Software Models for Smart Grid

Anjali Singhal
Dept of Computer Science
Mahamaya Technical University
India
anjalisinghal2000@yahoo.com

R.P. Saxena
Dept of Computer Science
Mahamaya Technical University
India
rp_saxena@yahoo.com

***Abstract*—Smart grid technology is progressing worldwide. Various Countries are investing to transform their traditional power grid to Smart grid. They have started realigning their organization to support a Smart grid vision. At this initial stage some software models are required to quantifiably evaluate, monitor the progress and plan for the realization of a smart grid.**

At present some models like Smart Grid Interoperability Maturity Model, Smart Grid Investment Model, Smart Grid Maturity Model and Smart Grid Conceptual Model are available. Smart Grid Interoperability Maturity Model is used to measure the current status of automation in the areas like transmission, distribution and demand side resources. The Smart Grid Investment Model is used in calculating different smart grid investments, along with their strategies. Smart Grid Maturity model is used in planning of utilities in smart grid transformation; prioritize the tasks and measuring their progress at every stage. Smart Grid Conceptual Model is used to analyze different standards and interoperations of smart grid development. A new proposed Smart Grid Monitoring Model will help in understanding smart grid deployment and capability within electric utility companies.

Keywords-Smart Grid software models, Smart Grid Interoperability Maturity Model, Smart Grid Investment Model, Smart Grid Maturity Model, Smart Grid Conceptual Model, Smart Grid Monitoring Model.

I. INTRODUCTION

The power grid delivers power from generation points to consumers (Personal, Industrial). This process is done mainly in two primary systems, i.e. the Transmission System (TS) and Distribution System (DS). The TS delivers power from power plants to distribution substations and the DS delivers that power from distribution substations to final consumers. Traditionally, the power grid refers to interconnected transmission system using analog technology. On the other hand, the term Smart Grid is a nebulous term spanning various functionalities geared towards modernizing the power grid. At its core, a smart grid utilizes digital communications and control systems to monitor and control power flows, with the goal of making the power grid more resilient, efficient and cost effective.

Smart Grids increase the connectivity, automation and coordination between suppliers, consumers and network by modernizing grid features like demand side management, generation, real-time pricing, and automated meter activation and reading.

As the Smart Grid technology is advancing with time, complexity in managing the power grid is also increasing. Audiences (Electric power utilities, Smart Grid Product and service suppliers, Owner/Operators, Stakeholders, Regulators and policy makers, Assessors, analysts and investigators, Customers, Standard Development Organizations, Academics, R & D Organizations) are becoming more concerned for environment, stability in energy and growth in demand. It becomes necessary to measure the efficiency, reliability and quality of services of smart grid to calculate its progress. Thus software model is required for providing current status of Smart grid deployment and setting future plans.

Till date many models are available for monitoring and measuring an organization's progress towards many substantial equivalents like efficiency, automation, integration, reliability and its effect on economy. These models assess the current status of smart grid implementation, investigate and analyze future plans to improve the current stage to next level to incur the benefits of smart grid technology

II. AVAILABLE SOFTWARE MODELS

Some of the popular software models available are as follows:

A. Smart Grid Interoperability Maturity Model (SGIMM)

SGIMM was developed by the GridWise® Architecture Council (GWAC) to monitor and measures the automation in the areas like transmission, distribution and demand side resources. It provides features like:

- Status/progress measuring statistics
- Gap analysis
- Prioritization of efforts to improve the current status

The main objective of SGIMM is to create a measurement model that can promote interoperability in key areas like configuration & evolution, operation & performance and security & safety in electric power system.

To accomplish this, interfaces between different products and systems with clear goals and standards are defined. These goals are then translated into a series of metrics. With the help of these metrics, the performance and progress of products and systems are measured. If some changes are identified, then new standards and set of goals are defined. SGIMM helps in enhancement in the quality of interface specifications involved in smart grid technology.

B. Smart Grid Investment Model (SGIM)

SGIM is a financial model, which helps in calculating the impact of different smart grid investments, along with their strategies. This helps in evaluating the costs and tracking the benefits of smart grid investments across the distribution spectrum. It provides features like:

- Complete framework for quarterly details of financial costs and benefits computation.
- Forecast of impacts of smart grid implementation program on customers and end users.
- Guideline for better smart grid investment analysis.
- Suggestions regarding smart grid strategies which are cost-effective.

SGIM identifies the individual technologies of smart grid and analysis the benefits of each technology in terms of costs and benefits parameters based on their utility and end user's characteristics for next twenty years. This framework helps in analysis of current level of smart grid investment analysis applications by evaluating different investment options with their impact on present utilities and demand response programs.

C. Smart Grid Maturity Model (SGMM)

SGMM is a management tool used to evaluate the progress of smart grid implementation process in eight domains(Strategy, Management, and Regulatory (SMR), Organization and Structure (OS), Grid Operations (GO), Work and Asset Management (WAM), Technology (TECH), Customer (CUST), Value Chain Integration (VCI), Societal and Environmental (SE)) stated in this model. It provides features like:

- Develop a shared smart grid vision and guidelines to process on the same.
- Communication with different stakeholders using common platform
- Assigning different task as per proper precedence
- Monitoring and measuring progress in different domains
- Develop new and modified plans if changes are required.

SGMM is based on compass survey, including questionnaire-based assessment survey generating different values. On the basis of these values, different domains are rated among five different maturity levels (Initiating, Enabling, Integrating, Optimizing and Pioneering). This model helps in planning of utilities in smart grid transformation, prioritize the tasks and measuring their progress at every stage.

D. Smart Grid Conceptual Model (SGCM)

Smart Grid Conceptual model provides a visualized diagram explaining how different components of smart grid can be integrated. It has seven domains (Customers, Markets, Service Providers, Operations, Bulk Generation, Transmission and Distribution). It provides features like:

- It provides descriptive overview of smart grid development.
- It provides a context for analysis of different standards and interoperations between them.
- It shows the interactions between different domains, which help in Distribution Management System (DMS).
- It also focuses on cyber security, network management, data management and application integration.

III. OBJECTIVES AND SCOPE OF SMART GRID MONITORING MODEL (SGMOM)

We are planning to design SGMoM, which consists of an assessment model based on key areas like technology, people and processes. It will help in assessment of proper architectural and communication standards for monitoring and management technologies so that proper modeling and simulation can be achieved. It will perform following tasks:

- Formalize current understanding of system processes and dynamics
- Identify linkages of processes across disciplinary boundaries
- Identify the bounds and scope of the system of interest which can contribute to communication among scientists, managers, stakeholders, program staff and customer
- Explore the interrelation between various smart grid segments

Components of Smart Grid taken under key areas of SGMoM will be:

A. Technology

Under this section SGMoM will adhere to technical strategy which can contribute in risk free success.

It helps in evaluating the adaptability, safety, modifiability and efficiency of organization's smart grid IT infrastructure. It will assist in developing IT investment plans in relevance with industry standards.

It will include the assessment of practical applications of various sensors and monitoring devices, communication devices, control systems, business intelligence tools and IT infrastructure needed for Smart Grid.

Sensors and monitoring devices will include all the sensors installed in power system used to limit voltage and current, sensors based on process control requirements and condition monitoring which is important, in order to maintain system reliability.

Communication devices will include power line communications, mains communication, power line networking used for carrying data needed for power transmission.

Control system includes self managing system which can respond to cyber security incidents and any adverse effect on the infrastructure. Under this how automated control systems can help to improve the productivity, flexibility, and reliability of energy systems will be assessed.

B. People

Under this section SGMoM will adhere to all the active and passive participants in Smart grid transformation. It will include the assessment of impacts on various audiences like electric power utilities, customer, stakeholders, owner/operators, standard development organizations, academics, R & D organizations of new implementations. It will help in developing new services with proper security features, efficiency, price control and customization.

C. Processess

Under this section SGMoM will adhere to all the processes involved in end to end design. It will help in assessing effort and progress in designing power network. it will help in finding all the possible features of smart grid which can be provided to the end host.

It will help in achieving organizational alignment in a strategic manner, so that significant benefits can be extracted. This section will include sub domains like end to end design, organizational alignment, documentation and investment framework.

Under the end to end design, it will help in determining the facilities of power network and access the end host correctly.

Under the organizational alignment, it will help in human resources activities of organization to enable effective employee's performance to achieve the vision of the organization.

Under the documentation, it will help in recording of all the responsibilities and goals critical for any organization. This can help in isolating mistakes and replicating success. It will also helps in protecting organization against the risk of possible litigation.

The investment framework will help in managing processes within defined rules. It also helps in evaluating different model portfolios and targets.

IV. APPLICATION OF SMART GRID MONITORING MODEL

The aim of this research is to design a model to facilitate the working of network management, data management, application integration and security. This will contribute to achieving the performance features of a smart grid like defining different architectural standards, communication standards, monitoring and load management technologies, advanced components and operating concepts, modeling and simulation and Global Information system.

Architectural Standards include the initial architectural framework and systems along with its components to enable the nation's power grid. Equipment quality standards, interface standards, back-end database and evaluation criteria that should be standardized and unified.

Communication Standards includes the proper standards between organization, stakeholders and customers. Monitoring and load management technologies include monitoring and control of industrial/commercial/residential loads for demand-side management.

Advanced Components & Operating Concepts include interconnection technologies, substation and equipment advancements, and advanced system operating concepts.

Modeling and Simulation include the Planning and operational support for contingencies and disturbance events.

Global Information System includes as utility for implementing advanced software systems for Smart Grid. It can be used in mapping and analyzing the volumes of information generated by smart grid technology. The interconnection between various components is shown in Fig. 1.

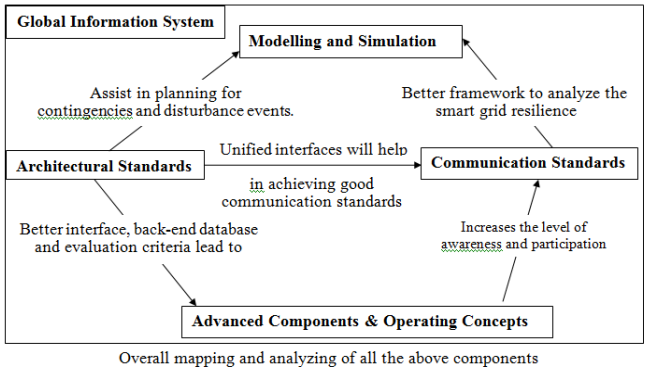

Fig. 1. Interconnection between various components

V. CONCLUSION

A model will be designed to provide a complete framework for understanding the smart grid deployment and capability within an electric utility. This will assist an

intelligent testing and monitoring in Smart Grid. Main Characteristics of this model will be as follows:

- New Products and Services and Markets – Opportunities for New Products and Services and new Markets opened with higher level of Smart Grid Adoptions.
- Power Quality – Power Quality in terms its availability, voltage stability, resiliency and self-healing capability from disturbances and disasters.
- Generation and Storage Options –Integrating diverse and distributed generation resources like Solar, Wind, and Geo Thermal Sources with the power system grid.
- Consumer Participation – The level of consumer awareness and consumer participation in Smart Grid implementation program.
- Operational Resiliency against Disaster – Achieving Operational Resiliency in the event of a Disaster with Smart Grid Implementation.
- Asset Optimization and Operational Efficiency – Achieving Operational efficiency by realizing Asset Optimization with real time monitoring of equipment and its operation.
- Response to Disturbances – Response to system outages and disturbances become quick with Smart Meter technology.

At the end this will provide a context for establishing strategic objectives and implementation plans which can support grid modernization.

REFERENCES

[1] Enrique Santacana, Gary Rackliffe,Le tang, and Xiaoming, "Getting Smart" IEEE power & energy magazine, April. 2010.

[2] Khosrow Moslehi, Ranjit Kumar, "A Reliability Perspective Of the Smart Grid" IEEE Transactions on. Smart Grid, June. 2010.

[3] A. Levinson, J. Mater, "Smart Grid Interoperability Maturity Model" Power and Energy Society General Meeting, 2010 IEEE, July. 2010.

[4] Libao Shi,ZhengXu, "Challenges Of Large Wind Generation Intermittence and Fluctuation for future Smart Grids" Actions on. Smart Grid, June. 2010.

[5] Smart Grid Interoperability Panel, "Smart grid Conceptual Model" Version 10 ,March. 2010.

[6] Przemyslaw Stangierski, Mariusz Przybylik, Krzysztof Jedziniak,Wojciech Luczax, "Smart Grid Ready Concept" International Conference on the European Energy Market, May 2011.

[7] Chollot, Yves; Biasse, Jean-marc; Malot, Alain; Feeder automation improves medium voltage network operating efficiency, Smart Grids for Distribution, 2008. IET-CIRED. CIRED Seminar 23-24 June 2008

[8] China Electric Power Research Institute. YU Qingang. Research and Application of Digital Line [Z]. China's Power Development and Technological Innovation. October, 2008.

[9] Software Engineering Institute,""Smart Grid Maturity Model Update", Press Release Pittsburg,Pa., Sep 2011

[10] "The Smart Grid: Introduction ",US DOE

[11] Anutosh Maitra,Rahul Walawalkar, Anil Khanna," An Assessment Of Information Technology for power Sector", Tata Infotech Ltd,SEEPZ, 2010.