

What is the “Smart Grid”?



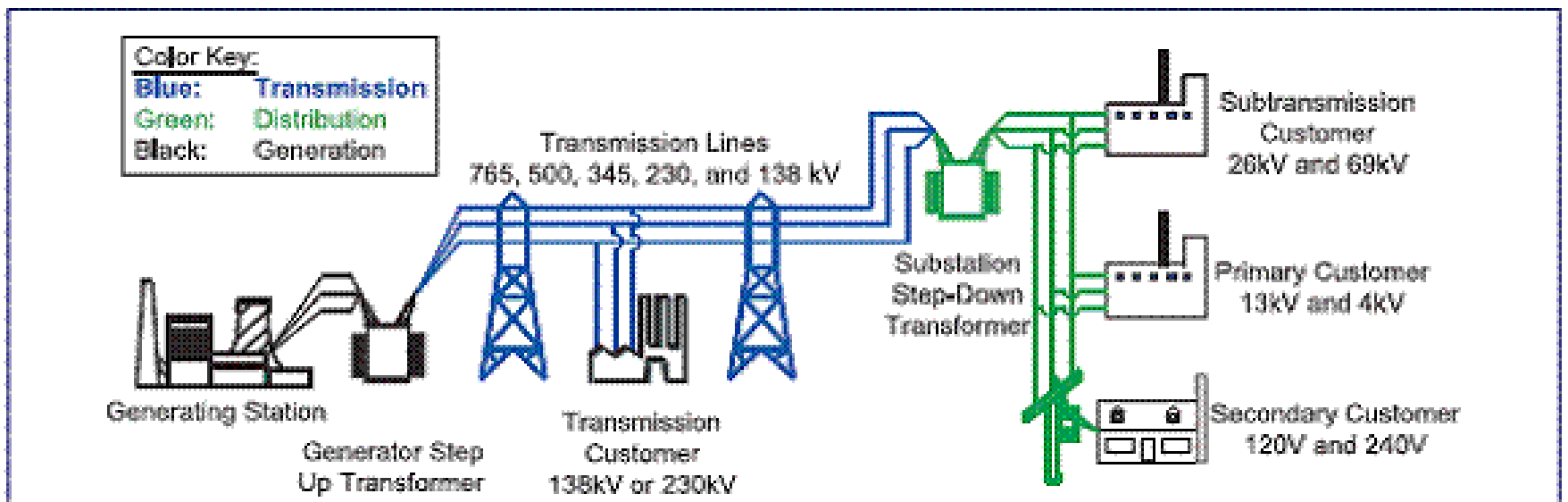
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Outline of today's presentation

- Introduction to the grid
- Making the grid smarter
- Smart Grid benefits
- Smart Grid technologies
- Concluding remarks

Power system overview

Functional parts of a power system

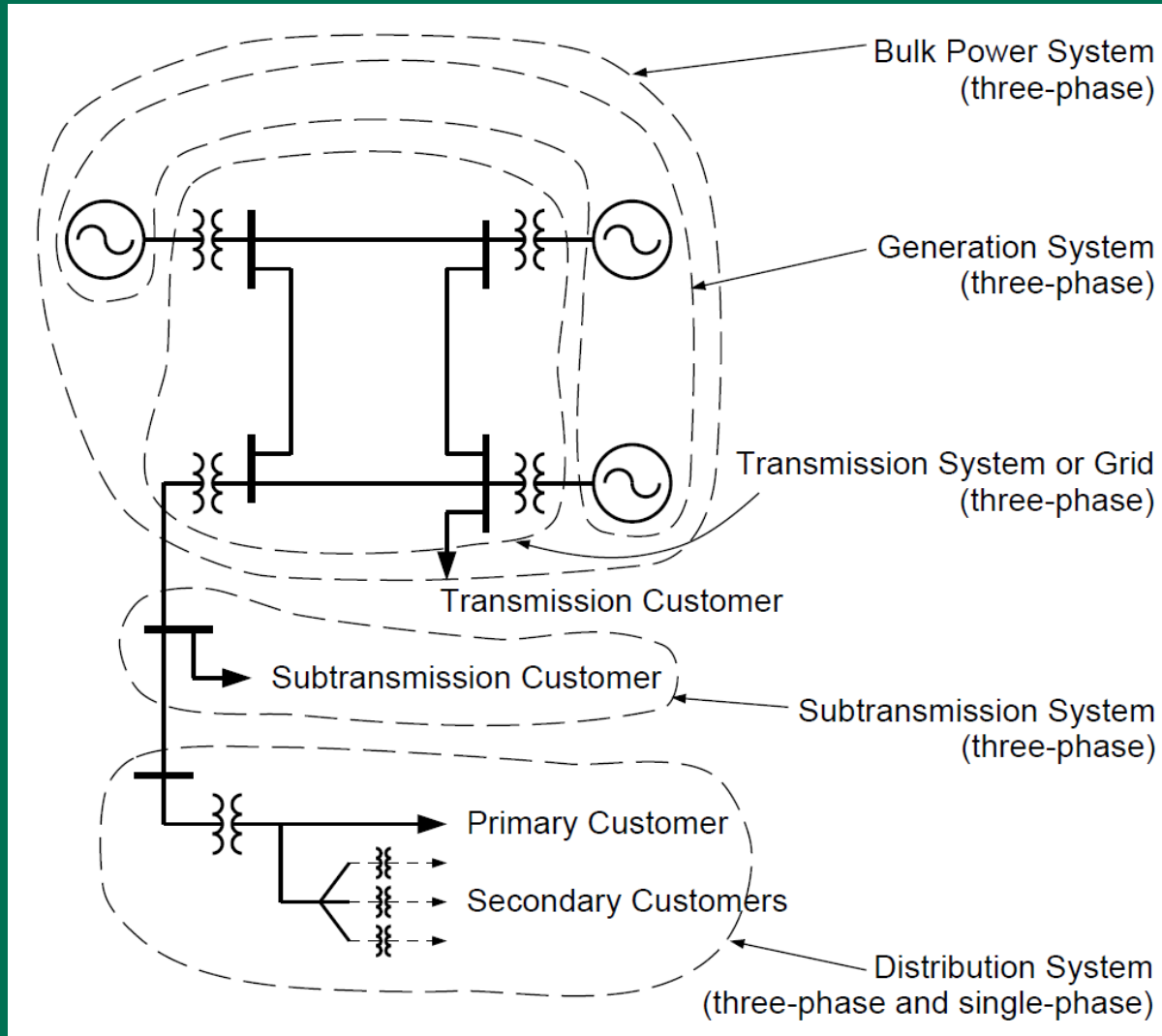


Source: North American Electric Reliability Corporation (NERC)

The major functional parts

- Generation system
 - generates *three-phase* power at 4–25 kV
 - interfaces with transmission system through the *generating station* where voltage is stepped up to 115–765 kV range
- Transmission system
 - meshed network transports 3-phase power at 115–765 kV
 - interfaces with other transmission lines or sub-transmission lines at *switching stations*
 - switching stations connecting to sub-transmission system step down voltage to the 20–69 kV range
- Distribution system
 - mostly radial system transports power through primary (3-phase) or secondary (1-phase) feeders to customers
 - connects to the sub-transmission system through the distribution substation where the voltage is stepped down to 33 kV and below

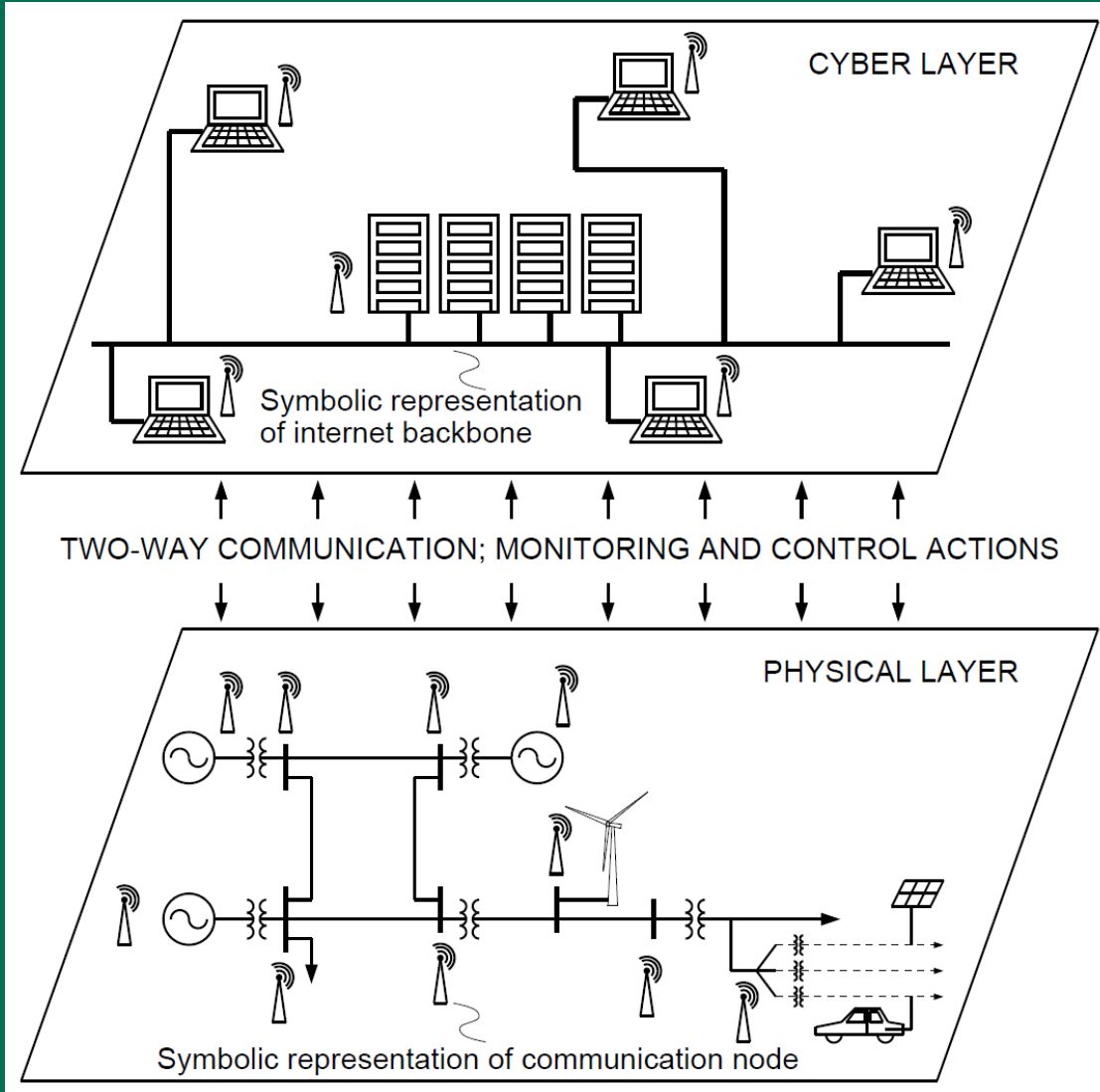
The Grid



Do we need a smarter grid?

- Today's grid is very complex and very smart, with highly sophisticated features:
 - Monitoring and control for normal operation;
 - Protection from abnormal conditions.
- Adding advanced communication and information technologies will increase system-wide awareness and *may* enhance performance in several areas:
 - Higher efficiency;
 - Higher resilience (reliability, security, automated recovery);
 - Lower consumption of fossil fuels (coal, oil, natural gas);
 - Lower pollution (oxides of carbon, sulfur and nitrogen; solid particulates).

The Smart Grid: A Cyber-Physical System



- The “Cyber” layer is a connected system of computers for
 - Data acquisition
 - Decision making
 - Supervisory control of the “physical” layer
 - The “Physical” layer is the electric grid, an inter-connected system of
 - Generation and storage
 - Transmission and distribution
 - Loads
- Measurement data collected by meters and synchrophasors are communicated to the “cyber” layer

Smart grid benefits

- To utilities
 - Higher reliability
 - Higher security
 - Higher asset utilization and deferred capital spending
 - Reduced operation and maintenance costs
 - Efficient power delivery
- To customers
 - Consumption management and cost savings
 - Ability to connect DG
 - Convenience from advanced meters
 - Enhanced business consumer service
 - Reduced industrial consumer cost

Technology: smart transmission system

- Technologies in transmission systems
 - Phasor measurement units (PMU) / synchrophasors
 - Flexible ac transmission systems
 - Dynamic rating of transmission equipment
- Monitoring and control
 - System state (voltages, service status)
 - Component loading and configuration
- Requirements and challenges
 - Very complex and widespread communication network
 - Enormous data management and optimization capability
 - Highly complex control
 - Operator interface

Technology: smart distribution system

- Technologies in distribution systems
 - Advanced metering infrastructure (AMI)
 - Distribution automation
 - Demand response / smart home / smart appliances
 - Plug-in hybrid electric vehicles (PHEV) / vehicle to grid (V2G) interfaces
- Must enable
 - Automated sensing, protection and restoration
 - Demand management and price signal communications
 - Increased penetration of distributed resources and power electronic devices
- Challenges include
 - Complex communication and data management
 - Investment cost control: distribution system components are much more numerous than transmission system components

Technology: smart appliances in the home

- “Smart” appliances respond to price signals, resulting in several cost saving opportunities:
 - They can operate during off-peak, low price periods
 - Refrigeration, water heating and HVAC systems can benefit from longer “on times” during off-peak periods
 - Operation of appliances and heating / cooling systems can be staggered, resulting in peak reduction for utilities
- Consumers adopting these technologies end up using more efficient and environmentally friendly appliances

Concluding remarks

- The Grid is a very complex system, and the “smart upgrade” comes with many benefits and complex challenges.
- In the next three presentations we will show how we plan to bring the “Smart Grid” to MSU.