A 21st Century Control System: Changing Role of System Operations

EMS Users Group Meeting - Rancho Cordova, California

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Evolution of System Operations in 21st Century

“You’ve got to be very careful if you don’t know where you’re going, because you might not get there.” – Yogi Berra

Why do we have to do anything?
What’s Driving the Change?

Changing Paradigm

- **Consumer** – expects reliable electricity and more control of how/when its used
- **Prosumer** – Consumer and producer of electricity – ability to export to the grid
- **Utility** – Must evolve to meet increasing customer and regulatory expectations
- **Government** – Increasing requirements for alternative energy and power quality and reliability

These forces will change the way power is generated and delivered
Evolving Distribution System

- Communication Networks to the Customer Premise
- Demand Side Management
- Distributed Generation
- “Green” Energy
- Self-healing
- Intelligent Devices

System Operations will need to be able to handle a more complex network than in the past
A robust view of the “Utility of the Future” should include the influences of both producers and consumers.
Transformation of the Grid Will Drive Change in System Operations

<table>
<thead>
<tr>
<th>20th Century Grid</th>
<th>21st Century Smart Grid</th>
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<tbody>
<tr>
<td>Electromechanical</td>
<td>Digital</td>
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<tr>
<td>Very limited or one-way communications</td>
<td>Two-way communications everywhere</td>
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<tr>
<td>Few, if any, sensors – “Blind” Operation</td>
<td>Monitors and sensors throughout – usage, system status, equipment condition</td>
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<td>Limited control over power flows</td>
<td>Pervasive control systems – substation, distribution and feeder automation</td>
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<td>Reliability concerns – manual restoration</td>
<td>Adaptive protection, semi-automated restoration and eventually, self-healing</td>
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<td>Sub-optimal asset utilization</td>
<td>Asset life and system capacity extensions through condition monitoring and dynamic limits</td>
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<td>Stand-alone information systems and applications</td>
<td>Enterprise level information integration in a cyber secure way, interoperability, and coordinated automation</td>
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<td>Very limited, if any, distributed resources</td>
<td>Large penetrations of distributed, intermittent and demand-side resources</td>
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<td>Minimal cyber security</td>
<td>Cyber security is one of the major technological challenges facing utilities</td>
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<td>Voluntary reliability standards</td>
<td>Mandatory and enforceable reliability standards</td>
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<td>Emergency decisions by committee</td>
<td>Decision support systems, predictive reliability</td>
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<tr>
<td>Limited price information</td>
<td>Full price information, dynamic tariff, demand response</td>
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<td>Few customer choices</td>
<td>Many customer choices, value added services,</td>
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Can the same approach to System Operations for a 20th Century grid be used for the 21st Century SG?
Load Characteristics are Changing
Could this change “Distribution Business” as we know it today?

Challenge is forecasting this

Conventional Technology

Smart Technology

Mono-Directional Grid

Multi-Directional Grid

DG

DG, EV, Storage

Smart Consumer

Source: DNV KEMA
Potential Impacts to System Operations

- Control room operators are going to be seeing conditions that they haven’t experienced before.

- As new devices are introduced to the grid, operators will be shifting their paradigms from operating radial feeders to a dynamic distribution network.

- Switching plans will become more complicated and the protection of life, both utility and public will become a more intense activity to manage, especially during storm conditions.

- Operators will require a common map and seamless integration of outage management, switching, crew management, and reliability.

- Operations support teams will be need to transform data into information that will produce actionable results for operators.

- Control room operators will need to be “retooled” - many companies have down played the skills needed to manage and dispatch crews to trouble locations.

- Long outages will continue to be a major concern for regulators.
Future – “Day in the Life” of System Operations Influenced by:

- Retirements start to change the control room age demographics
- Regulation continues to promote conservation, reliability and safety
- Electric vehicles are common, smart appliances are available
- Distributed generation is main stream, and distributed storage is emerging
- Utility technology and related work process changes continue to be developed
- ADMS technologies being deployed in the control center
System Operations Control Room - Challenges

- **Evolving technologies**
  - Devices are not fully implemented
  - Computer systems, user interface, and models are not fully integrated
  - Systems operators are in a “prove it” mode

- **The legacy work force in the control room is retiring**
  - New operators don’t come from the traditional feeder pool
  - More techno-savvy workforce
  - Training becomes even more important
  - Importance of network apps to support daily activities increases significantly

- **Introduction of new advanced distribution and transmission applications**
  - New to operators – requires time to gain trust
  - Need to develop Operator confidence to run in a closed loop control mode for controlling the devices on the network
  - Operators are reviewing recommendations from the systems and approving or correcting them based on their knowledge
Control Room Changes Driven by SG Technology

- Equipment outages/shutdowns will be done taking into consideration how best to optimize the network, instead of just considering the loading of the assets.
- When a major storm hits the area - the AMI system will indicate the severity of damage the network has received. Knowing this information will enable proactive call in of additional crews and well as help management teams pull the trigger on calling in mutual assistance (foreign) crews.
- There will be “islands” of power that will need to be re-synchronized to the Distribution Network
- Fault signatures read by sensors on substation breakers, reclosers, and other interrupting devices as well as AMI “last gasp” will inform the outage location algorithms, providing further improvement in outage location and less dependence on customer calls.
- Distributed generation (DG) and direct load control management (DLCM) will be leveraged to manage ad hoc islands as an alternative to switching.
Other Potential Changes

- GPS location of trouble shooter and construction crews shown on geographical map
- Operators will use more integrated voice/video to communicate with crews
- Advanced distribution applications are needed to determine optimal switching order and optimization of the network
- Large, interactive touch screens
- HD video feeds from critical infrastructure sites
- New weather forecasting applications to predict solar PV supply variations and predict maximum allowable operating limits
EMS System Changes

- Transmission Applications
  - Integration with Smart Grid deployments
  - Treatment of Smart Grid as Virtual Power Plant
    - Virtual Power Capture – Combination of consumer distributed generation, storage, and demand management to participate in energy markets and grid operations
  - Increased EMS/DMS/OMS/AMI integration
  - Severely increased data volumes, much of it stored in historians
    - Storage and communications impacts
  - Increased integration with external “Business Intelligence” applications
  - Increasingly dynamic load curves – can’t rely on historical info
  - Increased deployment of Volt/VAR optimization apps
EMS System Changes

- Transmission Applications (cont)
  - Integration of PMUs (phasor angles, phase angle differences)
    - Faster monitoring of grid disturbances (oscillation detection/alarming)
    - State Estimator – improved network observability and detection of bad data
  - Contingency Analysis - Probabilistic Risk Assessment
  - Voltage and Transient Stability Analysis
  - Improved Wide Area Situational Awareness
  - Improved arming/disarming of Special Protection Schemes
  - Dynamic Remedial Action Plans – Improved real-time sequence enhances
    - Improved operating boundary visualization
  - Increased Transmission utilization
    - Integration of Dynamic Thermal Circuit Ratings
EMS System Changes

- Transmission Applications (cont)
  - Improved Asset Management
    - Condition-based line ratings
    - Tracking of component usage, failure mechanisms
    - Focus on life extension
  - Increased System Restoration flexibility
    - Decentralized electricity generation (Micro-grids)
    - De-centralized controls
  - Geographic view of grid dynamics
    - Increased integration with Distribution systems
    - Increased focus on asset utilization
    - Increased situational awareness
EMS System Changes

- **Generation Applications**
  - Increased integration with markets
  - Support for Distributed/Renewable Generation
    - Improved AGC, Economic Dispatch, and Load Forecasting
      - More frequent, higher resolution forecasting and scheduling
      - Fast ramping replacement generation
      - Increasing amount of uncertainties in load and duration
  - Better holistic and forward view of system conditions and generation patterns
  - Integration of Demand Response and Dispatchable Storage resources
  - Enhanced load forecast tools
    - Account for impact of wind, solar, PHEVs, etc
EMS System Changes

- **Architecture/System**
  - Increased integration between EMS, DMS, and OMS systems
  - Improved visualization tools for temporal and spatial correlation of anomalies, losses, etc
  - Increasingly sophisticated operator station designs
  - Virtualization of servers
  - Development of applications that computer performance and software development tools wouldn’t allow in an economically feasible manner in the past (e.g. TSA)
  - Increased use of Service-Oriented Architecture
    - Decoupled applications within EMS, simpler upgrades
    - Easier integration with non-EMS applications
EMS System Changes

- **Architecture/System (cont)**
  - Extreme cyber security for critical assets
    - Minimal “core” within Security Perimeter
  - Improved “root-cause” alarm packages
  - Faster, two-way, IP-based, secure communications to field devices
  - Increased IED integration
    - Increased Health Monitoring of assets
  - Increased incorporation of CIM
Distributed generation enabled by Smart Grid – energy networks need to be managed

- New DG is predominantly renewable based
- Grid coupling via controllable smart inverters
- Consumers have more control of their load
- New business models around Energy Network Management
- Aggregation and Control of DG

Sustainable generation business will “own” and ensure control of the load along with building, community, industrial and consumer distributed generation
Demand Response providing control of individual loads in real-time

- Peak shaving potential
- Real-time control of load
- Control of heating and Cooling loads
- Aggregation of the DR
- Integration into DMS and EMS systems

“Intelligent load” - residential, industrial and commercial aggregated to create virtual power / megawatts
Networking and Merging management of DG, DR and Storage

Demand Response:

Balance and Integration:

Electric Storage:

EMS and DMS

Distributed Generation:

VPP
Operating the 21\textsuperscript{st} Century Smart Grid – Another Approach

- **How to get there?**
  - Understand where you currently are in terms of people, process, and technology
  - Understand the current market place – its evolving
  - Understand the major influences impacting your utility – they differ from utility to utility
  - Develop a realistic roadmap and revisit as needed
    - Sufficient time
    - Sufficient resources
    - Appropriate technologies
    - Appropriate change management

It’s important to know where you are going so you actually get there
Thank you

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