White Paper

Convergence of Information and Operation Technologies (IT & OT) to Build a Successful Smart Grid
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Smart Grid is a new buzzword that has become an intrinsic part of the electric utility industry language in the past few years. Nearly every participant in the industry -- investor owned utilities (IOUs), municipalities, operators, vendors, consultants, analysts, regulators, etc. -- promotes Smart Grid as the vehicle that will allow the industry to modernize its infrastructure and use the latest technologies, particularly in communications and real time operations, in order to be more efficient and reliable.

Market needs and expectations are different in every part of the world; even in the same geographical region, requirements and necessities can be quite different between market agents. In general however, three main sets of drivers are fairly common to all utilities. These three drivers aim at meeting high demand growth, increased need for reliability and reduced carbon emissions.

Utilities have found that the newest technological advancements can help achieve significant progress towards the requirements of those three drivers. These advancements appear most visible in the areas of communications, sensors, control and protection apparatus, remote operations, near real time metering, distributed and renewable generation, electric vehicles, demand response management, customer interaction, operations and optimization software applications, and enterprise business intelligence.

Some major challenges emerge in this context. The first set of challenges refers to the adoption of these new technologies, which are, for the most part, untested and unproven in the field. The second set of challenges refers to the lack of industry standards, protocols and operational guidelines that should be required in an industry that has very high requirements for reliability and control.

The final set of challenges refers to the existing gap between technical operations and business decision making within the utility's organization. This gap reflects on the business process, IT infrastructure and integration, workflow consistency, and timely interaction.

Basically the gap is between business applications (IT realm) and operations and control systems (OT realm).
The integration of IT and OT is vital to a successful implementation of new technologies under the Smart Grid umbrella.

Information Technologies are mostly software applications for commercial decision making, planning, business processes management and resource allocation. Information Technology applications can include, among others:

**Enterprise Resource Planning** – ERP. For managing financial and human resources, materials and assets.

**Enterprise Asset Management** – EAM. For supply chain, inventory management, work and asset management.

**Mobile Workforce Management** – MWFM. For managing mobile field crews, mapping, work scheduling and optimization.

**Customer Information Systems** – CIS. For managing customer data, metering data, settlements and invoicing.

**Energy Portfolio Management** – EPM. For energy planning, portfolio optimization, scheduling, energy trading and risk management, market analysis, retail management, price and load forecasting, ISO bidding, settlements and post analysis.

**Demand Response Management** – DRMS. For managing demand response programs and Virtual Power Plants (VPP).

**Advanced Metering Infrastructure** – AMI. For gathering and managing metering data (interval and non-interval). Includes remote reading, and possibly remote control.

Operation Technologies are software applications that provide operational control of assets in the electric network in real time (or near real time). Operational Technology applications can include, among others:

**Supervisory Control and Data Acquisition** – SCADA. For real time data acquisition.

**Distribution Management Systems** – DMS. For managing and control of distribution networks includes advanced applications such as Fault Location, Isolation and Restoration, Vol/Var Optimization, State Estimation, Outage Management Systems (OMS), etc.

**Energy Management Systems** – EMS. For managing and control of transmission systems.

**Geographical Information Systems** – GIS. For mapping and geographical information.
Integration of IT and OT

Historically, IT and OT reside in different parts of the organization. The operations side of the utility is responsible for execution, monitoring and control of the electric system, making sure the network is operating within the allowed ranges of reliability, quality and cost set by the regulations and parameters of the corresponding agencies (i.e. in the United States, NERC, Public Utility Commission, FERC, etc.).

The operations groups have actual control over the assets and infrastructure that is part of the electric network: power generation units, transmission systems, substations, distribution networks, feeders, meters, etc. This control and monitoring is executed via control and protection devices such as relays, circuit breakers, switches, voltage regulators, capacitor controls, and feeder protection. Due to the nature and properties of the electric power systems, speed and precision are fundamental elements within the operations groups (electrons travel very fast and require a balanced equation between load, losses and generation) in order to keep the system “live”, basically complying with Ohm and Kirchhoff's laws, among many others. The decisions that the operations group make are aimed at (in priority order):

1. **Protecting the network** – Prevent a failure that can damage or destroy expensive equipment and infrastructure.

2. **Keeping the “lights on”** – Prevent outages and blackouts by ensuring that electric demand is met.

3. **Reducing cost of operation** – Ensure that demand is met in the most economical way.

These goals are achieved through the use of effective Operations Technology (OT).

The business side of the house is responsible for decision making, energy planning, operations planning, resource and asset allocation, and support of any activities required to facilitate the tasks of the operations group such as trading, fuel nomination, field crew dispatch, customer service, etc.

Decision making at the enterprise level usually involves (directly or indirectly) multiple departments within the utility; for example, sending a field crew to repair a transformer will involve field operations (personnel and vehicles), finance, human resources, inventory/warehouse and customer service (if the maintenance task will affect end customers). The involvement of multiple departments on any given task or decision making process demand a tight integration of systems and applications at the enterprise level that must be provided by a solid and consistent IT infrastructure.

Information Technology (IT) plays a major role in the success of effective decision making at the utility. Data and application integration, business intelligence, hardware capabilities to run complex algorithms and display mapping features, workflow coordination and reporting are some of the elements that IT facilitates to the business groups for efficient operation.
With the advent of Smart Grid, two major issues arise:

1. The need to integrate new types of assets/agents to the electric network and make them “operational ready,” taking into consideration all the complexities of operating interconnected electric systems. These assets can be electric vehicles, demand response programs, home area networks (HAN), distributed generation (including solar panels), and large scale renewable generation (particularly volatile generation such as wind).

2. The need to manage very large quantities of “new” data in near real time that will be available to the operations and business groups within the utility. Data will come from new devices and sensors spread throughout the transmission and distribution networks, metering devices (AMI), recharging stations (for electric vehicles), and home area networks, among others.

Both, the business and operations groups will face significant challenges in terms of infrastructure, communications, business processes and coordination when trying to deal with the two issues outlined above. Now, for the first time, there is a real need to integrate real time operations with business decision making processes and applications. An effective integration of these two groups not only will solve the problems discussed earlier, but more importantly, will transform the utility industry like never before.

The Smart Grid concept promises to increase operational efficiency, reduce costs and be more environmentally friendly by enabling new assets/agents to be part of the electric network. Real integration of IT and OT not only helps fulfill that promise, but enhances the opportunities to add more value and effectiveness to the energy value chain.

Integration of IT and OT brings together real time systems such as SCADA, EMS and DMS with corporate applications such as EAM, EOM, CIS, MWFM and DRMS.
Under Smart Grid we have heard new concepts such as Asset Health Center or Substation Self-Healing; these concepts are possible through the integration of IT and OT. The following describe possible scenarios for applying these concepts:

**Asset Health Center**

Asset Health Center (AHC) is the next generation of Enterprise Asset Management (EAM). Under AHC a utility can run automatically monitoring tasks on all the assets in a substation in near real time using the SCADA system (or similar infrastructure for data acquisition). This data comes into the EAM application. Traditionally, EAM would store and manage asset data and work-related tasks such as maintenance for that particular asset, based mostly on manufacturer specifications of standard maintenance and required work without taking into consideration actual working or loading conditions, connectivity, operational parameters, etc. When near real time data can be retrieved for that particular asset, advanced applications can be implemented to perform predictive maintenance, trending and forecasting of equipment performance. This analysis can determine not only the impact that the asset’s particular performance index is having on the overall system (technical and economic), but also remedial actions that can be taken to improve the asset’s performance. In some occasions, the actions needed to improve the performance in a particular asset are related to another asset or system arrangement.
Substation Self-Healing

Substation Self-Healing (SSH) is the next generation of integrated Enterprise Asset Management (EAM), Mobile Workforce Management (MWFM), Distribution Managements System (DMS) and Substation Automation (SA). With SSH, a utility can automatically monitor, control and operate a substation. SSH has a broad scope, depending on the level of integration and automation. Some of the basic functionality for SSH may include remote control and monitoring, asset management, fault location, isolation and restoration. SSH could allow a utility, through near real time monitoring of asset performance and conditions, to run algorithms to simulate not only current operational conditions, but also future system trending, and predict possible equipment failure or system emergency conditions. Upon analysis of this information, it can determine the course of action to repair or replace the equipment that is predicted to fail (asset and work management and mobile workforce management) as well as generate a network scenario that will isolate the future fault and minimize its impact on end customers. This can be accomplished through feeder reconfiguration or by adding Distributed Generation (DG) or Demand Response (DR) to the resource mix. Customer service would notify the affected customers of the upcoming outage and the estimated time of repair. Once the equipment has been replaced or fixed, the switching scenario is prepared to reconfigure the system back to normal conditions.

AHC and SSH are just two examples of possible features and functionality that can be deployed by using an integrated IT and OT infrastructure. Many more examples and scenarios can be created on expansion of the technologies and agents that will integrate the utility industry. As mentioned before, these new technologies and participants create not only new integration and operational challenges but great opportunities to increase efficiency and reduce costs in the industry.
Smart Grid Control Center

Traditional utility operations have relied on large transmission control centers, responsible for monitoring and control of the transmission and bulk generation system over large geographical regions. Due to the characteristics of G&T systems, these control centers were originally able to focus on “simplified” approaches, such as one line or balanced load flows to analyze the system. Also, these control centers had a relatively small number of control points (injection, interchanges, generation units and transmission substations – usually in the range of hundreds or a few thousand).

Smaller distribution control centers were designed to monitor and control smaller geographical regions, usually metropolitan areas or service territories, with a very large number of monitoring and control points (substations, feeders, distribution and service transformers and meters – usually in the range of hundreds of thousands or a few million).

As Smart Grid takes off, more control points will be added to the network (i.e. electric vehicles, PV, storage, small DG, DR, VPP, etc). These control points, once deployed in a massive scale, will affect not only geographically isolated distribution networks, but will impact transmission systems, interconnections and bulk generation.

A new concept that is gaining momentum is the Smart Grid Control Center (SGCC). Basically it comprises a control center mounted on top of a D-SCADA (or Distribution-SCADA) infrastructure that integrates advanced DMS applications, OMS, GIS, MWFM, EAM, VPP, DRMS, CIS, AMI and EPM systems (including UC/ED and ETRM), which facilitate the operational and business integration of electric vehicles, distributed generation, demand response, renewal resources, virtual power plants and home area networks into the distribution grid.

SGCCs will take the front seat of distribution operations. Traditional G&T control centers will monitor and control interconnections and exchanges between SGCCs. The graphic below describes some of the infrastructure that is part of the future SGCC. The first level from the bottom up represents the electrical infrastructure, including traditional and “Smart Grid-ready” apparatus. It forms a complete level of infrastructure from bulk generation and transmission to end customers, including DR, HAN, AMI, PV and electric vehicles (in blue).
The second level has two main areas: on the left hand side (in green) are the “enablers”. These include the communications infrastructure; protection and control devices (relays, CB, voltage regulators, etc.); NIST standards to facilitate protocols, interfaces and operating procedures; and enhanced security that prevents hackers from attacking an infrastructure that relies more and more on software, communications and interconnectivity. On the right hand side (in purple) are the advanced concepts of Smart Grid such as Asset Health Centers, Substation Self-Healing, Distribution Automation, Virtual Power Plants, etc. These concepts deliver the value that Smart Grid promises. It is in this area where modern business applications increase operational efficiency and reliability, reduce costs, and minimize negative impacts on the environment.

The third level on the top (pink) is the Smart Grid Control Center (SGCC). It is a composite of proven technologies (EAM, CIS, DMS/OMS, MWFM, EPM, AMI, etc.) architecturally mounted on a D-SCADA infrastructure with advanced DMS applications (Unbalanced load flow, VVO, FLIRS, etc.) that allows operators to monitor, control, and operate the electric network in an efficient and cost effective manner while facilitating the integration of VPP, DRMS, PV, Electric Vehicles, Distributed Generation and Renewables.
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