# Integration of Renewable Energy Resources: A Survey©

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**Abstracts:** This survey: report includes a review of different schemes of integration of renewable energy resources. Which includes different objective, constraints and solutions are discussed. The research and technology is rapidly developing to solve the challenges of RES integration. Energy storage, voltage & current stability, and fluctuation in the system to be minimized. This survey report will help to describe the challenges and available solution, also address the new technologies and future directions.
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**Keywords:** Micro grid, smart grid, large scale and small-scale integration, energy storage system (ESS), Maximum Power Point Tracking (MPPT), interconnected and island, RES (Renewable Energy Resources).

**Introduction:**

The use of renewable energy resource was greatly increased in last decades due to increasing the price of electricity per unit by convectional generation from oil, gas and coal. Due to serious oil crisis, oil price per barrel is high in the mean while economic issues are more important factors to be considered and overall national economy. On the other hand fossil fuel based energy generating system causing the harmful gases emission like CO2, SO2 etc. and ultimately verse effect on environment and global warming's a better emission management and clean energy system required to solve this emission problem. The constraints and objective covered in this report are, problems for island and interconnected mode micro grid, storage size, storage technology selection, maintenance and financial cost. Frequency and voltage stability problems, transmission problems. Also discussed the large scale and small scale RES integration challenges, solution and future work.

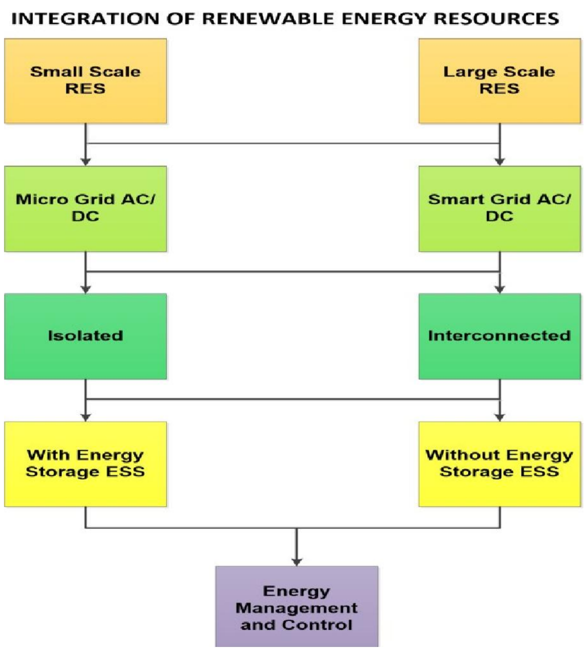
*I. AC MICRO & SMART GRID (ISOLATED & INTERCONNECTED) RES INTEGRATION CHALLENGES AND SOLUTIONS:*

[1] Power generations (DG) are used in micro grid to fulfill the needs of consumers. Integration of DG to microgram is clean, reliable and economic system of providing electricity to consumers. Many DG and load management strategies are: Sterling dish technology is used in Solar thermal in this method heat collected by receiver transferred to hot side of engine and its uses working fluid to push pistons which in turn rotates Induction generator. Its range is from 10-25kW. In this method blades move because of winds kinetic energy, which in turn rotates rotor of generator. Its range is from 700kW to 1.5MW. Most commonly used method of storing energy is battery storage and for this lead acid battery. Ever increasing energy demand, rapid depletion of fossil fuels and also environmental issues made greater interest in Renewable Energy Sources (RES) by distributed power generation (DG) technologies. The micro grids are classified as ac micro grid, and dc micro grid. Micro grids are systems that have minimum of one Distribution Energy Resources (DER). In Micro grids, loads and energy sources can be disconnected and reconnected from power system with minimum disturbance to the local loads.

[2] The major problem is the irregular voltage and frequency of different energy resources subject to availability and how an autonomous micro grid design to achieve these parameter with latest feasible technology and economically. Modeling a good autonomous micro grid (MG) with regards to frequency stability for the integration of renewable energy resources. The particular MG is comprised within a wind energy place (WPP) in addition to a battery energy storage system (BESS). The major purpose of BESS to control voltage and frequency in the meanwhile WPP supply active/real power to the grid with unity power factor. The model use for modeling of this autonomous system was dominant element of the system, in which dynamic frequency and control efficiently achieved for variable load and variable wind speed with minimum system complexity. With the help of software simulation result when the number of dominant poles of WPP

increases then damping of the system decrease on the other hand frequency oscillation increase so to cater this problem more BESS was added to the system to increase damping of the system which was helpful to achieve particular frequency behavior of autonomous MG and its better way and more reliable so the maximum people of the remote areas of world can get benefit from it.

**Review:**




[3] Renewable energy resources are considered as future energy source to meet the growing energy demand, particularly this study includes PV & wind generation system. The challenges are the fluctuations in the electric power network which may affect the scheduling process of electricity generation. In the proposed system the efficacy of wind and PV generation is significantly improved and also improve the coordination with traditional energy generation system. For this purpose a micro grid used with the energy storage system. The technical key issues of RES Integration are:

1. Power Fluctuations
2. Power Quality
3. Storage required
4. Protection sachems
5. Island
6. Optimal placement of RES

[4] RES Integration with the ESS (Energy Storage system) in the isolated micro grid mode is used. Multi agent concept is used with the central controller to collect the load and sources data and made an intelligent real time decision. The data acquisition through the sensors nodes with the Micro grid central controller (MGCC) would use for the energy management algorithm to make decisions. This whole proposed system greatly improved the overall system efficiency and reliability.

[5] The isolated mode micro grid system for the micro communities where RES is available in huge amount to be used. A reliable energy storage system with the micro grid to supply energy to the micro communities in a solution of standalone micro grid is to supply energy to the people living remote areas with reliability continuity, sustainability and good quality. On the other hand another important goal is also achieve which is minimization of CO2 emission and a better emission management to minimize the global warming. The system is, a centralized hybrid system, which provides.

[6] Energy generation form the RES with the isolated mode micro grid, on the other hand power production by conventional mean and gasified biomass also considered. The economic evaluation of all the proposed system showed highly profitable and great impact on the balancing of resources using demand side renewable variability. The characterization for the proposed system as geographical site and availability of the RES, type of community and energy demand, type of grid connection and type of storage system used. The simulation platform used computed the optimized results as per energy demand and financial concerns. The energy storage system is still a big challenge to be solve for the island micro grids in terms of economic, size and efficiency concerns.

In [7], the design specifications and development proposed for the standalone micro grid, which supply the hybrid RES wind and solar. The major of this proposed 380-VAC -60Hz to users. SCADA system is used to control the system auxiliaries and also monitor the charging/discharging of battery bank. This system is physical implemented and achieve better results to resolve the power issue with better reliability and financial concerns.

For the minimization of the overall system fluctuation and improving the power quality high speed and efficient power electronics devices used to solve this issue. MPPT (Maximum Power Point tracking) used to minimize the fluctuation in the installed PV system. But still for the storage system more research and development required to enhance the storage efficiency and increase the life of ESS.

*II. LARGE – SMALL SCALE RES INTEGRATION CHALLENGES AND SOLUTIONS:*

[8] Today most of the electric power of the world is generated by burning of fossil fuels, which are the leading cause of greenhouse Effect.40% of the greenhouse gases in the atmosphere were emitted during the generation of electric power from burning of fossil fuels. There are certain treaty or protocol,

which are contributing towards green environment reducing the emission of Green House gases in atmosphere. Several alternatives of electric generation methods were proposed such as solar energy and wind turbines. The electric generation using wind turbine and highlights some problems associated with the wind turbine use. These problems include the high noise of the turbine, Voltage fluctuations, and the Shadow effect of turbine blades in nearby residential areas. Factor. Another problem is interference of turbine equipment with radar or television that disturbs the signal strength. Several technical and social aspects of wind turbine were discussed and order to implement the wind turbine electric generation to replace dependency on fossil fuels.

[9] The analysis of basic characteristics, IT technology, structural design and communication for the computerization of distribution network with Renewable Energy Source. Nice Grid is complicated and complex system due to decentralized type management, but it is more attractive than others. Basically, automation is based on IT technology as well of the communication. Communication standard is IEC61850 in IREC's micro grid, which allows the transmission of data accordingly for the sake of better automation and better energy management. For more accuracy in the application in an electric grid, adding DG requires more complex algorithms. The new automated network system with the combination of DGs. A new architecture, IT based technology and a standard IEC61850 must be entered in the system for equivalent networks and management systems because automation is dependent upon communication ways and controlling algorithms for having good efficiency and effective use of power.

[9] The different distribution network topologies are discussed and their basic characteristics & communication system was analyze for the distributed energy resources integration. The major question was how enhance the efficiency and intelligence of the distribution system network for efficient and economic integration of renewable energy resource in large scale and small scale. To solve the serious problems associated with the conventional power generation problems ecological and economic constraints as a result of vast CO2 emissions as a result use of fossil fuel. To meet with the peak demands a storage system was introduced in the installation to use save energy. So because of this an economical and reliable solution required subject to the size and price for storage. Another problem was the frequency synchronization; variable voltage control, isolation and fault detection to solve these problems specific control algorithms was introduce. Large power plants with the integration of different scale of energy resources integration required highly intelligent communication system to automate energy generation as the requirement demand and storage of energy subject to source availability. The architecture of power system with RES integration in order to improve the automation of distribution network for this purpose a decentralized management of distribution grid system was introduced in order to meet with these problems and challenges. A new architecture and IT technology based solution was introduced having improved communication system and control algorithms to enhance the performance of the system with efficient and economical use of energy. At this time this technique has several stages needs to be accomplished in ten years. Moreover, the improved control algorithms and prediction tools have been introduced for efficient and smart automation of power system.

[10] At this time, the progress of proposed network is divided in round about ten years. But still only one group of load is real time simulated. Control set of rules and prediction tools are getting technologically advanced for the automation of distribution system. In the last, for a smart automatic system, control machine procedures must be applying on overall system and the parts involve.

[11] The scale of wind power that is integrated in China and analyzes the problem from a policy perspective. In recent years, China has doubled its established wind power capacity but still is unable to match consumer's demand, which is an area of concern for policy makers. Wind power only accounts for 1.17% of country's total power production. Such low ratio is due to the problems in grid connection. Add to that the geographical distribution of wind energy resources is mismatched with electrical load. To tackle that China started building wind farms to increase its wind power capacity. By end of 2009, those farms had a capacity of more than 8 GW. Few reasons which hamper the dispatch of wind power into the transmission network are inept growth between wind power and power grid, lack of appropriate codes for wind power integration, inadequate cost-effective incentives for grid enterprises.

[12] To solve this, policy makers should reinforce the administration for the creation of wind power projects. Technical codes should be recognized and policies for managerial involvement should be incorporated to inspire the grid enterprises' eagerness to take up wind power generation.

[13] Analysis of three demanding responses paradigms for evaluating the advantages of demand flexibility, first one is the central co-optimization of generation and demand by the system operator, demand bids and coupling of RS with deferrable loads. They stimulated the coupling as a substitute for overcoming the disadvantages of two alternating demand responses choices and they offered an

energetic programming algorithm for managing deferrable demand with renewable source. Furthermore, a stochastic unit commitment model that covers the large scale integration of RES and demand response resources. Demand-side bidding left behind the coupling w.r.t operating cost resulting in a cost increase between 2.43% to 6.88% of the budget analogous to centralized load dispatch. Therefore, they determined that it's impossible to convert a constraint on the total energy consumption into an hourly elastic demand. They concluded from the case studies that further integration of deferrable demand carries out no extra capacity requirements to the scheme.

[14] The cost of anarchy carried out by coupling RES with deferrable demand is the price for overcoming the

Institutional and regulatory barriers linked with the significant integration of demand response that can one by one facilitate the large scale integration of renewable resources.

*III. DC MICRO & SMART GRID RES INTEGRATION CHALLENGES AND SOLUTIONS:*

[15] Multiple modes of Dc micro grid. Advantages of Dc over Ac are higher reliability, transmission efficiency and safety. Main two algorithms used for grid control are centralized and distributed control. In Centralized Control system cost of Energy Management System and Speed are the main issues where as in distributed control system operation is based on local information. Most common example of distributed control is DC Bus Signaling. As we know there is maximum charging and minimum-discharging range of battery is given beyond these ranges battery life would be affected so constant power mode is suggested in this paper. Renewable sources are designed to work on maximum power point tracking. And in case of extreme emergency we will use nonrenewable energy resource. Three regions discussed in this paper High intensity region, zero intensity region, low intensity region. In high intensity region renewable source will work to provide load demand as well charge battery here it will work in MPPT mode. In zero regions renewable energy will provide load demand and also charge battery but here it will work in monitoring bus mode. In low intensity region battery will supply power and in case of extreme emergency nonrenewable source can be used.

[16] The renewable energy resource considered are the solar energy, wind energy and fossil fuel, as the system

Known as hybrid power system. This proposed system used to meet the increasing energy demand. Moreover a

Systematic approach used for intelligent control & conversion of DC to AC and AC to DC energy for Distributed generation and main grid. In the proposed approach generation line and consumption lines separately used so the DG's can supply its surplus energy to the main grid with minimum fluctuations and maximizing stability.

[17] Analysis and modeling of a DC grid, which is operated under different, load conditions, which are working with storage battery and without battery. DC Micro grid consist of photovoltaic cells, wind turbine and solid oxide fuel cell. Boost regulator is used to step up the dc voltage. Objective of this paper to improve the efficiency and reliability of the DC Micro grid with the proposed control scheme which includes design and operational analysis simulated in MATLAB for the distributed generation with and without battery storage. Modeling of the variable speed wind turbine is done which is coupled with the three phase induction generator and ac power supply to the ac load where surplus ac power converted into dc and supply to the dc loads. In the meanwhile PV cells with MPPT generate dc power, to maintain the dc voltage level boost regulators are used. Constraint is the BESS (Battery energy storage system) is expensive and limited, also battery management system required but on the other hand BESS increases system reliability and security. Mainly boost regulator used for SOFC to maintain the output dc voltage equal to the DCMG voltage and also maintain the power balance of DCMG by controlling current. Bidirectional choppers are connects the BESS and DCMG, which control the charging and discharging of BESS. A complete modeling of wind turbine, solar photovoltaic cell, SOFC system and BESS has been done and simulated them with control scheme together, to minimized circulating current. Selecting the proper voltage level of DCMG eliminates the main milestone achieved in this paper transformer at load side converters end. Advantages are the proposed system is reliable, secure and work satisfactory on any voltage level. But on the other hand disadvantages are the limited Lead acid battery storage, battery management system is required, frequency synchronization is problem to be solve. Increasing demand of electricity has attracted large interest in renewable energy sources. Advantages of DC micro grids over AC micro grids are Better quality of power supply, More Reliability, Due to absence involving reactive power, it leads to greater utilization and reduce losses and Greater Efficiency. Now we will discuss dc grid configuration and sources that are used will be solar and wind respectively. Wind generating station is connected to main grid via step down transformer and bidirectional voltage source convertor (VSC) respectively. Local load connected with wind turbine station so when output of wind is absent then main grid will supply voltage to this local load by help of local VSC. The main grid can supply both ac and dc

voltage. Three-phase load is connected with main grid via voltage source invertor (VSI). In Solar configuration it is connected to main gird via dc boost convertor. Solid oxide fuel cell is connected to main grid via dc boost convertor. Batter storage system is connected to main dc gird via bidirectional switch and dc boost convertor. Ac loads connected with main grid are three-phase ac load and single-phase ac load. The actual recommended "smart dc micro grid" with autonomous coordinated management plan proposed in this paper has a number of advantages like stable & high quality of power and reliable at desired dc voltage for different connection of DG's BESS and DC & AC loads. This type of DC micro grid can perform satisfactory for any type of viable under steady state and transient condition.

[18] Using the present concept, evaluate the advantages and disadvantages of smart grid for the distributed generation from RES. Discuss and evaluate the smart grid design applications and its future technology direction. Furthermore smart grid applications for the RES distributed generation.

[19] The renewable energy Integration scheme is proposed for the Maharashtra state of India, where high potential of renewable energy resources is available. By using these large scale RES the increasing demand of energy can be meet and forced load shedding can be minimized. Maharashtra state of India having high RES potential mainly wind, solar and Biomass. Micro grid is used to integrate the distributed energy resources, which is, consist of small-scale network. Challenging RE integrations is majorly distance between DGs, RES are highly inflexible, stochastic in nature and limited capacity regardless how much load is contend so generation cannot be enhance. Frequency, frequency control and the voltage balancing between the DG's is also a big challenge. Constraints are the capital cost & maintenance cost, limited planning and for large scale RES to be autonomous system which requires more investment cost. In the proposed solution of RES integration subject to availability, flexibility, weather condition and location the components are Main Grid, RES are wind, solar energy, biomass, water, biomass and bagasse are considers. The proposed storage system is this paper is fuel cells, battery, super capacitor, pump storage device and fly wheel.

*IV. POWER MANAGEMENT AND CONTROL KEY ISSUES AND SOLUTIONS:*

[20] The current strategies of agent-based control and with event-based control are unable to constantly guarantee an optimized power flow in the electric power distribution networks. The major problem is renewable energy resources integration efficiently and problem of fluctuated loads. To solve this problem a new technique was introduced virtual agent server in smart grids to improve the overall power system management. To reduce the demand in order to implement a load side management a finical incentive approach use to set the price for use of electricity for particular time period to reduce the peak hour's load. If demand of electricity is high along with a minimal power generation, then the price of electricity per unit increases or vice versa. The plan for power management in smart grid that can be implemented with smart grid could be carried out with agent-based control and also with event-based control for the time shift able sauces and loads as well. In this paper a virtual agent server is introduce in the smart grids, to adjust the price of electricity in the transmission network. The result of this virtual agent technique was the optimize power flow in the distribution network achieved. So implementing a virtual agent server based technique the overall power management of the smart grids was improved, and integration of various renewable energy resources with fluctuated loads the average power flow is optimized. So the main advantage to implement this virtual agent server based techniques was to improve the power management in the smart grinds with floated loads and integration of renewable energy technique was improved also.

[21] A management and control system was introduced for the large-scale integration of wind energy resources for both offshore and onshore subject to availability of source. To improve the power distribution network operation a management and active control system structure was introduced to make the system more efficient, stable and reliable. These type of management structure enhance the overall intelligence of the power system from transmission side to the distribution side, to support this type of management and control system the micro grid system play vital role to support the integration of renewable energy resources efficiently.

[22] Variety of issues raising with the increasing the demand of electricity, due to relaying on the fuel, the price for electricity per unit sufficiently increase and on the other hand a huge impact on the environment by emission of toxic gases and waste, large transmission losses so in order to meet these problem improving transmission and distribution system and large scale renewable energy resource integration specially wind energy integration was introduce with the management and control systems. The solution discussed in this paper mainly involve an intelligent management and control system, which decisions are enhancing the power network capability, operation planning of the system and compete with other power systems for safe and robust power system operation. This type of management system contribute a vital role for increasing society economic benefits and its energies polices & strategies.

[23] Since the inception of renewable energy systems, the use of conventional energy systems is revolutionized. Though a renewable energy system is an emerging field and it's much expensive but increasing the efficiency and improvising the technology can result in decreasing the cost of such a system. The road map which was adopted by National Renewable Energy Laboratory (NREL) to develop an Energy Systems Integration Facility (ESIF) which can focus on R & D in this sector for the improvement of existing renewable energy technologies. ESIF aims to galvanize the R & D in the domain of renewable energy systems which is equally desired by NREL. This facility is aimed to have a high performance computer and data center (HPC) and electricity systems visualization center (ESVC). The main purpose of these centers is to assist in the improvement and development of new technology of the wind, solar and hydrogen energy systems. In a nutshell, this paper is about establishing a facility aiding the technological advancements, which can modernize the energy infrastructure of the nation. Hence, it is aimed to help the country to cater for its ever-increasing energy needs.

[24] Grids are now modified and improved to integrate and storage of energies. Droop control allows the parallel generator operations allowing the integration of small-distributed power i.e. renewable energies into the grid. Different levels have been initiated for multilevel control of ac and dc MG's. The standards have been defined through proper hierarchical control consisting different.

For DC hierarchical control system is used as follows:-

*1. Primary Control:*

If there is voltage change in the DC load the supplies will generate a current in each source. To adjust the voltage, virtual impedance is adjusted to voltage level provided the inner current and voltage control loops.

*2. Secondary Control:* Voltage deviation problem is solved in this control. The voltage level of MG is sensed and compared with the reference voltage and the difference is sent to all the units to restore output voltage.

*3. Tertiary Control:*

The power flow is controlled by changing the voltage inside the micro grid depending whether system wants to import or export the energy.

For DC hierarchical control system is used as follows:-

1. *Inner control Loops:*

Min grid's and the electric generation sources have an interconnection through current source invertors and the phase lock loop using VSI's and CSI's to stay synchronized.

2. *Primary Control:*

In this level frequency and amplitude of voltage referenced are adjusted with reference to voltage and current loop. It controls the behavior of Synchronous generator i.e. reduces the frequency with the increase in actual power.

3. *Secondary Control:*

In Secondary Control the deviation of frequency and voltage deviation are regulated towards zero after every change of load generation inside the micro grids.

4. *Tertiary Control:*

The power flow inside the system is controlled by adjusting the frequency and amplitude of voltage of the micro grid. Thus the tertiary control acts as a primary control of micro grid allowing the interconnection of the multiple micro grids. Through territory, secondary, primary and inner control loop ensuring the flow of energy. Similarly the bypass switch designed to meet grid interconnection standards. The hierarchal control is organized through primary control, which deals with inner control of DG unit, the secondary control which restores the frequency and amplitude deviation and the territory control, which regulates the power flow between the grids. For large power system with high inertia and inductive network this system is used. The System for the hierarchy control of AC micro grids used as follows.

[25] Proper designing and sizing of the hybrid energy system, and testing of the proposed system in the laboratory to make a decision for the system either large scale or small scale use. Moreover real time data acquisition and evaluation making system reliable and also for the future demand analysis.

[26] Optimal sizing and allocation the RES in smart grid, consider the voltage stability in the system, power quality, and optimal placement as an objective. The proposed strategy to find the optimal sizing of distributed levels for efficient communication between the supplier and the consumer. For example ISA-95 is adopted generation (DG) and reactive power injection in the system for the overall voltage stability of the system.

*V. RES INTEGRATION WITH ENERGY STORAGE SYSTEM (ESS) CHALLENGES AND SOLUTION:*

[27] Energy generation from RES with the modern power electronics technology having a great contribution in the future energy market in order to maximize the financial benefits and reduce the load from the conventional energy generation. On the other hand RES.

[28] The environmental effects due to the emission of harmful gasses to be minimized by the effective emission management plan. The technical benefits and functions of energy storage system are the give voltage & frequency support to the main grid,

maintain grid transient stability, minimize the peak load of the main grid, providing better power quality and increase the power reliability.

[29] In the recent year there is increasing energy demand, PV generation contributing in the current and future load demands but the sizing and the financial concerns are the key issues for the PV generation system to make system more economical and reliable. To solve these key issue an effective and suitable system is prosed which includes financial and technical aspects for smart grid PV generation.

[30] The proposed storage systems which can be used are pump storage device, flywheel, compressed air energy storage, fuel cells, batteries, superconducting magnetic energy storage and super capacitors. The main focus on the medium ESS because of the size and financial concerns etc. This overall system will provide better support to the main grid in order to meet the increasing energy demand, which will be reliable and economical.

**Future Work:**

In the future directions more system stability analysis required, fast and reliable communication system required for the DGs and MGs communication, grid protection analysis, frequency synchronization, frequency and voltage stability analysis required for more reliable, secure and efficient RES integration.

**Conclusion:**

The demand for the electricity for emission free is the renewable energy to the grid. There are many technologies, network topologies, working mode, energy storage system are introduce but still there is more research & development required to improve the RES integration

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