Role of the Smart Grid in Facilitating the Integration of Renewables

Invited 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 the electricity delivery and use to be more efficient.
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

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Starting and End Points of a Smart Grid

From Generator to Refrigerator

Power Plant  Transmission  Distribution  Home Business  End-use Appliances
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

Source: Altalink, Alberta, Canada
Merging Power Flow with Information Flow:

Integrated Communications

Electric Power & Communication Infrastructures

1. Power Infrastructure

2. Information Infrastructure

Source: EPRI
Changing Landscape for the Electric Utility

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

BPA Wind Output and Load Mismatch
(A typical day in January)
BPA Wind Output and Load Mismatch
(A typical day in April)

BPA Wind Output and Load Mismatch
(A typical day in July)
BPA Wind Output and Load Mismatch (A typical day in October)

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

Source: NREL
Wind output can drop 113 MW in 10 minutes, and increase 106 MW in 10 minutes.

Source: NREL
Solar Panels in Winter

7-Day Solar PV Output

[Graph showing PVAC power output during one sunny week]
7-Day Solar PV Output (intermittent)

Daily PV Output

PV AC Power Output During One Sunny Day
Can the Intermittency be Absorbed by the Network?

Battery storage

Compressed Air Storage

Pumped Storage
New Paradigm for the Electric Power System

- Historically: Demand driven supply
  (supply responds to demand)
- New Reality: Supply driven demand
  (demand needs to adjust to meet fluctuating supply with help from storage)

THE SMART GRID ECOSYSTEM

The Smart Grid Ecosystem

**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…

Supported by ICT and distributed networks of intelligent sensors, data centers/clouds
Intelligent Load Demand or price-driven control of appliances

Sensors Detect outages, fluctuations, disturbances

Distributed Arch. Distribution Network Interconnected micro grids

Wind Power Park Smart Inverters and Storage
Minimize voltage and power fluctuations

Control Room Functions Balance electricity Supply/demand across the grid

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Thank You
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