The Smart Grid
What Makes it Practical

IEEE PES Chapter
05 July 2013
Osijek, Croatia

Invited talk by Prof. Saifur Rahman

Virginia Tech

Advanced Research Institute, Virginia Tech, USA

Copies of slides are available from:

www.saifurrahman.org/presentations

This is the Electric Power Grid

Source: 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.

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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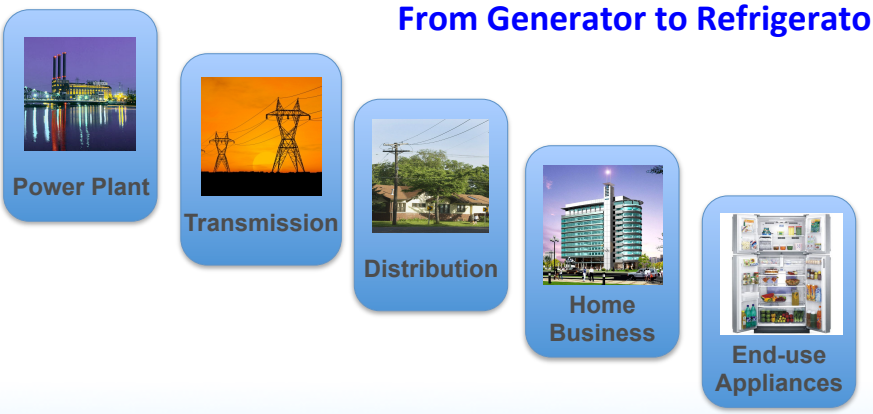
Difference Between a Normal Grid And a Smart Grid

Normal Phone

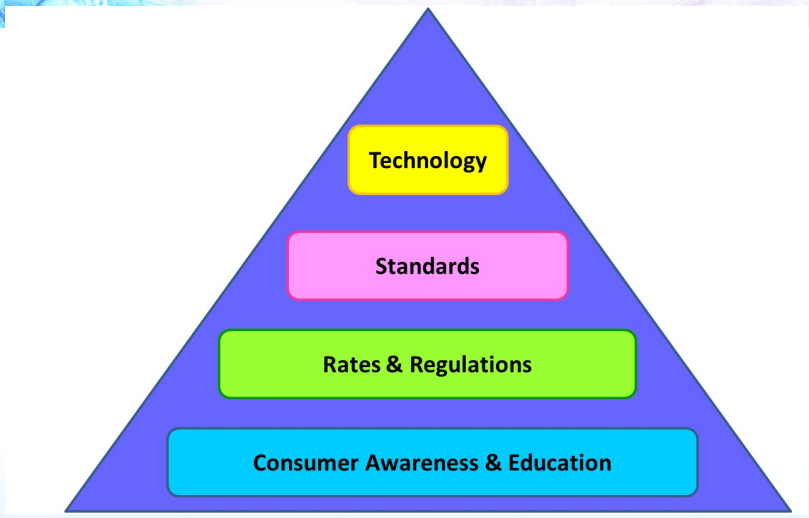
Smart Phone

Starting and End Points of a Smart Grid

From Generator to Refrigerator



Building Blocks of the Smart Grid



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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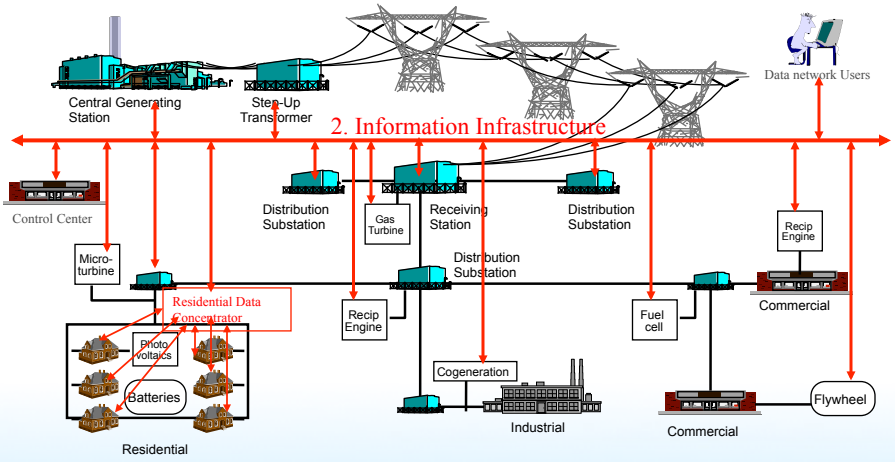
Electric Power & Communication Infrastructures

1.Power Infrastructure



Source: EPRI

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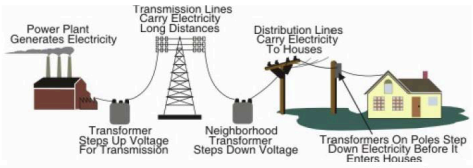
Evolution of the Grid

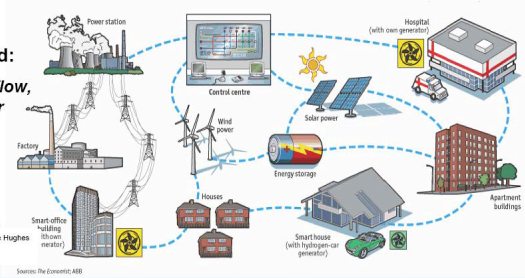
***Before* Smart Grid:**

One-way power flow, simple interactions



***After* Smart Grid:**

Two-way power flow, multi-stakeholder interactions



Source: Altalink, Alberta, Canada

Issues in Smart Grid Deployment

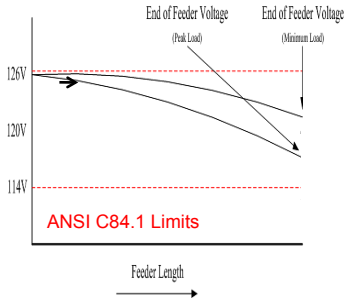
- Technical
- Regulatory
- Business

Technical Benefits

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

Conservation Voltage Reduction

- Customer voltages are maintained higher near the substation to provide an acceptable level near the end of the circuit.
- For each 1% reduction in voltage, there is as much as a 0.5% to 1% decrease in energy use at the customer end.



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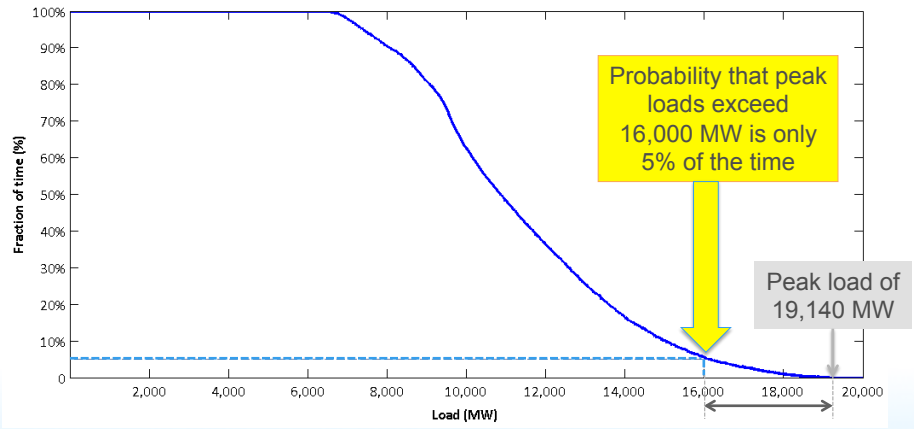
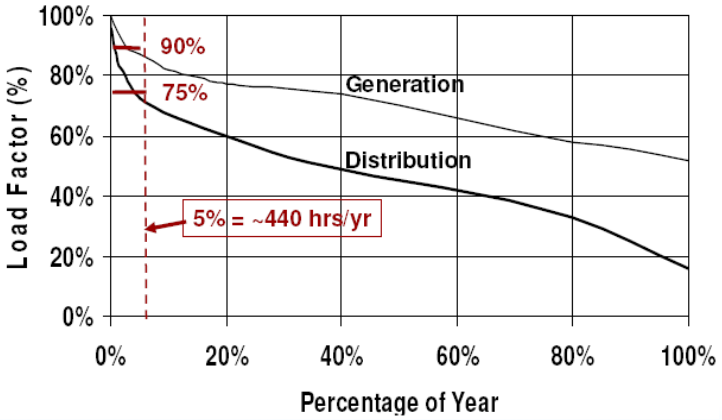
Load Duration Curve
Dominion Virginia Power (2010)



Impact of Peak Load



>25% of distribution and >10% of generation assets are needed less than 5% of the time ($100s of billions of investments)

Source: US Dept of Energy

Peak load and its duration

- In the US 20% of the load happens 5% of the time
- In Australia 15% of the load happens 2.5 days in a year or less than 1% of the time
- In Egypt 15% of the load happens 1% of the time

Capacity (MW) is INVESTMENT
And
Energy (MWHr) is REVENUE

Several US states are regulating capacity growth
(eg., Indiana limits its capacity to negative growth)

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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

Changing Landscape for the Electric Utility

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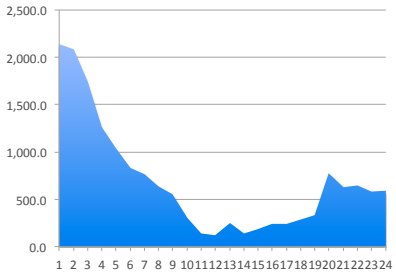
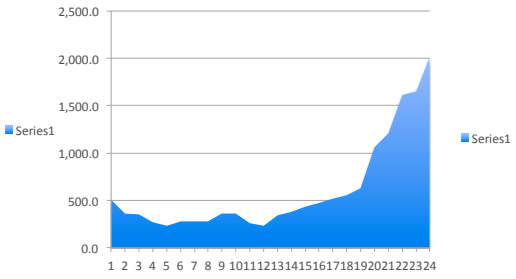
Hourly wind power variation (MW) in Texas, USA (01 and 02 Jan 2008)



01 Jan 2008



02 Jan 2008

Installed Capacity 4,541 MW

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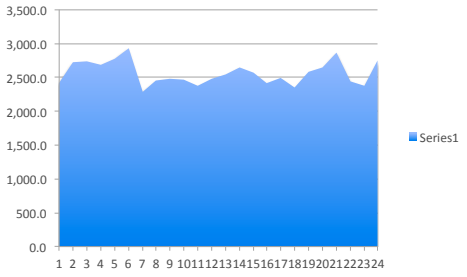
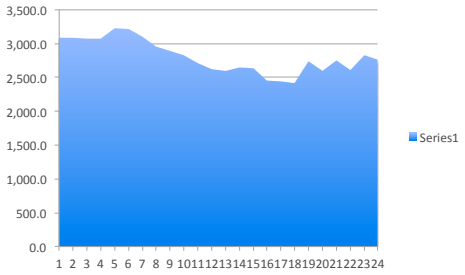
Hourly wind power variation (MW) in Texas, USA (03 and 04 Jan 2008)



03 Jan 2008



04 Jan 2008

Installed Capacity 4,541 MW

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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

Load Control
at the Customer Level can provide
significant short term load reduction

A cheaper option to get load relief

How to incentivize the customer?

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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.
- This is based on prior agreements with the customer.
- The customer has no control beyond the initial consent.

VT Approach:

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

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Appliances to be Controlled

- Focus on power-intensive loads, including:

Space heating/ cooling unit (2-5 kW)

Clothes dryer (4-5.6 kW)

Water heater (3.8-5.5 kW)

Electric vehicle (3.3-16.8 kW for level-2)

- Customers have a choice to decide which appliances to control based on their priority and customer preference.

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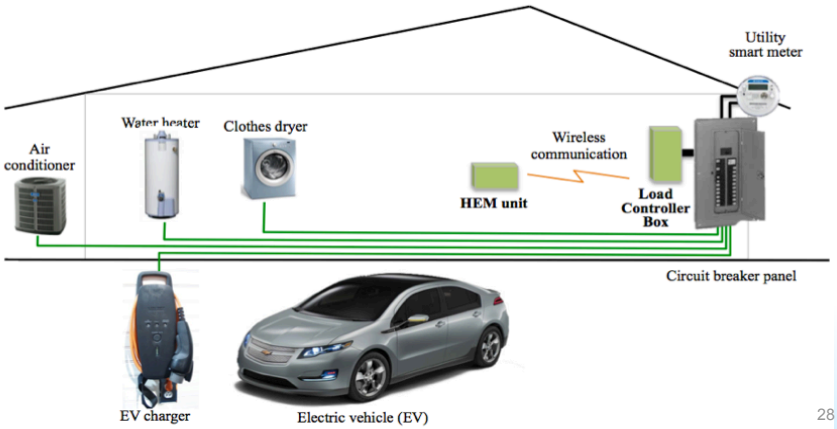
VT's Conceptual HEM Hardware

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



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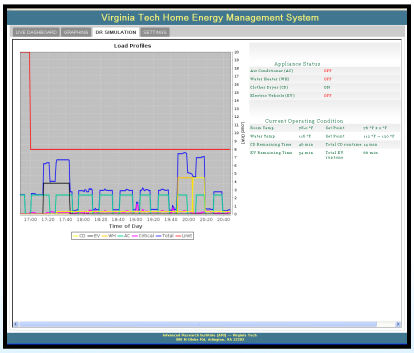
HEM Unit

Component 1: Home Energy Management (HEM) Unit

provides customer interface to monitor & control appliances. It includes embedded algorithms for managing power-intensive loads based on their priority and customer preference.



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Regulatory Issues

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

Business Issues

- Cost recovery
- Customer acceptance
- Trained manpower

Smart Grid Information Clearinghouse

PIs: Dr. Saifur Rahman and Dr. Manisa Pipattanasomporn

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

www.SGIClearinghouse.org

Sponsored by US Department of Energy

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The SGIC Project page archives both American Recovery and Reinvestment Act of 2009 (ARRA) funded projects, and other smart grid projects in the United States. Use the menu below to navigate through the ARRA and other projects.
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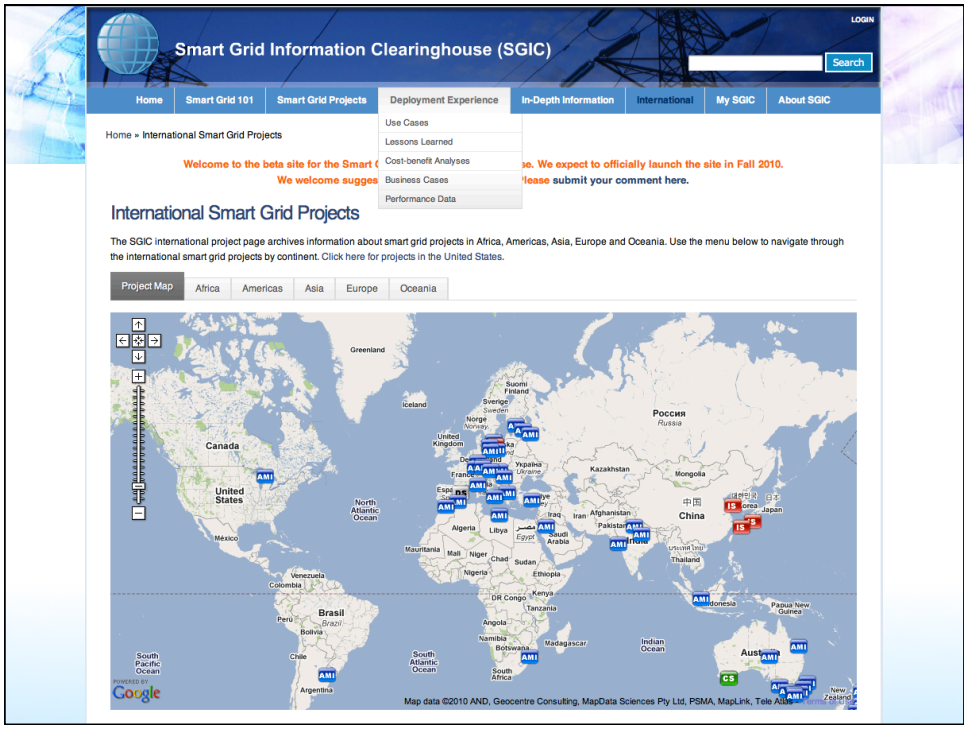
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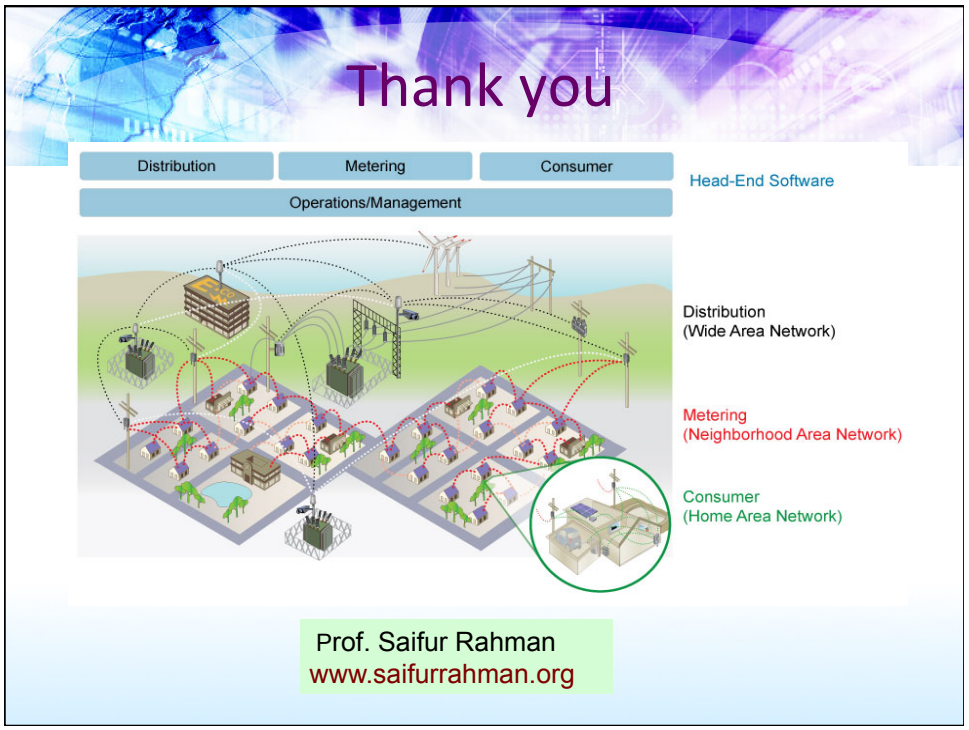
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