A MODEL-DRIVEN APPROACH FOR SITUATIONAL INTELLIGENCE & OPERATIONAL AWARENESS

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Abstract - In order to design, operate, and maintain an oil and gas facility, one must first understand its behavior. A model-driven engineering and operation solution is required to analyze and identify problems early on and then improve design to ensure further problems are less likely.

Predictive models are already shaping our experiences. They recommend products and services based on our habits. Predictive models of electrical power networks serve as a "digital twin" of the system including network topology, engineering parameters, and other pertinent information with real-time data acquired for depicting the actual operation of the system.

A clear and thorough understanding of the operational system increases uptime and reduces the number of unnecessary shutdowns. Predictive simulation models help engineers and operators increase their understanding of systems in a cost-effective and repeatable environment by offering Situational Intelligence & Automation.

This paper will include the benefits of adding such a system, the challenges that must be overcome and the lessons that have been learned from the implementation of several of these systems. It will also serve as a handbook on justification for a model-driven power management and automation of oil and gas facilities.

Index Terms — Situational Intelligence, Operational Awareness, Model-Driven Design, Predictive Simulation, Digital Twin, Predictive Maintenance, Load Shedding System, Power Management System

I. INTRODUCTION

The Industrial Internet of Things (IIoT) and the Industrial Digital Transformation are the buzzing topics. The connectivity between devices, software, and systems is being rapidly adopted and implemented in the oil and gas process and power operations where increased attention is focused on Analytics of Things (AoT) i.e. operation, safety, maintenance, regulatory compliance, and business intelligence awareness needed to support real-time data-driven decision, prediction, planning, and control.

This connectivity platform is making it even more practical and economical to generate more data. However, the sensors, trends, real-time event-lists and systems behind the scene generate voluminous amounts of data (big data) that outpace our ability to consume, analyze, and make informed and timely decisions.

Most managers, engineers, and operators make daily operating decisions based on instinct due to lack of timely information. Failing to act timely on impending failure of operating assets causes production outages, whereas early detection and appropriate action could prevent compromised throughput, plant safety or unplanned shutdown. Hence, the need for systems to utilize data through the use of predictive simulation models and real-time analytics, which enable a new paradigm of actionable information and decision support to engineers and operators within the production and process facilities.

Furthermore, the demand to take proactive action rather than simply reacting to events after they occur is requiring intelligent applications to provide predictive system simulation, optimization and automation – what we refer to as Situational Intelligence.

The efficient and content specific information exchange embedded with real-time model-driven engineering systems is essential to the operation of the modern power networks; The step beyond analysis and simulation where big data and analytics meet to provide predictive behavior and action together with efficient fault diagnosis and faster recovery times after outages and disruptions.

II. MODEL-DRIVEN DESIGN AND ANALYSIS

Oil and gas owner-operators expect a system for continuous design and operation in all stages of a plant's life cycle - from original concept through specification, design, integration, test, commission and in-service support.

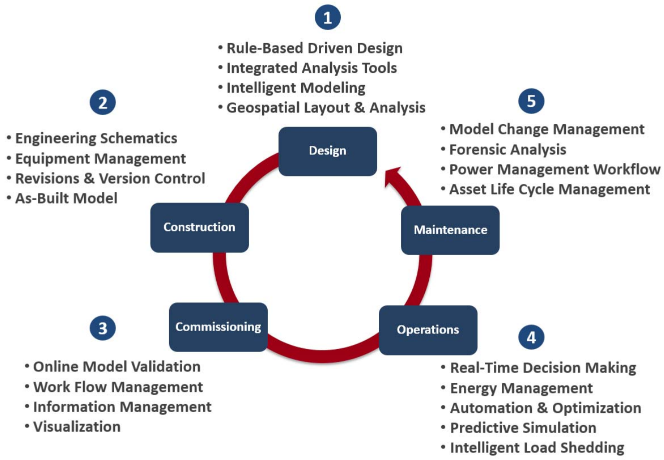

Fig. 1 Electrical Distribution System Life Cycle

This system must deliver complete integration of logical schematic & geospatial topology technologies, intelligent analytics & predictive tools, scalable energy & power management systems, smart automation & remote controls with embedded edge connectivity, mobility & cyber security.

Organizations need a specification common to all teams and open to little subjective interpretation to facilitate collaboration. Further, engineers require the ability to add details and enhancements to the specification as the project progresses, so that it evolves in parallel with the project. With model-based design, these needs are typically addressed by the simulation model, which serves as an executable specification of the system under development. Simulation models help engineers increase systems' understanding in a cost-effective and repeatable environment.

A model-driven approach codifies the engineering design team's intent to ensure that facilities operate precisely as they were intended to, or better. A power system model is the collection of engineering and design data and related interconnections for an oil and gas facility.

Creating an electrical model of the facility offers a centralized location for a system knowledgebase and electrical network assets. The model includes parameters of the electrical components and how these components are inter-connected to form the complete power system layout. To have a complete and updated model is an essential component to lower the risk and cost of engineering, operations and maintenance. Key to this is to minimize equipment failure and improving system reliability by ensuring that all information is instantly available, fully up to date, easy to maintain, and simple to apply to facility design upgrades.

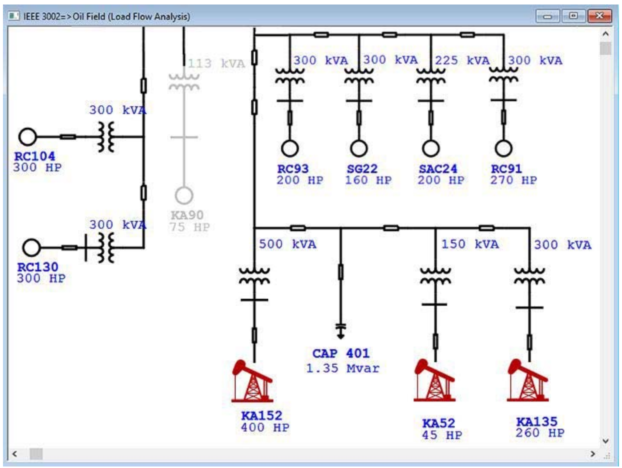

Fig. 2 Intelligent Electrical One-Line Diagram Model

For example, the electrical system model used to design the facility is brimming with details about the topology, capacity, and reliability of the power network that sprawls throughout the oil and gas facility. This data provides a valuable benchmark for understanding the electrical impact of adding new equipment to the facility and safety implications of changes to the system.

The electrical network-modeling platform must have the ability to join independent data and views for the purpose of creating varying design and operation scenarios. These data include engineering parameters (ratings), operational data (loading, generation), network topology (system configurations), and system one-line diagram views.

Furthermore, the model should be able to conveniently realize various data combinations through an integrated database, and to different one-line diagrams and system configurations (status of switching devices). Using this multi-dimensional database and modeling approach allows for unlimited graphical presentations, status configurations, base & revision data, and operational parameters within the same project database.

A well-designed, well-maintained, and clearly documented electrical system model is not only imperative for these reasons, but it is a common regulatory requirement that the electrical system is current and covers issues such as:

- System and equipment loading
- Fault ratings and arc flash analysis
- Switching instructions and safety interlocks
- Effective earthing and controlled step-and touch potentials
- Protection coordination and relay settings
- Transient stability studies
- Load shedding scenarios
- Harmonic Distortion and Resonance analysis

An automated rule-based design tool combined with a model-based predictive analysis platform provide the foundation for a Situational Intelligence solution that transforms information to actionable decisions. Using the predictive model of the system, multi-scenario calculations are performed based on scripted rules and system conditions to generate notifications and output results, which in turn trigger additional runs in order to meet the system design and operational requirements and constraints.

Utilizing the model-driven design approach helps determine the electrical behavior through creating various scenarios that allow the engineer to predict future behavior, analyze expansion projects, or identify improvement opportunities of the power system.

1) The power system model is validated for optimal performance at the outset of the project (power flow, short circuit, protective device coordination, arc flash, reliability assessment, and more).
2) The model continues to function in online mode once the facility is operational, comparing 'as-is' versus 'as-designed' data.
3) The model serves as the basis for real-time simulations and 'what-if' studies, e.g. capacity, upgrades, faults, reliability, etc.
4) As the facility evolves over time, the model can be easily updated to serve as a digital asset repository i.e. digital twin.

Hence, an integrated model-driven system becomes essential for sustainable and safe operation during the complete life cycle of the electrical distribution system.

III. INTELLIGENT MONITORING AND PREDICTIVE SIMULATION

A. *Intelligent Monitoring and Visualization*

Utilizing the electrical system model synchronized with real-time operating data via interface with metering devices, data acquisition, and archiving systems serves as the foundation to accurately monitor, visualize, analyze, operate and maintain the facility. Such a platform must include an embedded SCADA layer or be capable to provide a reliable operation interface with the existing data acquisition systems.

In addition, the indication of abnormal conditions is an important function of a power monitoring system. Alarm and warning schemes provide immediate signals for abnormal parameters, including critical areas in the facilities that are not directly metered. Dedicated Human Machine Interface (HMI) views, thin-client dashboards and web-enabled reports provide operational parameters and effectiveness of new energy saving projects.

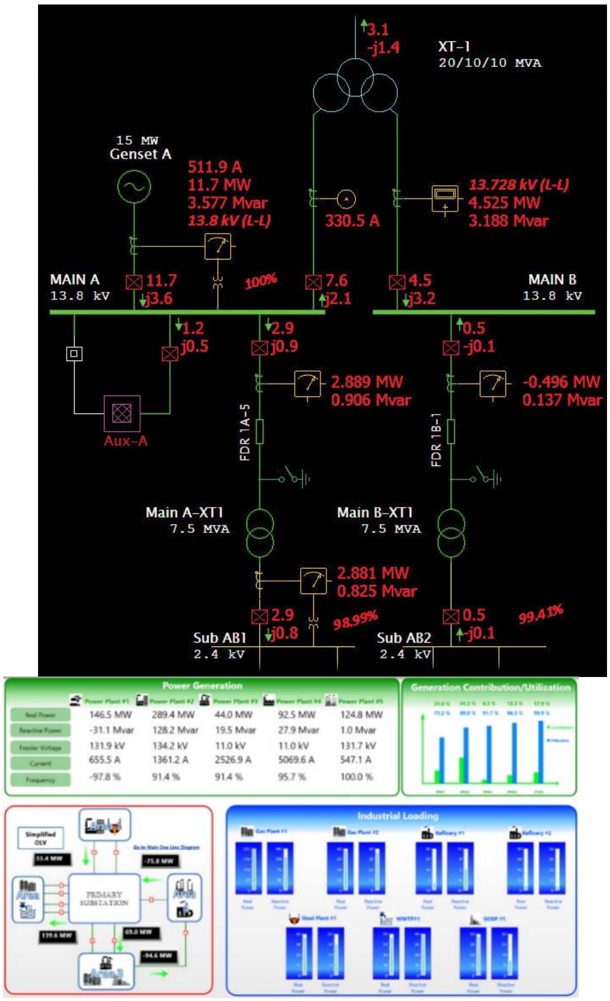

Fig. 3 Electrical SCADA & HMI Views

The model-driven power management system must extend the traditional data acquisition systems to an intelligent and reliable power management solution for operators, dispatchers, engineers, and decision makers. It should contain modular applications that can be tailored to fit the needs of small to large power systems.

B. *Predictive Simulation and Analytics*

Unplanned downtimes and outages can be disastrous and costly ranging from $ 1M a year for a mid-size facility to over $60M for a large oil and gas facility. The operator must have first-hand experience with the system under various operating conditions to effectively react to changes. This will avoid the inadvertent plant outage caused by human error and equipment overload.

The ability to use real-time and archived data to predict the system behavior in response to operator actions and/or system disturbances and events is a powerful capability of a model-driven solution.

System engineers and operators must have instant access to energy information and analysis tools that allow them to predict an outcome before actions are taken on the system. The ability to perform system evaluation and simulate "what-if" scenarios using real-time operating data on demand is of fundamental importance in order to avoid inadvertent plant outages caused by human error, equipment overload, etc. Some examples of online simulation and practice analysis include:

- Start of a motor or group of motors for determining the impact in the electrical system.
- Energize/de-energize feeders (steady state and dynamic).
- Check for short-circuit and arc flash levels under existing operation.
- Evaluate sequence-of-operation of protective devices under existing configuration of the network and validate settings.
- The ability to simulate the sequence-of-operation using real-time data.
- Build, simulate, and verify a complete switching sequence using a graphical user interface and execute the approved switching scheme in one-step while maintaining compliance with safety and security procedures.
- In locations with limited power supply, by combining electrical with process data, the operator can simulate and determine which systems to run, in order to maximize the use of available power for maximum production.

The model-driven power management system shall be capable to function as both an operator workstation to monitor, simulate, and control power systems and an engineering workstation capable of performing system studies. It should be set-up to automatically and continuously acquire measured data, perform the appropriate performance monitoring, predictive simulation, and/or optimization calculations, and store the results in a historian (data logger) system.

Similarly, if an overload condition is detected, the plant operator would be notified and have sufficient information to interrupt any non-essential loads; or the operator could allow the power management system to automatically take control after a predetermined amount of time. This would prevent any essential loads from tripping. If a trip occurs, the maintenance personnel would have sufficient information to locate the overload, magnitude of the overload and the plausible reasons for the overload. This develops better troubleshooting methods, reducing any future downtime. Such preventive analytical capability provides automated alarms and warnings to the operator, based on events that may potentially occur such as generator outages, contingencies, and suggest remedial actions.

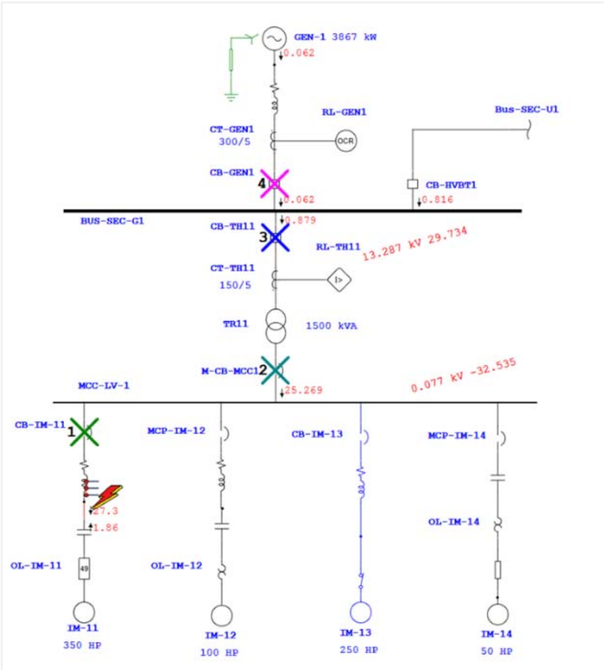

Fig. 4 Predictive Simulation

C. *Operator Training Simulator*

The system must provide virtual testing of operator actions (predicting system response) prior to implementation to reveal potential problems, hence reducing human errors, minimizing the risk of service interruptions, and improving reaction time during emergency situations. The system shall be capable of assisting the operators in making informed and logical decisions to reduce operating costs and improve system reliability. Such a system must also serve a training environment that is effective for operator training and assistance, i.e. Operator Training System (OTS). Operator training is accelerated using dynamic graphical and interactive simulation of the power system. Analytical applications allow pre-configured scenarios to be assessed and analyzed to deliver real-time predictive simulations and decision solutions as well as provide a platform to accelerate the traditional training method and to make the training an ongoing process.

IV. FORECASTING AND RISK ASSESSMENT

A. *Event Playback*

The ability to recover from a system disturbance depends on the time it takes to establish the cause of the problem and take remedial action. This requires a fast and complete review and analysis of the sequence of events prior to the disturbance. This situational intelligence tool can assist operation staff to quickly identify the cause of operating problems. Such a system should also be able to reconstruct exact system conditions to check for operator actions and probe for alternative actions after-the-fact. This important tool serves as an on-going learning process for the operator. Forecasting system response will eliminate errors and system downtime. The system should be configured to allow the operator to re-play previously recorded message logs while controlling the playback of archived data to re-run at original or accelerated speeds.

The ability to playback historical events is especially useful for root cause-and-effect investigations, improvement of system operations, identification of potential security vulnerabilities related to the electrical network, and exploration of alternative actions via replay of operating scenarios.

This platform shall be capable of being configured to provide a complete picture of the electrical system from the stored data. This includes playback of a previously recorded monitored data, calculated system parameters, sequence-of-events, protective device actions, and message log. Features such as Event Log, Playback Historian and Playback Console can utilize archived data for forensic investigations, improvement of system operations, exploration of alternative actions, and replay of "what-if" scenarios.

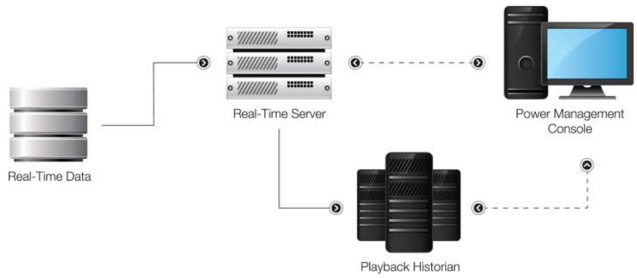

Fig. 5 Event Playback and History Architecture

Given the architecture of a model-driven solution, the historical data are seamlessly transferable without the need of import\export files to the simulation and analysis modules.

B. *Predictive Maintenance*

Maintaining production uptime and reducing operating and maintenance costs are key drivers in the oil and gas industry. Studies by the Electric Power Research Institute (EPRI) show that the annual maintenance cost per horsepower can be reduced by up to 50% using predictive maintenance.

Alerting the operator when the equipment is operating outside its normal range can provide sufficient time to react and correct the problem before an unplanned outage occurs. Based on the severity of the alert, engineers and maintenance personnel will be able to make sound decisions as to whether it is appropriate to correct the problem right away or to postpone the correction until a planned maintenance outage. This is the concept of "predictive maintenance" that allows personnel to strike a balance between safety, plant uptime and operating cost.

V. OPTIMIZATION AND AUTOMATION

Intelligent monitoring is the base of the power management system. Besides improving data gathering capability and real-time prediction of system response, the model-driven solution is used for reducing losses and determining where energy supply and demand can be optimized. The monitored data and collected information are used to provide supplemental automation via user-defined actions that can be added or superimposed on the existing system.

Features of supplemental automation must contain the following controls:

- Automatically determine the loading requirements and manage the loading demand for each operations unit.
- Switching sequence and work order management to verify whether the sequence is compliant with safety switching procedures and requests confirmation during execution simulation of each step before proceeding to the next step in order to avoid inadvertent actions.
- Based on the generation cost, availability, efficiency curves, determine the amount and mix of available distribution energy resources (DER) needed to run the facility without an unnecessary amount of power abundance.
- Load preservation via load curtailment application that monitors system's conditions and makes decisions about when and how load shedding will be required.

This intelligent load shedding application then executes the desired optimal strategies and performs the controls necessary to shed the minimum required load.

A. Fast Optimal Load Shedding

Load shedding systems serve as the ultimate guard that protects the power system from an overload-induced collapse. Often, this critical load preservation is done with the use of under-frequency relaying, and PLC-based schemes. Common drawbacks of these schemes include the lack of detailed pre- and post-disturbance data, online system topology, type and duration of the disturbances, and other pertinent information.

A model-based load shedding system that combines online data, equipment ratings, user-defined control parameters, and a knowledgebase obtained from power system simulations can continually predict and update dynamic optimal combinations of loads to be shed based on the type and location of the disturbance. The system shall be capable of fast load shedding that can dynamically manage the stability of the system. It shall calculate the minimum required MW to be shed for the entire electrical network and per each islanded subsystem according to the type and location of the disturbance, actual operating generation, spin reserve, loading, configuration, load distribution, and process and operator priority.

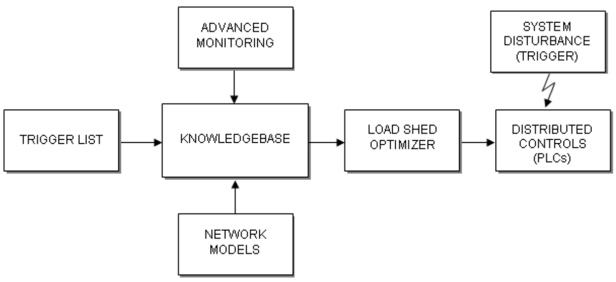

Fig. 6 Model-based Load Shedding Scheme

The intelligent load shedding shall be capable of selecting the best combination of loads that will satisfy this requirement. System response to a disturbance shall be virtually instantaneous unless configured by the system engineer due to process constraints. Steady-state conditions such as overloads shall be handles after user-defined time delays as configured.

The intelligent load shedding system must have the features to continuously predict system response if they were to happen at that particular instant in time. Its predictions shall be monitored continuously from any of the power management consoles. Data shall be displayed through the HMIs and dedicated dashboards as well as through the one-line diagram.

The system operator shall have the capability of utilizing real-time and user-definable data to perform load shedding simulations and be able to override analog and digital data for simulation purposes. A unique advantage for this model-driven load shedding system is the ability to transfer the load shedding simulation results to transient stability analysis application for validation of the shedding schemes under various conditions and triggers/actions.

Lastly, the intelligent load shedding system shall provide the capability to change the load shedding priority, logic, and schedules easily and directly from the power management and engineering consoles with user-friendly interfaces.

VI. LESSONS LEARNED AND EXAMPLES

A. Integrated operations

An important part of integrated operations is the ability to share data between operators on the oil and gas facility and supporting engineers located elsewhere. This could be experts from the operator company, vendor experts or others. These supporting engineers would benefit from being able to do calculations (short circuit, motor start, etc.) on the system as it is operated in real time. Normally, this means that the supporting engineers will need to configure a digital model manually and perform the calculations, something which in practice is seldom done due to time constraints and the effort of configuring the model. With a real time model being readily available, the on-demand analysis can be performed by support engineers using important actual online information about the operation of the electrical system.

B. Warranty claim documentation

If electrical equipment fails within the warranty time, it is sometimes difficult to document that the equipment has operated within the technical requirements set out in the warranty agreement. The vendor may claim that the harmonic distortion has been too high, or that settings of protective devices have been wrong, etc. Having a real time model of the electrical system together with historical data storage and event playback functionalities will aid the support for the claim.

C. Early fault detection

A real time load flow program on an oil and gas facility reported that the measured current in a circuit breaker was different from the calculated current. It was quickly observed that the breaker had an "Open" status, which caused the load flow program to calculate zero current. At the same time, the measurement showed a small current through the breaker. The breaker was controlled and was found to be very hot. After examination of the breaker, it was found that the breaker had not moved to the complete open position but was stuck in an intermediate position with arcs burning over the breaker gap.

At another oil and gas facility, a pump motor had a sudden and unexpected small increase in the electrical load in the medium voltage motor driving the pump. The load increase was too small for the motor protection to trip the motor. This motor was expected to run with a very stable load and thus the motor was examined. It turned out that the bearing was damaged. The motor bearing would likely have failed catastrophically had the motor not been stopped, controlled and repaired. The early warning made it possible to repair the motor at low cost and short downtime.

D. Debugging and validating the electrical system

An important lesson learned is that a real time system is a must-have when a facility is new and still has small “bugs” in measurements and instrumentation that the commission crew did not find. A few examples:

- A temperature sensor in a motor had a loose wire, which caused the measurement to be intermittently incorrect/wrong. The real time system correlated the motor temperature with the current in the motor, giving alarms when the measurement was wrong.
- A current measurement in a UPS had “frozen” and did not change. The real time load flow calculation system compared the measured current with the calculated current and issued an alarm when the difference became too large.
- While performing an installation at a site, and bringing the real time system online for the first time, it was noticed that many of the circuit breakers were turning “red” (in alarm state) on the electrical one-line HMI views. When checking the analysis alarms, it was identified that those breakers were in fact undersized. The continuous current capacity of the breakers was being exceeded due to additional loads in the process.
- At a facility where a real time model was not in operation, a differential protection unit was not properly connected to the current transformers of an intertie cable between two offshore platforms. The faulty connection did not cause trip in the “normal power flow” direction but tripped the cable when the power flow direction reversed. The real time calculation system would have found the erratic behavior of the measured values and the faulty connections could have been corrected, had the real time system been in operation.

These types of problems are difficult to identify unless a model-based system is continuously evaluating the capacity of all components in the model using real-time power flow analysis.

E. Maintenance

More operators of oil and gas facilities want to change the maintenance practice from time-driven into corrective or predictive maintenance. The idea being that this gives longer operating periods between maintenance. Hence, higher production in the facility and lower maintenance cost. In order to do this, it is essential that the condition of the equipment and the total electrical system be monitored.

By implementing a real time system, it is possible to monitor the equipment and system continuously and have a good decision basis for performing maintenance on electrical equipment. If measurements, real-time calculations and state estimations are used together, the maintenance engineer gets a much better basis for planning maintenance on equipment and systems.

Real time electrical model driven systems are used for this purpose and are especially useful when combined with measurements and model-driven real time systems that incorporate vibration, temperature etc. in the equipment.

Intelligent monitoring is a powerful tool to assess the decline in the projected lifespan of an asset by measuring and comparing the initial “electrical footprint” of the equipment when it was first installed and comparing it with the operating “electrical footprint”. When using systems like Electrical Submersible Pumps to extract crude, this information can enable the operators to plan rig times and replacement units in order to minimize the downtime of their production.

F. Energy management

The demand by operators of oil and gas facilities to improve the system energy efficiency and performance, by implementing Energy Management according to ISO 50001, is on the rise. In some countries, this is already mandatory. This standard requires an organization to document that they improve their energy performance continuously. In order to do so, it is essential that the energy use be monitored on a detailed level to determine how much energy is saved when an Energy Improvement Opportunity is planned and implemented. The ISO 50001 methodology (the Plan-Do-Check-Act circle) is almost dependent on the electrical system being monitored and calculated in real time.

Further, fuel consumption (and hence, cost and CO_2 emissions) can be reduced if the generator operation on a facility is optimized in real time. It is not uncommon to have several different types of generators and driving machines (gas turbines, steam turbines, diesel machines etc.) in one facility. Solar and wind power is also used today, and the use is expected to increase in the future due to the declining cost for such power sources. The differences in efficiency, fuel cost, emission cost etc. for the different types of power, and the stochastic behavior of renewable sources like solar and wind, makes it almost impossible to operate the power sources manually in an optimal way. However, a real-time model of the electrical system, together with online information of fuel types and energy costs, can do such an optimization automatically.

G. Real time arc flash calculations

Arc flash calculations are typically performed for “worst case” scenarios in an electrical system. This typically includes assumptions such as: All generators are running, all motors are running and the power grid (if grid connected) is operated in the maximum short circuit mode. This is however a very rare operating mode. If a real time model- based system is used, the operators can determine in real time what the arc flash energy levels are, what personal protective clothing and equipment to wear and what safety distances to meet.

If the calculations show high arc flash values and the operator wants to lower the values before work is being done on live equipment, the operator can take the real-time model off line and make changes in order to see how the arc flash level is reduced. For instance, the changes could be to take a generator off line, to split the system into two smaller systems, taking transformers or distribution feeders out of operation or stopping some motors, if possible. The operator will then see exactly what is needed in order to reduce the arc flash energy to a required level.

H. Operator training

It is mandatory for airline pilots to train on a simulator. Such simulator training is also being used in the oil and gas business, but typically only for control room operators monitoring and operating the process. The operators (electrical / process) typically receive no such simulator training. It is not uncommon that operators make mistakes, especially in stressful situations like emergencies. However, rare operating modes, which typically is the situation during maintenance or modifications, also results in misunderstandings and operators making mistakes. It is essential to train the operators before such operating modes occur, and a model-based system is very useful for that. Even more so if the system communicates with the actual electrical system in real time.

I. Incident investigation

Whenever an electrical fault happens in a facility it is important to investigate the incident and verify that the protective devices, Power Management System, generator controllers etc. have performed as they are supposed to. However, this is often much more difficult than expected. For instance, the difficulties are:

- The actual operating situation is unclear. (How many generators were running? How was the system configured? What was the load? etc.)
- The alarm lists come from different sources and the time stamping is not always synchronized
- The tripping curves stored in the protective devices are not taken out and stored (caused by the confusion that followed the trip)
- Unclear or contradicting information regarding the incident from operators

By implementing a model-driven real time system with data logging and playback functionality it is possible to scroll back in time when/until the incident happened and see exactly how the system was configured, the loads etc. If this system also stores the tripping curves from the protective devices and further logs the power quality etc., the system engineer will quickly understand the sequence of events and can perform calculations of short circuit currents at the time of the incident and dynamic calculations that show how generator controllers etc. behaved.

J. Power quality vs. real time electrical calculations

It is common to have power quality meters installed in oil and gas facilities. These instruments typically measure harmonic content in the voltage and current, voltage dips, flicker etc. These measurements have much more value if they are correlated with the actual operating mode of the electrical system and real time calculations. The power quality in an electrical system will typically vary with time. In order to understand what is causing high harmonic distortion etc. it is essential that this be investigated on a system that stores the operating status in a database and that it is possible to scroll back in time, see how the system was operated and do necessary electrical calculations on the system at the given time.

If a harmonic filter is necessary, it is very helpful to have a full history of the actual operating status of the electrical system together with actual measurements of the power quality.

K. Monitoring and control of systems with different brands of control equipment

If a facility (or group of facilities) has different brands or models of control equipment, the complete operation of the electrical plant is often difficult. We try to solve the problem by sending a small amount of data between the control systems. However, the operator on one facility does not have complete information regarding the status of the other facilities. A modernized real time model driven system is completely independent of the brand and model of the control system. Hence, it can incorporate a complete model of the complete electrical system across all facilities. This makes it easier for the operators and supporting engineers to have complete control of the electrical system and avoid mistakes and wrong decisions.

This becomes essential as more and more intertie cables are installed between offshore installations.

VII. CONCLUSIONS

A modern power management system requires new techniques and innovative technology to allow continuity of the electrical system model from design to operation. Unlike a traditional power management system that does not consider nor recognize power and process network interdependencies, a model-driven power management system combines electrical and non-electrical data, model, analytics, prediction, optimization, and automation.

A smart power management system should have the capability to integrate an active blueprint of the system including system topology, engineering parameters, and other pertinent information with time-synchronized data acquired for depicting the actual operation of the system.

Extending the power management system by equipping it with an appropriate electrical system context, prediction simulation modules, and event playback routines will provide the system operator and engineer with a powerful new set of tools. Using these tools, the user can accurately predict the behavior of the electrical system in response to a variety of changes. The event playback of recorded message logs into the simulator-equipped monitoring system provides the operator with an invaluable means of exploring the effects of alternative actions during historical events. Simulation techniques readily extend into power system control and can be used to perform system automation, control, and load shedding functions.

Finally, all of these capabilities should be included in one application with the flexibility and compatibility that allows the owner-operator to expand and upgrade the power management system based on the facility growth and process changes.

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IX. VITA

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