

Smart Grid Simulation Diversification of Demand Side Power Management

M.Tech. Scholar Sheetal Mangal
Dept. of Electrical Engineering, YIT Jaipur
mangalsheetagmail.com

Assistant Professor Neeraj Kumar Kumawat
Dept. of Electrical Engineering, YIT Jaipur
ankay16@gmail.com

Abstract - The main objective of this thesis is to propose and develop a flexible simulation framework to study the behaviors and impacts of smart grid enabled household appliances. This proposed simulation framework should be accurate enough to reflect the general or average behaviors of traditional patterns of energy consumption. It should be designed to be flexible to allow expansions for other purposes, such as a study of the integration of renewable energy sources. It should be scalable to enable metro scale and also precise individual household simulations. It is desirable to have a smart grid centric test/simulation platform that is multipurpose and easy to expand to meet different needs. Whether developers need to evaluate the results of their product, or utility companies want to examine the effects of changing price profiles, it is beneficial to have a simulation framework that already implements the general energy consumption model, supply model, and information communication model.

Keywords: Power System modeling, pvccl, energy sources Matlab Software.

I. INTRODUCTION

The current power grid is a great engineering masterpiece that started with Thomas Edison. From then on the development of the big power grid known today went fast, but the information technology has since then overtaken the grid and is now providing a lot of possibilities that society is not using efficiently. In the not so distant future, energy will be in short supply as more and more electrical devices are developed. This is intensified by an increasing number of countries developing a high need for energy. Additionally, today's main sources of energy such as coal, gas and oil are finite and will eventually be depleted. Therefore it is essential that energy can be used more intelligently and that an increased amount of renewable energy is incorporated into the grid. A challenge with relying on renewable energy resources is that the time the energy is generated (and the amount) is unpredictable as they rely on weather conditions. Therefore it will be highly useful to be able to shift the energy consumption such that it matches the time of the energy production. A solution to this could be an upgraded version of the power grid that incorporates the consumer and motivates them to shift their energy consumption and thereby be an active part in the environmental challenges that will be faced in the future. This concept is called the smart grid. Sustainability, climate change, increasing cost of fossil fuels and a political imperative for energy independence have combined to increase interest in the use of renewable energy sources to meet growing electricity demands, as

well partially displacing existing thermal power generation. Current power systems are still dominated by fossil fuel based electricity generation and operated on supply following the changing demand. The increasing use of renewable energy resources adds additional complexity to power systems and makes them more challenging to operate.

An emerging revolutionary change is happening in the power distribution industries around the globe, known as the smart grid development. Smart grid binds information network technologies into the outdated traditional power distribution network to enhance its resiliency and to reduce its carbon footprint. While smart grid is gradually becoming less of an unheard-of-phrase to more and more people due to governmental project roll out and various commercials and promotional activities all over the world.

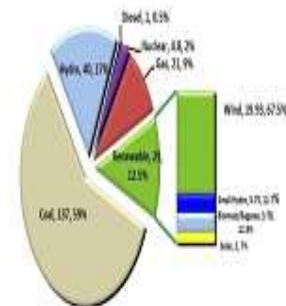


Fig.1 Distribution chart.

It is accordingly essential that development of the Power Sector shall be commensurate with the overall economic growth of the nation. Government of India has taken several initiatives and announced various policy measures to strengthen the sector. Presently total installed generation capacity in the country is about 232 GW which constitute capacity from conventional sources (88% share) viz. Coal (137GW), Gas (21GW), Nuclear (4.8GW) and large hydro (40GW). Balance 29 GW (12%) contribution is from renewable generation capacity which has 70% contribution from Wind generation alone. As discussed earlier, coal still dominates as fuel resource (52%) in overall electricity resources portfolio. Present generation capacity along with their resource composition is shown at Fig-1.1. India has been continuously progressing in conventional as well as renewable capacity addition. Since 9th Plan period, share of renewable capacity has increased from 2% to 12% as on today (about 6 fold increase). Electricity generation due to renewable has also increased to about 6% in overall electricity generation mix as on today. With such multifold growth, penetration of renewable power in Indian grid has increased.

As indicated above, presently, about 29,537MW grid interactive (Wind-19,934 MW, Solar-2080 MW, SHP-3,747 MW Biomass/Bagasse- 3,776 MW) as well as 927 MW off grid Renewable Energy (RE) generation capacity is available in the country.

II. LITERATURE REVIEW

Optimal operation of the electrical power system is a central objective in power systems engineering and includes the transmission and distribution grid, generation facilities and loads, and interconnections to other power system control areas. The overall goals are to reduce costs, improve overall system efficiency and ensure system reliability. Traditionally, these operational goals have been achieved mainly by managing the supply side (SSM) and by trading electricity, when available, with neighbouring power systems. Today's power system is already complex and poses many challenges for system operators to ensure grid stability and reliability. The increasing integration of various renewable energy source (VRES), such as wind and solar power, adds further complexity and operational difficulties to the overall system.

III. MODELLING SMART GRID

Software evolutions

The choice of using MATLAB/Simulink came about after several months of understanding what was needed from a simulation tool in lieu of available residential consumption and generation data. Among the important traits required of a modeling tool was its compatibility

(i.e., import capability) to accept the recorded data provided data, State refers to known levels of voltage, currents, and power flows everywhere in the distribution system presented. This chapter presents the evaluation efforts undertaken by the identify MATLAB/Simulink as the software of choice for modeling and simulating. Given that software packages are continuously improving and that this particular task required the import of data in a particular format and widespread use of the software in a smart city project environment. Load flow simulations return voltage and current phases. These quantities are computed in the frequency domain using complex numbers, and by specifying the fixed frequency of interest (e.g., 50/60 Hz). Phases, however, only contain information about their magnitude (root-mean square, RMS) and phase angle. In fact, from these RMS values, it is not possible to assert whether or not the waveforms are sinusoidal. Phases do not provide information on the harmonic distortion or transient stress. Transient simulations, on the other hand, return instantaneous voltages and currents. These quantities are computed at microsecond intervals and provide waveform-level detail. From waveform-level results, one can determine whether or not the system voltages and currents are sinusoidal.

- **Time Step**

The simulation time step (or interval) defines how often the simulation's solutions are computed. Since it was determined that load flow simulations were appropriate for this work, the time step was matched to the time step of the recorded data provided by given data ($\Delta t = 1 \text{ min} = 60\text{s}$).

- **Run Time**

Load flow simulations execute faster than transient ones for the same circuit topology. This stems from the total number of solutions required to complete a simulation. For example, a 24 Hour load flow solution requires $24 \times 3600 / 60 = 1,440$ solutions. A 24 hour transient solution requires $24 \times 3600 / 50 \times 10^{-6} = 1.728 \times 10^9$ solutions.

- **Simulation Time Span**

The simulation time span defines the stop time of the simulation. Since load flow simulations execute rapidly, this stop time can be set to 24 hours or 7 days or Monthly or Yearly. On the other hand, in the case of transient simulations, setting these stop values to anything more than seconds produces undesirable simulation wait times.

Load flow simulation is commonly used early in simulation tasks, because they execute fast, provide high-level results that are necessary to guide further research, and allow for longer simulation time spans. Transient simulations, on the other hand, are normally used late in the modeling or design stage. For example, transient simulations can be used to observe en origination inrush currents after it has been decided how many transformers will be installed in a distribution system.

- **Major Limitations**

Load flow simulation does not allow simulating power electronic converters or dc systems. Additionally, because of the fixed- frequency simulation type and large time step (e.g., 1 min.), load flow results do not show transient-level detail. The major limitations of transient simulations are its speed, lack of high-fidelity models to make results credible, and the imposed restriction of using reduced time spans.

- **Major Advantages**

Load flow simulations execute rapidly, are compatible with available data, and allow for long simulation time spans. Transient simulations provide a high-level of detail and can be used to assess voltage stability concerns.

Simulation Models

a) **Smart Grid Simulation model at Distribution end.**

Major Components:

- Substation
- Transformer
- Transmission cable
- Residential Load
- Circuit Breaker
- Three Phase V-I and Power Measurement
- Trip Circuit
- Energy Storage System
- PV's Power Generation.

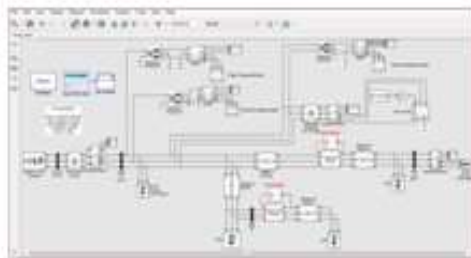
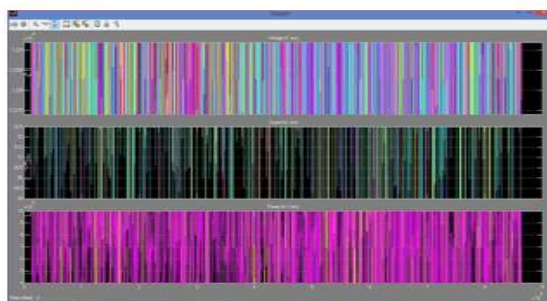
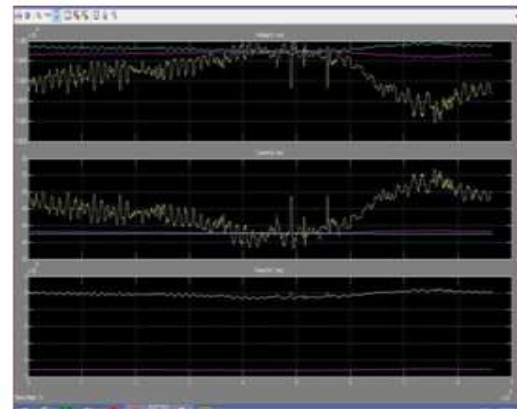


Fig 2. Plot House Load Data.



(a)



(b)

Fig 3. Residential Transformer (a) Light Loaded, Heavy Loaded.

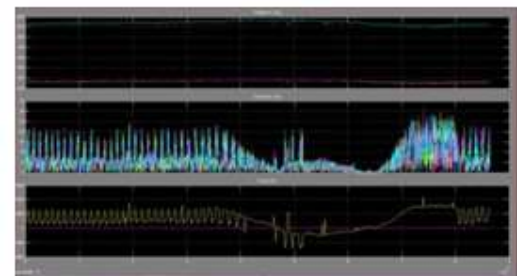


Fig 4. Voltage, current and Power Measurement.

IV. CONCLUSION

A modeling and simulation framework was constructed and successfully used to validate a smart grid environment. The model allows the implementation of a large scale smart grid that includes complex transmission and distribution feeder topologies, several thousand residential houses with their appliances and controllers, and various generation supply options. However, the size and complexity of the model requires significant computational power to solve the power flow problem and for postprocessing of simulation data. The results derived from the simulations showed that smart grid technology and demand response can mitigate the already existing load variations, as well as the change in net load variations that are a consequence of the use of wind power and other renewable energy resources. Demand response in principle can enhance the overall system operation. Positive outcomes are especially associated with the increased level of penetration of variable renewable electricity generation made possible by demand response and grid operation reliability. Demand response can reduce the amount of generator cycling and ramping, reduce wear and tear on generating equipment,

improve generator efficiency and avoid grid and generator capacity additions by shaving load peaks.

REFERENCE

- [1]. R. Brown, —Impact of smart grid on distribution system design, □ in Proc. IEEE Power Energy Soc. Gen. Meeting, 2008.
- [2]. International Energy Agency: World Energy Outlook 2011 © OECD/IEA 2011.
- [3]. J. R. Aguero, P. Chongfuangprinya, S. Shao, L. Xu, et al., "Integration of plug-in electric vehicles and distributed energy resources on power distribution systems," in IEEE Electric Vehicle Conference, 2012.
- [4]. A. Kwasinski, A. Toliyat, and F. M. Uriarte, "Effects of high penetration levels of residential photovoltaic generation: Observations from field data," in International Conference on Renewable Energy Research and Applications (ICRERA), Nagasaki, Japan, Nov. 11-14, 2012.
- [5]. L. Bird, M. Milligan, and D. Lew, —Integrating Variable Renewable Energy: Challenges and Solutions, □ Technical Report NREL/TP-6A20-60451 September 2013.
- [6]. R. K Singh, S.K Choudhary, and Paul, R. Kumar, —study of Indian Power Sector for Planned Capacity, ÄKGEC International Journal of Technology, vol.4, No.2, pp.34-38, 2013
- [7]. Anthony Papavasiliou, and Shmuel S. Oren, —Large scale Integration of deferrable demand and renewable energy source, □ IEEE TRANSACTION ON POWER SYSTEMS, VOL. 29, NO. 1, JANUARY 2014
- [8]. S.J. Ben Christopher, —Dynamic demand balancing using demand side management technique in a grid connected hybrid system, □ International Journal of Renewable Energy Research, Vol. 4, No. 4, 2014.
- [9]. Fabian M. Uriarte and Robert E. Hebner, —Residential Smart Grids: Before and After the Appearance of PVs and EVs □, IEEE International Conference on Smart Grid Communications 2014.
- [10]. Yogita Ashtekar, and Gopi Dhole, —Effect of demand management on present Indian power sector scenario, □ IJIRSET Transl. J. Magn.
- [11]. Japan, Vol. 4, Issue 2, February 2015.
- [12]. Sushmita Banerjee and Abhisek Meshram, —Integration of renewable energy sources in smart grid, IJIRSET Transl. Vol. 3, Issue 3, March 2015.
- [13]. Bethany Speer and Mackay Miller, —Roll of smart grid in Integrating Renewable Energy, □ Technical Report NREL/TP- 6A20-63919 May 2015.