Role of the Smart Grid in Facilitating the Integration of Renewables

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 our electricity delivery and use more efficient.

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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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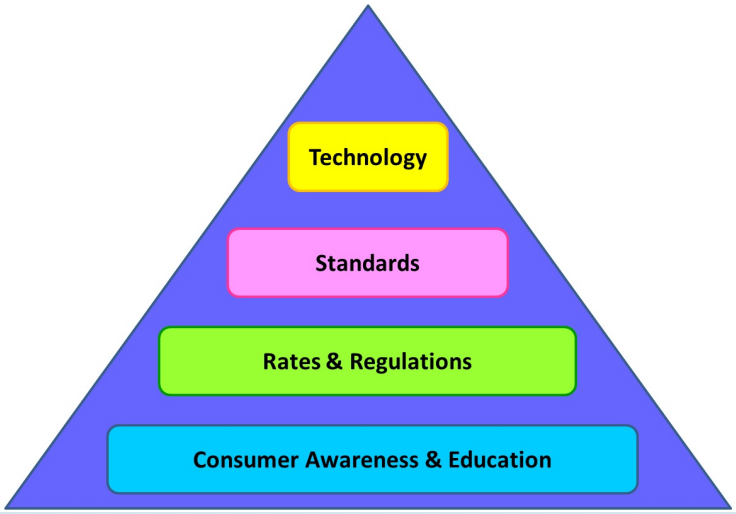
Motivation for a Smart Grid

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

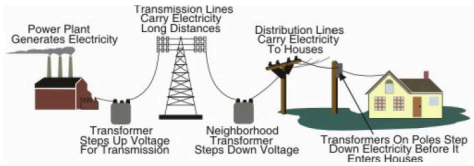
Smart Grid Building Blocks



Evolution of the Grid

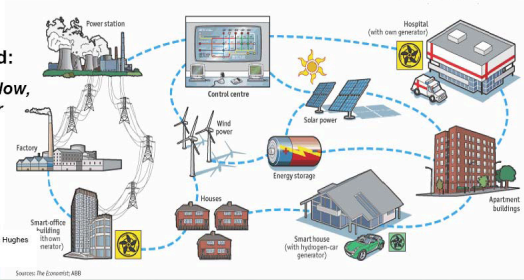
Before **Smart Grid:**

One-way power flow, simple interactions



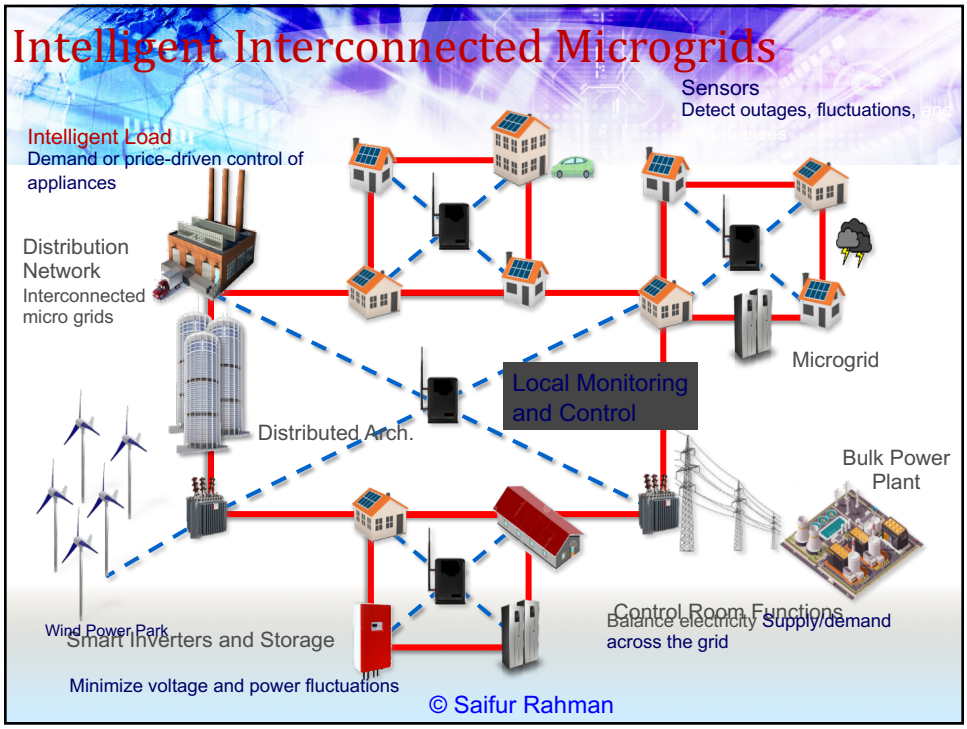
After **Smart Grid:**

Two-way power flow, multi-stakeholder interactions



Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

Source: Altalink, Alberta, Canada



Merging Power Flow with Information Flow:

Integrated Communications

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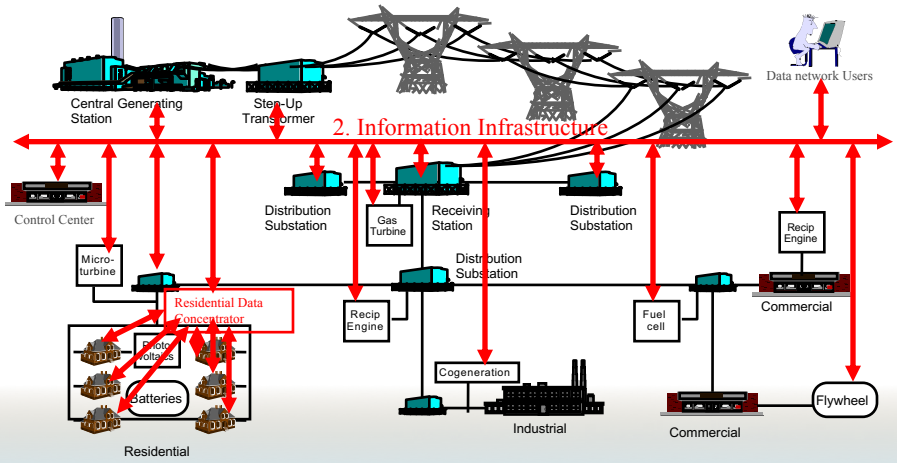
Electric Power & Communication Infrastructures

1.Power Infrastructure



Source: EPRI

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Changing Landscape for the Electric Utility

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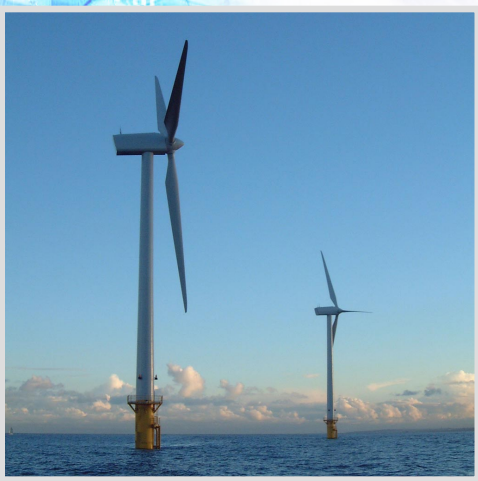
Issues with Distributed Generation

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



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

Wind Energy

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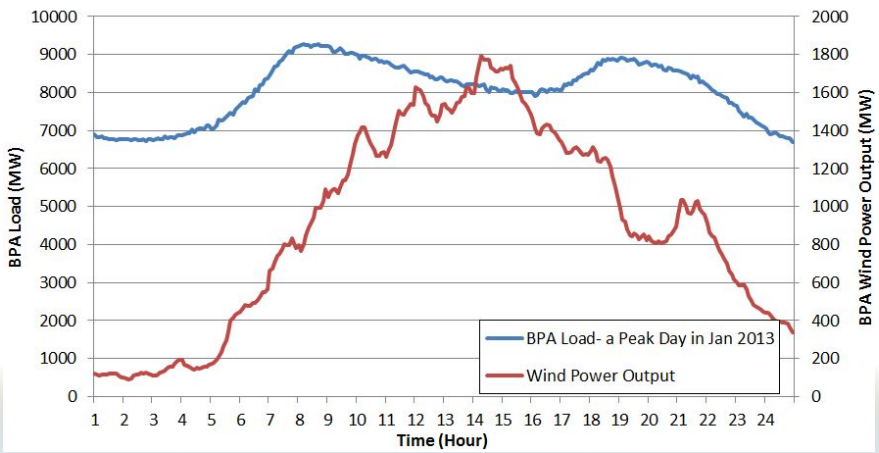
BPA Wind Output and Load Mismatch (January 2013)



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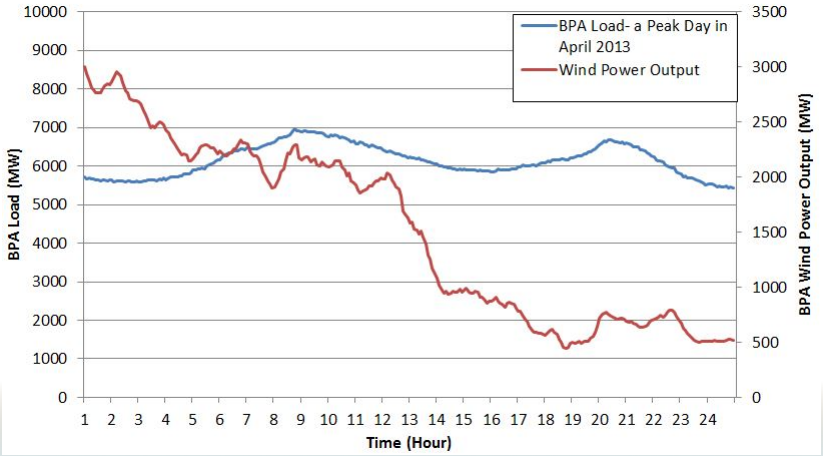
BPA Wind Output and Load Mismatch (April 2013)



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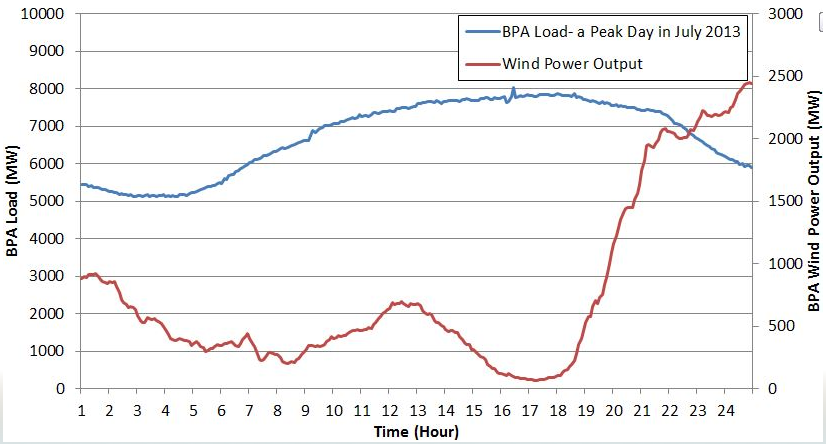
BPA Wind Output and Load Mismatch (July 2013)



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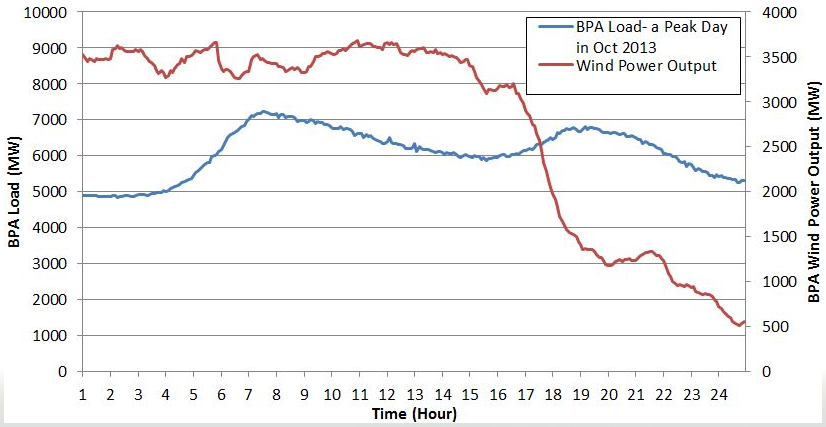
BPA Wind Output and Load Mismatch (Oct 2013)



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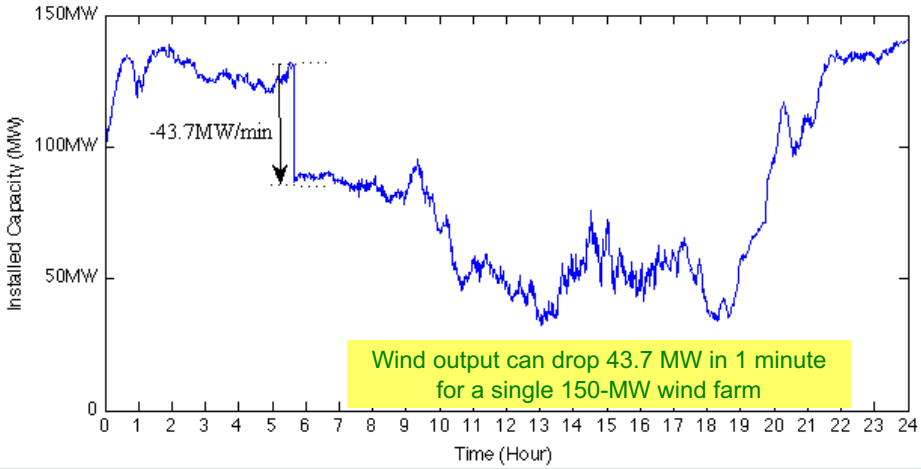
1-minute Variation of a 150MW Wind Farm Output in Texas, 2008



Source: NREL

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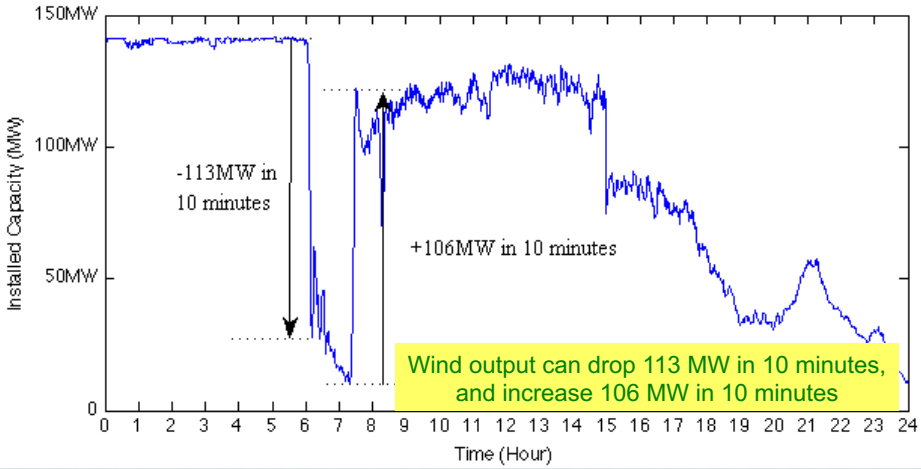
10-min Variation of a 150MW Wind Farm Output in Texas, 2008



Source: NREL

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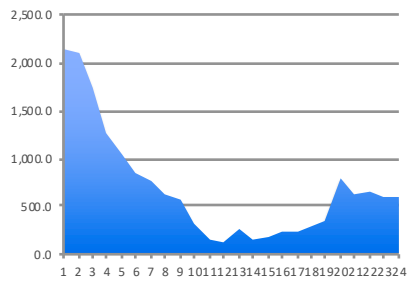
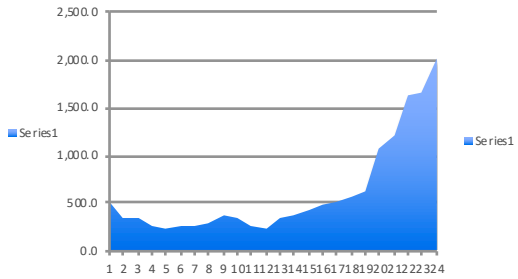
Hourly wind power variation (MW) in Texas, USA (01 and 02 Jan 2008)



01 Jan 2008



02 Jan 2008

Installed Capacity 4,541 MW

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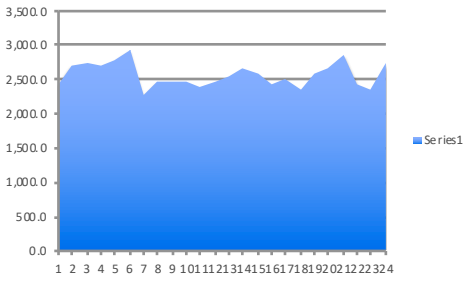
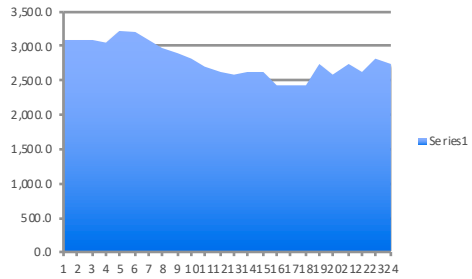
Hourly wind power variation (MW) in Texas, USA (03 and 04 Jan 2008)



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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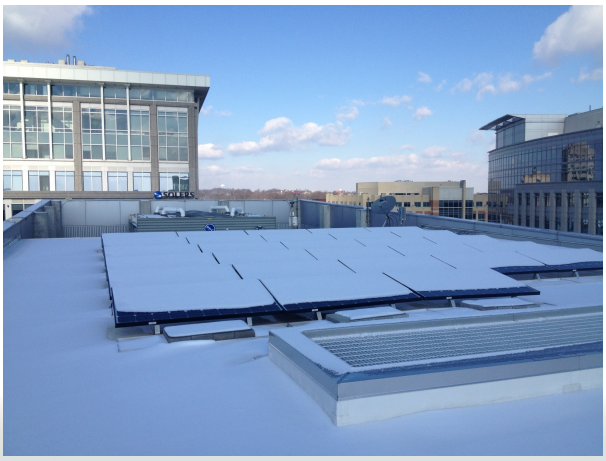
Solar Panels in Winter



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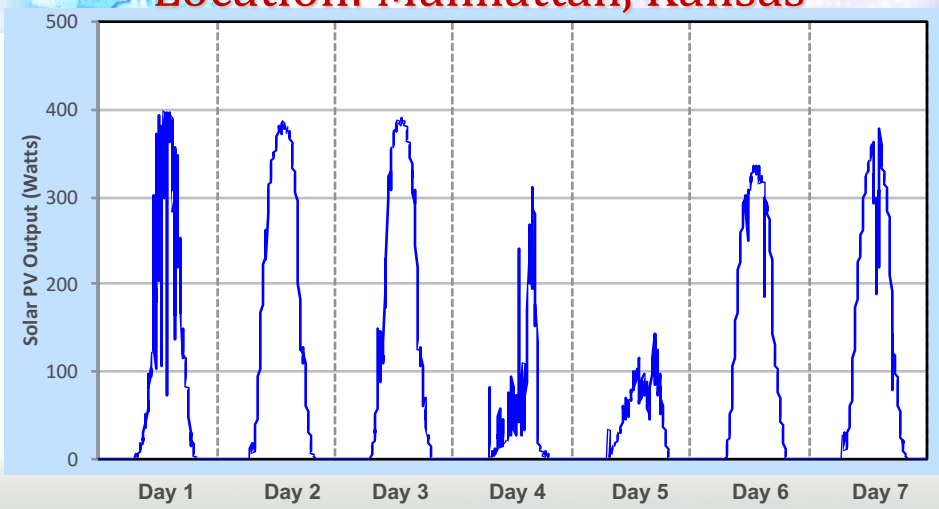
7-Day Solar PV Output
Location: Manhattan, Kansas



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Can the Intermittency be Absorbed by the Network?

Storage?

- Batteries
- Pumped storage hydro
- Compressed air energy storage (CAES)

Demand Response?

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Demand Response

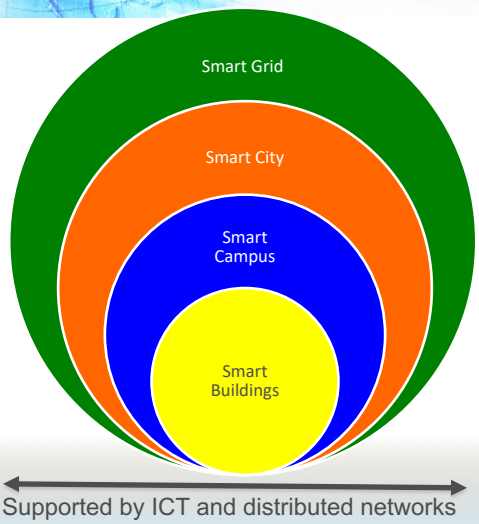
"Demand Response is a customer action to control load to meet a certain target. Here the customer chooses what load to control and for how long".

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

- Historical: Demand driven supply
- New Reality: Demand needs to be supply-driven

From Smart Buildings to Smart Grid



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…

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What Makes a City Smart

- There is no single consensus definition of a smart city, but there is some agreement that a smart city is one in which information and communication technology (ICT) facilitates improved insight into and control over the various systems that affect the lives of residents.

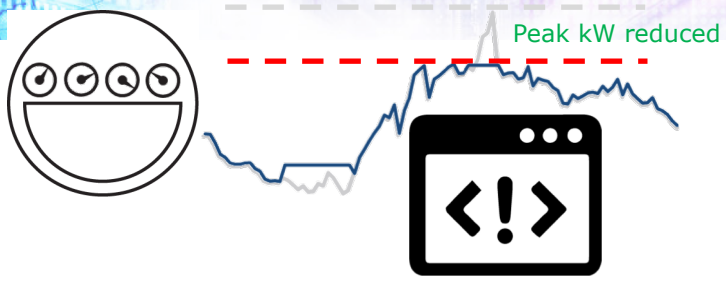
Picture from: http://politic365.com/2017/09/01/smart-cities-require-smart-planning-policy-to-benefit-communities/

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.

Peak Load Reduction



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Cumulative Benefits of Building Load Control

- A large number of buildings can be controlled to absorb large fluctuations of supply in the short term.
- No new storage is required
- Only investment is for monitoring and control

Thank you for your attention

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