An Integrated & unified model base approach from design to operation & optimization of power system

Metodología Unificada e Integrada desde Diseño a Operación y Optimización de Sistemas de Potencia Eléctrica

Shaikh Sahid Hossain, *Member, IEEE & Tanuj Khandelwal, Senior Member, IEEE*

Abstract-- With the growth of power system and the maturity of the utility and movement towards smarter grid gives the birth of lots of innovative technologies and applications. Verities of solutions, systems etc. and their respective humungous amount of data, multiple operating system and different data base etc. creates the non-uniformity of usage and differences in data sharing within utility groups hence the challenge in integrated system approach. Traditionally the operational system uses electrical models/data base that differs considerably in detail & structure from the models used during the design and planning stage. Linkage between different models, mapping applications, operational systems etc. are typically not being maintained. Hence the incompatible and different data formats in turn creating the differences in design, engineering, planning, operation & maintenance group and cost in millions of dollars for every upgrade, addition of network, maintaining the system and improving the system for optimization and smarter grid.

Thus there is need of unified approach. This paper describes and examines the complete cycle of power system implementation (from design, planning, GIS, operation, maintenance, optimization, CIS etc.) with unified electrical model & data base approach. The major objective is to have the similar technologies involved at this stage with the one network model sharing approach from power system off line analysis to real time environment for SCADA, Smart Grid, DMS applications by interfacing with GIS & other mapping tools. This will also make the availability of electrical asset at all level. Use of the unified model base approach for the smart grid with real time power analytics solution in DER environment empowers the engineers and operators for taking the right supervisory decision and optimization of electrical system.

Keywords: Power Management, E-SCADA, Model, Smart Grid, DMS, Power Analytics

Palabras Clave: Gerenciamiento de Sistemas de Potencia, SCADA Eléctrico, Redes Inteligentes, DMS, Análisis de Sistemas de Potencia.

I. Introduction

With the ambitious efforts of deployment of the smart grid across the globe with the conventional grid and integrating the newly developed renewable sources and elements like microgrid, a zero-net energy commercial building, Plug-in (Hybrid) Electric Vehicles (PHEV), a wind farm or solar panels etc. puts questions on the data interpretability and ease in integration to realize the objective of a smarter grid. This creates a vulnerable availability of various newer technologies, solutions, platform, interfaces, standards, operating systems, SCADA, DMS, EMS, SAS, Real Time Analytics, decision making tools, M2m, MDAS, GIS etc. with the chaos of mix and match the designer, contractor, engineer, planner, protection, operator, maintenance, asset management etc. falls under the trap of multi-product mix within the utility/industrial Power system.

This aim of this paper is to introduce the unified and integrated model based enterprise solution which provides unified model across different process and stake holders for ease in design to maintain the power system. Also this paper describes and examines the complete cycle of power system implementation (from design, planning, GIS, operation, maintenance, optimization, CIS etc.) with unified electrical model & data base approach. The major objective is to have the similar technologies involved at this stage with the one network model sharing approach from power system off line analysis to real time environment for SCADA, Smart Grid, DMS applications by interfacing with GIS & other mapping tools. This will also make the availability of electrical asset at all level. Use of the unified model base approach for the smart grid with real time power analytics solution in DER environment empowers the engineers and operators for taking the right supervisory decision and optimization of electrical system.

- Emphasis on Power system modelling on design environment
- Integration of Model with GIS for Geospatial view and analytics
- Graduating the as-built model with GIS from Design to Operation
- Operating on top of the electrical GIS model for supervisory control
- Maintenance support & Electrical Asset Information
- Optimization with Power Analytics

II. The Challenge & Deficiencies in Current Practice

The below are the daily challenges and deficiencies seen in the operating conditions:

- Traditionally, Real-Time systems such as SCADA, PMS & DMS use power system models that differ considerably in detail and structure from the models used for offline studies, Analysis and planning

Shaikh Sahid Hossain is with ETAP Automation FZ-LLC (ETAP) DIC-1, Suite 207, Dubai, UAE (e-mail: Hossain.shaikh@etap.com).
Tanuj Khandelwal is with ETAP/OTI, 17 Good Year, Irvine, CA, USA (e-mail: Tanuj@etap.com)

- Linkages between the different models at various stages of projects are typically not maintained, and the different models often have incompatible data formats
- Power system models for real-time systems are typically much simpler than the corresponding representations for offline power flow and dynamics studies
- State estimation is required in order to predict missing measurements.
- Systems that use model calibration methods are ineffective for majority of practical power networks since limited measurements are available
- Identification & automatic filtering of errors in source of measurements
- Different stake holders in the project cycle have spate tools for modelling, engineering, analysis, operation & maintenance hence the chaos of data base incompatibility

In summary there is no fundamental approach for interoperability in single system which can provide the conception to the inception of production. Hence this paper approaches on linking the tools and tackles used at different stages of the project for a unified and integrated model based approach.

Successful power systems engineering projects start at the design stage. Because of the opportunity afforded by "model-based" power system analysis, the choice of a modeling and analysis platform is now a strategic decision with substantial long-term implications. In the model-based world, the one-line model – and all of the intelligent devices within in – functions as a synergistic "ecosystem" of shared data and resources.

III. Description of Electrical Model

Electrical model is a user-friendly intelligent single line diagram interface for creating and managing the network database used for schematic network visualization. The purpose of the model is to supply in concise from the significant information about the system. Traditionally, the importance of different features in a single line diagram (SLD) varies with the problem under considerations, and the amount of information included in the SLD, depends on the purpose which the diagram is intended. For instance, the location of circuit breakers and relays are unimportant in doing a load study. Similarly showing the CT/PT, line, cable, node etc. are unimportant in a SCADA/PMS/DMS system. This is the birth of various model used for many application like planning, study to operation & maintenance.

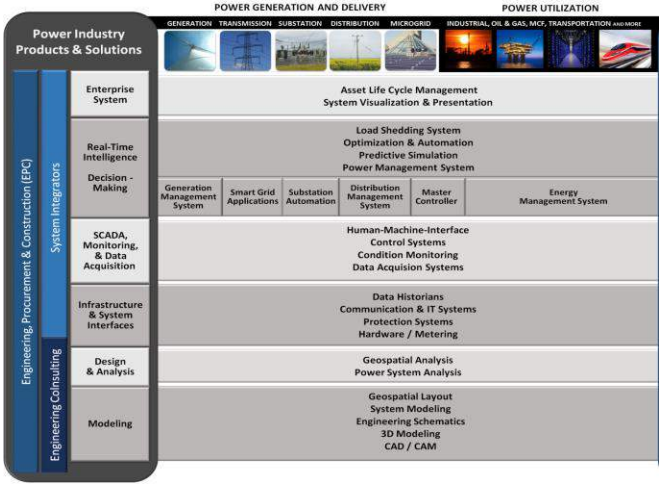
However the aim of this paper to define the structure where the users can interactively create, analyze, monitor, operate and manage the electrical network as well as execute simulation scenarios, analytics and analyze their results in a simple and intuitive manner in one unified model and database.

IV. Explanation on Project Cycle

Project Cycle	Development Environment
Design	• Intelligent Modeling Environment • Integrated Analysis Tools • Rule-Based Driven Design • Geo-Spatial Data base
Construction	• Engineering & Schematics • Equipment (Load, Cable, etc.) Management • Revisions & Version Control
Commission	• Information Management • Work Flow & Permits • Records Management
Operation	• PMS/EMS/SCADA - Real-Time • Simulation & "What If" Analysis • Automated Optimal Control • DMS & Smart Grid
Maintenance	• Asset Management • Power Management Workflow • Emergency Recovery

In the different project cycle various responsible stake holders get involved from consultant, FEED engineering contractors, EPC contractors, Switch Gear Manufactures, Power Automation Solution provider, then operator & maintenance team. Among the different stake holders, various teams will further engage on execution of the project such as planning, engineering, designing, constructions etc. With the various people involvement it's merely possible to manage the common data base and one single electrical model from start to end. Unless a process and unified solution is being proposed which not only full-fills the unified and integrated model approach but also have rich suite of operational applications and design algorithms.

V. Application Mapping at Each Cycle of Project



At each cycle the various applications are required as per the above mapping. Thus it's creates multi data base and multi-layer of information. This also complicates the data and model management by all the parties involved in the project.

Thus the need is to have the unified model for ease in design, engineering, analysis and operation.

VI. Approach to Have a Verified and Validated Model

The first thing towards providing an integrated and unified electrical model from design to operation needs a verified and validated model.

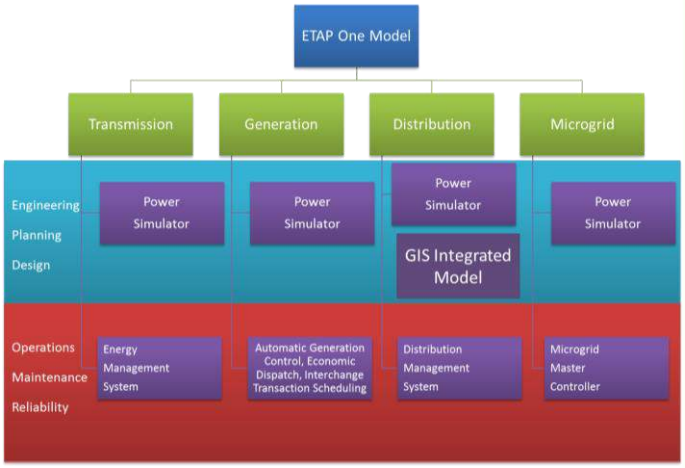
- Planning and operating decisions are based on the results of power system simulations & analysis
- Optimistic models can result in under-investment or unsafe operating conditions
- Pessimistic models can also lead to unnecessary capital investment, thereby increasing the cost of electric power
- Realistic & validated models are needed for ensuring reliable and economic power system operation. Hence it is a very crucial phase
- Validate the network model with real-time and/or archived data in order to prepare a benchmarked model used for:
  - Designing, analysis & expansion
  - State estimation & load distribution
  - Monitoring & Control
  - Predictive simulation "what-if"
  - Forensic analysis
  - Global Optimization
  - Proactive contingency analysis & Remedial Actions
  - Embedded Real Time & Historical Power Analytics
  - Model based Automated operation
    - PMS
    - SCADA
    - DMS
    - EMS
    - Smart Grid
    - EMCS
    - SAC
    - SCMS etc.
  - Integrated Asset Information
  - Maintenance Management
  - Used for future planning & expansion
- Observe, Measure, Analyze actual behavior to understand system behavior
- Engineering judgment and generally accepted practices applied to:
  - Measuring or testing components or systems
  - Selecting component models
  - Determining component model constants
  - Tuning the overall system

Validation means confirming that the simulated response (whether for a component or the overall power system) to a disturbance (steady-state or transient) reasonably matches the measured response to a similar disturbance

VII. Migration Journey from Design to Operation with Unified Model

With the approach of ETAP enterprise solution which provides the fundamental applications into the control, protection and management of future power systems with unified approach. Figure 1 provides major strategies through Electrical Transient and Analysis Program (ETAP) enterprise software to graduate from design to operation in a verified and validated model used from design to operation.

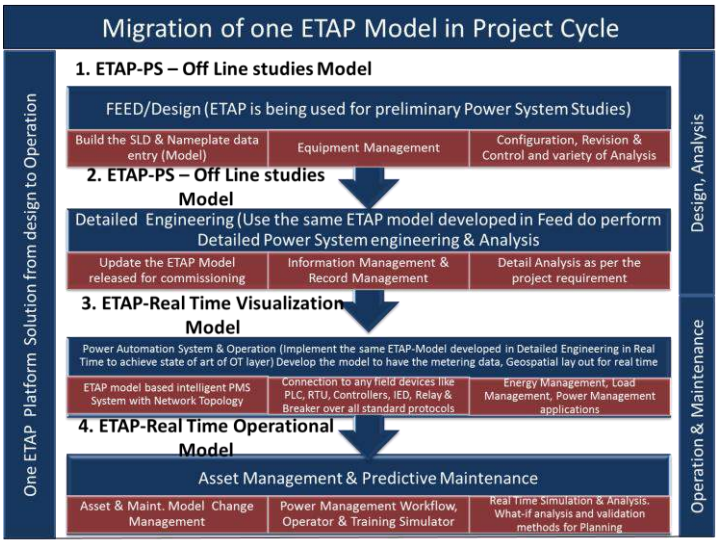
The above picture shows ETAP one model approach from intelligent modelling to power system network analysis to protection coordination, transient and finally graduate to operational environment for EMS, PMS, DMS, SCADA etc.



The approach shows the conventional off line power system studies model graduating to the real time operational model by connecting to the existing automation infrastructure or directly with the filed devices to realize the state of art of operational application.

VIII. Step by Step Approach on the Migration

The below figure shows the process flow and conversion of design model to operator and maintenance model with integrated system. The model keeps on updating at each level.

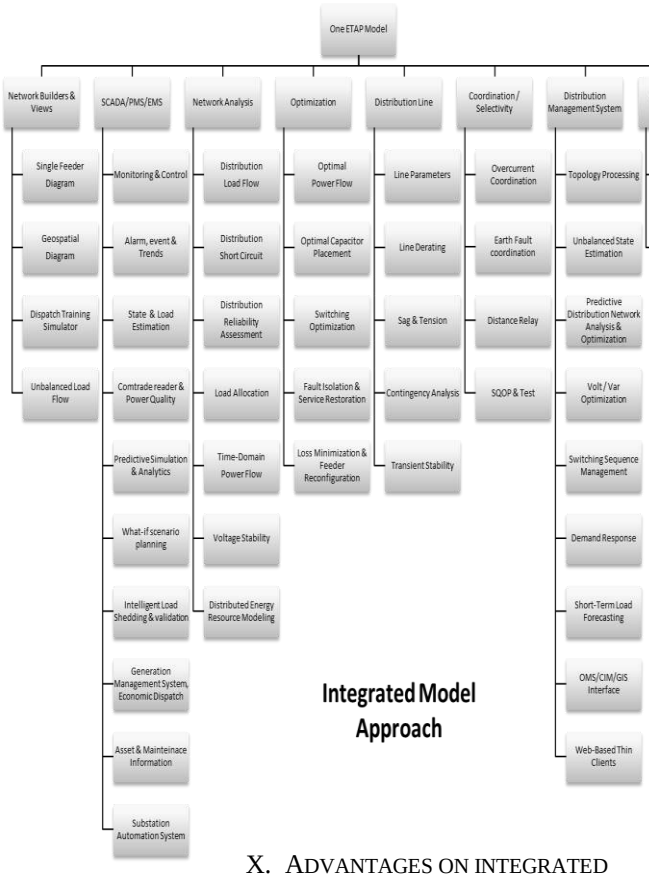


Some of the crucial steps are defined below with the methodology:

1) Model gets generated with inception of the project
2) Same gets updated at detailed engineering level after all studies being completed
3) Model gets created per the industry either as SLD format, equivalent circuit model or geo-spatial diagram
4) The same model gets updated with all the field communicable devices such as breaker, relay, meter, CT, Pt, bus, transformer, sensor etc.
5) The updated model with field devices gets mapped to the actual device for real time data monitoring over various communication protocols
6) Simplified operator views will be created per the project requirement on the same model
7) With the sophisticated operational algorithms the power automation objectives are run on the model to achieve the functional requirements
8) Along with the components characteristics the system also analyzes the reliability and maintenance requirement

Thus by the above explained steps one model gets into various phases by various department to achieve the project objective while maintaining the integrated and unified model approach with high engineering accuracy with less efforts.

IX. Application Mapping in One Model Approach



X. Advantages on Integrated Model Based Approach

With the integrated model approach the below advantages could be realized by an engineering construction, consulting & operating company:

- Avoid duplication of data
  - Data is in one location
  - Eliminates man-hours spent synchronizing multiple databases
- Common Graphical Interface
  - Engineers and Operators can become familiar with each other's requirements
  - Eliminates duplicate graphics - CAD, SCADA, Analysis Tools
  - GIS, underground cables, protection, dynamic controls, substation grounding, renewables, distributed generation, logical single line diagram, AC & DC networks
- Connectivity with Real-Time and Built-in Real-Time Applications
  - Complete network predictive simulation can be performed at any combination of system voltage levels
- Reducing IT Burden
  - Managing multiple licenses and software's
  - Integration or Data Adapter maintenance

- Improved operations by close integration of Operational tool with Power Analytics
- Increased operator efficiency with one system, eliminating the need to go to multiple systems with potentially different data
- Integrated security analysis for substation and circuit operations to check for tags in one area affecting operations in the other
- Streamlined login and authority management within one system
- Simplified data engineering via coordination of SCADA point and GIS data changes

Furthermore the below advantages will be realized:

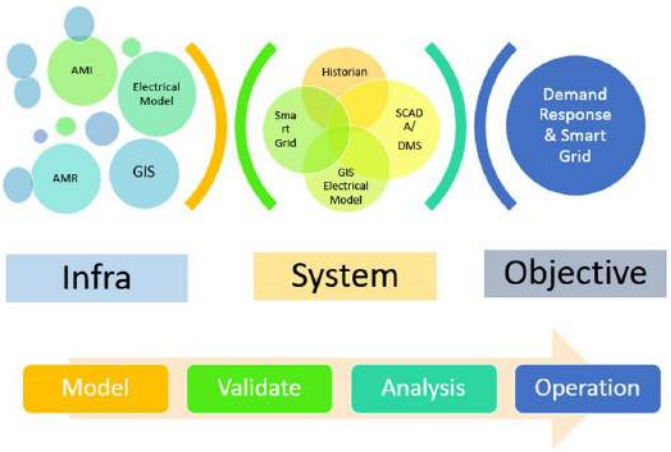
- Bring your designed offline model and integrate with Automation infra for PMS functions with less effort and have the up to date model
- Perform Predictive analysis viz. Load Flow, Short Circuit, Relay Co-Ordination, Transient Stability with online data from the field
- Monitor power system performance & assets for stable operations
- Get to the root cause of process interruptions with historical data with the flexibility to see them in a digital play back mode
- Predict & prevent events before they occur
- Reduce the engineering Man Hour for developing the accurate models and networks as those are readily available from design.
- Support to the operation and maintenance team with switching procedures, work order management, energizing & de-energizing the components/feeders
- Conduct "what-if" analysis for better operation and optimization in cost
- Captive generation at plant then you can conduct the Automatic Generation Control to calculate the demand supply gap and tune your governor and exciter accordingly
- Future expansion power system study will be seamless
- You would have the entire plant's electrical asset information available with their physical and real time attributes
- This will help to achieve the uniformity of operation within your organization from design, engineering, operation, maintenance till finance etc.
- You could always update the advisory mode to Supervisory mode for control operations and achieve the functionalities like: ILS, control, AGC etc.
- Achieve the maintenance information
  - Empower operator with validation tools
  - Operator & Training simulations
  - Decision based on the power analytics
  - Validation of action peace of mind
- SCADA, DMS, Smart Grid & Microgrid operations with the domain knowledge based on model
- Always having updated electrical network information of the plant/facility
- INTEGRATION OF DEPARTMENTS

XI. CONCLUSION

With the approach of integrated and unified model based system from design to operation the biggest benefit is the peace-of-mind of knowing that operational unprecedented predictive analytics and simulation capabilities are at work around-the-clock, protecting you from power problems, even issues that are far in the future.

With one suite of design & operational tool that offers a fully integrated enterprise solution. Through design, analysis, continuous monitoring, simulation, and optimization of electrical, process, manufacturing, and management systems that are in place, this unified model approach with system software can maximize the entire production process, reduce losses, and increase profits.

Using a model based design & Power automation software allows the users to extend the traditional data acquisition systems to an intelligent power software solution for operators, dispatchers, engineers, and decision makers. The robust and proven analysis algorithms combined with portable and flexible foundation provides a highly available Power Automation system, comprehensive modeling environment, operator-friendly user interface, and state-of-the-art power & energy management applications.



A standard operational system evaluates collected data in a non-electrical system environment without recognizing the

interdependencies of equipment. Extending the power monitoring system by equipping it with an appropriate electrical system model, simulation Modules, and playback routines will provide the system operator and engineer with a powerful new set of approach to a project. Using these tools, the user can accurately design, analyze, and predict the behavior of the electrical system in response to a variety of changes.

Finally, the unified and integrated model approach from design to operation gives the flexibility from thinking, designing, analyzing, implementing, operating, maintaining the electrical system in one environment which is ease in use and sharing and transferring with minimum engineering effort and maximum return.

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XIII. BIOGRAPHIES

Shaikh Sahid Hossain received his Bachelor's degree in Electronics and Instrumentation Engineering from B.P.U.T, Orissa in 2004 and his Master's degree in Business Administration from Preston University, USA in 2008 followed by Post Graduate Program in General Management from Indian Institute of Ahmedabad in 2009. Before joining ETAP, he worked as a Development consultant at Larsen & Toubro. His projects involved implementation for Power Management System, Process Automation. He was also involved in the establishing the power automation business in MENA & SAARC region. Mr. Hossain has been working as Vice President for MENA & SAARC for the Engineering Consulting Services, Power Automation Solutions and Power System Design department at ETAP since 2010 at Dubai office. His duties involve product architecture design, creating the new process for development of automation solutions, training and pre-sales application engineering for ETAP family of products. He has been a member of IEEE-Smart Grid for over three years and is a working group member of the PCIC-ME.

Tanuj Khandelwal received his Bachelor's degree in Electronics and Telecommunications Engineering from University of Bombay in 1999 and his Master's degree in Electrical Engineering from California State University, Long Beach in 2001. Before joining OTI, he worked as an Associate Engineer at PricewaterhouseCoopers. His projects involved application development for Power Derivatives in a deregulated market. He was also involved in the Operating Procedures Audit of CAISO in 2001 and worked on streamlining power contracts for Nevada Power. Mr. Khandelwal has been working as an Electrical Engineer for the Engineering Consulting Services department at OTI since 2001. His duties involve algorithm design, testing, engineering and software support, training and application engineering for ETAP family of products. He has been a member of IEEE for over five years and is a working group member of the IEEE Std. 739 (Bronze Book), IEEE Std. 551 (Brown Book) as well as a member of the IEEE Rail Transit Vehicle Interface Standards Committee.