An Introduction to Intelligent Grids for Distributed Generation and Demand Management

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What is a Smart Grid

- Is it intelligent? Is it self-healing?
- Is it at the transmission level or at the distribution level?
- Is it at all a grid? Or it is a collection of sensors and data collection devices?
- At the transmission level today's grid is efficient, smart, intelligent, etc.
- At the distribution level and at the customer level, there are opportunities for automation, intelligent appliances, advanced data collection networks, etc.
- The Smart Grid makes it possible to integrate large scale intermittent generation through demand response.

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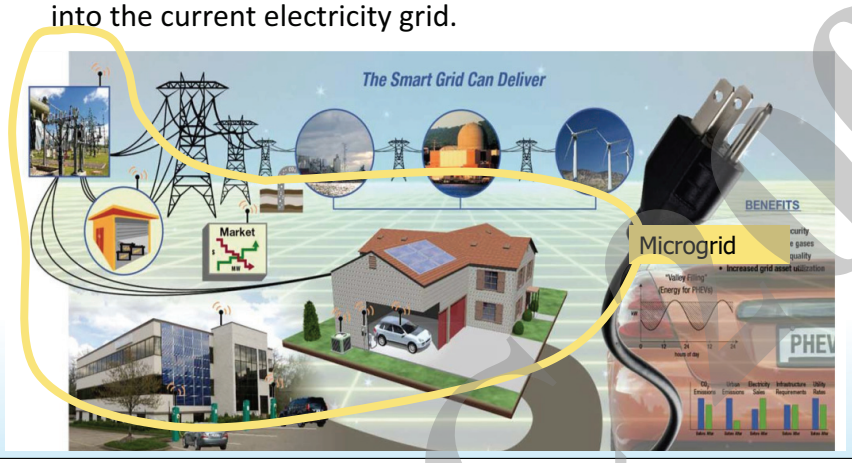
Smart Grid Definition

- According to United States DOE's modern grid initiative, an intelligent or a smart grid integrates advanced sensing technologies, control methods and integrated communications into the current electricity grid.



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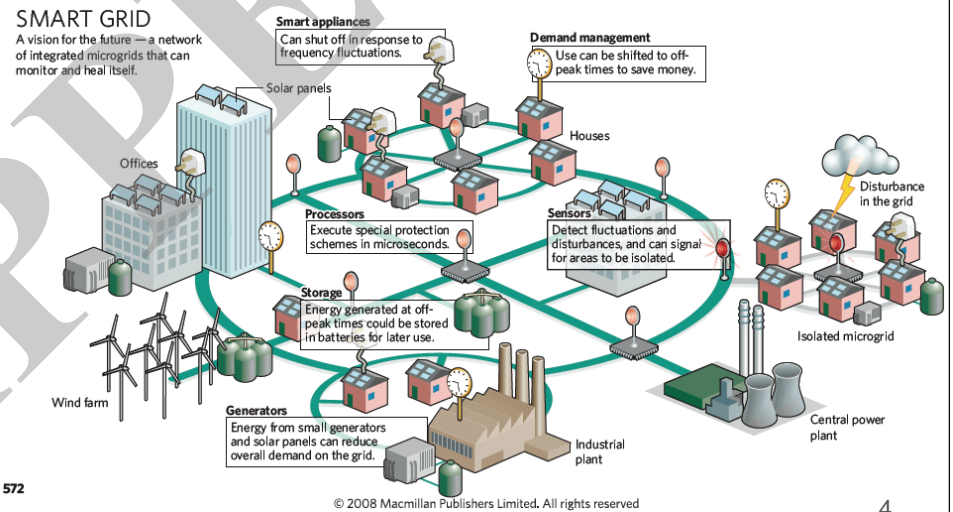
Intelligent Power Delivery Systems



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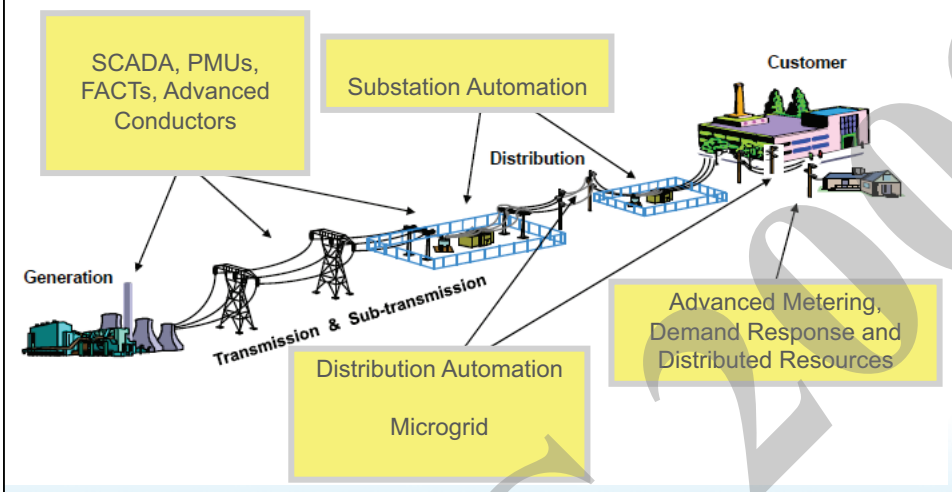
Source: "Upgrading the Grid", *Nature*, vol 454, pp. 570-573, July 2008

Components of the Smart Grid



Source: Michael Montoya, Southern California Edison, Smart Grid Strategy & Development

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1. Integrated Communications

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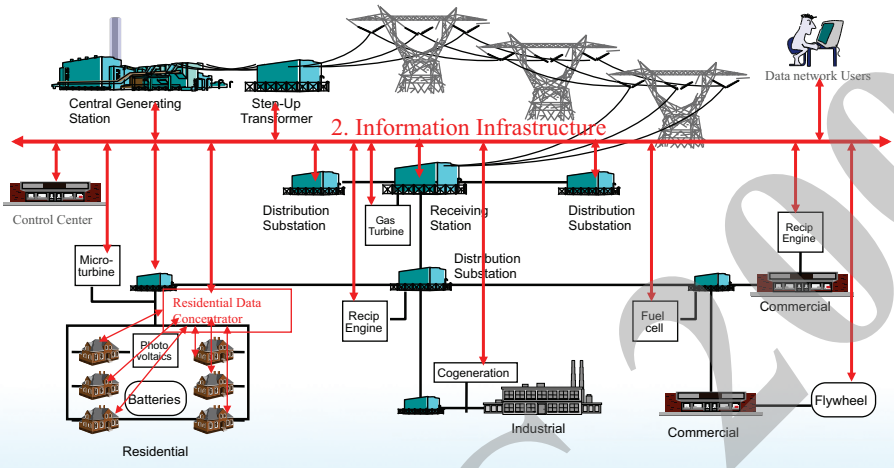
Electric Power & Communication Infrastructures

1.Power Infrastructure



Source: EPRI

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2. Elements at the Customer Level

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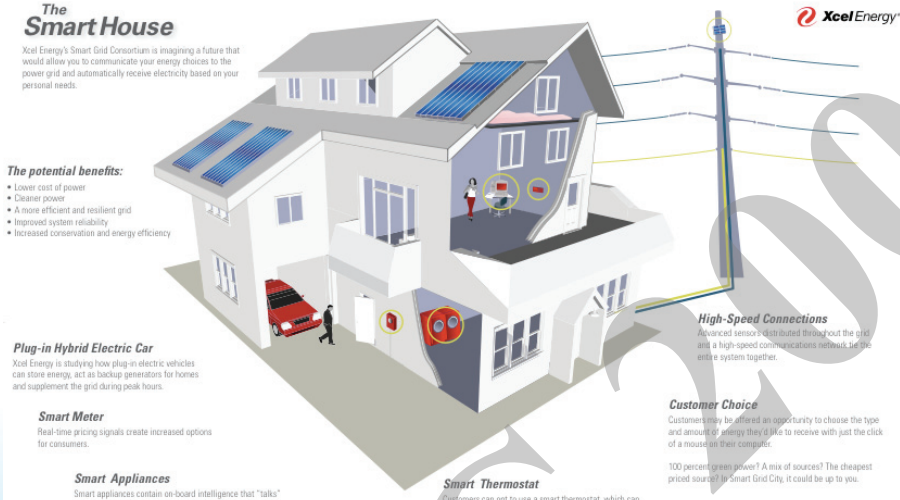
A Conceptual Smart House



Customer Gateways

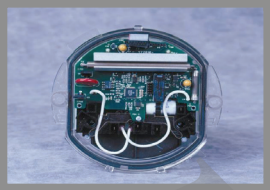
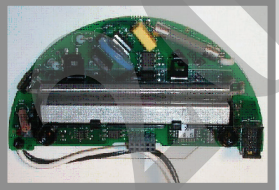
This "energy joule" displays weather forecast, current temperature and current electricity cost.

http://www.ambientdevices.com/products/energyjoule.html

Tendril home display & web access

http://www.tendrilinc.com/consumers/products/vantage/

Metering Technologies

Traditional Meters	Automatic Meter Reading (AMR)	Advanced Meter Infrastructure (AMI)
		
		
Electromechanical	Hybrid (Electromechanical + Electronic)	Hybrid or Solid State

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Customer-Focused Applications for AMI and Customer Gateway

- Pricing:
  - Choices of dynamic pricing, facilitating demand response.
- Outage handling:
  - Automatic response and restoration verification
- Load controls:
  - Customers monitor energy use and determine load control strategies in response to price signals
- Usage information:
  - Real-time meter reading
  - Web data access
  - Hourly, daily or monthly data for customer education

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3.Renewable Resources as Distributed Generation

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Solar Photovoltaics

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Solar Photovoltaics

Roof-mounted Solar panels, Virginia Tech

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Grid-connected Photovoltaics, New York City

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Photovoltaics for Railway Signaling in Tibet

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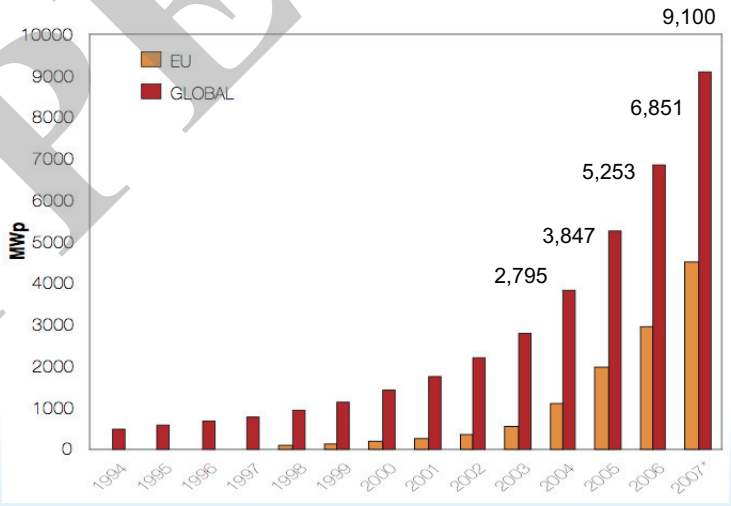
Global Installed Solar Photovoltaics



Source: EPIA, 2008

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Wind Turbines

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Wind Turbines

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Wind Farm in Hawaii

Source: NREL

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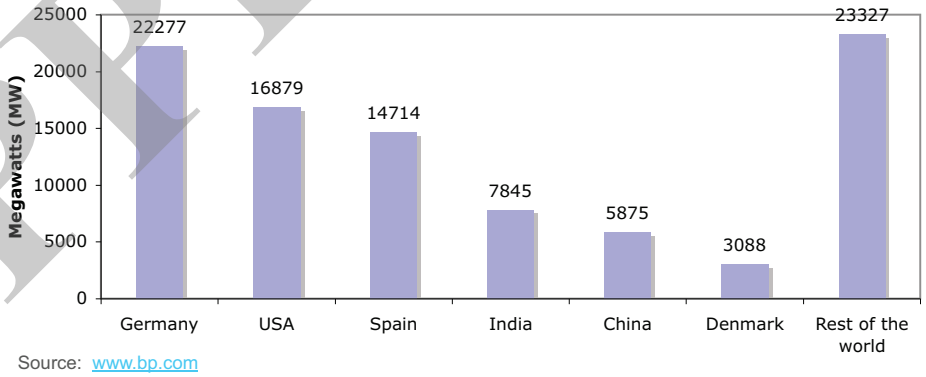
Worldwide Cumulative Installed Wind Turbine Capacity (End of 2007)



Source: www.bp.com

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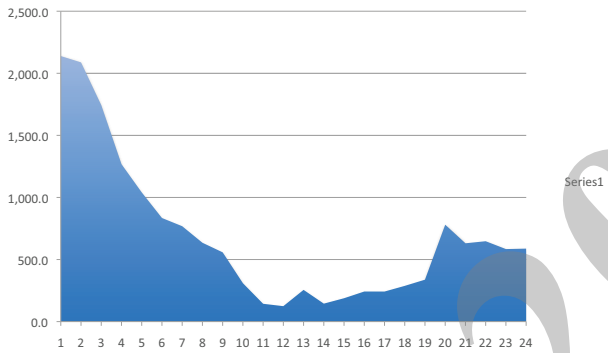
Hourly wind power variation (MW) in Texas, USA



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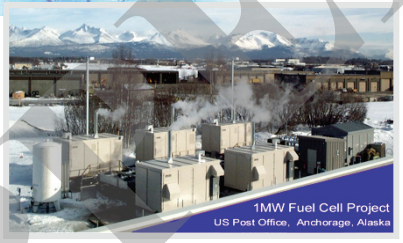
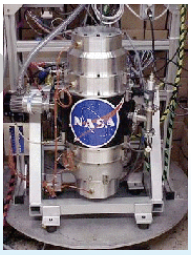
4. Back-up and Storage Options





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Plug-in Hybrid as a Storage Option

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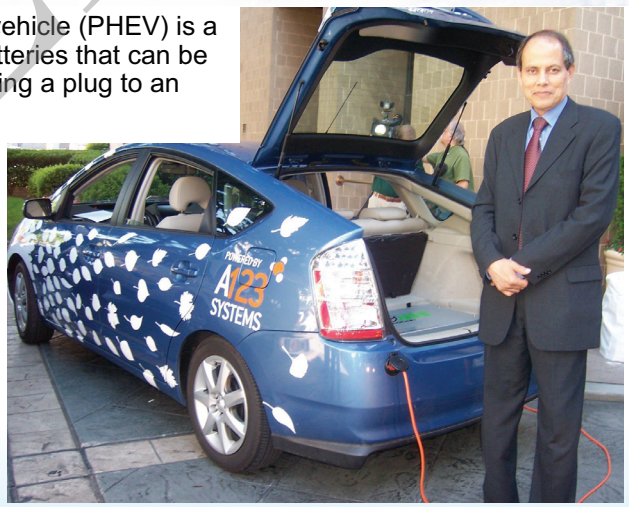
Plug-in Hybrid Electric Vehicle (PHEV)

A plug-in hybrid electric vehicle (PHEV) is a hybrid vehicle with batteries that can be recharged by connecting a plug to an electricity outlet.



20-40 kWhr of Storge Available

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4. Cost and Value of Storage Options

Price ranges from
US $2,000 to $4,000 per kilowatt

Return on investment depends
on life and usage

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Impact of Distributed Generation on the Grid

Large Variations in power outputs cannot be optimally handled by storage and back-up generation alone.

Short term load control for a large number of end-use devices will make it possible to get quick load relief to match fluctuations in generation.

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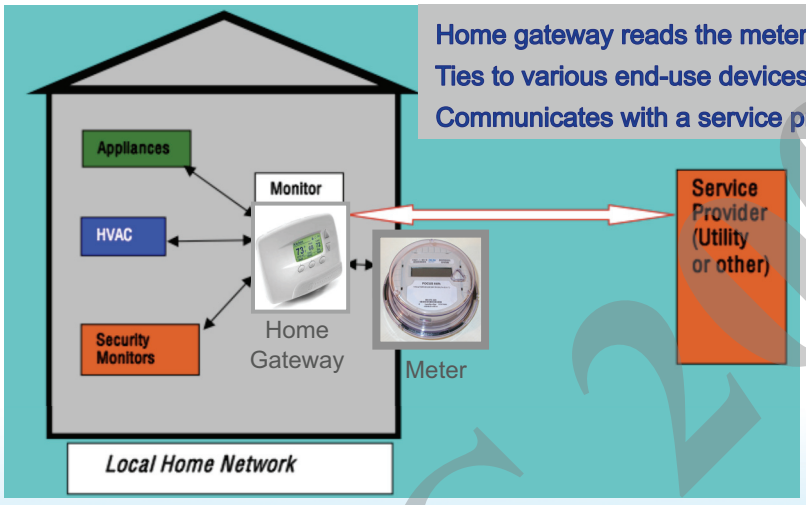
Load Control at Residential Customer Level



Source: NETL

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Demand Response

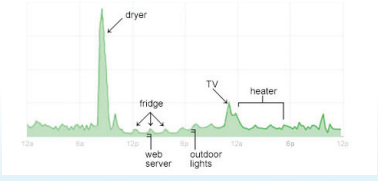
Demand response refers to mechanisms to manage the customer demands in response to supply conditions.

- Shed loads in response to a utility request
- Shed loads in response to market prices
- On-site generation to reduce the demand

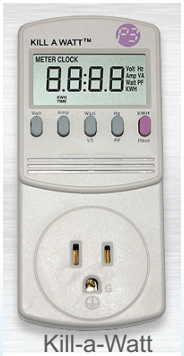
Energy usage monitoring tools:

Google POWERMETER

Home Electricity Use



http://www.google.org/powermeter/



Kill-a-Watt

http://www.p3international.com/products/special/P4400/P4400-CE.html

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Grid-Friendly Appliance (GFA) Controller

- GFA is a controller that senses grid conditions by monitoring frequency.
- If a disturbance is detected, the GFA controller will respond by shedding load.
- Example:
  - A GFA-enabled dryer would turn off the heating element but the tumbler would keep turning, resulting in 80-90% load reduction.
  - Appliances are typically turned off for 1-2 minutes

Source: GridWise

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Utility's Water Heater Controls

- Water heaters can be controlled in a utility load control strategy.
- Water heaters can be turned off when load peaks.
- Water heaters can be turned off for 30 minutes at a time without customer dissatisfaction.

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Summary

- Smart grid makes distributed generation more practical through demand management
- Enabling technologies
  - Integrated communications
  - Sensing and measurement
  - Advanced components
  - Advanced control methods
  - Improved interfaces and decision support
  - Time of Use (ToU) rates

Thank you for Your Attention

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