The Design, Development & Use of the Smart Grid

Invited Talk

Beijing Jiao Tong University, China

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PPT slides will be available at
www.srahman.org

What is the Smart Grid ?

This is the Electric Power Grid

Source: www.sxc.hu

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.

Difference Between a Normal Grid And a Smart Grid

Normal Phone

Smart Phone

Beginning and End of Smart Grid

From Generator to Refrigerator

Power Plant

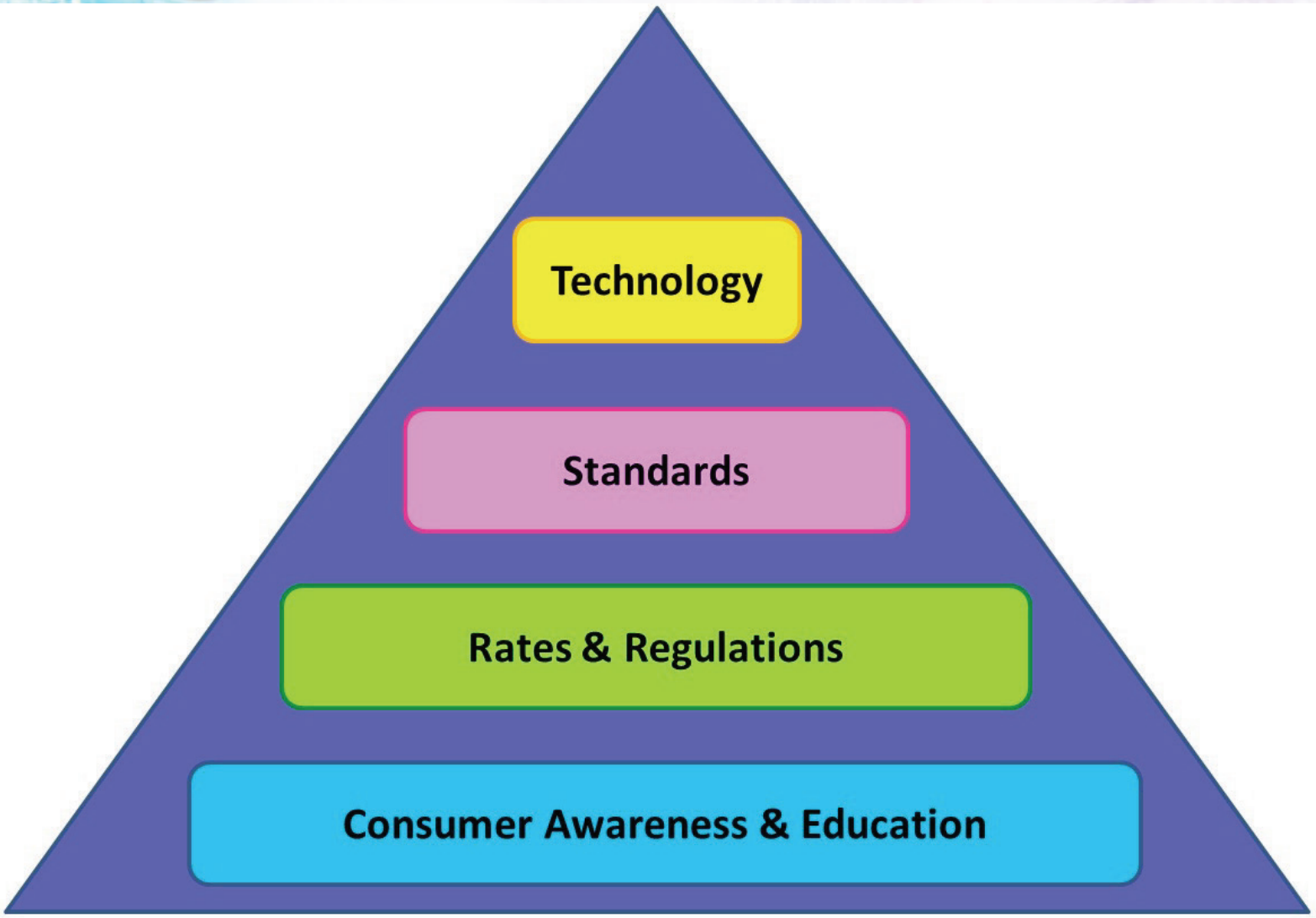
Transmission

Distribution

Home Business

End-use Appliances

Building Blocks of a Smart Grid



What Makes it Smart?

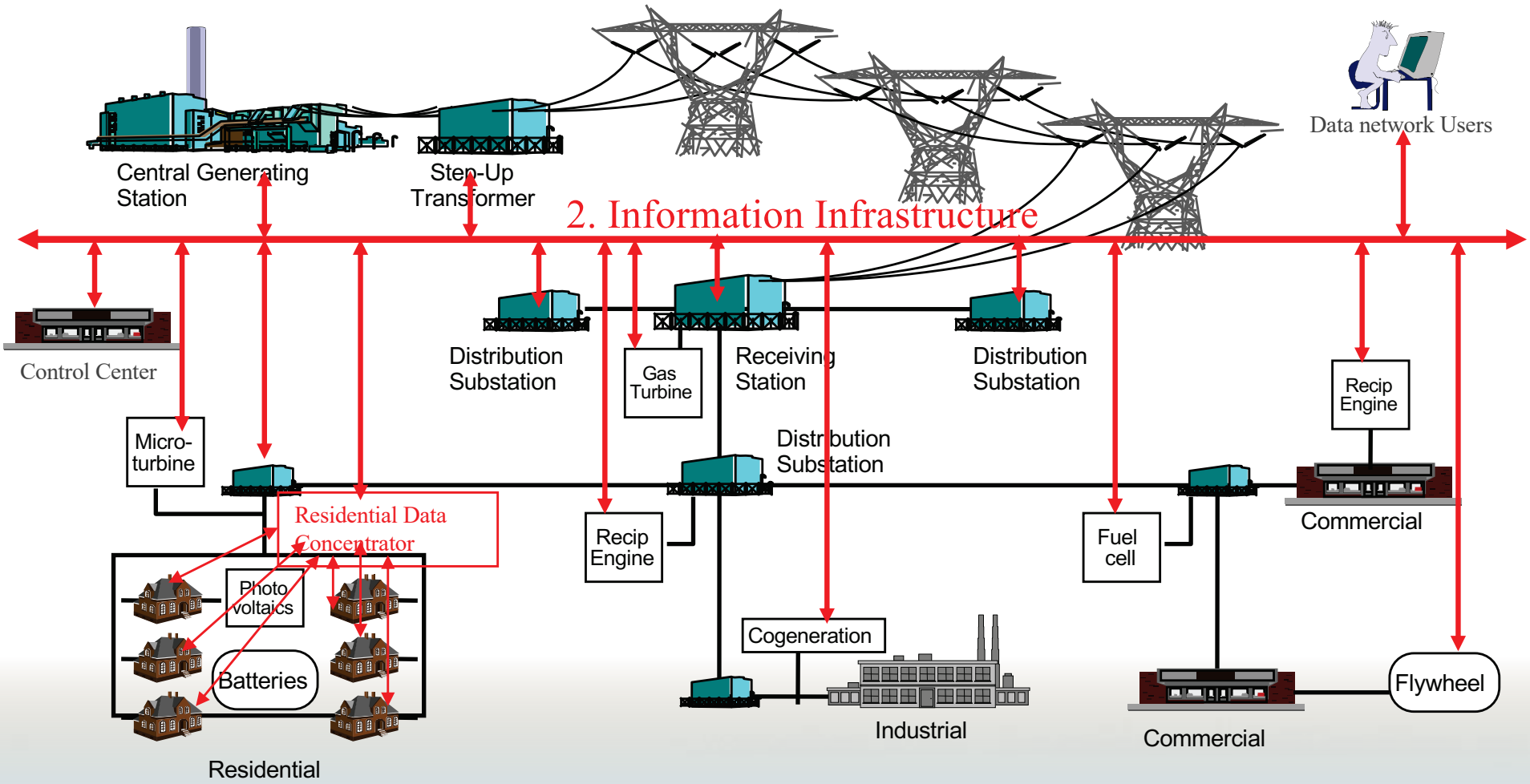
Intelligence
Two-way communication
Real-time monitoring & control

Merging Power Flow with Information Flow

Integrated Communications

Electric Power & Communication Infrastructures

1.Power Infrastructure

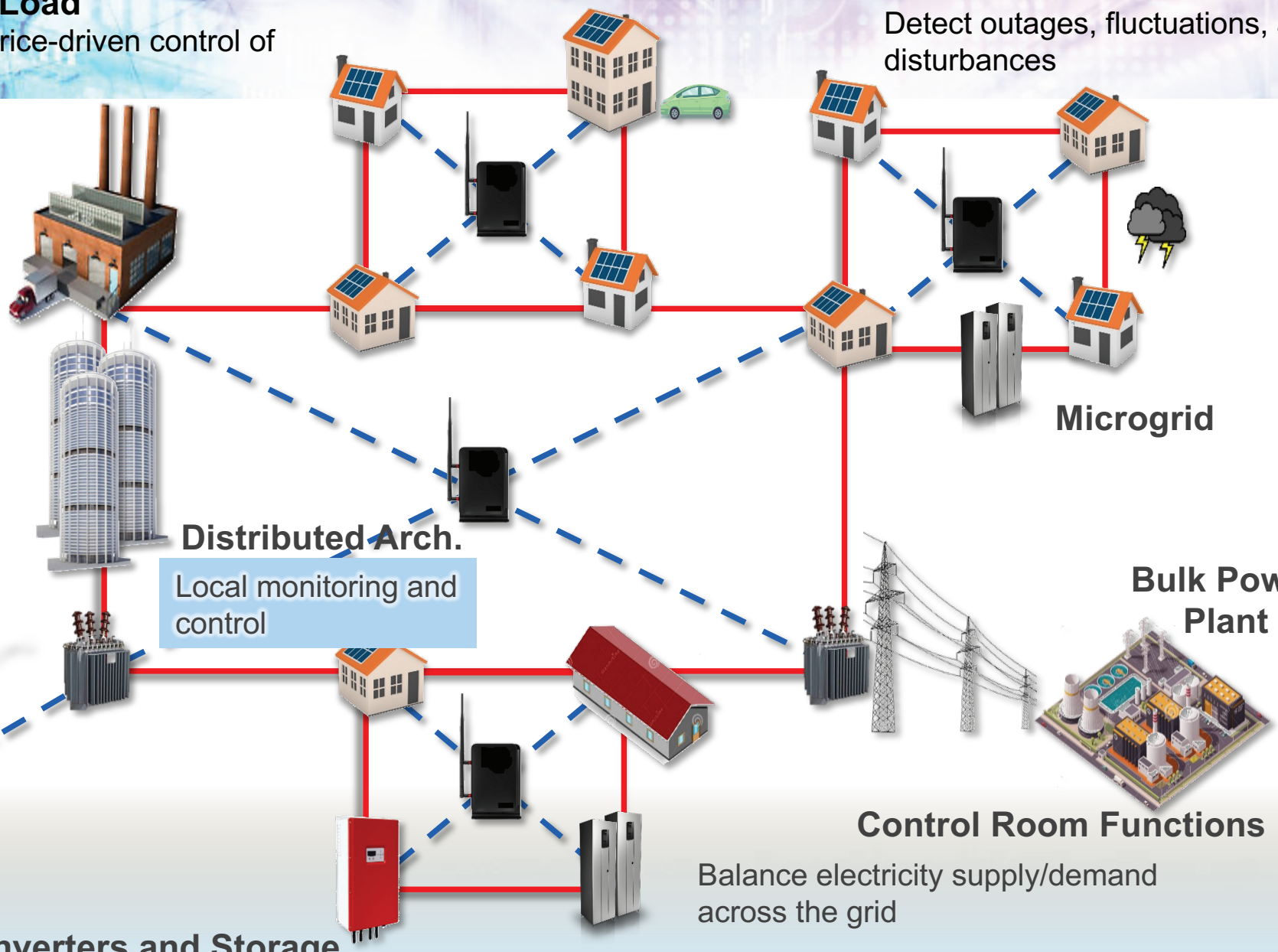


Source: EPRI

Interconnected Intelligent Microgrids

Intelligent Load
Demand or price-driven control of appliances

Sensors
Detect outages, fluctuations, and disturbances



Distribution Network
Interconnected micro grids

Microgrid

Distributed Arch.
Local monitoring and control

Bulk Power Plant

Wind Power Park

Control Room Functions
Balance electricity supply/demand across the grid

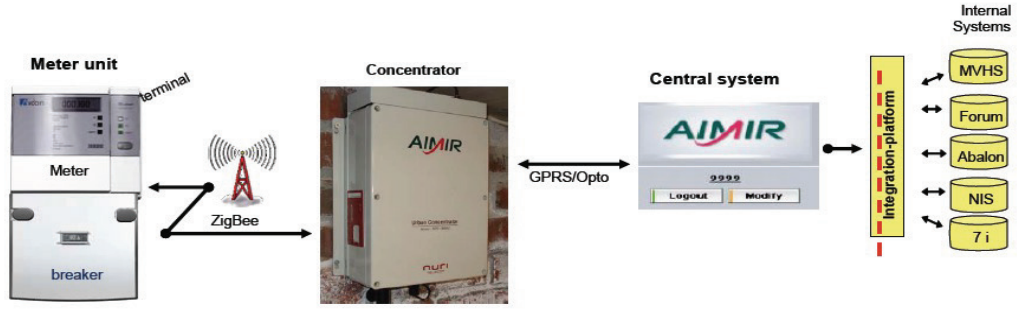
Smart Inverters and Storage
Minimize voltage and power fluctuations

Beginning of the Smart Grid

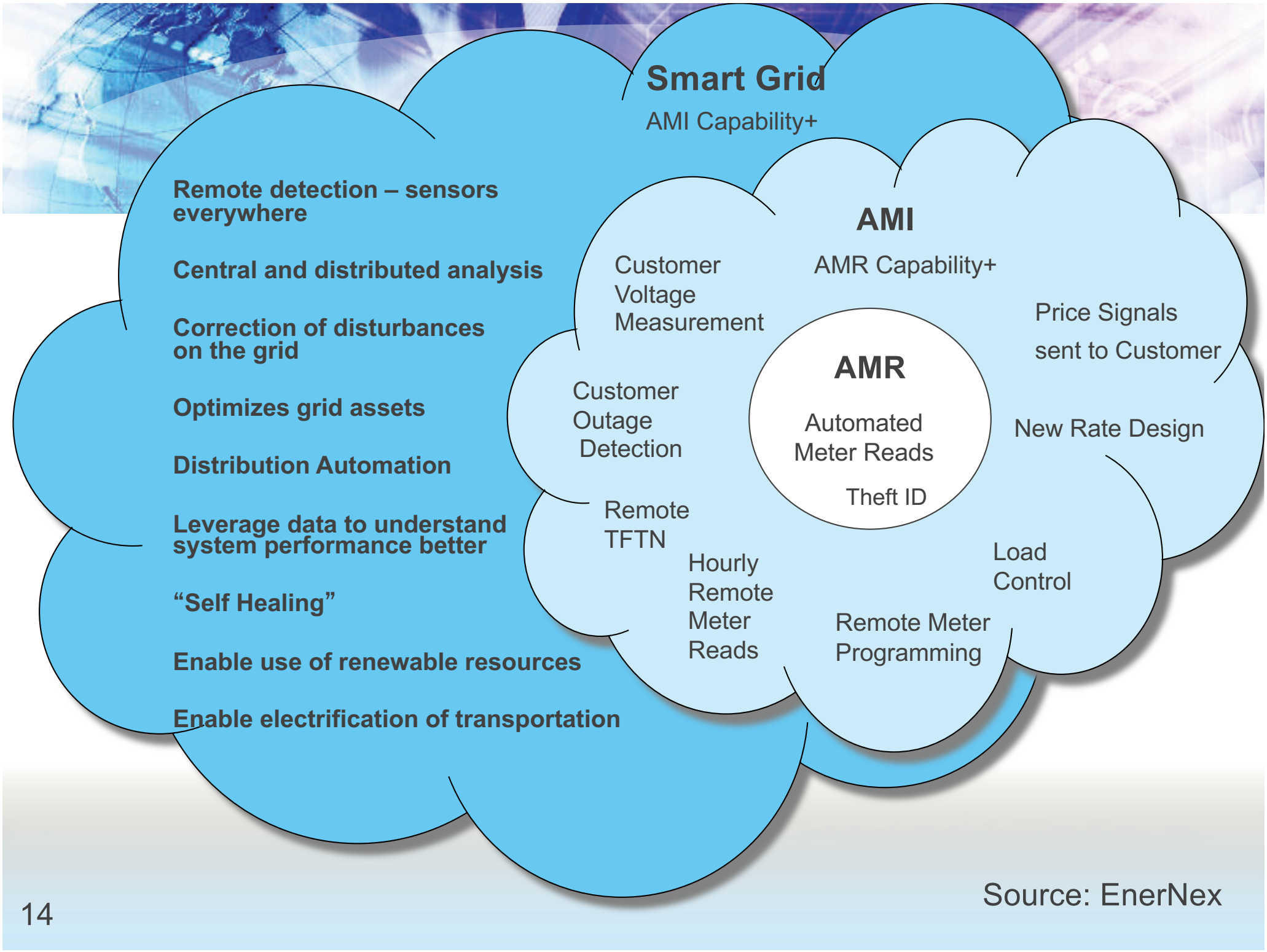
- Smart meter is just the beginning of a smart grid

The Flow of Metering Data

- Two-way communication allows customer participation



Göteborg Energi



Source: EnerNex

Issues in Smart Grid Deployment

- Regulatory
- Business
- Technical
- Security and Privacy

Regulatory Issues

- Time varying rates
- Who pays the upfront costs
- Customer desire for information

Business Issues

- Return on investment
- Customer acceptance
- Trained manpower

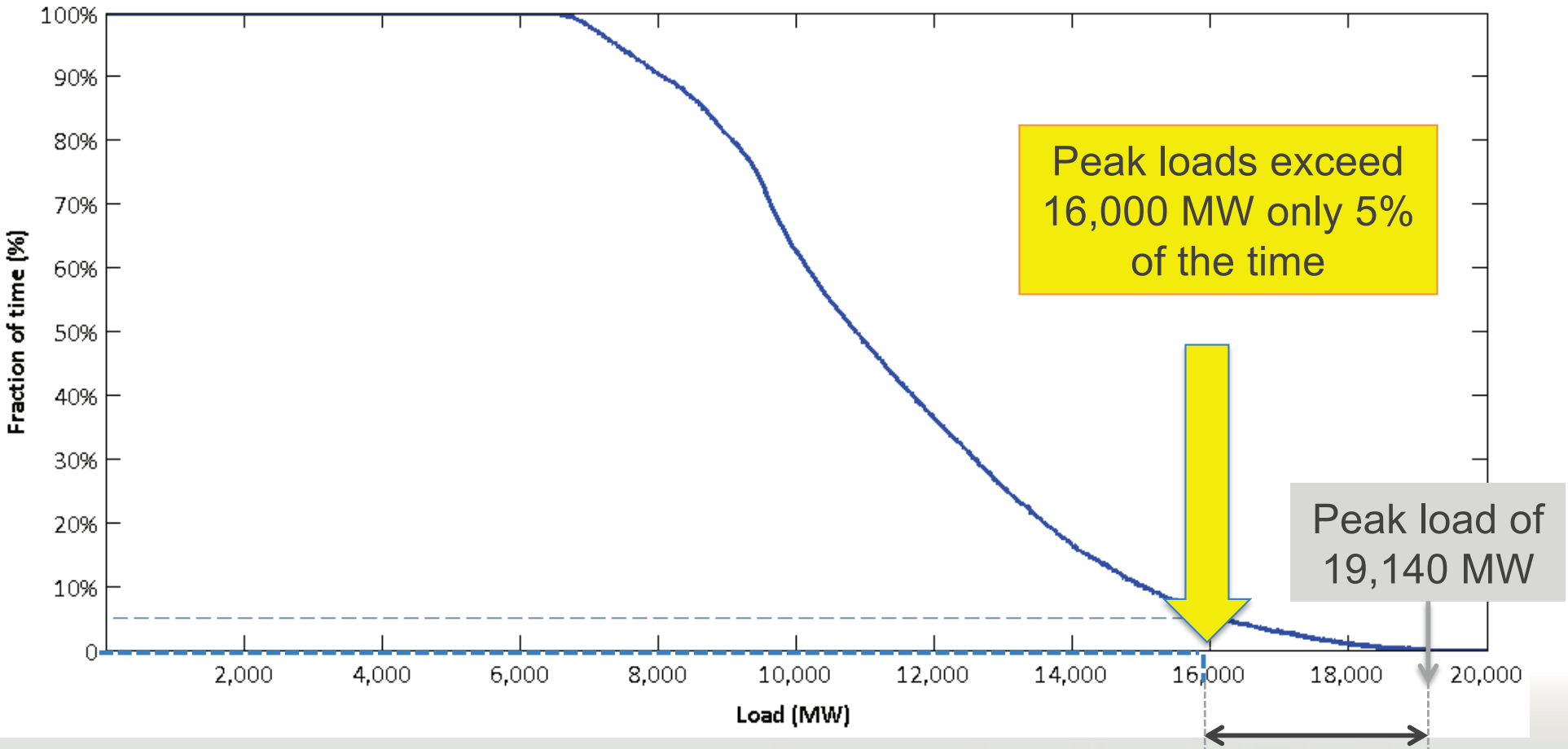
Technical Issues

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

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 Management



Peak Load Management Opportunities

- In the US 15% 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

The presence of smart meters allow conservation voltage reduction (CVR)

Smart meters can be equipped with WiFi capability to address thermostats, water heater controllers, etc.

Security & Privacy Issues

- Secure the communication between the customer meter and utility data center
- Points of vulnerability
  - Smart meter, communication between the meter and data collection point, utility data storage
- Who owns the data?
- What can the utility do with the data?

Changing Landscape of the Electric Utility & the Smart Grid

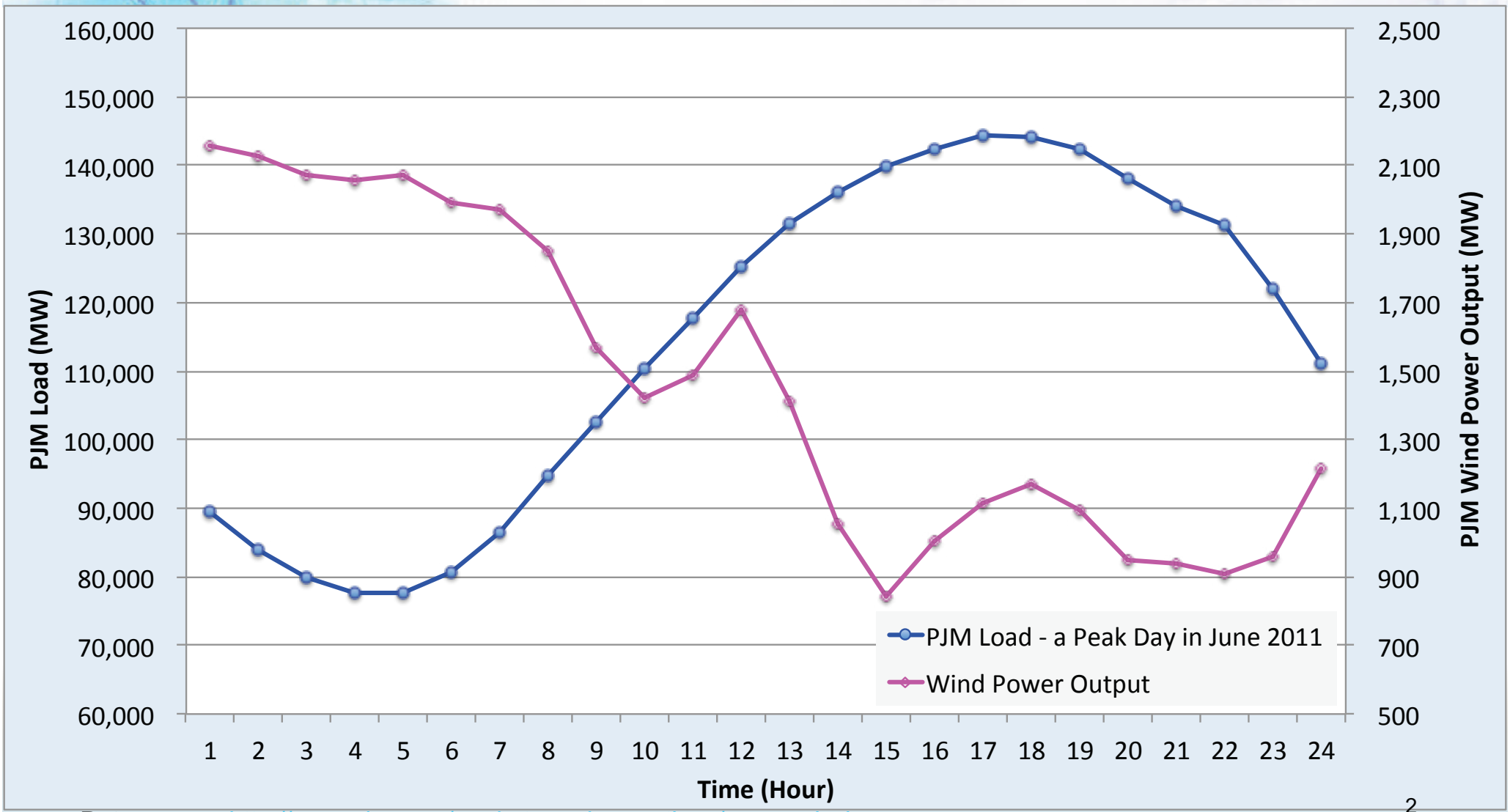
Issues with Distributed Generation

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

Wind Energy

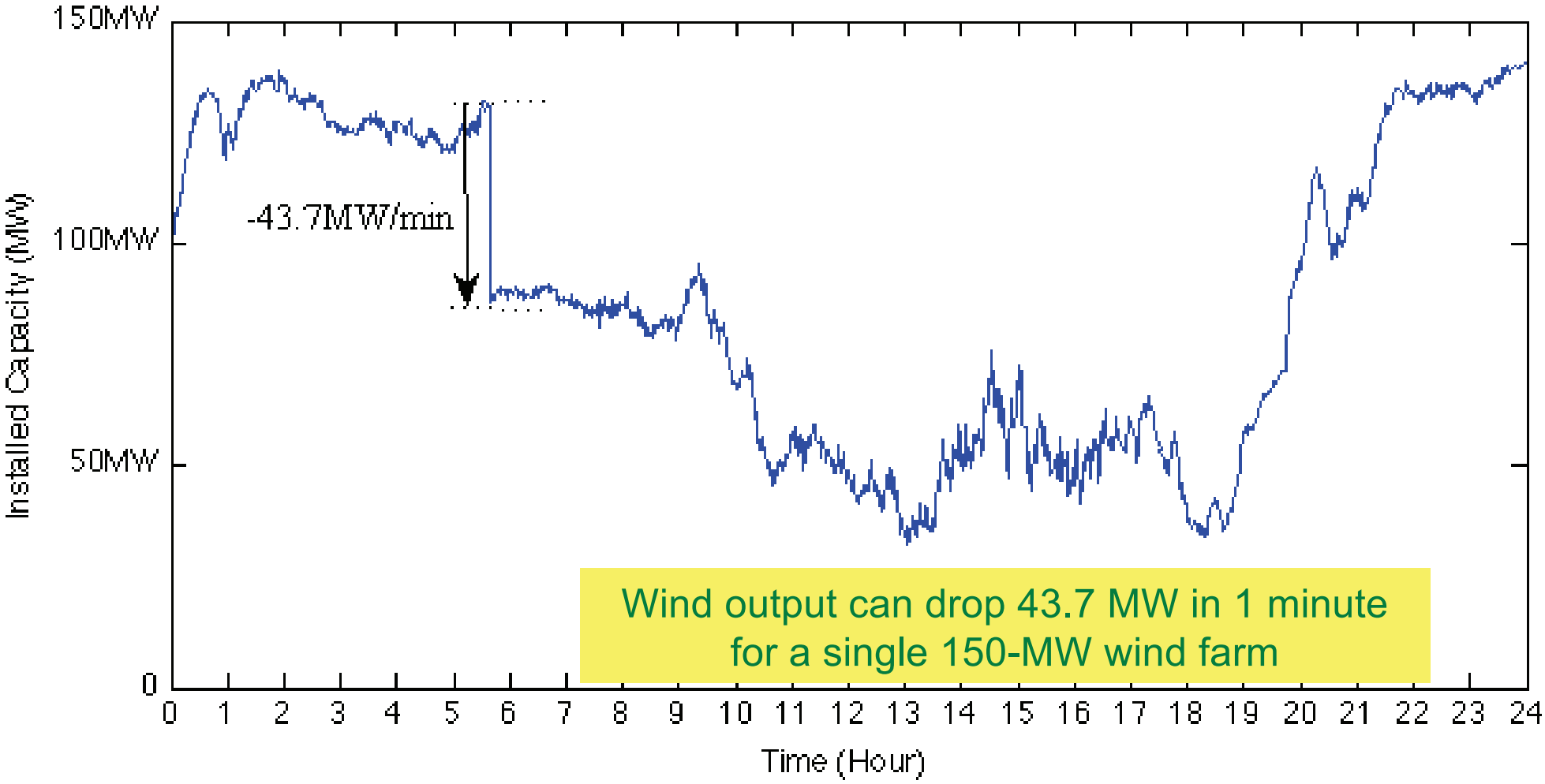
Wind Output & Load Mismatch (PJM)

(A peak day in June)



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

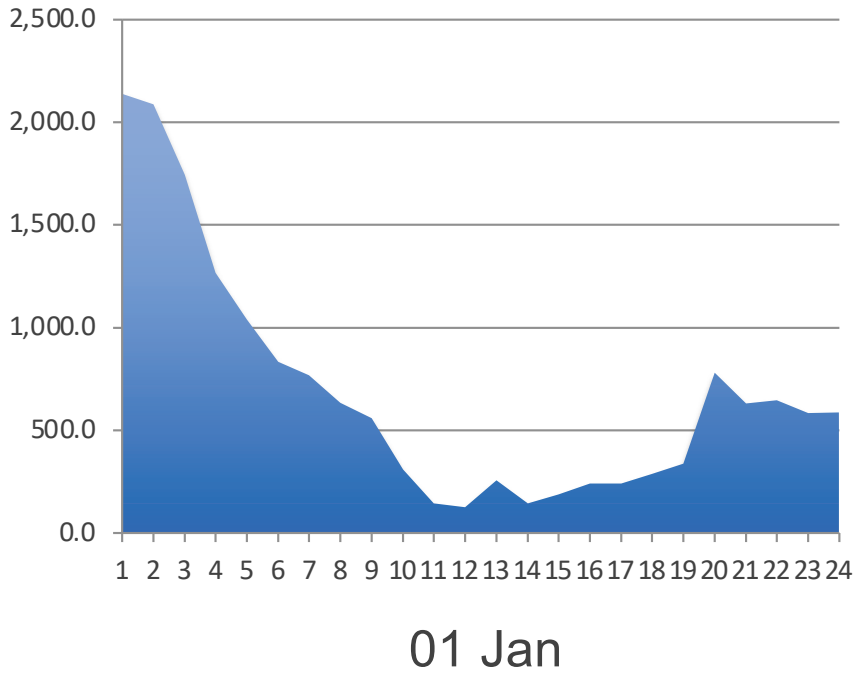
1-minute wind power variation at a150-MW Farm in Texas, USA

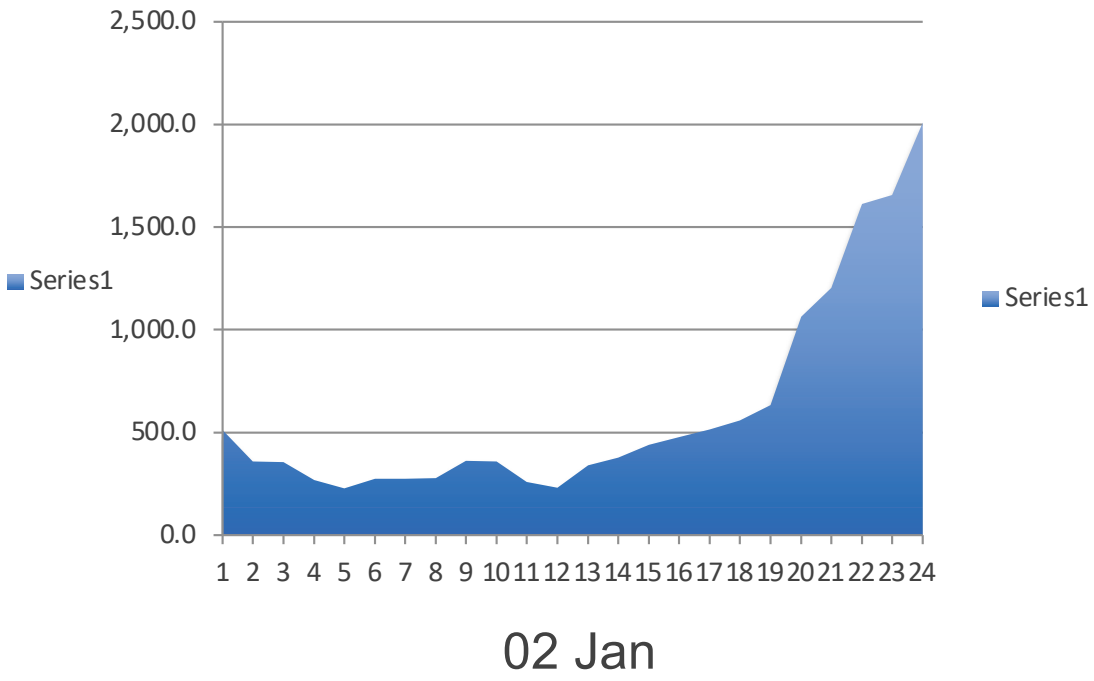


Wind output can drop 43.7 MW in 1 minute for a single 150-MW wind farm

Source: NREL

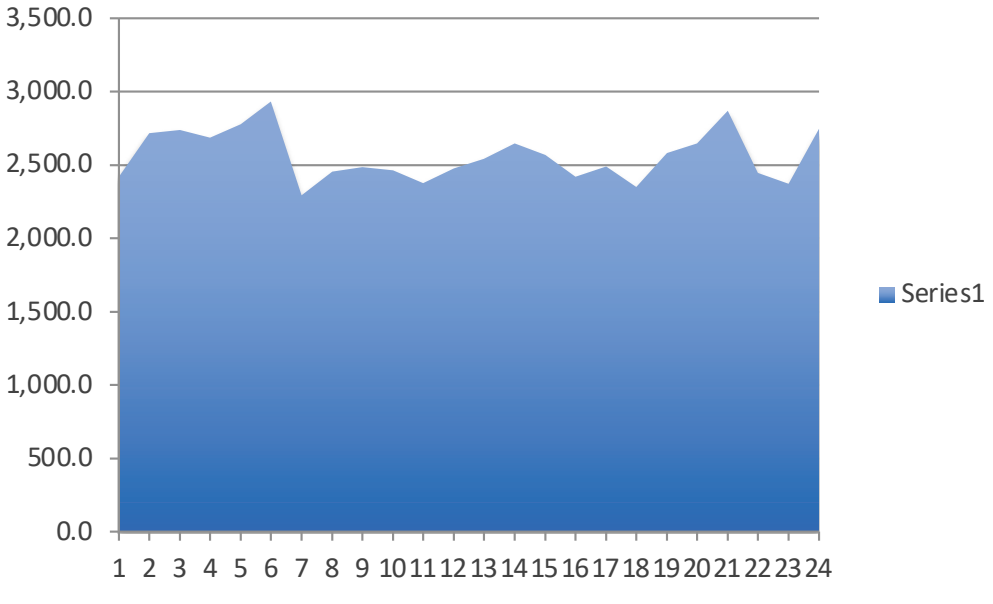
Hourly wind power variation (MW) in Texas, USA





Installed Capacity 4,541 MW

Hourly wind power variation (MW) in Texas, USA



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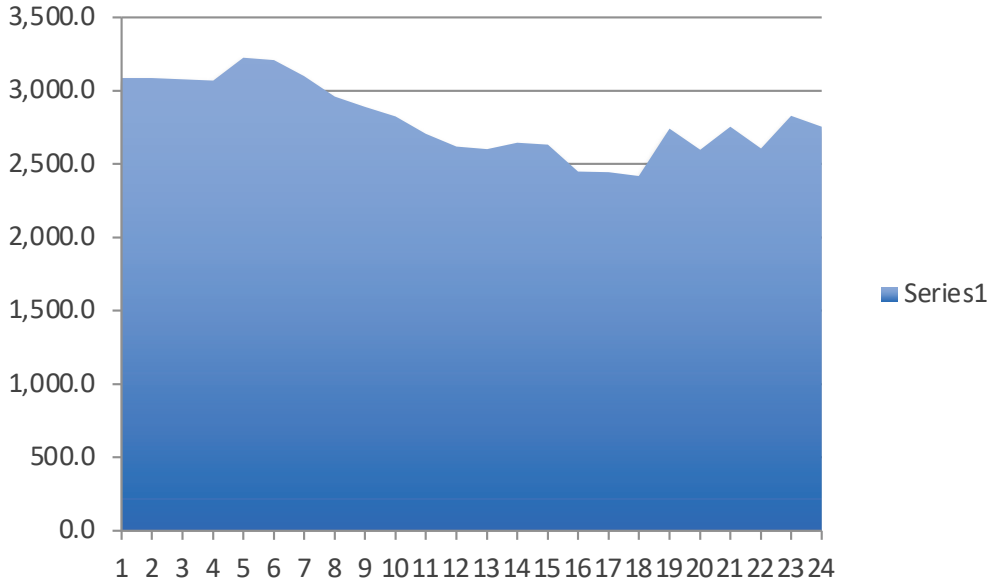
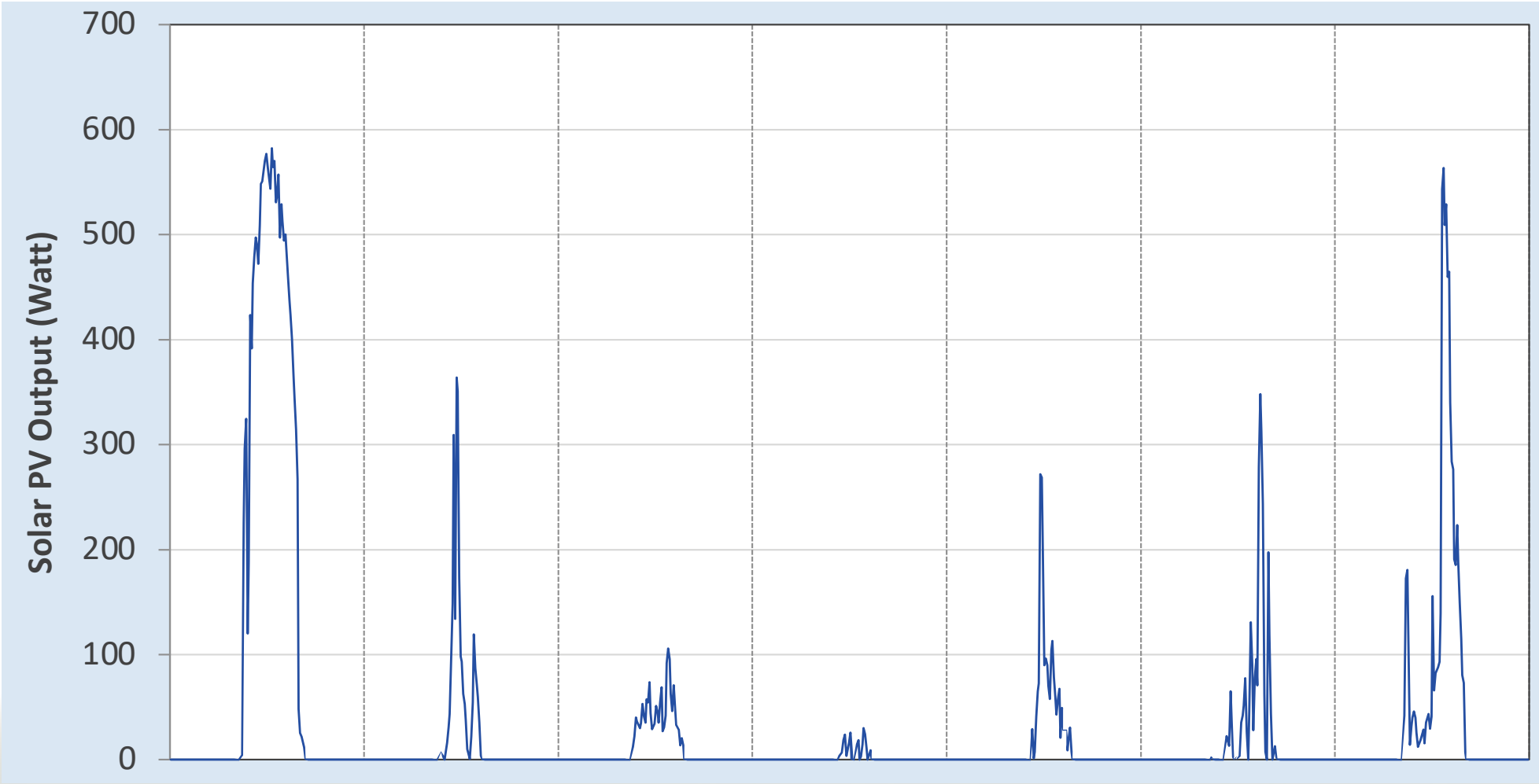


04 Jan

Installed Capacity 4,541 MW

Roof-top Solar Photovoltaics in Virginia

7-Day Solar PV Output in Virginia



How Can the Smart Grid Help?

Smart grid can provide a balance between the variable supply, demand and storage.

Short term load control for a large number of end-use devices through demand response makes it possible to get quick load relief to partially match fluctuations in generation.

Demand Response

Demand Response is a customer action to control load in response to signals that could be price driven or triggered by system reliability concerns. Here the customer can choose 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, but the customer has no control beyond the initial consent. Water heater control, A/C control, etc.

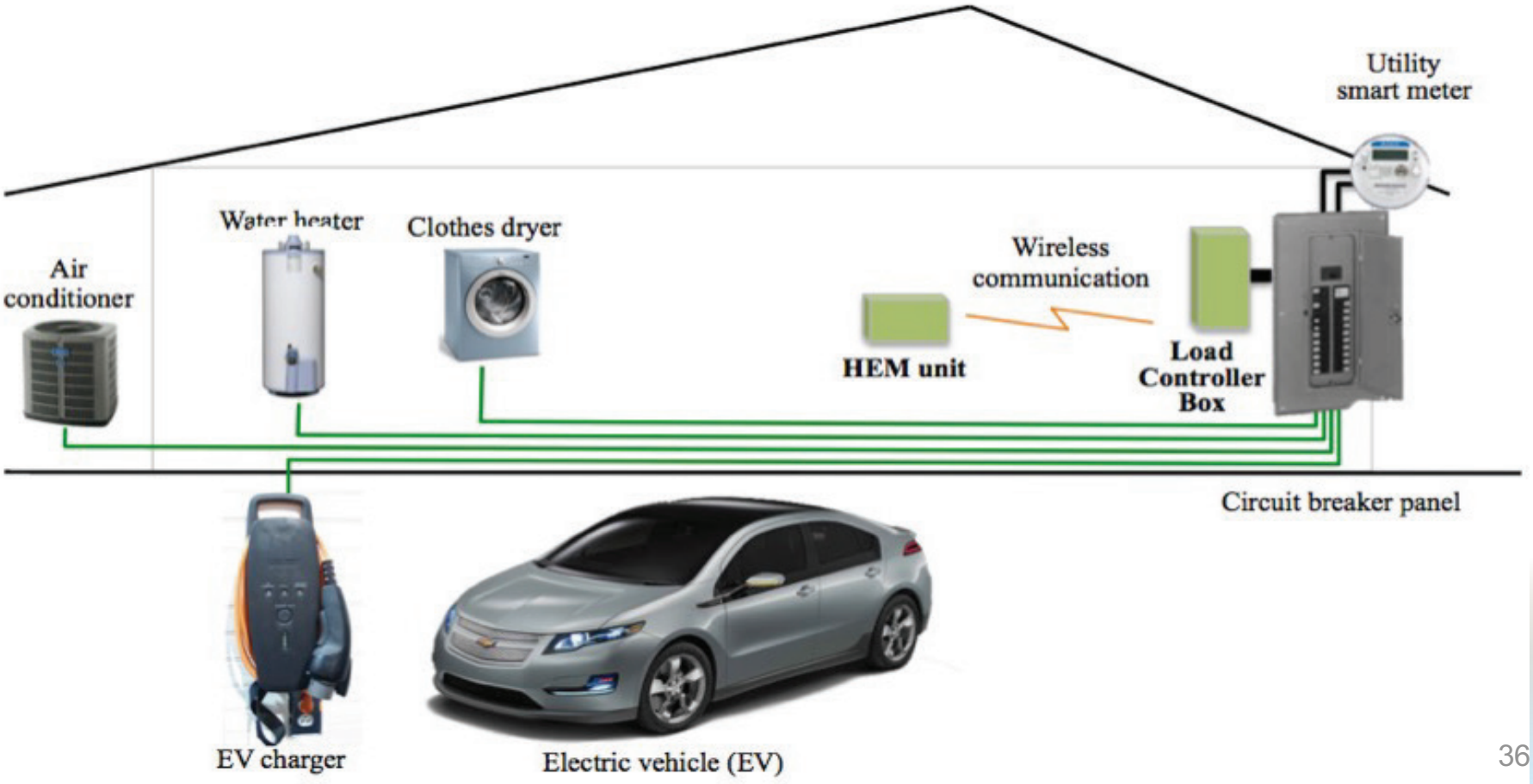
Demand Response Application

A Customer-facing 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.

Customer Load Control

1) HEM unit and 2) load controller box



Thank you

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