

CPET 581 Smart Grid & Energy Management
Friday 6:00-8:45PM
2013/12/6

Lecture 16

Topics of Discussion

- **Smart Grid Standards**
 - IEEE P2030 Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS) and End-Use Applications and Loads
 - Smart Grid Standards Mapping Tools, IEC, <http://smartgridstandardsmap.com/Standards.jsp>
 - Wholesale Energy Market
 - Enterprise
 - Electric System Operation
 - Power Plant
 - Substation
 - Field Force
 - Distribution Automation
 - DER
 - Retail Energy Market
 - AMI
 - Industrial Automation
 - Home & Building Automation
 - Elec-Mobility Infrastructure
 - Example of Use Cases
- **PLMA Demand Response Dialogue**, Dec. 5, 2013, <http://www.peaklma.org/event/MikeFarrelloGE>
- **Team Project – Review & Discussion**

Smart Grid Standards Mapping Tools, IEC, <http://smartgridstandardsmap.com/Standards.jsp>

- Generation | Transmission | Distribution | DER (Distributed Energy Resources) | Consumption | Communication | Crosscutting
- Market | Enterprise | Operation | Field | Station | Process

Generation | Distribution | Distribution

- **Wholesale Energy Market**
 - Registration
 - Settlement
 - Energy Market Management
 - EMS (Energy Management System)

- SCADA (Supervisory Control and Data Acquisition)
- Intra-center Integration Bus
- Router
- **Enterprise**
 - Power Scheduling
 - ERP (Enterprise Resource Planning)
 - Asset Management
 - Energy Trading Application
 - Energy Trading Application
 - GIS (Geographic Information System)
 - CIS (Customer Information System)
 - Customer Portal
 - Intra-center Integration Bus
 - Router
- **Electric System Operation**
 - Secondary Generation Control
 - Condition Monitoring
 - EMS (Energy Monitoring System)
 - WAMS (Wide Area Monitoring System)
 - Model Exchange Platform
 - SCADA
 - DMS (Distribution Management System)
 - OMS (Outage Management System)
 - DRMS (Demand Response Management System)
 - Communication Front-End
 - AMI Head End
 - Intra-center Integration Bus
 - Router
- **Field – Power Plant**
 - Balance of Plant
 - RTU (Remote Terminal Unit)
 - Voltage Regulation
 - Primary Generation Control
 - Operation Meter
 - Relay
 - Intra-center Integration Bus
 - Router
 -
 - Power Electronic
 - Generation Equipment
- **Field - Generic Substation**
 - PMU
 - Phasor Data Concentrator
 - RTU

- HVDC Control
- FACTS Control
- Bay Controller
- Digital Sensor
- Grid Meter
- NIC (Network Interface Controller)
- Station Controller
- Voltage Regulator
- Cap-Bank Controller
- Fault Detector
- Relay
- Intra-center Integration Bus
- Router
-
- FACTS
- HVDC
- Capacitor
- Reactor
- Switch Breaker
- Transformer
- **Field – Field Force**
 - Radio
 - Mobile Device
 - Laptop
- **Field - Distribution Automation**
 -
 - Intra-center Integration Bus
 - Router
 -
 - Reactor
 - Capacitor
 - Recloser
 - Switch Breaker
 - Transformer

Distributed Energy Resources (DER) | Consumption

- **DER**
 - Station Controller
 - DER Control
 - Revenue Meter
 - RTU
 - NIC
 - Intra-center Integration Bus

- Router
-
- Energy Storage
- DER
- **Retail Energy Market INCL VPP**
 - Balance Scheduling
 - Customer Information System
 - Energy Trading Application
 - Customer Portal
 - MDMS (Meter Data Management System)
 - DRMS (Demand Response Management System)
 - AMI Head End
 - Intra-center Integration Bus
 - Router
- **AMI**
 - Meter Data Concentrator
 - Revenue Meter
 - Router
 - NIC
- **Industrial Automation**
 - Building Management System
 - Customer Energy Management
 - Process Automation System
 - DER Control
 - Load Control
 - Revenue Meter
 - Operation Meter
 - Charging Station
 - Intra-center Integration Bus
 - Router
 -
 - PEV (Plug-in Electric Vehicle)
 - DER
 - Local Storage
 - Load
- **Elec-Mobility Infrastructure**
 - Charging Station
 - Revenue Meter
 - Radio
 - NIC
 -
 - PEV (Plug-in Hybrid EV)
- **Home & Building Automation**
 - Building Management System

- Customer Energy Management
- DER Control
- HAN Gateway
- Charging Station
- Operation Meter
- Smart Plugs
- Appliances
- Intra-center Integration Bus
- Router
- NIC
-
- Local Storage
- Load
- DER

Communication

- Communication Infrastructure
 - Backbone Network
 - Operational Backhaul Network
 - AMI Backhaul Network
 - Inter-Substation Network
 - Neighborhood Network

Use Cases, <http://smartgridstandardsmap.com/Standards.jsp>

Elec-Mobility Infrastructure – Use Cases

- **Charging Station** – Use Cases
 - PV Charging at Premise,
 - Consumer Portal – EV Management
 - PV Output Forecasting
 - Customer Attributes
 - EV Load Management
 - EV Network Testing & Diagnostics
 - EV Roaming
 - Impact of EVs on Distribution Operations
 - EV as Storage
 - EV Charging Mode
 - EV Accounting Services
 - EV Participates in Utility Events
 - EV Diagnosis
 - Substation Protocol Conversion
 - WAMS Protocols
 - EV Home Connection
 - EV Connections Outside of Home Territory

- EV Connections at Public Location
- EV Charging
- EVSE Connection
- Premise EVSE
- Premise EVSE & Charger
- **Revenue Meter** – Use Cases
 - **Meter Remote Connect/Disconnect**,
http://www.smartgrid.epri.com/UseCases/Meter%20Remote%20Connect%20Disconnect_ph2add.pdf
 - Addresses the messages exchanges between CIS and Smart Meter through the AMI Head End and AMI Network when a meter connect/disconnect request is issued by CIS.
 - **Outage Management System Poll/Multicast**,
http://www.smartgrid.epri.com/UseCases/Outage%20Management%20System%20Poll%20Multi_ph2add.pdf
 - The OMS poll is an OMS Poll of certain Smart Meters that will enable operations personnel to determine if an outage is still valid. The OMS Poll is a multicast which can be initiated manually or automatically. This is used when trying to diagnose the extent of an outage event.
 - **Outage Management System Poll/Unicast**,
http://www.smartgrid.epri.com/UseCases/Outage%20Management%20System%20Poll%20Uni_ph2add.pdf
 - Outage Notification,
http://www.smartgrid.epri.com/UseCases/Outage%20Notification_ph2add.pdf
 - Outage Restoration Notification,
<http://www.smartgrid.epri.com/UseCases/UC-4%20Version%201%202013.pdf>
 - **Performing Real-Time Price Auction**,
<http://www.smartgrid.epri.com/UseCases/UC-4%20Version%201%202013.pdf>
 - Utility implements integrated management of DER.
 - **Remote Programming of Smart Meter**,
http://www.smartgrid.epri.com/UseCases/Remote%20Program%20of%20Smart%20Meter_ph2add.pdf
- NIC (Subscriber Access Network) – Use Cases
 - **AMI Network (AMI Head-End to/from Smart Meter)**,
http://www.smartgrid.epri.com/UseCases/AMI%20Network_ph2add.pdf
 - **Communication Network Management**,
<http://www.smartgrid.epri.com/UseCases/FunctionalRequirementsforNetworkManagement.pdf>
- Radio (Backbone Network)– Use Cases
 - **AMI Network** (AMI Head-End to/from Smart Meter),
http://www.smartgrid.epri.com/UseCases/AMI%20Network_ph2add.pdf

- Communication Network Management,
<http://www.smartgrid.epri.com/UseCases/FunctionalRequirementsforNetworkManagement.pdf>
- PEV – Use Cases

Home & Building Automation – Use Cases

- Building Management System
- Customer Energy Management
- DER Control
- **Charging Station – Use Cases**
 - **PEV Charging at Premise**,
http://www.smartgrid.epri.com/UseCases/PEV%20Charging%20at%20Premise_p h2add.pdf
 - **Consumer Portal – EV Management** (nighttime rate),
<http://www.smartgrid.epri.com/UseCases/ConsumerPortalScenarioP9.pdf>
 - **PV Output Forecasting**,
<http://www.smartgrid.epri.com/UseCases/NEDO%20L5%20PV%20Output%20Forecasting%20Use%20Case%20%20ver%204.1.pdf>
 - Customer Attributes,
<http://www.smartgrid.epri.com/UseCases/Different utility plans to identify the basic customer attributes V1.pdf>
 - **EV Load Management (PEV)**,
<http://www.smartgrid.epri.com/UseCases/Electric Vehicle Load Management v1.1.pdf>
 - **EV Network Testing & Diagnostics** (Energy Service Interface – ESI),
<http://www.smartgrid.epri.com/UseCases/EV Network test v1.1.pdf>
 - EV Roaming
 - **Impact of PEVs on Distribution Operators**,
<http://www.smartgrid.epri.com/UseCases/Impact of PEV as Load and Electric Storage on Distribution Operations.pdf> **EV as Storage**,
<http://www.smartgrid.epri.com/UseCases/Impact of PEV as Load and Electric Storage on Distribution Operations.pdf>
 - EV Charge Mode,
<http://www.smartgrid.epri.com/UseCases/PEV default charge modes v1.0.pdf>
 - EV Accounting Services,
 - EV Participants in Utility Events (demand side management),
<http://www.smartgrid.epri.com/UseCases/PEV Participates in Utility Programs V1.pdf>
 - EV Diagnostics,
<http://www.smartgrid.epri.com/UseCases/Electric Vehicle Diagnostics v1.1.pdf>
 - Substation Protocol Conversion,
<http://www.smartgrid.epri.com/UseCases/System Engineer Configures IEC 61850 Gateway to DNP3 Substation 2010-08-10.pdf>

- WAMs Protocols,
- EV Home Connection, <http://www.smartgrid.epri.com/UseCases/PEV-L1-CustomerconnectsPEVatHome-premise.pdf>
- **EV Another Customers Home Connection**,
<http://www.smartgrid.epri.com/UseCases/PEV-L2-CustomerconnectsPEVatAnotherHome.pdf>
- **EV Connection Outside of Home Territory**,
<http://www.smartgrid.epri.com/UseCases/PEV-L3-CustomerconnectsPEVOutsideHomeTerritory.pdf>
- **EV Connection at Public Location**,
<http://www.smartgrid.epri.com/UseCases/PEV-L4-CustomerconnectsPEVatPublicLocation.pdf>
- EV Charging, <http://www.smartgrid.epri.com/UseCases/PEV-PR1-CustomerchargesthePEV.pdf>
- EVSE Connection (Electric Vehicle Supply Equipment),
[http://www.smartgrid.epri.com/UseCases/PEV-S1-Cordset\(RevD\).pdf](http://www.smartgrid.epri.com/UseCases/PEV-S1-Cordset(RevD).pdf)
- Premise EVSE, [http://www.smartgrid.epri.com/UseCases/PEV-S2-PremiseEVSE\(RevD\).pdf](http://www.smartgrid.epri.com/UseCases/PEV-S2-PremiseEVSE(RevD).pdf)
- Premise EVSE & Charger, [http://www.smartgrid.epri.com/UseCases/PEV-S3-PremiseEVSEthatincludesthecharger\(RevD\).pdf](http://www.smartgrid.epri.com/UseCases/PEV-S3-PremiseEVSEthatincludesthecharger(RevD).pdf)
- PEV – Use Cases

Wholesale Energy Market

Registration – Use Cases

- Market Operation – Day Ahead Market Operations (54 pages),
<http://www.smartgrid.epri.com/UseCases/MarketOperations-DayAheadMarketOperations.pdf>
- Market Operations - Long Term Planning (26 pages),
<http://www.smartgrid.epri.com/UseCases/MarketOperations-LongTermPlanning.pdf>
- Market Operations – Midterm & Short Term Planning (38 pages),
<http://www.smartgrid.epri.com/UseCases/MarketOperations-MediumandShortTermPlanning.pdf>
- Market Operation – Overview (12 pages),
<http://www.smartgrid.epri.com/UseCases/MarketOperations-Overview.pdf>
- Market Operation – Post Dispatch (44 pages),
<http://www.smartgrid.epri.com/UseCases/MarketOperations-PostDispatch.pdf>

Settlement – Use Cases

Energy Market Management – Use Cases

Energy Management System – Use Cases

- Market Operation – Day Ahead Market Operation,
<http://www.smartgrid.epri.com/UseCases/MarketOperations-DayAheadMarketOperations.pdf>

- Market Operations - Long Term Planning
- Market Operations – Midterm & Short Term Planning
- Market Operation – Overview
- Market Operation – Post Dispatch
- Load Forecast Data between EMS & Planning
- Load Shedding by Order
- Maintain SCADA Database
- Alarm Management
- Direct Load Control Event
- AGC Frequency Control
- Load/Capacity Balancing
- EMS Data Transfer Operations to Planning
- EMS Data Transfer Planning to Operations
- EMS Data Transfer Planning to Planning
- Contingency Analysis & Future (advanced)
- Control Islanding
- Transmission Outage Schedules
- Demand Response & Utility Commanded Load Control
- DER Management
- DER Islanding
- DER Forecasting
- DER Equipment Interface
- Earth Fault Localization
- Power Export
- Field Control Request
- Import Operational Model to Planning
- Automated Demand Response for Network Operators
- Inter-Area Oscillation Damping
- ISO Uses Synchronphasor Data
- Load Forecast Data between EMS & Planning
- Load Shedding (by order)
- EMS Contingency Coordination
- Virtual MicroGrid
- Peak Shifting by Battery Aggregation
- PV Output Forecasting
- MicroGrid Power Quality
- MicroGrid Energy Management
- MicroGrid Autonomous Control
- DMS Control of MicroGrids
- MicroGrid Connected
- MicroGrid Islanded Operation
- Interaction between EMSs

- Network Coloring
- Network Equivalents between EMS & Planning
- Network Extension
- Network Modifications
- Power Quality Contracts
- Power Quality Event Notifications
- Process Contingency Definition
- Process Dynamic Rating
- Network Model Management
- Model Change Request
- Model Manage Data
- Post Fault Analysis
- Real Time Topology Processor
- SCADA Data Update
- SCADA Data Update – KCPL
- International Islanding
- Study Mode Topology Processor
- New Transmission Line with IEC 61850
- CIM Model from IEC 61850
- System Engineer Retrofits a Substation
- System Operator Identifies, Locates, Isolates and Restores Service
- System Operator Switches Feeders based on Contingency Analysis
- Telemetry Definition in CIM Database
- Transport Contingency Specifications
- Utility Implements Integrated Management of Distributed Energy Resources
- Utility and/or Customer Provides Electrical Energy Storage in Conjunction with Photovoltaic
- DER for Voltage Regulation
- Voltage Security
- WAMAC Emergency Operations Baseline
- Wide Area Control System for the Self-healing Grid
- Wide Area Control System Advanced Auto-Restoration
- Wide-Area Monitoring and Control & Automated Control Functions
- Wide-Area Wind Generation Forecasting

SCADA (Supervisory Control and Data Acquisition) – Use Cases

- Data Acquisition, <http://www.smartgrid.epri.com/UseCases/DataAcquisition.pdf>
- Data Acquisition and Control, <http://www.smartgrid.epri.com/UseCases/DataAcquisitionandControlDAC.pdf>
- Data Acquisition from External DMS Network Monitoring Subsystem
- SCADA Database Maintenance, <http://www.smartgrid.epri.com/UseCases/MaintainSCADADatabase.pdf>

- Remote Supervisory Control,
<http://www.smartgrid.epri.com/UseCases/RemoteSupervisoryControl-KCPL.pdf>
- SCADA Data Update,
<http://www.smartgrid.epri.com/UseCases/SCADADataUpdate.pdf>
- SCADA Data Update KCPL,
<http://www.smartgrid.epri.com/UseCases/SCADADataUpdate-KCPL.pdf>

Smart Grid Standards

- SGIP (Smart Grid Interoperability Panel), <http://www.sgip.org/the-smart-grid-interopability-panel-inaugural-conference-fosters-progress-through-collaboration/#sthash.7XxMKhnf.dpbs>
- Smart Grid Standards Mapping Tool, International Electrotechnical Commission (IEC), <http://smartgridstandardsmap.com/>
 - Architecture view, Mapping view
- Smart Grid Standardization Analysis, Version 2.0, Feb. 2012,