

Prof. Saifur Rahman

2022 IEEE President-elect

Director, Virginia Tech Advanced
Research Inst., USA



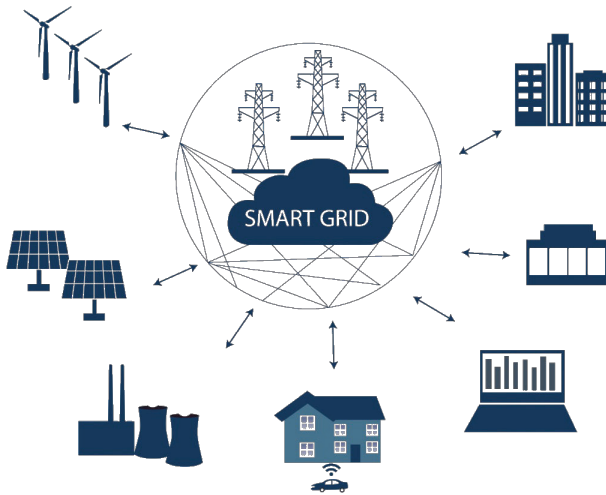
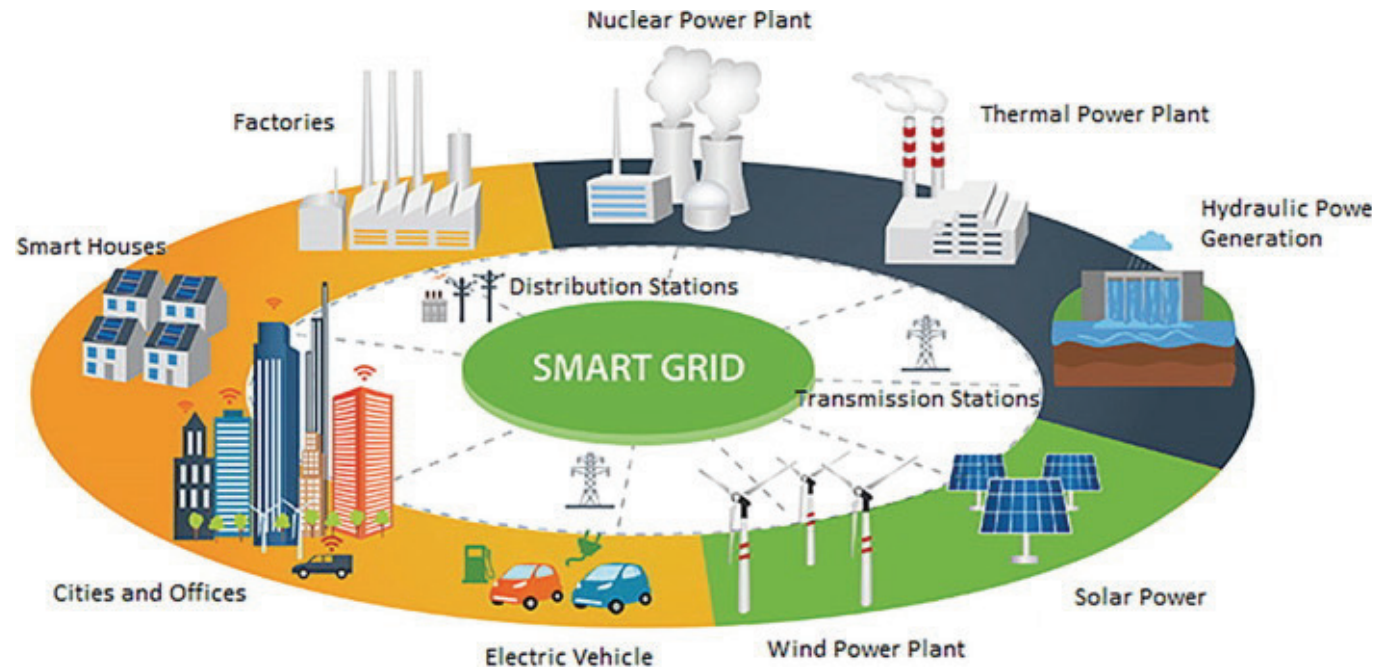
Engineering Education and Research in the Age of Smart Grid and the Evolving Power System



3rd International Forum on Engineering Education
Beijing, China, 08 December 2022



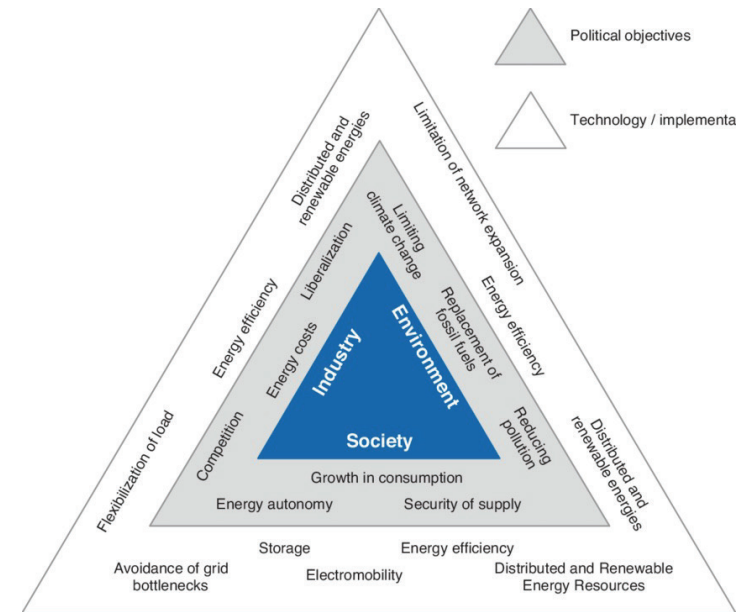
What is a Smart Grid



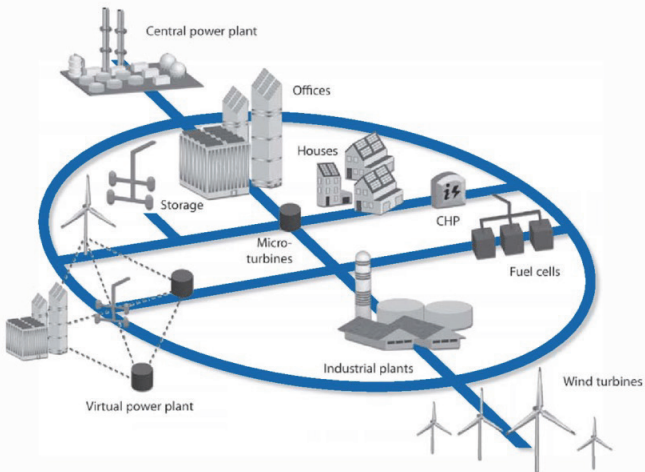
"**Smart grid**" is a concept with many elements where monitoring and control of each element in the chain of **generation, transmission, distribution and end-use** allow the electricity delivery and use to be more efficient.

Motivation for a Smart Grid

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



https://www.researchgate.net/figure/Motivation-for-a-Smart-Grid-on-the-basis-of-the-energy-management-triangle-political_fig1_263264024



Desire to make the grid smarter, safer, reliable and more cost-effective using advanced sensors, communication technologies and distributed computing.

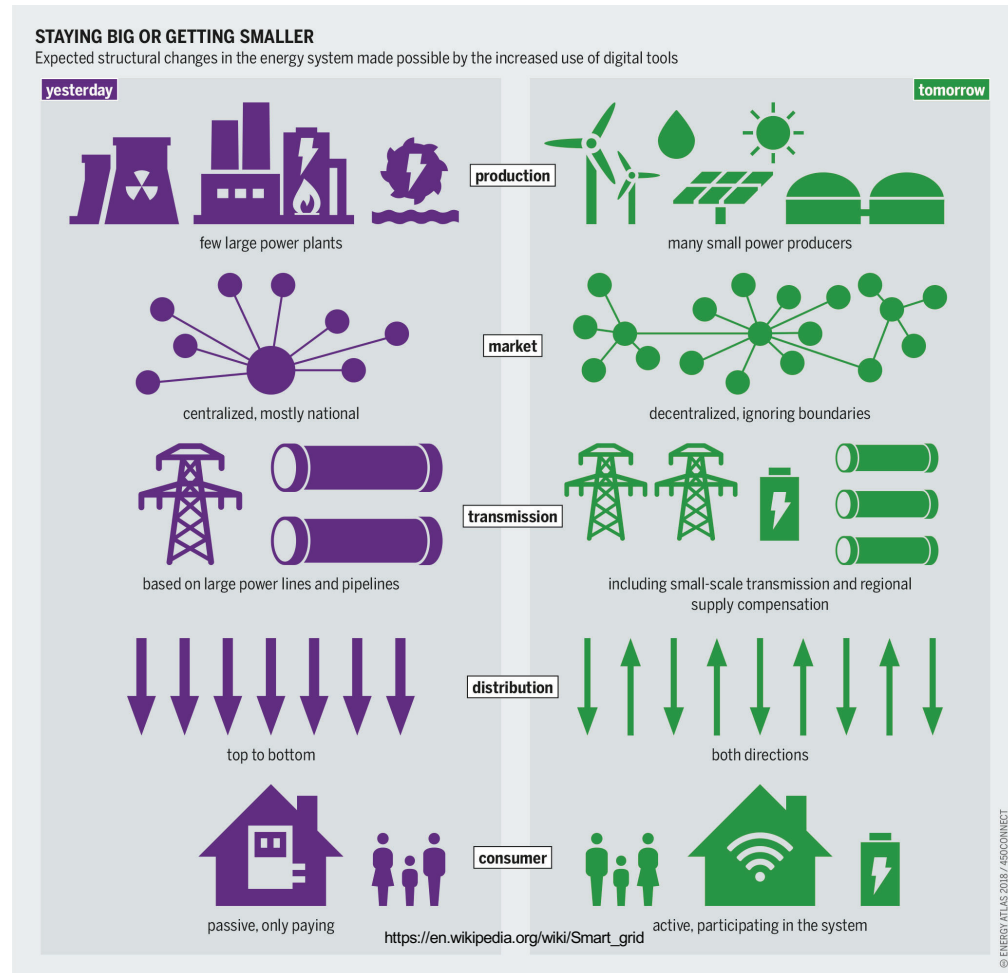
Difference Between a Normal Grid And a Smart Grid



Normal Phone



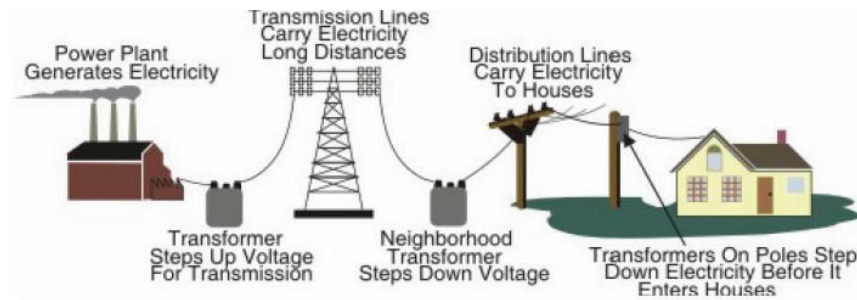
Smart Phone



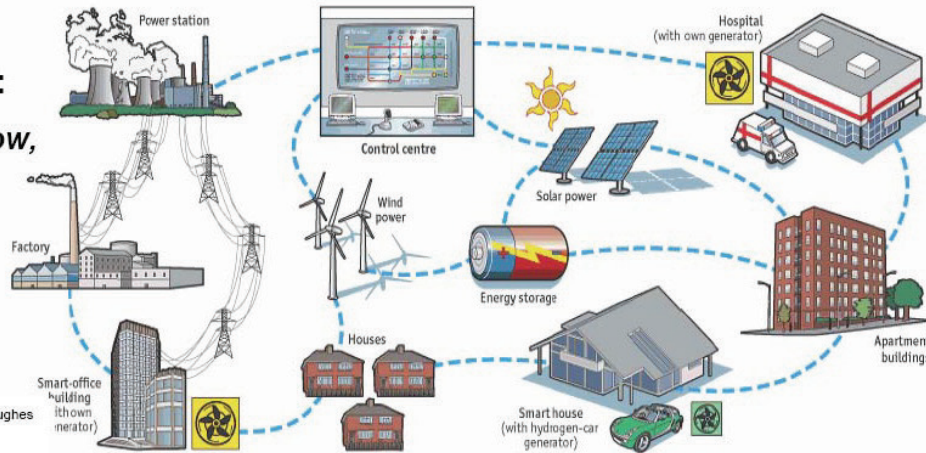
Evolution of the Grid

Smart Grid

Before Smart Grid:
*One-way power flow,
simple interactions*



After Smart Grid:
*Two-way power flow,
multi-stakeholder
interactions*



Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

Sources: The Economist; ABB

Source: Altalink, Alberta, Canada

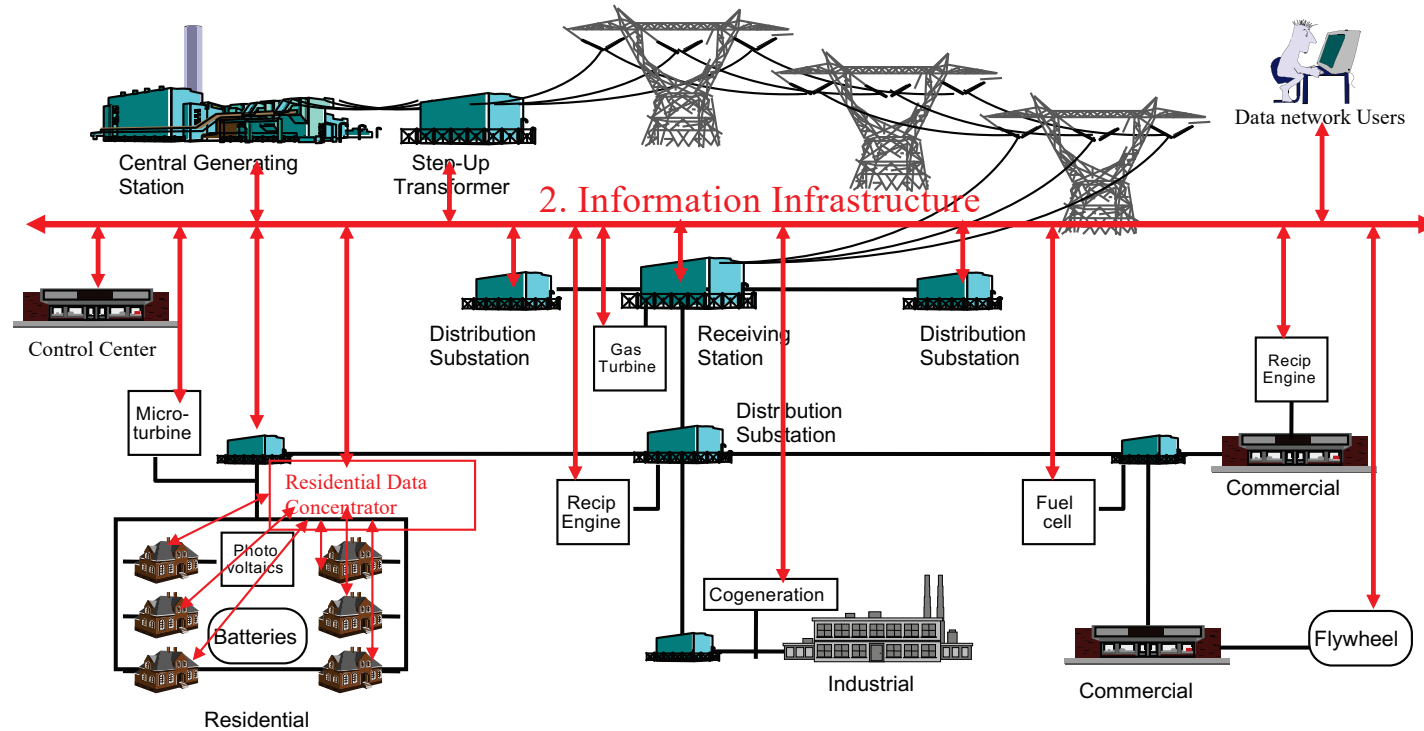


Merging Power Flow with Information Flow:

Integrated Communications

Electric Power & Communication Infrastructures

1. Power Infrastructure



Source: EPRI

Changing Landscape for the Electric Utility

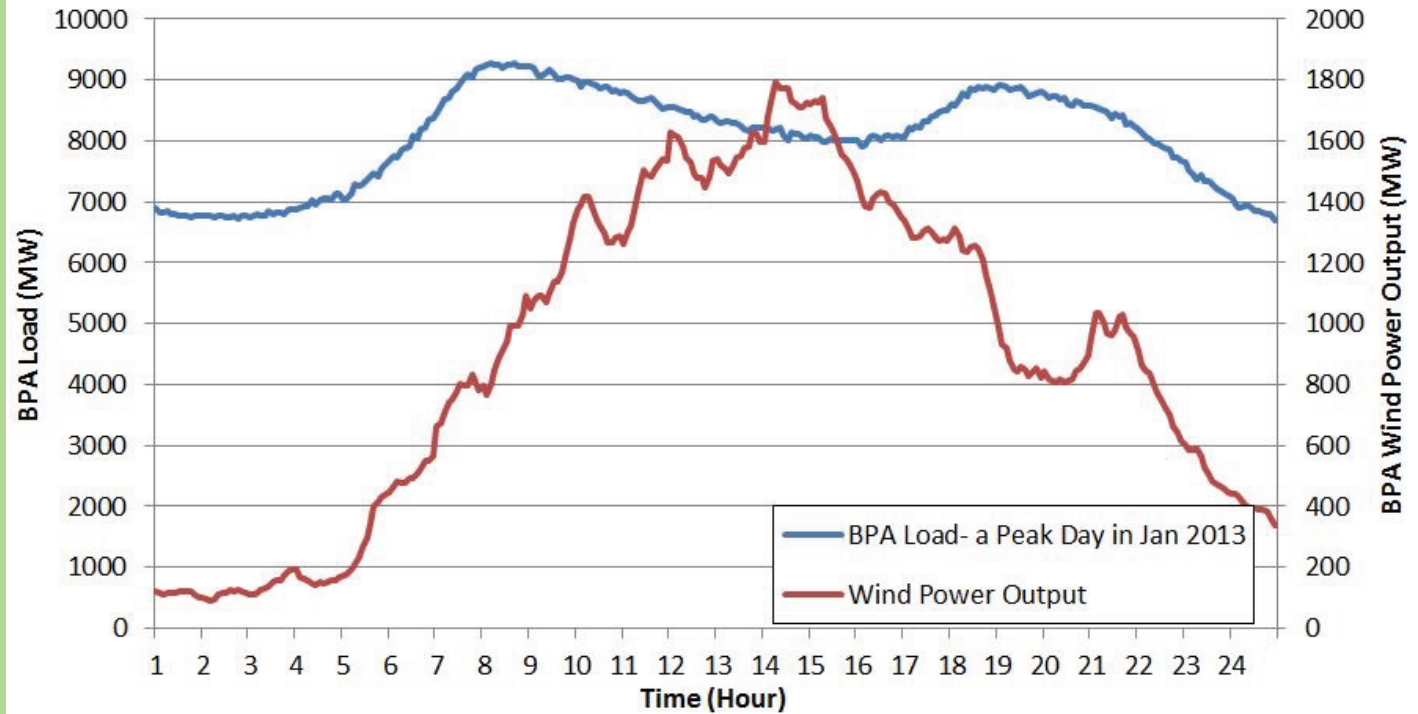


A photograph of a wind farm with a long line of white wind turbines stretching across a grassy field towards a blue ocean under a clear sky. The turbines are arranged in a perspective that leads the eye from the foreground towards the horizon.

Issues with Distributed Generation

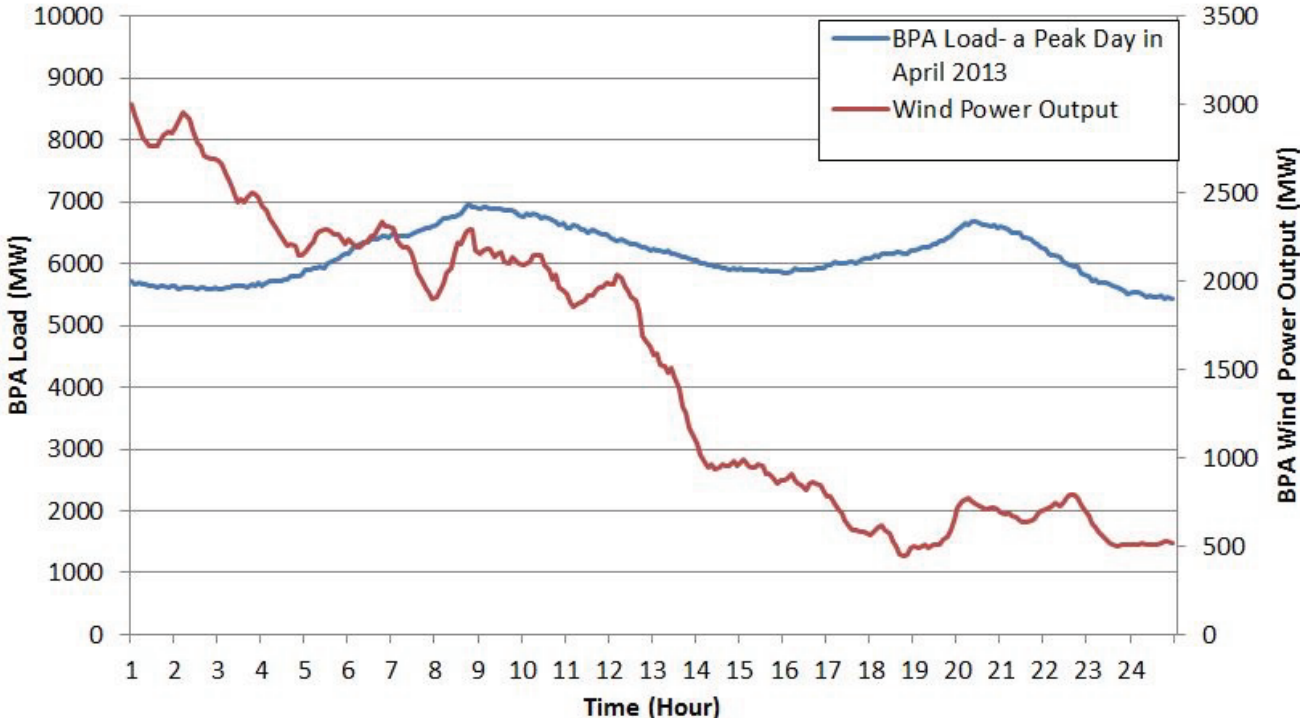
- Wind and solar are intermittent
- Hydro is space limited
- Resource is free but not always usable

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



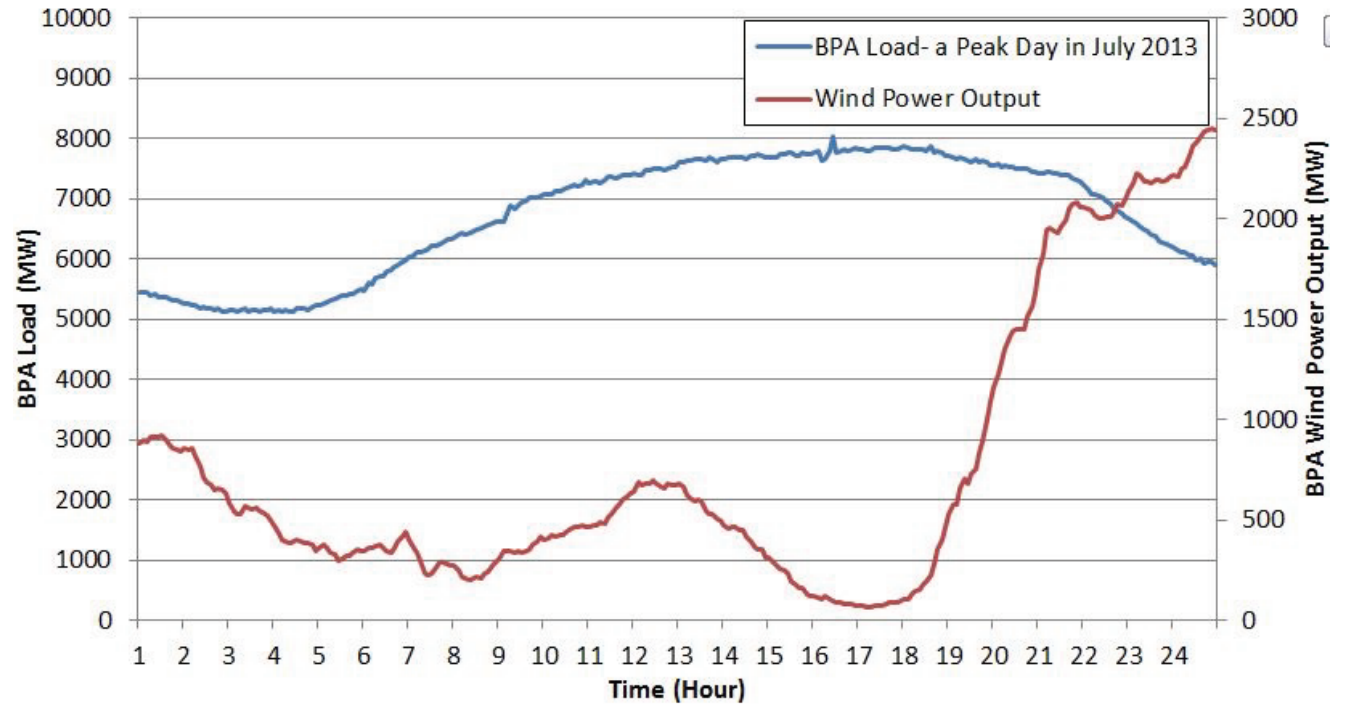


BPA Wind Output and Load Mismatch (A typical day in April)



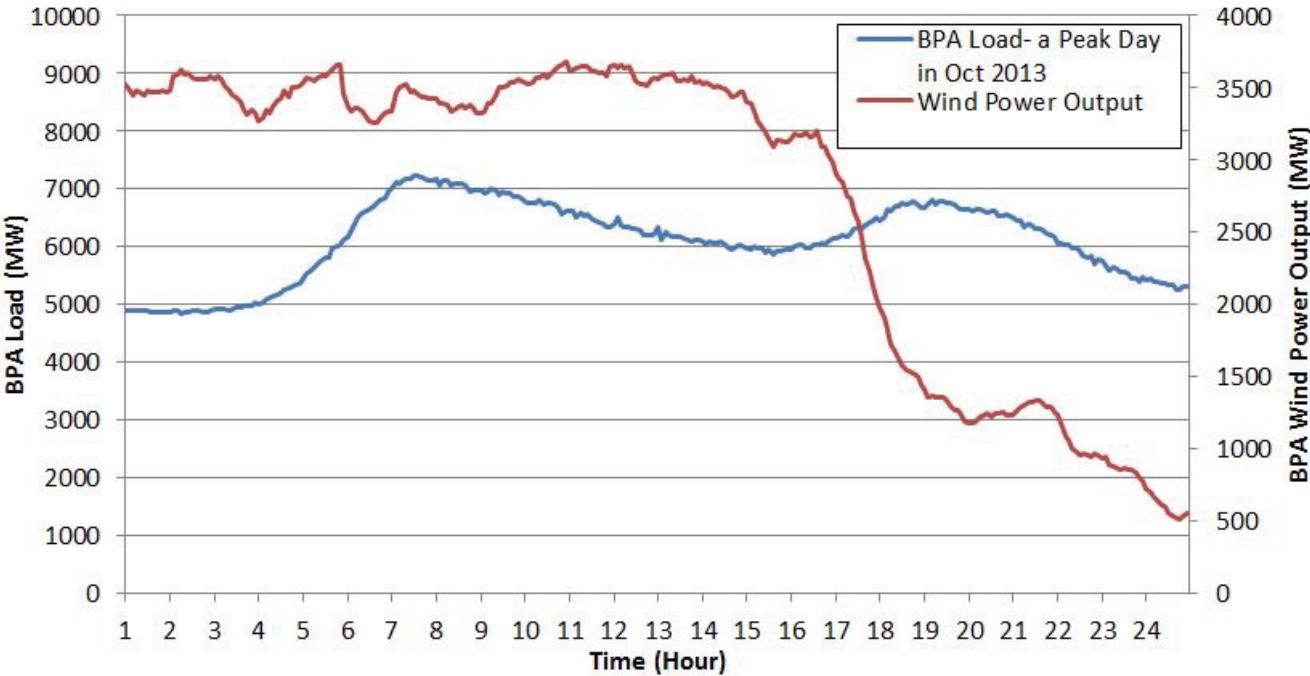


BPA Wind Output and Load Mismatch (A typical day in July)





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

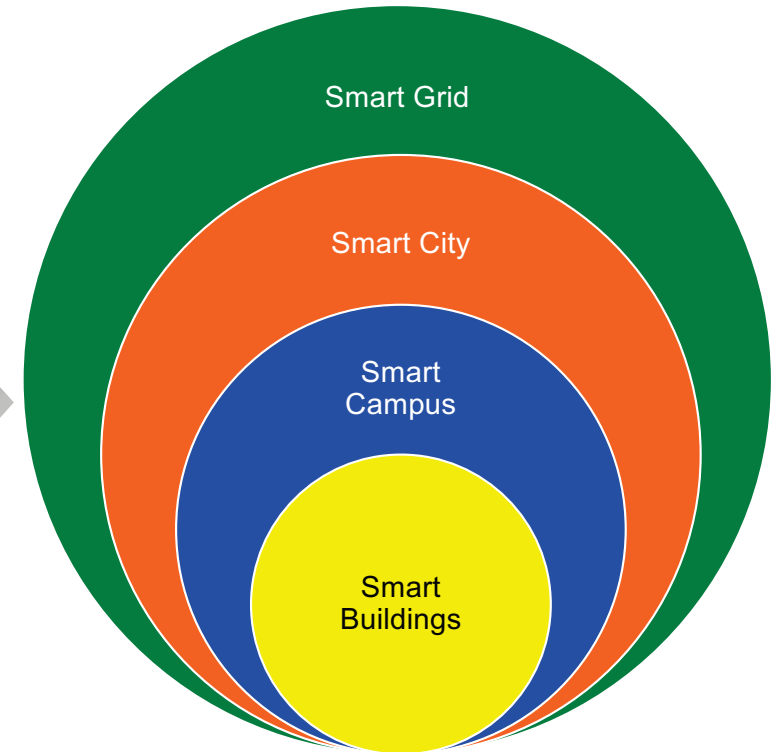
Smart grid: Bi-directional flows of energy, remote control/automation of power, integrated distributed energy...

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...

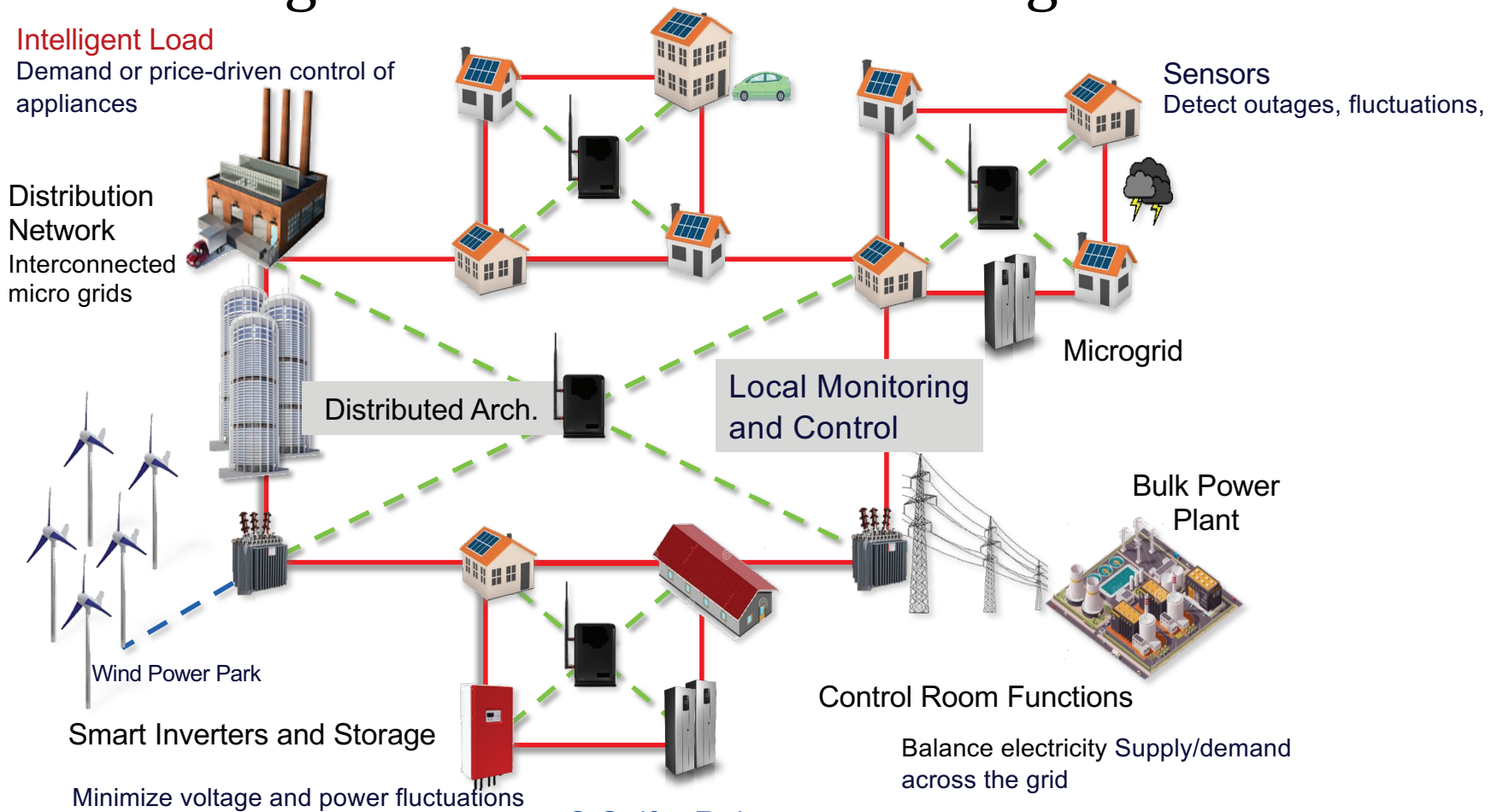
Ecosystem

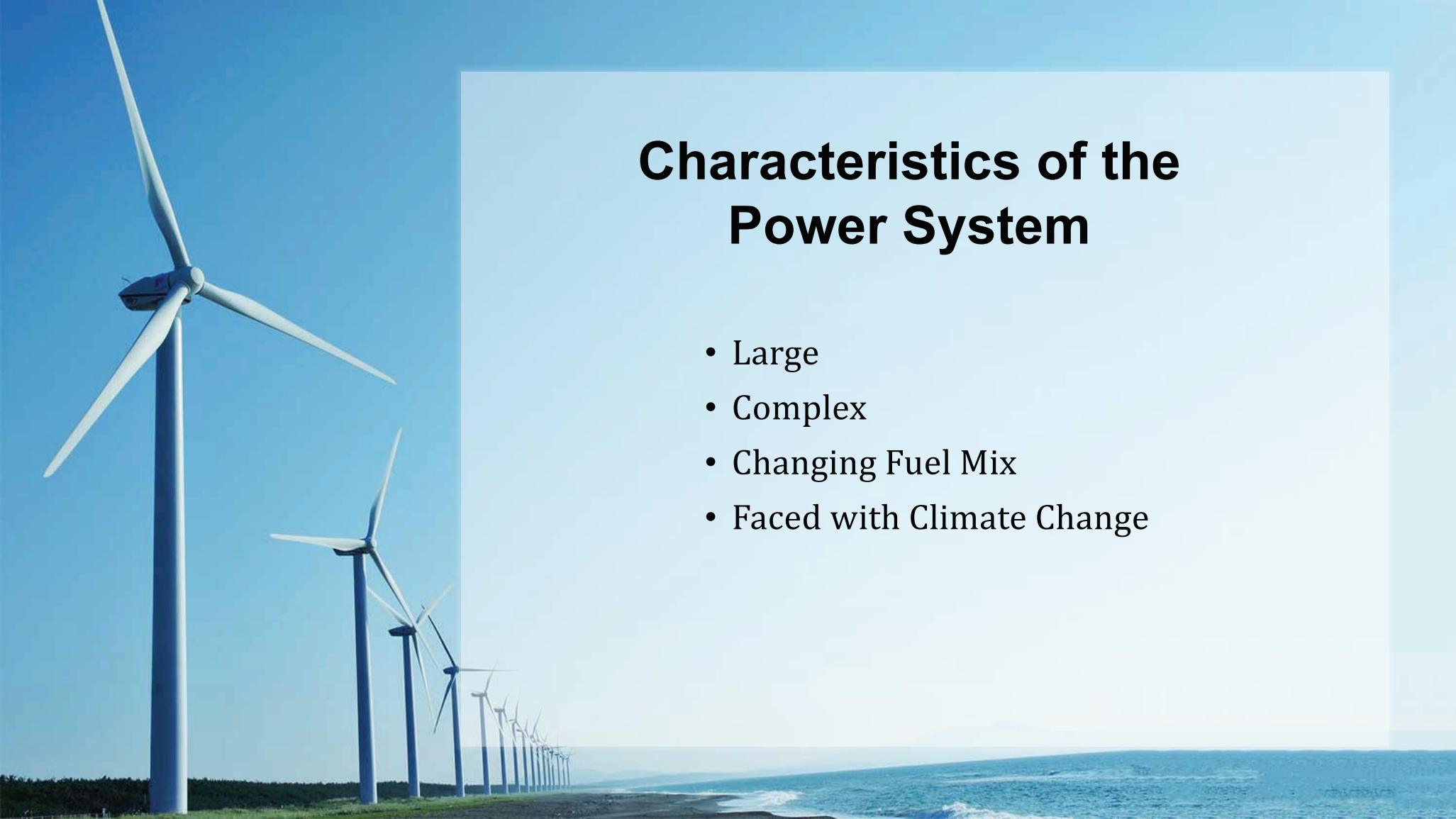


← Supported by ICT and distributed networks of intelligent sensors, data centers/clouds →

Power System of the Future

Intelligent Interconnected Microgrids



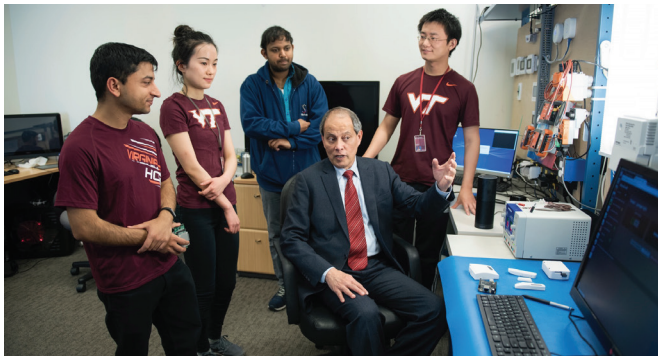


Characteristics of the Power System

- Large
- Complex
- Changing Fuel Mix
- Faced with Climate Change



Engineering Education & Research



- 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

Inspires the Engineers of Tomorrow

IEEE launched in 2006 is 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

Prof. Saifur Rahman

www.srahman.org