Effects of Renewable Energy Sources on the Power System

Rahul Abhyankar

Department of EE, University of Mumbai, Palghar-401305

Abstract*— *Recently, growing electrical energy market and increasing integration of renewable energy sources (RES) in power systems have led to new challenges on network planning step and operation, thus it is required to investigate and analyze properly the impacts of integrated RES on the power system.

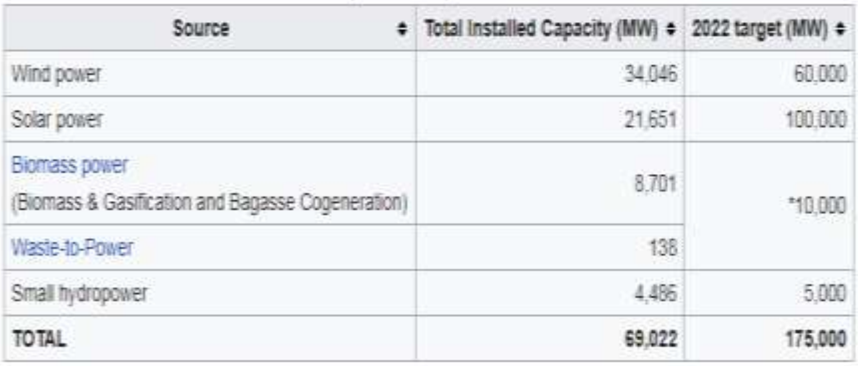
In this paper, the electricity transmission network with wind farms (WF) is modeled. For the grid model, a part of Izmir region is chosen due to the amount of installed generation plants based RES especially wind energy in this region. The comparison between unexpected variations to voltage profile of the power system before and after RES integration to the power system is demonstrated. In the modeling of the electricity transmission network with RES, Digsilent /Power Factory is used as software. The different case studies in integration of different amounts of RES are implemented on the developed grid model. As a result of the conducted case studies, effects of RES on existing power system are evaluated and graphics obtained from the simulation are presented. Especially, the voltage profile of power system is examined.

Keywords*— *Electricity transmission network, Digsilent, Renewable energy sources, Voltage profile, Wind farms.

I. INTRODUCTION

Smart grids are becoming an important issue in today' and future' power system network configurations. New modern power grids offer detailed information about the power grid in real time, rapid analysis of failures and also offer the ability to connect large quantities of RES to the power system. The quick growths of global industry and business have caused a significant shortage of available energy in the circumstances of excessive utilization of fossil fuels. As well as security of supply concern, environmental concerns have placed investment in low-carbon power generation technologies as one of the priorities on the energy agendas of many countries around the world. Therefore, generation of electricity from RES is viable option which will not only fulfill the growing energy demand but also take care of the environment.

India is one of the countries with the largest production of energy from renewable sources. In the electricity sector, renewable energy (excluding large hydro) accounted for 20% of the total installed power capacity (71.325 GW) as of 30 June 2018. Large hydro installed capacity was 45.29 GW as of 31 March 2018, contributing to 13% of the total power capacity. Unlike most countries, India does not count large hydro power while accounting for renewable energy targets as it comes under the older Ministry of Power instead of Ministry of New and Renewable Energy. Thus, renewable energy including large scale hydro-power currently adds up to more than 33% of the total installed power capacity in India.



Source ⬍	Total Installed Capacity (MW) ⬍	2022 target (MW) ⬍
Wind power	34,046	60,000
Solar power	21,651	100,000
Biomass power (Biomass & Gasification and Bagasse Cogeneration)	8,701	*10,000
Waste-to-Power	138	
Small hydropower	4,486	5,000
TOTAL	69,022	175,000

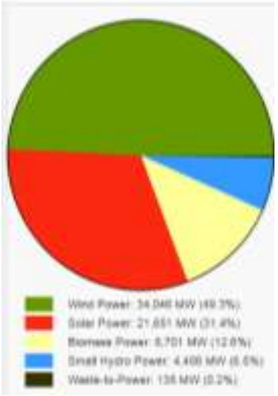


FIG.1 Installed grid interactive renewable power capacity in India as of 31 May 2018

Integration of RES has imposed additional uncertainties and challenges on power systems, as RES are intermittent and their location are geographically dispersed. The sharp electricity generation which is increased by RES creates a necessity for different studies to analyze impacts of integration of RES on the power system. Nowadays, while power systems have evolved through continuing integration of new units into power systems and the increased operation in highly stressed conditions, different forms of the system instability and security have emerged. For example, voltage stability has become greater concerns than in the past. Thus, the system stability analysis including static voltage stability analyses are very important in order to maintain hold the equilibrium of the system.

Voltage is considered as an important index because of its effect on system stability and security. Variations in P and Q affect the voltages at all the buses in the system as well. Voltage stability may be defined as the ability of a power system to hold steady voltage at all buses in the system for a given initial conditions and after being subjected to a physical disturbance. Therefore, the voltage stability analysis can be implemented so as to make decision whether voltage level at all buses is at acceptable level or not. Increasing distributed generation systems which are based RESs impact power grids. Moreover, because constant generation can't be generated from RESs with regard to conventional energy sources, maintaining of the system equilibrium and stability are difficult.

II. LITERATURE REVIEW

In this respect, in the literature many different studies are conducted to be seen the effect of renewable energy.

- Lima et al. investigated to the effects wind generation on the electricity market of Iberian. Some forecast analysis presented with historical data using for between 2008 and 2016 years. As result of this study especially the undesirable situations were seen on the grid when the wind power production forecasts cannot be done correctly.
- Ozdemir et al. analyzed to the impact of largescale integration of RES on electricity infrastructures of EU corridors up to 2050 using economic optimization under different integration conditions.
- Fleury et al. explained the Brazilian experience on the integration of renewable energy, emphasizing lessons learned and new challenges to be faced.
- Similarly Shafiullah et al. simulated a power system model for Australia power grid to investigated impacts of large scale renewable energy on high voltage transmission system.
- Also Molina et al. investigated to the contribution of renewable with regard of costs, technological diversity, CO2 emission and energy injection on the Chilean electricity system.
- Duan et al. proposed a method to analyze the effects of wind energy on transmission system with using the Weibull Distribution Function. And the results of method were used to estimate transmission capacity on the lines.
- Syafawati et al. made a case study of the potential evaluation of solar energy in Malaysia. Also this study gave the information about solar radiation and the geometrical relationship of its natural resources in order to determine the potentiality.
- Lenci et al. showed the importance of RES forecast accuracy for power systems and the needs of control reserve with increasing RES integrations.

Also, increasing the distributed generation effects the behaviors of the grid in the fault cases. After being occurred faults, it is expected to regain equilibrium of the system. Therefore, these abilities of the distributed generation sources must be investigated and analyzed. Also khiry et al. investigated the fault – ride through capability distributed generation and the difference between the base case with and without DGs when a transient fault is occurred on power system.

III. POWER SYSTEM PLANNING

The increasing penetration of renewable resources will have a significant impact on the performance and reliability of the electricity grid. This is largely because of the variability of renewable resources and the lack of large-scale economical storage capability. This impact will be discussed with respect to planning and operation, primary functions related to grid performance and reliability. Traditional planning for a power system and for expanding transmission functions has been undertaken in response to the needs of the transmission system based mainly on past and projected loading levels, which have traditionally been estimates of future demand. In the deregulated market, and in the present case of using different renewables (i.e., different in source and in temporal characteristics, as well as in geographic location), transmission planners must respond to the needs of power generators. In other words, planning to expand transmission may now be driven by the location and type of generation, rather than by the needs of the transmission system. To compare, traditional transmission planning processes are driven by loads and have a "bottom up" structure, whereas current transmission planning is driven more by generation needs.

The term "integrated system planning" (see Figure 2) refers to the inclusion of the temporal, stochastic, and voltage-level characteristics of generation sources in plans for system expansion. In addition, because renewable resources have characteristics that favor large-scale energy storage, the storage components must be included in the integrated system plan. In the real-world environment, federal and state projections and long-term plans and portfolios may also strongly influence the expansion of the transmission system. The factors that must be considered in planning for increased renewable energy transmission are briefly described below.

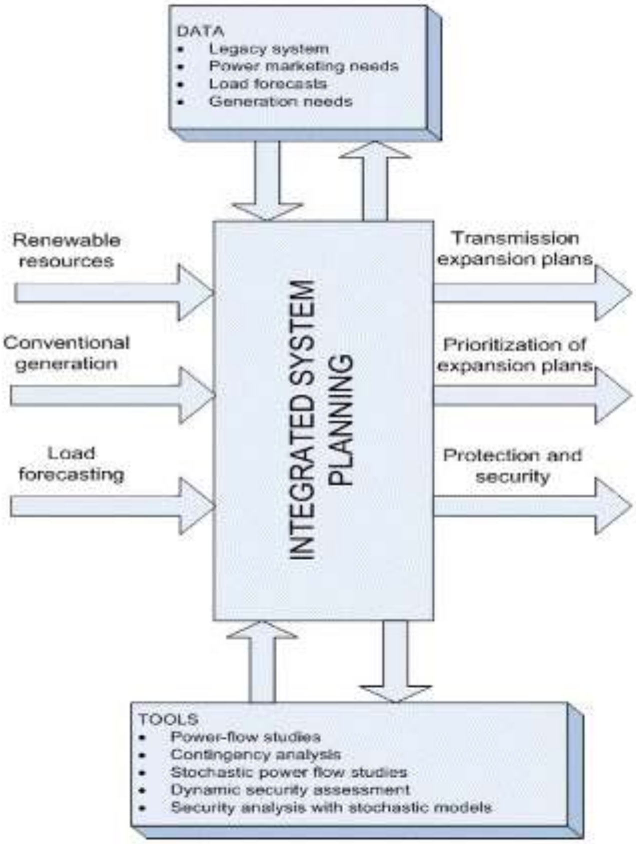


FIG.2: integrated system planning

IV. SCALABILITY OF NETWORK TOPOLOGY

Because a future power transmission and distribution network with a high percentage of renewables may have more generation sources than existing networks, scalability will be a significant factor. Planners will have to determine (1) the network topology best suited for this new scenario and (2) the effects on system performance and reliability of having a large number of spatially distributed generation sources. Network topology will significantly impact total transmission losses, as well as performance of the overall network when subjected to disturbances. If the network has a very large number of power sources, the range of possible power-flow configurations will be enormous (Hecker et al., 2009). Although this will make the performance and reliability problems much more challenging, it will also provide opportunities for designing networks that can out-perform traditional networks.

4.1 Transmission Architecture

The main objective for legacy transmission systems was to transmit power from relatively local (e.g., within a radius of about 500 kilometers [km]) generation sources to load centers. Under deregulation, this objective has migrated to much longer distances and much higher operating power levels (e.g., many hundreds of megawatts, perhaps > 1,000 MW, for 1,200 km or more). With the assumed renewable energy portfolio and the degree of variability from wind and solar sources, it will be critical for planners to take advantage of the geographical diversity among renewable resources. To facilitate a balance, a large high-voltage backbone may be necessary. This backbone network could consist of an interconnected transmission grid at voltage levels of 765 kV or greater that would provide the capability of moving a large amount of power from where it is generated to the locations where it will be used.

Because distributed resources may be widely dispersed and have diverse temporal characteristics, their operating level and transmission paths are a combination of high and low MW levels and long and short distances. At the 50 percent penetration level, one might expect transmission paths and transmission loading well into the hundreds of kilometers and hundreds of MW. These changes in transmission topology to account for distributed resources can be facilitated, at least in part, in the following ways (Osborn and Zhou, 2008):

Voltage-level and power-level upgrades would be made to existing high-voltage DC (HVDC) systems and/or new parallel HVDC systems to convert existing 12-pulse bipolar designs into 24-pulse bipolar designs. These changes could dramatically increase operational power levels and reliability and concomitantly decrease the impact of HVDC converters on power quality.

Transmission routes would be determined after taking into account the intermittency of resources, load patterns, and available rights-of-way. The performance of planned routes under varying conditions would be evaluated, including the analysis of adequacy and reliability. The stochastic nature of the renewable resources would also have to be accounted for.

- Optimal Storage
- For optimal use, many renewable resources require energy storage. The following factors must be considered in designing optimal storage systems:
- type of storage (batteries; flywheels; superconducting magnetic energy storage systems; pumped hydro storage systems; compressed-air, molten-salt, fuel cells + hydrolyser; and other active and passive innovative systems)
- voltage level and power level at the point of interconnection
- energy-storage rating
- time duration and time profile of the charge/discharge cycle
- physical location of the storage device in the system (e.g., proximity to loads, sources)
- control objectives
- ownership and operator of the storage elements
- maintenance of the storage elements
- cost and efficiency (energy recovered/energy stored)
- availability and commercialization—including availability at a specific time in the future

V. INTERFACES BETWEEN THE GRID AND RENEWABLES

In light of the very wide range of capacity ratings for the renewable mix and the well diversified technologies used to integrate them into power grids, renewable sources can be categorized into concentrated energy resources (CERs) and distributed energy resources (DERs). Concentrated Energy Resources. Among CERs, geothermal, biomass, and concentrated solar systems have conventional synchronous generators and steam prime movers. As a result, integration of these CERs is expected to be less challenging than for DERs. However, large-scale wind farms and large-scale PV systems present a spectrum of technical challenges that will require thorough investigation. The technical challenges arise mostly from the expanding application of electronic devices at high power ratings. For instance, large wind turbines with power ratings of more than 1 MW nowadays commonly have DFIGs. A wind generation system with DFIGs requires an AC-DC-AC power converter rated at about 30 percent of the full power rating of the generator to achieve variable operation frequency within the range of ±30 percent of the nominal frequency of 50 Hz. In addition, emerging direct-drive wind generation systems that use permanent magnet synchronous generators (PMSGs) are expected to prevail at the power rating of 3 to 5 MW, which is suitable for offshore wind farms. Systems with PMSGs require power converters that can handle the full power rating of the generator. For CERs with large-scale PV, the power electronic interface is indispensable because of the necessity of converting DC voltage generated by PV into the 60 Hz AC voltage of the grid. Distributed Energy Resources. For DERs, namely distributed wind and PV generation systems, large numbers of small-scale generation sources are dispersed at the distribution level. Facilitating the integration of DERs will require microgrid and power management systems that transparently provide control and regulation

VI. CONCLUSION

Increasing energy demand and environmental concerns have led to increased use of RES over the world. Generation of electricity from RES is an alternative and effective method in order to overcome energy problems in the global scale; however, integration of RES has caused some negative impacts on the power systems. This article has highlighted the potential impact of increased penetration of renewable resources on the planning and operation of the bulk power system. Increased penetration of renewable resources has the potential to introduce major technological challenges that would have to be met to satisfy existing planning and reliability standards.

REFERENCES

[1] S. Guner, A. Ozdemir, "Turkish Power System: From Conventional Past to Smart Future", Innovative Smart Grid Technologies (ISGT Europe), 2nd IEEE PES International Conference and Exhibition, 2011.
[2] J. Dudiak, M. Kolcun, "Integration of Renewable Energy Sources to the Power System", 14th Environment and Electrical Engineering (EEEIC) International Conference, 2014.
[3] L.Wng, Y.Lin, S. Ke, "Stability Analysis of on Offshore Wind Farm Connected to Taiwan Power System Using DIgSILENT", IEEE, OCEANS, TAIPEI,2014
[4] L. Ochoa, D. Wilson, "Angle Constraint Active Management of Distribution Networks with Wind Power", IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT Europe), 2010 .
[5] A. M. Majeed, R. Vireck, F. Oechsle, M. Braun, S. Tenbohlen, "Effects of Distributed Generators from Renewable Energy on the Protection System in Distribution Networks", 46th International Universities' Power Engineering Conference, 2011.
[6] R. Mosobi,T. Chichi, S. Gao, "Modeling and Power Quality Analysis of Integrated Renewable Energy System", IEEE Eighteenth National Power Systems Conference (NPSC),2014
[7] Load Dispatch Department Operational Reports. http://www.teias.gov.tr/Eng/DispatchReports.aspx
[8] Turkish National Renewable Energy Action Plan. http://www.eie.gov.tr/duyurular_haberler/document/Turkiye_Ulusal_Yenilenebilir_Enerji_Eylem_Plani.PDF
[9] R. Lira, D. Wang, D. Wilson, P. J. C. Salter, C. Galzin, N. Stearn, " WAMS Application for Improving The Stability and Security of Latge Interconnected Electrical Power Systems", 4th International Exhibition&Conference,2013.
[10] E. Vilchez, J. Stenzel, "Impact of Renewable energy Generation technologies on The Power Quality of the Electrical Power Systems", 22nd International Conference on Electricity Distribution, pp.1- 4, 2013.
[11] P. Kundur, J. Passerba, V. Ajjarapu, G. Anderson, A. Bose, C. Canizares, N. Hatziargyriou, D. Hill, A. Stankovic, C. Taylor, T. V. Cutsem, V. Vittal, "Definition and Classification of Power System Stability", IEEE/CIGRE Joint Task on Stability Terms and Definitions.
[12] N .G .Khani, M. Abadi, G. B. Gharehpetian, G. Riahy, "Analyzing the Effect Iof Wind Farm to improve Transmission Line Stability in Contingencies", Indian Journal of Science and Technology, 2015.
[13] M. Sulaiman, A.F.M. Nor, "PV and QV Curves Approach for Voltage Instability on Mesh-Type Electrical Power Networks Using Digsilent", MGNT Research Report, vol.3, pp. 26-42, 2015.
[14] P. Kundur, "Power System Stability and Control", McGraw-Hill.
[15] S. B. Bhaladhare, A. S. Telang, P. P. Bedekar, "P-V, Q-V Curve- A Novel Approach for Voltage Stability Analysis", NCIPET, 2013.
[16] J. Lima, R. Jerónimo, T. Silva, "Impact of the Renewable Energy Generation on the Iberian Electricity Market", 5th International Conference on the European Electricity Market ,pp. 1-6, Lisboa, 2008.