Role of the Smart Grid in Facilitating the Integration of Renewables

Keynote Speech
IEEE Student Branch
Prince Mohammed Bin Fahd University
Saudi Arabia
25 October 2021

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IEEE President-elect 2022
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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

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 Load Demand or price-driven control of appliances

Distribution Network Interconnected micro grids

Sensors Detect outages, fluctuations,

Distributed Arch. Distribution Network Interconnected micro grids

Smart Inverters and Storage Minimize voltage and power fluctuations

Control Room Functions Balance electricity Supply/demand across the grid

Wind Power Park

Bulk Power Plant

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Merging Power Flow with Information Flow:

Integrated Communications
Electric Power & Communication Infrastructures

1. Power Infrastructure

- Central Generating Station
- Step-Up Transformer
- Distribution Substation
- Receiving Station
- Distribution Substation
- Distribution Substation
- Commercial
- Industrial
- Flywheel
- Fuel cell
- Recip Engine
- Gas Turbine
- Gas Engine
- Micro turbine
- Residential
- Residential Data Concentrator
- Residential Data
- Batteries
- Photo voltaics
- Control Center
- Data network Users

2. Information Infrastructure

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.
Roof-top Solar Photovoltaics in Virginia

Solar Panels in Winter
7-Day Solar PV Output

7-Day Solar PV Output (intermittent)
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
Solar PV Array (100kWp) Riyadh Area

- September
- July

Solar PV Panel Cleaning
Cost and Frequency
Can the Intermittency be Absorbed by the Network?

- Battery storage
- Compressed Air Storage
- Pumped Storage

Addressing the Intermittency in Renewable Generation

- Smart vs. not-so-smart load control
  (adjust temperature set points in an air conditioner or water heater vs. turning the unit off)
- Size the storage to take advantage of demand dynamics
- Control the renewable generation to avoid instability (output control from PV inverters)
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.

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
Thank You

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