Integration of Renewable Resources With Smart Grid- A Review

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Abstract- *In today's world maximum production and generation of Power is from Non renewable resources, due to which there is a solemn pressure of meeting the load requirement on non-renewable resources. With parallel problems of global warming and increasing pollution rate, new resources so called renewable resources are urgently needed in order to fulfill the desired demand. This paper reviews about the two major renewable sources model (wind power generators and solar power generators) by probabilistic output model, using Weibull probability method and Beta probability method. Through the analysis, renewable sources accommodation capacity based on Monte Carlo method is also discussed. Power system modeling is also reviewed for grid. Also this paper reviews about the Pilot Project being started at Puducherry based on renewable resources.*

Keywords- Renewable resorces, Nonrenewable resources, Weibull method, Beta method, Monte Carlo mthod, Pilot project

I. INTRODUCTION

In today's world, the demand for power consumption has been on hike due to the substantial increase in living standards of people. Due to this the centralized grid structure has been overloaded and is dependent solemnly on non-renewable resources like coal, petroleum, natural gas and nuclear energy. The cost of their generation along with distribution and production is very high and various issues are related to them such as environmental degradation, green house gas emissions production of nuclear waste, transmission losses and congestion of network. Due to these Issues- Reliability and efficiency of grid structure gets disturbed and it harms the consumers parallel with the producers. To overcome these issues, integration with alternative resources like solar, wind, biomass, hydropower and geothermal are to be widely used on a great extent so as to improve the present grid structure and make it more reliable, efficient and long living.

Renewable resources enhance the available energy resources. These technologies also enable integration of higher levels of renewable energy and conventional energy sources. The renewable sources are not "dispatch-able"—the power output cannot be controlled. Future energy sustainability depends heavily on how the renewable energy problem is addressed in the next few decades.

Renewable (Solar) energy could made more economical by reducing the investment and operating costs which will enhance solar plant performance. Integration of solar sources with the smart grid will come up with the challenges put up by solar systems like technology barrier, uncertainty, social impact with economical aspects, free acceptance etc. Renewable-energy resources will be used for power generation for standalone or isolated system.

However, integration of renewable resources benefits is significantly enhanced when they are integrated into bigger electric power grids. Each of the resources are different from the grid's perspective and some are easier to integrate than others. Emphasis with greater use of smart grid technologies, higher degrees and rates of penetration can be accommodated.

TABLE 1 CAPACITY OF RESOURCES

Renewable Potential	Power generation Capacity
Wind	49,132 Mw (55%)
Solar	1044.16 Mw(2%)
Hydropower	17,538 Mw (20%)
Biomass	15,385 Mw (17%)
Cogeneration	5000 Mw (6%)

Renewable integrated grid has the wholesome benefit of enhanced sustainability (reduced environmental impacts), reducing greenhouse gas (GHG) emissions, reduced dependence on local or imported fossil fuels, and increasing energy security through diversification of energy sources.

Smart grid generation can be controlled by renewable resources to induce changes in the grid's operating conditions and additionally provide benefits such as controlled distributed generation assets or when installed at the transmission level. Additional to all issues like voltage regulation, power imbalance, frequency disturbance and grid parallel connections are all resolved through integrated resources further enhancing reliability and sustainability giving better responses to both consumers and producers respectively.

II. METHODOLOGY

In this paper, the output model of the renewable energy unit's based time correlations is discussed. In the model of the accommodation capacity of power grid, the constraints caused by the practical operation were considered adequately and maximum accommodations capacity model was created. after the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of.

A. Algorithm Structure

The algorithm of this paper is for getting the sequential status of components in year including the chronological load curve, the sequential status of transmission lines, sequential output of wind generators and photovoltaic units. After all this it is to be find out whether an optimal solution constraint who aims at the maximum renewable energy accommodations capacity which will take generating units output as variable.

B, Model of output of renewable energy generators

(1) Wind turbine generator: For the review paper, weibull distribution method is being used to simulate the output of wind power units. The weibull distribution system is divided into two-parameter weibull distribution and three-parameter weibull distribution system. Based on the research two parameter weibull distribution can be used to simulate the wind speed and the probability density function is as:

$$f(v) = \frac{b}{a}\left(\frac{v}{a}\right)^{b-1} \exp\left\{-(\frac{v}{a})^b\right\} \quad (1)$$

Where *a* is the scale parameter of weibull generator which reflects the average of wind speed and *b* is the shape parameter of weibull distribution which reflects the skewness of Weibull distribution. And *v* represents wind speed.

The probability density function of wind speed is given by formula no (2).

$$F_V(v) = P(V \le v) = 1 - \exp\left\{-\left(\frac{v}{a}\right)^b\right\} \quad (2)$$

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads. This model of wind speed is simulated accordingly to the vast amount of historical wind speed data of the area. Then these parameters ***a*** and ***b*** of the model can be determined by maximum likelihood method.

On the basis of historical recorded data regarding the wind speed-the wind generator hub height can be calculated accordingly to the historical data which will extracts the relationship between wind speed and height.

C. Photovoltaic Power Generation:

The output of the photovoltaic power is being simulated with *beta* distribution which can be simulated by probability of illumination intensity in short time scale as well.

Probability density function given as:

$$f(r) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)}\left(\frac{r}{r_{max}}\right)^{a-1}\left(1-\frac{r}{r_{max}}\right)^{b-1} \quad (3)$$

Where r represents actucal illumination intensity in a given time interval and r(max) represents the maximum illumination intensity in choosen time interval with a as location parameter of distribution and b as shape parameter of distribution with gamma function.

The transition efficiency of photovoltaic cell η is:

$$\eta = \eta(0)[1-\gamma\{T(t)-T(0)\} \quad (4)$$

Where T(t) is the surrounding temperature in time t,T(0) is the reference temperature as 298K and η(0) isn the efficiency of the photovoltaic cell with ,γ is the temperature parameter of photovoltaic cell.

The output of photovoltaic cell can be given by:

$$P(t)=I(t).A.\eta/860.4 \quad (5)$$

Where P(t) is the power output of photovoltaic cell in time t, A is the average of photovoltaic cell represents the transition efficiency of photovoltaic cell which is related to temperature and can be calculated with equation (4) and I(t) which represents the illumination intensity in time t.

If there are n photovoltaic cells in work in time t, the sum power of the photovoltaic array inside will be the nP(t).

The parameters of beta distribution network are as selected as they remain different for spring, autumn, summer and winter in order to depict its efficiency and accuracy for the finite time interval.

table 2 Time sections of photovoltaic parameters

Season	Time interval
SUMMER	5-9 10-15 16-19
SPRING AND AUTUMN	7-12 13-18
WINTER	13-17 13-17

III. POWER GRID MODELLING

Without the loss of generality in a single-bus power system it is assumed to simplify the analysis of primary frequency response.

A. Aggregated Swing Function

Inertia with the kinetic energy stored in spinning rotor will b released to resist an angular deviation which when applied torque is changing. The impact on primary frequency response from the aggregated system inertia can be modeled by the following so called aggregated swing function.

$$\Delta\dot{f} = \frac{f_0}{2H\alpha S_B}\left[P_{sync} + P_{re} - (1 - D\Delta f)P_{load}\right] \qquad (1)$$

with

$$\alpha = \frac{\sum_{i=1}^{N} S_i}{S_B}, H = \frac{\sum_{i=1}^{N} H_i S_i}{\sum_{i=1}^{N} S_i}$$

Where *f* is the grid frequency(Hz), *Δf* the frequency deviation f(o)=50 Hz(sync) the total power output of online *N* synchronous generators (p.u), *P(re)* the total power output of renewable (p.u), *D* the load relief constant(load) the total load (p.u),*S(b)* system base constant(MW),*H* the aggregated inertia constants(i) the rated power of the synchronous generator.

After solving the equation one result are:

$$\Delta f = C_0 e^{-At} + f_{ss} \qquad (2)$$

Where,

$$A = \frac{f_0 DP_{load}}{2H\alpha S_B}$$

$$f_{ss} = \frac{\Delta P}{DP_{load}}$$

$$\Delta P = P_{sync} + P_{re} - P_{load}$$

C_0 can be derived from the initial condition

$$\Delta f\big|_{t=0} = 0 \qquad (3)$$

Sequential power control actively is being used to restore the Frequency to its nominal value via gradually injecting the Active power from the primary, secondary and tertiary Reserve. Governor response of synchronous generators with head room is first activated with a small time delay after a disturbance to prevent frequency dropping.

B. Maximum RoCoF and Frequency Nadir

The RoCoF and frequency Nadir should not be surpassing with the threshold set up by the grid operating codes, otherwise protection relays will be activated to trip the generators or loads. System inertia and the governor responses can be reduced to RoCoF and improve frequency Nadir. The maximum RoCoF can be observed at the beginning of a power unbalanced event. It can be obtained by:

$$\Delta\dot{f}_{max}\big|_{t=0} = \frac{\Delta P f_0}{2H\alpha S_B} \qquad (4)$$

By evaluating the first-order differential, we can calculate the frequency Nadir or the maximum frequency deviation as:

$$\Delta f_{max} = f_{ss} + \frac{B}{A^2}\ln\frac{-B}{A^2 C_1} \qquad (5)$$

C. Synchronous Generator Outage rate

Forced outage rate of a synchronous generator, defined as the ratio of the forced outage hours to the total serve and forced outage hours which is used by grid operators to plan generation portfolio. If a synchronous generator is in its forced outage, it means a certain amount of synchronous generation and above it, its inertia is not available for its entire power grid.

D. Renewable Forecast Error

The predicted power output of renewable energy can change drastically within a short time and therefore, corresponding minor variations can be corrected b the short-term economic dispatch.

Sudden change due to the forecast errors is assumed to happen, so as to form the worst grid event. The forecast timescale of renewable is set to be one- hour ahead.

E. Probability of Instability

Power grid Instability in this paper is defined as the state of operating equilibrium interrupted by severe upsets, resulting in the loss of load for generation.

It can endure a certain range of power unbalances according to its available inertia and primary reserve.

After to it a power unbalances ΔP, the frequency response of it will have a resultant maximum RoCoF and frequency deviation.

The RPG is able to safely restore its nominal frequency, if both frequency indices do not violate their key constraints, otherwise load shedding or generator tripping will be activated. Therefore, the maximum power unbalance can endure resulting in one or two associated frequency security indices reaching its limit.

If synchronous generator is online it will provide a fix amount of inertia according to its rated power, so that the minimum online capacity of synchronous generators can be derived from the minimum system inertia required thus to stabilize PRG.

The power unbalance of RPG can also be triggered by renewable variation or online synchronous generators tripping or both of them.

IV. PUDUCHEERY CASE STUDY

Now India is also contributing to the world in integration of renewable resources with smart grid. India's Central Government Electrical Power grid development Corporation has undertaken a pilot project. Under this project, micro grid has been developed for five residential smart home consumers. It consists of distributed generators plants, power converters, Information Technology network and smart electrical network with intelligent home equipments. Here renewable energy resources which were being used are solar photovoltaic system, micro wind and mini combined heat and power biomass. A total of about 20KW tri-hybrid distributed generation plant solar contributes 10 KW, wind turbine 5KW and biomass gasifier about 5KW.Variable speed turbine which is designed to as to get high efficiency from wide range of speed.

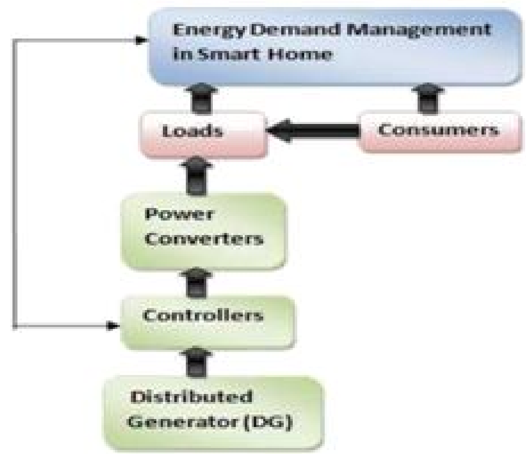

Fig 1 Puducherry Micro grid layout

Here process goes from power conversion from ac to dc and then back into ac for wind, small hydro and hydro and biomass distributed generation. Power electronic converters as shown are used so as to link between renewable energy resources a power grid also, the reactive power output is too controlled. Micro-grid operates autonomously. On side generation small scale with help of renewable based sources can be intended to act as a backup cover or to boost the main power grid during periods of peak demand. Micro grid will help the consumers in order to generate their own power which will further leads to reduced costs, more reliability with power quality.

At Puducherry single family 2BHK smart home was designed so as to look as pilot project for energy demand management study. Aim to analysis the effectiveness of intelligent home appliances for peak energy demand management. In these smart home, information and technology is used in houses where already installed smart appliances and meters communicate with HAN (Home area Network). This technology allows accessing and operating of home appliances smartly and optimally to save. Many electric loads like TV, refrigerator, two CFL, washing machine, dish washer and fans are used in study during peak hours. During peak energy demand, power tariff has high rates. So auto scheduling and time priority based use of home appliances will lead to reduce electricity bills by shifting loads from peak hours to non peak hours with smart sensors too data analysis of room temperature, light intensity and humidity carried out on daily bases. After all, the data is collected and is being transmitted to central computation system. Here, on basis of data proposed algorithm will be performed and thus, load control and shifting from peak to non peak hours will be done.

Fig 2 Smart Home structure

Fig 3 Schematic diagram

This schematic pilot project will be a step towards more and bigger project based on integration giving high reliability, quality and security of supply.

V. CONCLUSION

The renewable resources are getting explinished so we need alternative sources to generate power. The renewable sources are being integrated but they face many problems related to frequency and efficiency. By the study of methods, their maximum frequency to be needed for integration can be calculated. Also power stability criteria's will help the producers in a big way as they will be able to keep a brief of ongoing resources. The major drawbacks of this will only be that voltage regulation and fluctuations problems will keep on arising in it. But key benefits including high demand response, high rate of reliability, quality and security of supply will lead to more and more development. Consumer will lead to play a major role as this integration will not be succeed until and unless consumers join hands for their own benefits including peak hour load shifting.

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