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Engineering Education and Research in the Age of Smart Grid and the Evolving Power System
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

Motivation for a Smart Grid on the basis of the energy management triangle - political objectives and technical implementation.

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

https://en.wikipedia.org/wiki/Smart_grid
Evolution of the Grid

Smart 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

Central Generating Station → Step-Up Transformer → Distribution Substation → Receiving Station → Distribution Substation

Commercial → Industrial → Residential

Gas Turbine → Recip Engine → Cogeneration

Micro-turbine → Photo-volatics → Batteries

Residential Data Concentrator

Data network Users

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
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)
Solar Energy
Roof-top Solar Photovoltaics in Virginia
Solar Panels in Winter
Intermittency Caused by Weather Events

Solar PV Project in UAE

Sand Storm in Abu Dhabi
In-depth look at Solar PV in Saudi Arabia

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

Reality Check
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
Power System of the Future
Intelligent Interconnected Microgrids

Intelligent Load
Demand or price-driven control of appliances

Distribution Network
Interconnected micro grids

Distributed Arch.

Sensors
Detect outages, fluctuations, disturbances

Microgrid

Wind Power Park

Smart Inverters and Storage
Minimize voltage and power fluctuations

Bulk Power Plant

Local Monitoring and Control

Control Room Functions
Balance electricity Supply/demand across the grid

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Characteristics of the Power System

- Large
- Complex
- Changing Fuel Mix
- Faced with Climate Change
• Education for Students
• Education for Teachers
• Education for Working Engineers
• Availability of Educational Content
• Research in Academia
• Research in Industry/National Laboratories
• Dissemination of Research Results
IEEE TryEngineering

*Inspires the Engineers of Tomorrow*

IEEE launched in 2006 is a pre-university engineering education web portal with resources for **Educators and Students**. In January 2021, the volunteer section of the site, the IEEE **Volunteer STEM Portal**, was launched.

- **TryEngineering** aims to empower educators by enabling them to bring engineering and technology into their classrooms.

- The site provides teachers, students, and IEEE volunteers with pre-university resources to help engage and inspire the next generation of STEM professionals.
Thank You

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