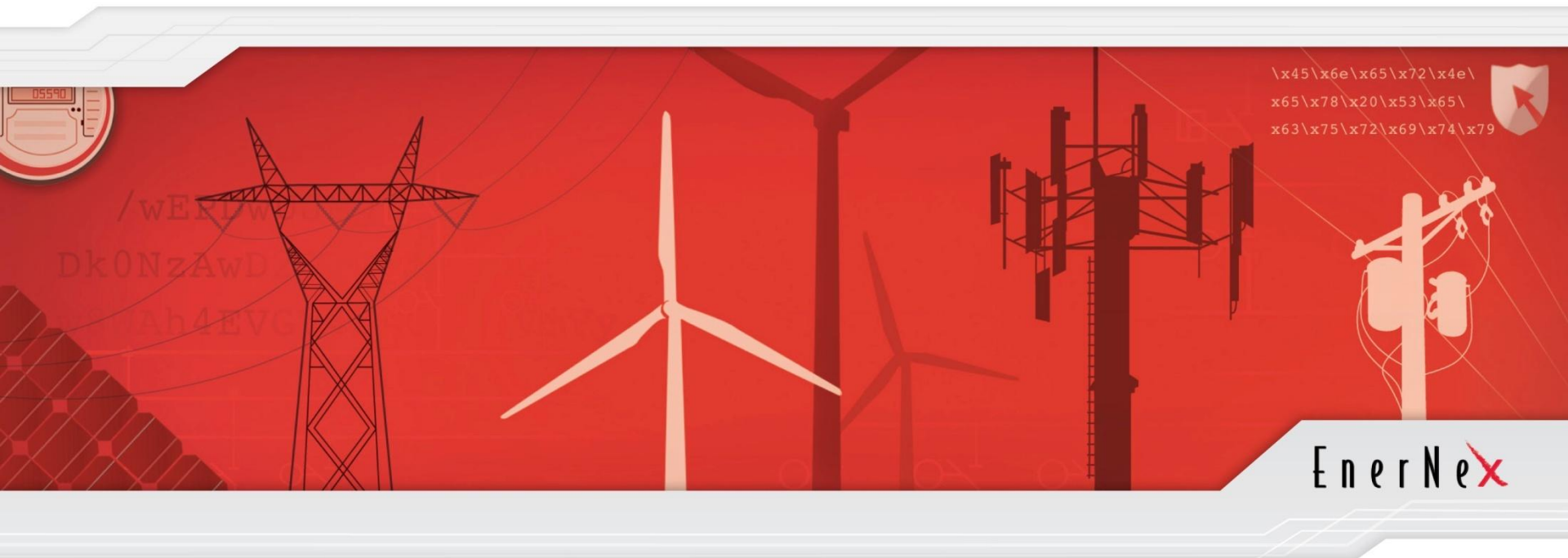


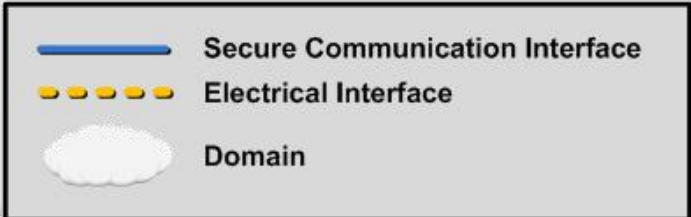
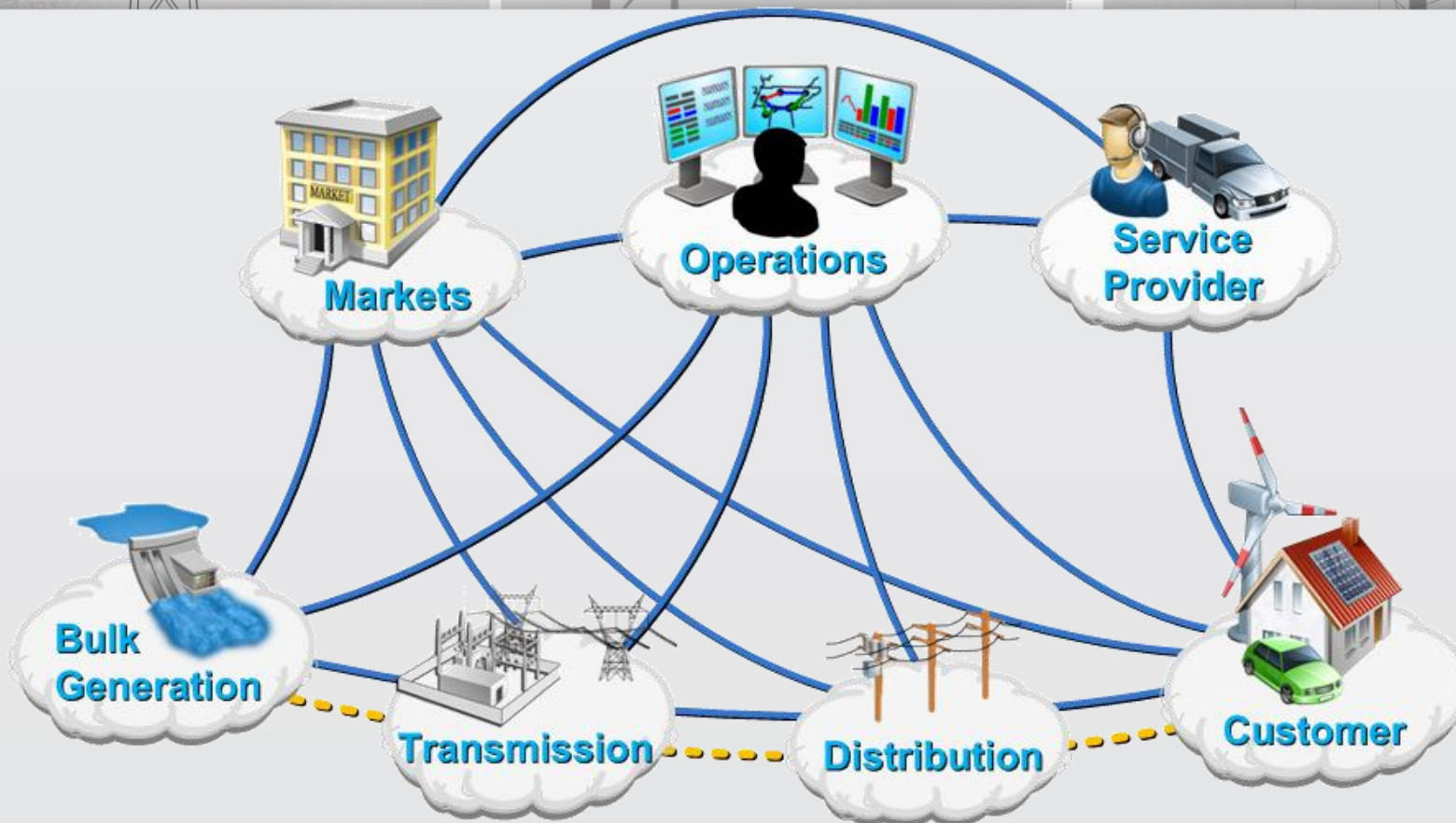
# Smart Grid

## Project Types and Technology



# NIST Smart Grid Model

\x45\x6e\x65\x72\x4e\  
\x65\x78\x20\x53\x65\  
\x63\x75\x72\x69\x74\x79





# Project Types

- ▶ Substation automation
- ▶ Distribution Automation
- ▶ Control Center Systems
- ▶ Electric Vehicle Charging Infrastructure
- ▶ Automated Metering Infrastructure
- ▶ Customer Side Systems
- ▶ Security and Privacy



# Technologies

- ▶ DER (DG/Storage/DR)
- ▶ Storage
- ▶ Demand Response
- ▶ Electric Vehicle
- ▶ Grid Components
- ▶ Information Systems
- ▶ Communication Systems

# Distributed Generation

	Renewable	Non-Renewable
Schedulable	Biomass Hydro Electric Biogas	Coal Gas Nuclear Diesel/Gas Engines
Non-Schedulable	Wind Solar	Industrial Process Co-generation Waste gases from refineries



# Storage

- ▶ Returnable
  - Batteries
  - Compressed air
  - Pumped Hydro
- ▶ Non-Returnable
  - Hot water and Ice
  - Process compressed air



# Demand Response

- ▶ Demand Limiting
- ▶ Pricing
- ▶ Direct load control



# Grid Components

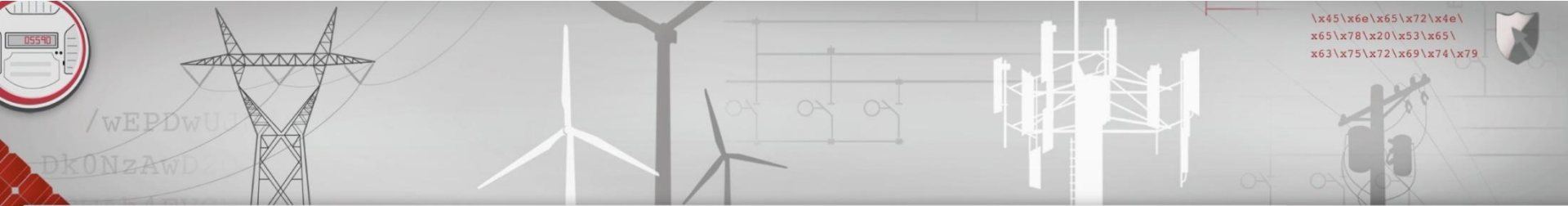
- ▶ Conductor
- ▶ Substation equipment
- ▶ Reclosers and other automated switches
- ▶ Intelligent devices
  - Sensors
  - Controls
- ▶ Next generation transformers





# Customer side systems

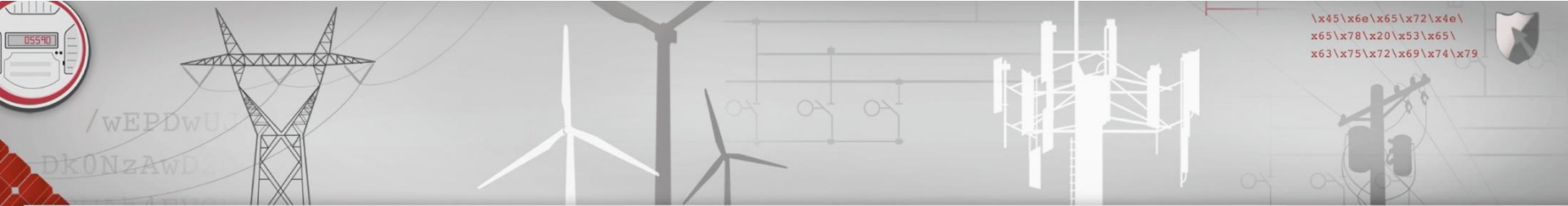
- ▶ Meters
- ▶ Displays
- ▶ Smart appliances
- ▶ Energy efficiency equipment
- ▶ Local storage



\x45\x6e\x65\x72\x4e\  
x65\x78\x20\x53\x65\  
x63\x75\x72\x69\x74\x79



# BACK UP SLIDES



## Cross Cutting

Tools for planning, operation, analysis

System wide monitoring, measurement, and control

Information and communications technology

Power electronics-based devices, including intelligent electronic devices (switches, relays, breakers, reclosers, transformers, capacitor banks), short-circuit current limiters, inverters & converters, regulators & circuit improvement

Distributed energy resources

Energy storage

Demand response

Standards and conformance testing

Cyber security

Electromagnetic compatibility

Novel market models

Operator training tools and emergency procedures

## End Users

Residential consumer energy management (including in-home displays, home area networks, consumer behavior integration, software tools, smart appliances)

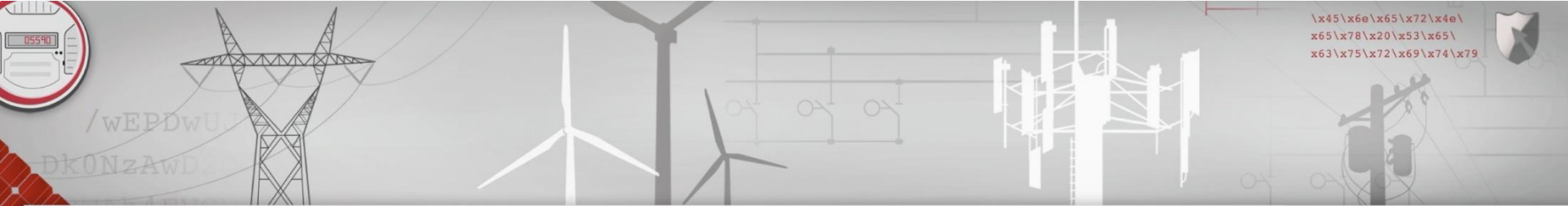
Building energy management and automation

Distributed energy resources integration

Electric vehicles and associated supply equipment

Microgrids and minigrids

Local sustainable energy



## Distribution

Distribution management systems and outage management systems

Distribution feeder circuit automation

Fault detection, identification, and restoration (FDIR)

Direct load control

Condition-based monitoring and maintenance

Voltage & VAR control

Capacitor automation

Advanced metering infrastructure (AMI)

Enterprise back office system – geographic information system (GIS), outage management system, customer information system, meter data management system

## Transmission and Substation

Resource planning, analysis, and forecasting tools

Large size variable renewables energy sources integration

Phasor measurement systems

Substation & transmission line sensors

High-voltage DC technologies

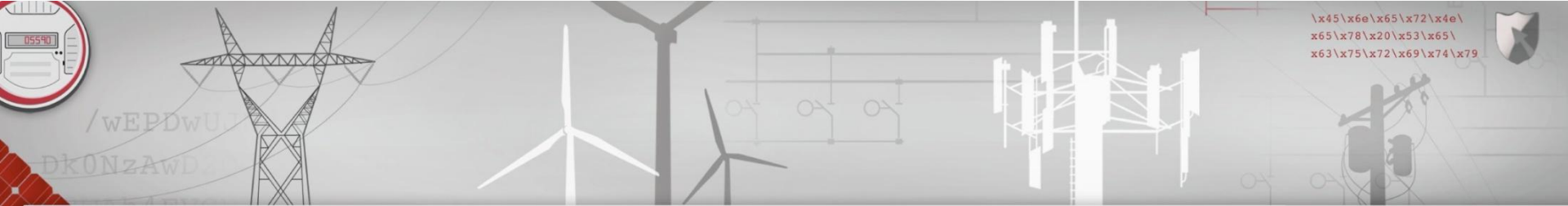
Flexible alternating current transmission system (FACTS) devices

Dynamic-thermal circuit rating

Advanced conductors for transmission lines

High temperature superconducting devices (e.g. SFCL, cables etc.)

High-voltage AC transmission lines



## Generation

Clean Coal, e.g., integrated gasification combined cycle (IGCC)

Natural gas combined cycle

Nuclear

Wind

Solar photovoltaic and solar thermal energy

Hydro power

Tidal power

Ocean thermal energy

Wave energy

Geothermal

Biomass

Biogas