Smart Grid as an Intelligent CPS
Its Impact on Climate Change Mitigation

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Plenary Keynote Speech
Why is Climate Sustainability a Challenge?

Unprecedented Natural Disasters
Africa, China and Florida, USA
Droughts in 2022

Dry riverbed in **Italy** (Po River) due to worst drought in 70 years, June 2022

The Jialing Riverbed at the confluence with the Yangtze River is exposed due to drought on 18 August 2022, in Chongqing, **China**


https://image.cnbcfm.com/
Wildfires in the US

July 2021: The Dixie fire burned close to a million acres in California’s Lassen county over three months and became the first fire to cross the Sierra Nevada. Photograph: Noah Berger/AP

Peaks glowing with thousands of spot fires on 13 June 2022, in Flagstaff, Arizona. Rob Schumacher/The Republic
How Do We Address This Problem?
Mitigation
  Slow down the impact

Adaptation
  Take action to live with it

Climate Resilience
  Prepare to recover quickly
Mitigation will allow time to adapt by developing new technologies, best practices and policy formulation
What is the Role of the Technologist?

Develop and Promote Universally Applicable Cleantech Solutions for Climate Sustainability?
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
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
How Can the Smart Grid Help?
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

How the Electrical Grid Works

Power Source → Transformer → Transmission Lines → Distribution Center → House

https://blog.arcadia.com/understanding-the-electrical-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

[Diagram showing the difference between a normal grid and a smart grid]

Expected structural changes in the energy system made possible by the increased use of digital tools

- **Yesterday**
  - few large power plants
  - centralized, mostly national
  - based on large power lines and pipelines
  - top to bottom
  - passive, only paying

- **Tomorrow**
  - many small power producers
  - decentralized, ignoring boundaries
  - including small-scale transmission and regional supply compensation
  - both directions
  - active, participating in the system

[Source: https://en.wikipedia.org/wiki/Smart_grid]
Starting and End Points of a Smart Grid

It starts at the Generator and ends at the Refrigerator
Smart Grid Building Blocks
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

2. Information Infrastructure

Control Center → Residential Data Concentrator → Residential

Source: EPRI
Intelligent Interconnected Microgrids (CPS)

Intelligent Load
Demand or price-driven control of appliances

Distribution Network
Interconnected micro grids

Distributed Arch.

Sensors
Detect outages, fluctuations, disturbances

Microgrid

Local Monitoring and Control

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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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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