Role of the Smart Grid in Facilitating the Integration of Renewables

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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.
Electric Power Grid

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

Technology

Standards

Rates & Regulations

Consumer Awareness & Education

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
Intelligent Interconnected Microgrids

- Intelligent Load: Demand or price-driven control of appliances
- Distribution Network: Interconnected microgrids
- Sensors: Detect outages, fluctuations, and disturbances
- Distributed Arch.
- Local Monitoring and Control
- Wind Power Park
- Smart Inverters and Storage: Minimize voltage and power fluctuations
- Bulk Power Plant: Control Room Functions
  - Balance electricity Supply/demand across the grid

Merging Power Flow with Information Flow:
Integrated Communications
Electric Power & Communication Infrastructures

1. Power Infrastructure
- Central Generating Station
- Step-Up Transformer
- Distribution Substation
- Recieving Station
- Distribution Substation
- Gas Turbine
- Recip Engine
- Fuel Cell
- Flywheel
- Micro Turbine
- Residential Data Concentrator
- Photovoltaics
- Batteries
- Residential

2. Information Infrastructure
- Control Center
- Data Network Users
- Commercial
- Industrial

Source: EPRI

Changing Landscape for the Electric Utility
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.
BPA Wind Output and Load Mismatch (January)

BPA Wind Output and Load Mismatch (April)
BPA Wind Output and Load Mismatch
(July)

BPA Wind Output and Load Mismatch
(Oct)
Wind output can drop 43.7 MW in 1 minute for a single 150-MW wind farm.

Wind output can drop 113 MW in 10 minutes, and increase 106 MW in 10 minutes.
Hourly wind power variation (MW) in Texas, USA (01 and 02 Jan)

Installed Capacity 4,541 MW

01 Jan 2008

02 Jan 2008

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

Installed Capacity 4,541 MW

03 Jan 2008

04 Jan 2008
Intermittency Caused by Weather Events

Sand Storm in Abu Dhabi

Solar PV Project in UAE

In-depth look at Solar PV in KSA

2-MW Roof-top Solar PV plant at KAUST
Solar PV Panels in Saudi Arabia

Reality Check

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Solar PV Array (100kWp) Riyadh Area

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Daily PV Output

PV AC Power Output During One Sunny Day

Virginia, USA

Daily PV Output (intermittent)

PV AC Power Output During One Cloudy Day

Virginia, USA
Can the Intermittency be Absorbed by the Network?

- Battery storage
- Compressed Air Storage
- Pumped Storage

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

New Paradigm for the 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

- **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.

What makes a Building Smart

A single platform for monitoring and control of HVAC, lighting, water supply, sensor networks, security camera & fire emergency.

Cumulative Benefits of Building Load Control

- A large number of buildings can be controlled to absorb large fluctuations of supply in the short term
- Minimal storage is required
- Investment is for monitoring and control

Thank You

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