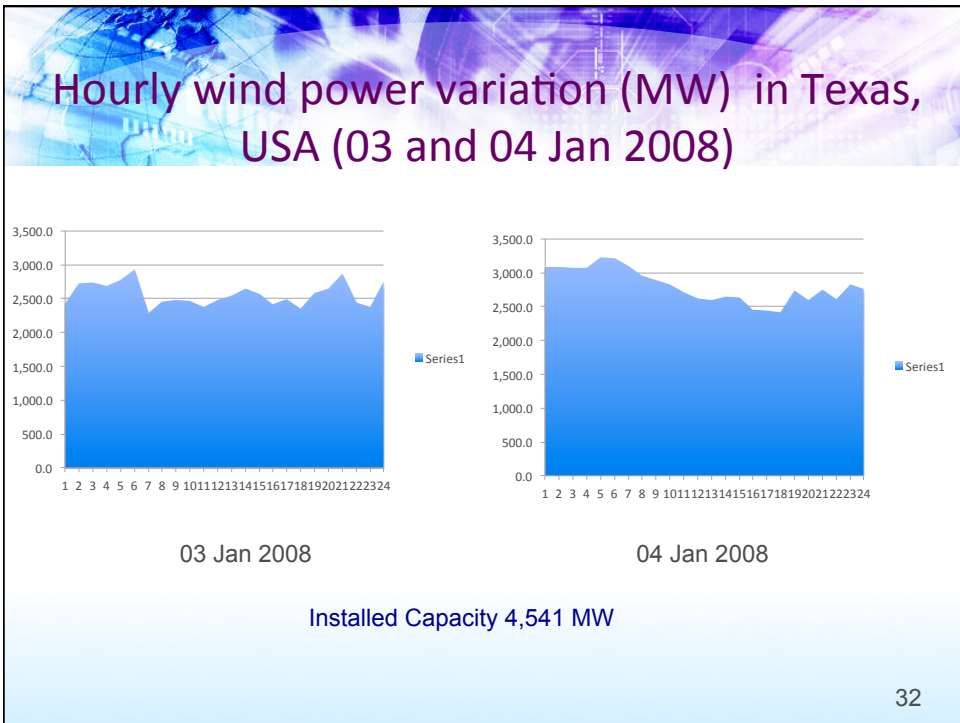
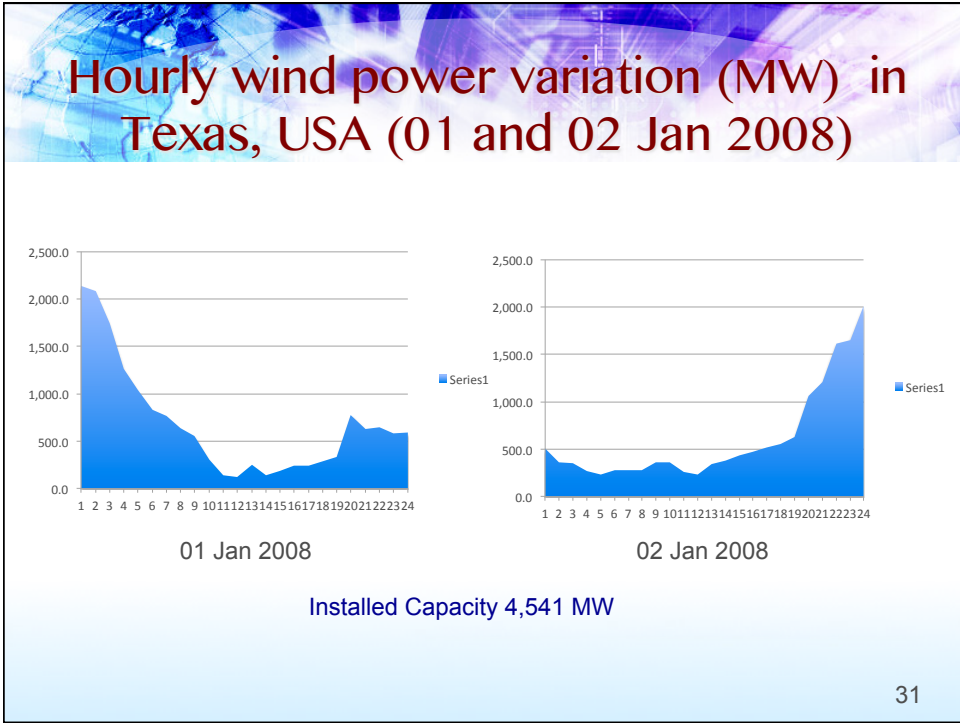
- Wind and solar are intermittent
- Hydro is space limited
- Resource is free but not always usable



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

## Wind Energy







## Roof-top Solar Photovoltaics in Virginia

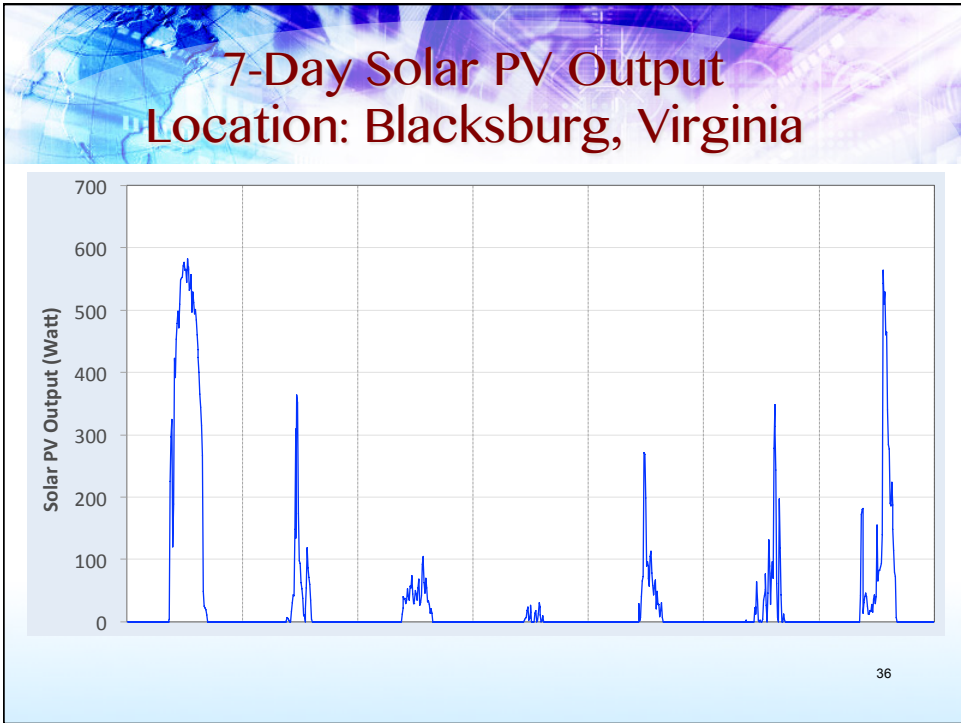
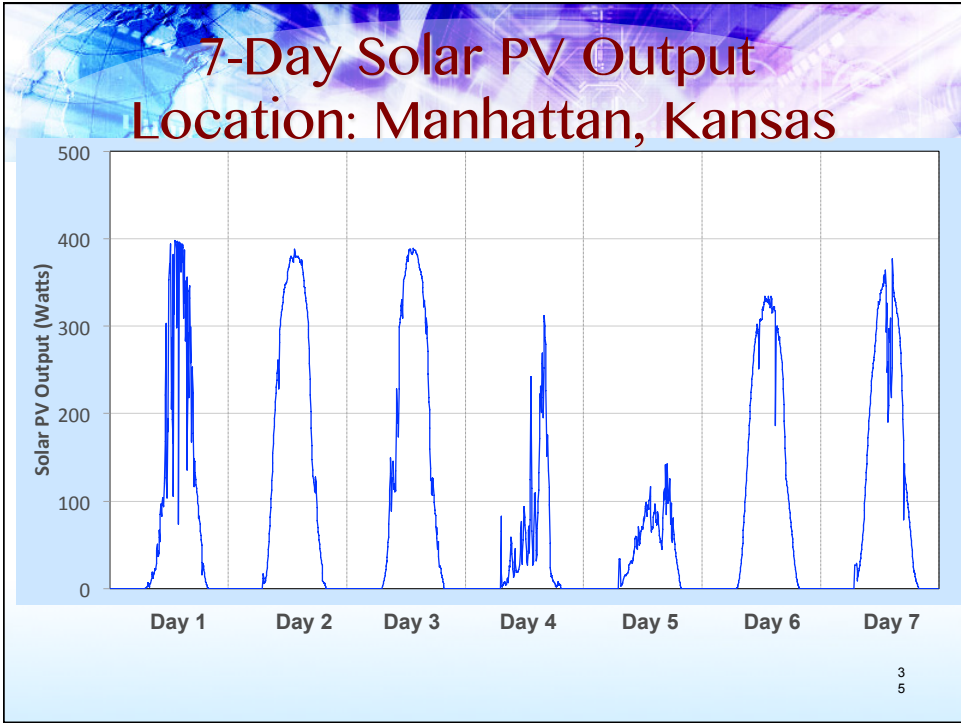


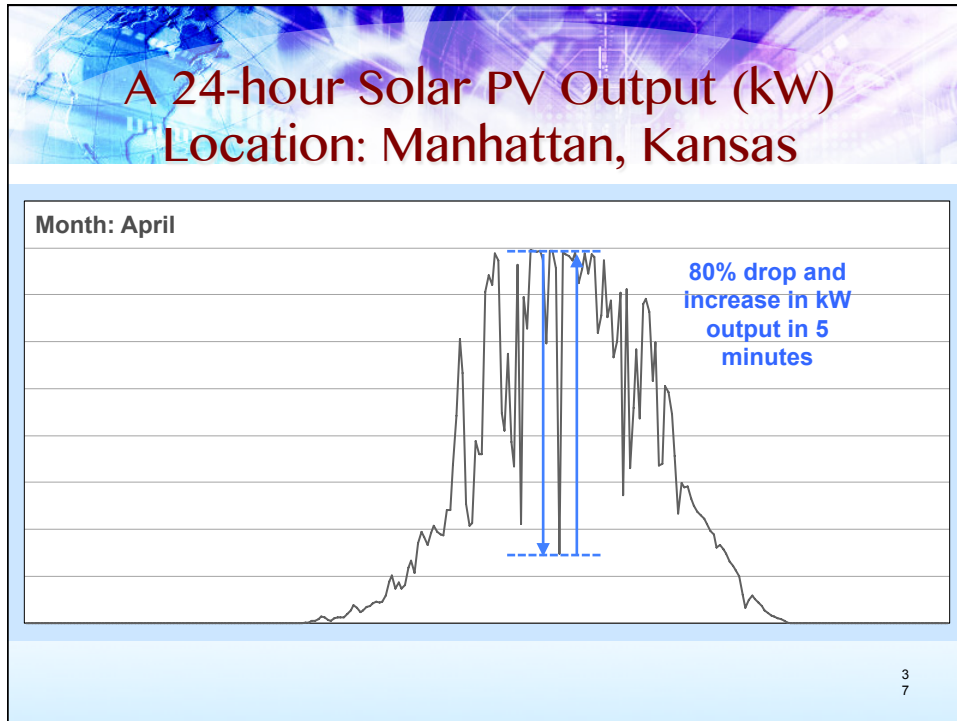
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## Solar Panels in Winter




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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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The slide features a header with a blue and purple abstract background of a globe and circuitry. The title "Demand Response" is centered in a large, bold, dark red font.

## 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.

The slide features a header with a blue and purple abstract background of a globe and circuitry. The title "VT's Demand Response Research" is centered in a large, bold, dark red font.

## VT's Demand Response Research

### Current Approach:

- During a power system stress condition, an electric utility sends control signals to shed selected commercial/residential loads.
- The customer has no control beyond the initial consent.

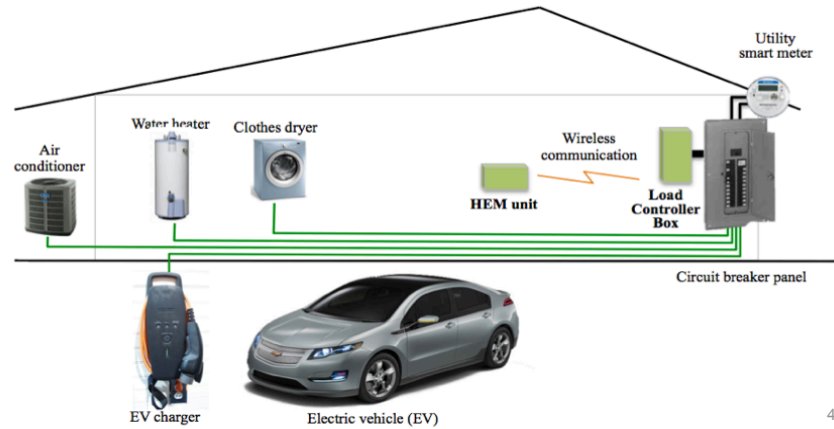
### Virginia Tech Approach:

- A demand reduction request (kW) is sent to individual residential/commercial/industrial customer through a customer interface device.
- The customer now has a choice and can decide which appliances to control based on their preference and load priority.



## VT's Conceptual HEM Hardware

Two components: 1) HEM unit and 2) load controller box.



## Security and Privacy Issues

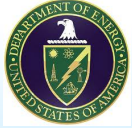
- Data transmission over the public internet
- Data sharing by multiple parties
- Ownership of the data

# Portal for Smart Grid Information Collection and Archival

## Smart Grid Information Clearinghouse

**Objective:** To design, populate, manage and maintain a public Smart Grid Information web portal that reaches out to a broad user community both for information gathering and knowledge delivery.

[www.SGIClearinghouse.org](http://www.SGIClearinghouse.org)



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What are the Smart Grid Technologies?

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## Platform for Smart Grid R&D

The electric power industry provides the platform and the context

Telecommunication, IT and computer industries provide the technology and software to interface with the electric power network

The electric power industry will require new generation of engineers who are versatile in several disciplines

## Thank you

